



**Bangalore Development Authority**  
**T. Chowdaiah Road, Kumara Park West**  
**Bangalore – 560 020**

**TENDER FOR THE WORK**

Of

**“Development of Major Arterial Road, Phase -1 in Nada  
Prabhu Kempegowda Layout”**

**(Through GOK e – Procurement Platform  
<https://eproc.karnataka.gov.in>)**

**VOLUME II**

**SECTION 7B: TECHNICAL SCHEDULES (PART 1),  
TECHNICAL SPECIFICATIONS,**

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## **SCOPE OF WORK**

### **GENERAL**

1. The appointed agency shall take up the 'Detailed Engineering Study' to ascertain further details and carry out detail engineering and working drawings with the latest IS, IRC & MORT&H NBC guidelines. Where the relevant guidelines are not available then international codes may be adopted.
2. The bidder shall quote total amount for the whole of works including all statutory (Excluding BWSSB and BESCOM) deposits prevailing at the time of execution including obtaining no objection certificate from police, BESCOM, BWSSB, Fire fighting, Tree Cutting, Forest Department, Pollution Control Board and other statutory necessary permissions.
3. The Appointed agency will get the design , detail engineering proof checking through the renowned Institute like IIT Bombay or IISC Bangalore or Central Power Research Bangalore Institute (CPRI) for all works and any civil structure or material or work as may be applicable and as desired by the Engineering Member .BDA shall pay the statutory charges for proof checking directly to the proof checking agency.
4. The Employer will undertake third party inspections and testing for all works and any civil structure or material or work as may be applicable and as desired by the Engineer. The Contractor shall be wholly responsible to make arrangements for carrying out the required tests. The Contractor shall be responsible to obtain permission for and provide all facilities to Employer for carrying out such inspections or testing as may be required. The Third Party Inspection charges and all the other costs for such independent inspection and testing shall be borne by the contractor. Third party inspection agency shall be approved by the Employer.
5. The impact of GST on various items is still being worked out and government has still in the process of issuing notification in this regard. It is proposed that the agency needs to quote rates with current rate of GST. If in the future after award of the work there is any change in item rate greater than 2% of the accepted cost of that item, then separate claim needs to be submitted by the agency which shall be scrutinized by a committee comprising of three experts and the decisions of the committee shall be binding. The committee shall have one expert nominated by agency, one by BDA and both the members shall appoint third referee if required.
6. The contractor shall have to submit the material procurement plans for next three months which shall be approved by the BDA representative/ engineer in charge. And the supplies of approved material quantity shall only be eligible for payment.
7. Warranties of the materials purchased shall have to passed on to the BDA and that shall be over and above the contractors own warranty as per the contract.
8. All required permissions/ROW issues from all concerned departments shall be obtained from the contractor and employers Engineers will assist for the same.

9. No Variation work will be executed by the firm unless approval is conveyed from the Competent Authority.
10. The Hard Rock obtained during execution, will not be auctioned by employers (Because of the restriction in stocking of hard rock in site and safety issues). However Rs.50.00 per cum of Hard Rock will be recovered from the firm in Running bills.
11. The contractor shall comply with the all the legal requirements in the matter of employment of workmen and provide all safety gadgets to the workmen while working in the hazards place or conditions during the execution of the contract.
12. Contractor shall be fully responsible in the event of death of employee/workman during the execution of the work and liable to pay adequate compensation to the dependents of employee/workman as per law.
13. On his/their failure, if the BDA is made to pay compensation the same shall be recovered by BDA from the contractor out of the amounts due to the contractor or by appropriate legal action.
14. If death of any employees occurs during execution of work due to negligence of contractor, the contract will be liable for termination.
15. In the event of such termination, the BDA may consider blacklisting of firm after due notice.
16. ESCROW ACCOUNT

The Agency shall, within 7 (seven) days of the appointed date, open and establish an Escrow Account with a Bank (the "Escrow Bank") in accordance with this agreement read with the Escrow Agreement

The nature and scope of the Escrow Account are fully described in the agreement (the "Escrow Agreement") to be entered into amongst the agency, the Employer, the Escrow bank, which shall be substantially in the form set forth in herewith.



#### 17. Common and Overlapping Works by Multiple Agencies

In the event of multiple agencies involved in executing items of work at the same/ common work site the BDA shall decide the Battery limits of each agency involved. It shall be incumbent on the involved parties to cooperate and complete such work with due diligence and cooperation, to the entire satisfaction of the BDA. It is envisaged in the Project that all the Surveys, investigations, Designs, plans, schedules, cost, work progress, funds flow etc. of the project are to be integrated in the Building Information modelling concept popularly known as BIM. Since it involves the entire work of the site and components as a single project. Therefore the BDA shall cause to appoint a single agency for this purpose. The BIM implementing agency shall integrate the different components of the project and also the various packages. It is to be noted that for the purpose of measurements and billing of completed works, it shall be mandatory for all the Agencies working on the project (for all the packages) to share their relevant details with the agency. All the measurements for recording in the measurement books of BDA shall be mandatorily generated through BIM. The bidders shall provide the interface for the BIM software and ensure necessary capacity building. The agencies shall deploy their own hardware & designate their manpower to act as BIM coordinator for this purpose at their cost. BDA reserves the right to deduct the payment of the contractor and directly pay to the agency at the estimated rates.

#### 18. Contractors' All Risks (CAR): The Sum stated in the Agreement plus 20% (Minimum cover for Insurance)

#### 19. The amounts of the Advance payments are

| Nature of Advance | Amount (Rs.)             | Conditions to be fulfilled                                                                                                                        |
|-------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| (1) Mobilization  | 5% of the contract price | After signing of the contract and on submission of un-conditional bank guarantee exclusively for the cost of mobilization in respect of the works |
|                   | 5% of the contract price | It is against mobilization of key equipment's listed in the contract and the work is commence (To be drawn before end of 20% of contract period)  |

(The advance payment will be paid to the contractor no later than 30 days after fulfillment of the above conditions)

## **1.1 SCOPE OF WORK**

The scope of work under this Contract includes the following technical schedules:

**SCHEDULE - B**  
**DEVELOPMENT OF THE PROJECT**

**1 Development of the Project**

Development of the Project shall include construction of the Project as described in this Schedule-B and in Schedule-C.

**2 Six-Laning<sup>1</sup>**

2.1 Six-Laning shall include the Six-Lane Project as described in Annex-I of this Schedule-B and Annex-I of Schedule-C.

2.2 Six-Laning shall be completed by the Appointed Agency in conformity with the Specifications and Standards set forth in Tender Documents.]

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<sup>1</sup>May be modified or substituted to reflect project-specific requirements.

**Annex - I**

**(Schedule-B)**

**Description of the Project<sup>2</sup>**

**1 Width of Carriageway**

**1.1**

Six-Laning for main carriageway shall be generally be undertaken from Ch. 0+000 to Ch. 10+130. The paved carriageway shall be 10.0m on either side in accordance with the typical cross section drawings.

For Service Roads, Four-Laning shall be generally be undertaken from Ch. 0+000 to Ch. 10+130. The paved carriageway shall be 7.0m on either side in accordance with the typical cross section drawings.

Provided that in the following stretches of tunnel approaches after Ch. 10+130 near Mysore Road, the width of carriageway shall be as described below.

| S. No. | Tunnel Approaches                      | Existing Location (km) | Proposed Location (km) | Width (m) | Typical cross section                           |
|--------|----------------------------------------|------------------------|------------------------|-----------|-------------------------------------------------|
| 1      | Tunnel approach from NPKL to Bangalore | -                      | 10+130 to 10+385       | 7.50m     | Refer Volume III (Drawings) of Tender Documents |
| 2      | Tunnel approach from Bangalore to NPKL | -                      | 10+130 to 10+385       | 7.50m     |                                                 |
|        |                                        | -                      | 10+750 to 10+800       | 8.70m     |                                                 |
|        |                                        | -                      | 10+800 to 11+080       | 7.50m     |                                                 |
| 3      | Tunnel approach from NPKL to Mysore    | -                      | 9+930 to 10+385        | 6.00m     |                                                 |
|        |                                        | -                      | 10+750 to 10+800       | 7.20m     |                                                 |
|        |                                        | -                      | 10+800 to 11+050       | 6.00m     |                                                 |

<sup>2</sup> This template is applicable to highway projects. It may be suitably revised in ease of other projects.

| S. No. | Tunnel Approaches                   | Existing Location (km) | Proposed Location (km) | Width (m) | Typical cross section |
|--------|-------------------------------------|------------------------|------------------------|-----------|-----------------------|
| 4      | Tunnel approach from Mysore to NPKL | -                      | 10+130 to 10+385       | 6.00m     |                       |
|        |                                     | -                      | 10+750 to 10+800       | 7.80m     |                       |
|        |                                     | -                      | 10+800 to 10+950       | 6.00m     |                       |

The contents of this Annex-I may be modified in accordance with the structure of the Project.

1.2.2 Except as otherwise provided in this Agreement, the width of the paved carriageway and cross-sectional features shall conform to paragraph 1.1 above.

## **2 Project Facilities**

Project facilities shall be constructed in conformity with Annex-I of Schedule- C.

## **3 Specifications and Standards**

The Project shall be constructed in conformity with the Specifications and Standards specified Volume II of Tender Documents.

## **4 Other Features of the project**

### **4.1. Cross Section**

The project highway Cross sections should follow Typical Cross Sections drawings provided in Volume III (Drawings) of Tender Documents.

### **4.2. Alignment Plan and Longitudinal Section**

An alignment plan and vertical profile of project highway is given in Volume III (Drawings). The minimum FRL given in enclosed drawing shall have to be achieved by Appointed Agency.

### **4.3. Bypass and Realignment**

There are \_\_ bypasses and \_\_ re-alignments in the project highway. The details of realignment to be provided are given at **Appendix B-III**.

### **4.4. Service Road/ Slip Road**

Service/Slip Roads shall be provided in length indicated in **Appendix B IV**.

Cross Sections should follow Typical Cross Sections drawings provided in Volume III (Drawings) of Tender Documents.

### **4.5. Type of Shoulder and Footpath**

(a) In built-up sections, Footpaths shall be provided in following table.

| S. No. | Existing Stretch (from km to km) | Proposed Stretch (from km to km)  | Fully paved shoulders(FPS)/ footpaths | Reference to cross section                      |
|--------|----------------------------------|-----------------------------------|---------------------------------------|-------------------------------------------------|
| 1      | -                                | Around Rotary Island at Ch. 1+650 | Footpaths                             | Refer Volume III (Drawings) of Tender Documents |
| 2      | -                                | Around Rotary Island at Ch. 2+950 | Footpaths                             |                                                 |
| 3      | -                                | Around Rotary Island at Ch. 5+540 | Footpaths                             |                                                 |
| 4      | -                                | Around Rotary Island at Ch. 7+900 | Footpaths                             |                                                 |
| 5      | -                                | Around Rotary Island at Ch. 9+420 | Footpaths                             |                                                 |

#### **4.6. Six Lane stretches (if any)**

Details of stretches to be construed as Six Lane without paved are as indicated in **Appendix V**.

#### **4.7. Proposed Right of Way (ROW)**

Proposed Right of Way (ROW) for development of Major Arterial Road shall be 90m. However for Phase 1, the Right of Way under consideration is 45m. The details of the proposed ROW are given in **Appendix B VI**.

#### **4.8. At Grade Intersection**

At grade intersection shall be provided as per locations specified in Appendix BVII for major and minor intersections.

#### **4.9. Type of Pavement**

Type of pavement shall be flexible. Pavement design shall be carried out in accordance with IRC: 37 - 2012.

The minimum pavement composition for Flexible pavement shall be 40 mm BC, 70 mm DBM, 250 mm WMM and 230 mm GSB over a sub grade of 500 mm (with Min CBR 8%) for Main carriageway and Bus Bay.

The pavement composition for service / Slip road shall be 25 mm SDBC, 50 mm DBM, 230 WMM mm and 150 mm GSB over a sub grade of 500 mm (with Min CBR 8%).

#### **4.10. Grade Separated Intersections**

The grade separated intersections shall be as provided as given at **Appendix-B VIII.**

#### **4.11. Utility Structure**

The details of the Utility Structure are given in **Appendix BIX**

#### **4.12. Underpasses**

Vehicular underpass and Light Vehicular Underpass shall be provided at location given at **Appendix-BX** and **Pedestrian /cattle underpass** shall be provided at location given at **Appendix-BXI.**

#### **4.13. Major bridges**

Major bridges as listed in **Appendix BXII** shall be provided, widened, reconstructed or extended

#### **4.14. Minor bridges**

Minor bridges as listed in **Appendix BXIII** shall be provided, widened, reconstructed or extended.

#### **4.15. Culverts**

Culverts shall be provided, widened, reconstructed or extended as listed in **Appendix-BXIV**

#### **4.16. ROB/RUB**

Details of ROB/RUBs to be provided are given at **Appendix BXV** following points shall be taken care of:

- I) The proposed span arrangements of the ROB/RUBs are tentative and subject to change as per availability of railway boundaries/ requirement of the railways.
- II) ROB shall be designed, constructed and maintained as per the requirements of Railway authorities. The construction plans shall be prepared in consultation with the concerned railway authority.
- III) The ROB/RUBs shall be constructed and maintained by the Appointed Agency under supervision of the Railways.
- IV) All expenditure related to construction, maintenance and supervision of ROB (except P&E charges) shall be borne by the Appointed Agency

#### **4.17. Slope protection**

The side slope shall be protected by using suitable slope protection measures wherever required along project highway.

#### **4.18 Utilities**

Various utilities like electric and telephone poles, OFC lines, water pipe lines/sewage pipes and Hand pumps are located close to the Project Highway. With the proposal of widening of the existing road from 2-lane to 4-lane with paved shoulders with divided carriageway, it will be necessary to shift the utilities falling in the widening alignment, in consultation with IE/Authority.

#### **4.19 Rainwater Harvesting**

As per Ministry of Environment and Forests Notification, New Delhi dated 14.01.1997 (as amended on 13.01.1998, 05.01.1999 & 6.11.2000), the construction of Rain water, harvesting structure is mandatory in and around Water Crisis area, notified by the Central Ground Water Board.

#### **4.18 Type and Width of Median**

The minimum width of median shall be 3.00m including kerb shy. Refer Volume III (Drawings) of Tender Documents.

#### **4.20 Location of Footpath and drains**

Drain cum footpath shall be provided in urban stretches as **Appendix – BXVII**. The dimensions of the footpath and drain shall be approved by Independent engineer.

#### **4.21 Provision for extra widening at sharp curves**

Extra widening to the carriageway shall be provided at sharp curve locations. The details of extra widening locations are as given in **Appendix BXVIII**.



## **Appendix B I**

### **Typical Cross Sections**

**Refer Volume III (Drawings) of Tender Documents**

**Appendix-B II**

**Alignment Plan and Longitudinal Profile**

**Refer Volume III (Drawings) of Tender Documents**

### Appendix-B III

#### Details of Bypass / Realignment

##### 1 Bypasses

| S.<br>No. | Name of Bypass (Town) | Chainage (km) | Length<br>(in Km) | Carriageway |      |
|-----------|-----------------------|---------------|-------------------|-------------|------|
|           |                       | From – To     |                   | Width (m)   | Type |
| NIL       |                       |               |                   |             |      |

##### 2 Realignments

| S.NO. | EXISTING CHAINAGE |    | DESIGN CHAINAGE (m) |    | LENGTH (m) | LOCATION |
|-------|-------------------|----|---------------------|----|------------|----------|
|       | From              | To | From                | To |            |          |
|       |                   |    |                     |    |            | NIL      |

**Appendix B IV**

**Details of Service Roads**

| S.NO | Design Chainage (m) |        | Length (m) | Side       | Service Road Width (m) | Total Linear Length (m) | Remarks                             |
|------|---------------------|--------|------------|------------|------------------------|-------------------------|-------------------------------------|
|      | From                | To     |            |            |                        |                         |                                     |
| 1    | 0+000               | 10+130 | 10130m     | Both Sides | 7.0m                   | 10066m                  | Length excluding CD Works & Bridges |

**Appendix B V**

**Schedules for Six laning (if any)**

| S.NO | Design Chainage (m) |        | Length (m) | Side       | Road Width (m) | Total Linear Length (m) | Remarks                             |
|------|---------------------|--------|------------|------------|----------------|-------------------------|-------------------------------------|
|      | From                | To     |            |            |                |                         |                                     |
| 1    | 0+000               | 10+130 | 10130m     | Both Sides | 10.0m          | 10066m                  | Length excluding CD Works & Bridges |

**Appendix B VI**  
**Details of Proposed ROW**

| S.NO. | DesignChainage(m) |        | Designlength(m) | PROW(m) |
|-------|-------------------|--------|-----------------|---------|
|       | From              | To     |                 |         |
| 1     | 0+000             | 10+130 | 10130m          | 45      |

## Appendix B VII

### At Grade Intersection

#### Major Intersections

| S. No. | From   | To     | Type of Intersection | Other Features |
|--------|--------|--------|----------------------|----------------|
| 1      | 0+000  | 0+000  | T                    | Major Junction |
| 2      | 1+650  | 1+650  | +                    | Major Junction |
| 3      | 2+950  | 2+950  | T                    | Major Junction |
| 4      | 5+540  | 5+540  | T                    | Major Junction |
| 5      | 7+900  | 7+900  | T                    | Major Junction |
| 6      | 9+420  | 9+420  | T                    | Major Junction |
| 7      | 10+770 | 10+770 | T                    | Major Junction |

#### Minor Intersections

| S. No. | From  | To    | Type of Intersection | Other Features |
|--------|-------|-------|----------------------|----------------|
| 1      | 0+800 | 0+800 | T                    | Minor Junction |
| 2      | 1+200 | 1+200 | T                    | Minor Junction |
| 3      | 1+570 | 1+570 | T                    | Minor Junction |
| 4      | 1+630 | 1+630 | T                    | Minor Junction |
| 5      | 1+690 | 1+690 | +                    | Minor Junction |
| 6      | 1+890 | 1+890 | T                    | Minor Junction |
| 7      | 1+950 | 1+950 | T                    | Minor Junction |
| 8      | 2+260 | 2+260 | T                    | Minor Junction |
| 9      | 2+940 | 2+940 | T                    | Minor Junction |
| 10     | 3+420 | 3+420 | +                    | Minor Junction |
| 11     | 4+730 | 4+730 | +                    | Minor Junction |
| 12     | 5+320 | 5+320 | T                    | Minor Junction |
| 13     | 5+500 | 5+500 | T                    | Minor Junction |

| S. No. | From   | To     | Type of Intersection | Other Features |
|--------|--------|--------|----------------------|----------------|
| 14     | 6+240  | 6+240  | +                    | Minor Junction |
| 15     | 6+820  | 6+820  | T                    | Minor Junction |
| 16     | 7+780  | 7+780  | T                    | Minor Junction |
| 17     | 7+900  | 7+900  | T                    | Minor Junction |
| 18     | 8+100  | 8+100  | T                    | Minor Junction |
| 19     | 8+150  | 8+150  | T                    | Minor Junction |
| 20     | 8+900  | 8+900  | T                    | Minor Junction |
| 21     | 8+950  | 8+950  | T                    | Minor Junction |
| 22     | 9+400  | 9+400  | T                    | Minor Junction |
| 23     | 9+480  | 9+480  | T                    | Minor Junction |
| 24     | 9+500  | 9+500  | T                    | Minor Junction |
| 25     | 9+620  | 9+620  | T                    | Minor Junction |
| 26     | 9+690  | 9+690  | T                    | Minor Junction |
| 27     | 9+800  | 9+800  | T                    | Minor Junction |
| 28     | 10+350 | 10+350 | +                    | Minor Junction |



**Appendix B VIII**  
**Details of Proposed Grade Separated Intersections**

| S. No. | Location         | Design Chainage (m) | Salient Features              | Minimum Length of viaduct to be provided (m) | Road to be carried over/under the structure | Remarks             |
|--------|------------------|---------------------|-------------------------------|----------------------------------------------|---------------------------------------------|---------------------|
| 1      | Near Mysore Road | 10+130 to 10+350    | Tunnel from NPKL to Bangalore | -                                            | -                                           | Ramp Portion        |
|        |                  | 10+350 to 10+385    | Tunnel from NPKL to Bangalore | -                                            | -                                           | Cut & Cover Portion |
| 2      | Near Mysore Road | 10+130 to 10+350    | Tunnel from Bangalore to NPKL | -                                            | -                                           | Ramp Portion        |
|        |                  | 10+350 to 10+385    | Tunnel from Bangalore to NPKL | -                                            | -                                           | Cut & Cover Portion |
|        |                  | 10+750 to 10+930    | Tunnel from Bangalore to NPKL | -                                            | -                                           | Cut & Cover Portion |
|        |                  | 10+930 to 11+080    | Tunnel from Bangalore to NPKL | -                                            | -                                           | Ramp Portion        |
| 3      | Near Mysore Road | 9+930 to 10+030     | Tunnel from NPKL to Mysore    | -                                            | -                                           | Ramp Portion        |
|        |                  | 10+030 to 10+385    | Tunnel from NPKL to Mysore    | -                                            | -                                           | Cut & Cover Portion |
|        |                  | 10+750 to 10+900    | Tunnel from NPKL to Mysore    | -                                            | -                                           | Cut & Cover Portion |
|        |                  | 10+900 to 11+050    | Tunnel from NPKL to Mysore    | -                                            | -                                           | Ramp Portion        |
| 4      | Near Mysore Road | 10+130 to 10+350    | Tunnel from Mysore to NPKL    | -                                            | -                                           | Ramp Portion        |
|        |                  | 10+350 to 10+385    | Tunnel from Mysore to NPKL    | -                                            | -                                           | Cut & Cover Portion |
|        |                  | 10+750 to 10+800    | Tunnel from Mysore to NPKL    | -                                            | -                                           | Cut & Cover Portion |
|        |                  | 10+800 to 10+950    | Tunnel from Mysore to NPKL    | -                                            | -                                           | Ramp Portion        |

**Appendix B IX**

**Details of Proposed Utility Structures**

| Sl. No. | Existing Chainage (km) | Design Chainage (km) | Type of Structure             | Proposed span Arrangement(m)      | Remarks    |
|---------|------------------------|----------------------|-------------------------------|-----------------------------------|------------|
| 1       | -                      | 0+000 to 10+130      | Underground Utility Structure | 1.8m x 2.0m (Internal dimensions) | Both Sides |

**Appendix B X**

**Details of Proposed Vehicular Underpasses and Light Vehicular Underpasses**

| S. No. | Location | Design Chainage (m) | Salient Features | Minimum Length of viaduct to be provided (m) | Road to be carried over/under the structure | Remarks |  |
|--------|----------|---------------------|------------------|----------------------------------------------|---------------------------------------------|---------|--|
|        |          | NIL                 |                  |                                              |                                             |         |  |

**Appendix B XI**

**Details of Proposed cattle/ Pedestrian Underpasses**

| S. No. | Location | Existing Chainage | Design Chainage | Proposed Span Arrangement | Min. Vertical Clearance (m) | Type of Super - Structure | Overall width |
|--------|----------|-------------------|-----------------|---------------------------|-----------------------------|---------------------------|---------------|
|        | NIL      |                   |                 |                           |                             |                           |               |

## Appendix B XII

### Details of new Major Bridges and Rehabilitation/Repair/widening Scheme for Existing Major Bridges

#### A. Construction of new Major Bridges

| S. No. | Existing Bridge at km | Proposed Bridge at km | Width of carriageway and cross-sectional features@ |
|--------|-----------------------|-----------------------|----------------------------------------------------|
| 1      | -                     | 9+270                 | Refer Volume III (Drawings) of Tender Documents    |
| 2      | -                     | 9+800                 |                                                    |

#### B. Reconstruction/Rehabilitation/Repair/widening of existing Major bridges

| S. No. | Existing Bridge at km | Proposed Bridge at km | Width of carriageway and cross-sectional features@ |
|--------|-----------------------|-----------------------|----------------------------------------------------|
|        |                       |                       | NIL                                                |

**Appendix B XIII**

**Details of new Minor Bridges and Rehabilitation/Repair /widening Scheme for Existing Minor Bridges**

**A. Construction of New Minor Bridges**

| S .<br>No | Existing Chainage | Design Chainage | Proposed Span Arrangement (m) | Proposed Structure Type | Type of foundation | Total Width of Proposed Structure (m) | Remark |
|-----------|-------------------|-----------------|-------------------------------|-------------------------|--------------------|---------------------------------------|--------|
|           |                   | NIL             |                               |                         |                    |                                       |        |

**C. Reconstruction/Rehabilitation/Repair/Widening of Existing Minor Bridges**

| Sl. No. | Existing Bridge location (km) | Proposed Bridge location (km) | Salient details of existing bridge | Adequacy of the existing vertical clearance, or the waterway, etc* | Remarks (Proposed Span) |
|---------|-------------------------------|-------------------------------|------------------------------------|--------------------------------------------------------------------|-------------------------|
|         |                               | NIL                           |                                    |                                                                    |                         |

## Appendix B XIV

### 1. Details of Proposed Scheme for Culverts

#### Reconstruction/Widening Scheme for Culverts

| S. No. | Existing culvert location | Proposed Culvert location | Proposal Arrangement                            | Remarks, if any. |
|--------|---------------------------|---------------------------|-------------------------------------------------|------------------|
| 1      | -                         | 1+895                     | Refer Volume III (Drawings) of Tender Documents | New Construction |
| 2      | -                         | 2+780                     |                                                 | New Construction |
| 3      | -                         | 3+070                     |                                                 | New Construction |
| 4      | -                         | 4+060                     |                                                 | New Construction |
| 5      | -                         | 5+150                     |                                                 | New Construction |
| 6      | -                         | 5+560                     |                                                 | New Construction |
| 7      | -                         | 5+960                     |                                                 | New Construction |
| 8      | -                         | 6+590                     |                                                 | New Construction |

**Appendix B XV**

**A. Construction of New ROB**

| Sl. No. | Existing Chainage | Design Chainage (Km) | Proposed span arrangement (m) | Proposed structural configuration | Over All width (m) |
|---------|-------------------|----------------------|-------------------------------|-----------------------------------|--------------------|
| NIL     |                   |                      |                               |                                   |                    |

Approval of GADs from concerned department should be obtained.

**B. Rehabilitation/Repair /widening Scheme for Existing ROB**

| S.no. | Existing Chainage | Remarks |
|-------|-------------------|---------|
|       | NIL               |         |



**Appendix B XVI**

**Type and Width of Median**

| <b>Type of Section</b>                    | <b>Minimum width of Median(m)*</b>            |
|-------------------------------------------|-----------------------------------------------|
|                                           | <b>Plan and Rolling Terrain (Raised Type)</b> |
| Open Country with Isolated Built- up Area | 3.0m                                          |
| Built-up Area                             | 3.0m                                          |

## Appendix B XVII

### Location of drain and footpath

RCC drains and footpath shall be provided in all built-up areas listed in Schedule 'B' as per provisions of Volume II and III of Tender Documents.

The Longitudinal drains shall be provided at the location specified below.

(a) RCC Covered Drain

| S.NO.           | Design Chainage |        | Length<br>(m) | Side                                                        | Drain<br>Width m                           | Total<br>Length<br>(m) |
|-----------------|-----------------|--------|---------------|-------------------------------------------------------------|--------------------------------------------|------------------------|
|                 | From            | To     |               |                                                             |                                            |                        |
| 1               | 0+000           | 10+130 | 10130         | Both sides of<br>main<br>carriageway<br>and service<br>road | 0.8m x<br>1.0m<br>(internal<br>dimensions) | 40520m                 |
| Total Length(m) |                 |        |               |                                                             |                                            | <b>40520m</b>          |

## **Appendix B XVIII**

### **Details of extra widening in sharp curves**

Refer Volume III (Drawings) of Tender Documents for required widening in tunnel approaches.

**SCHEDULE - C**  
**(See Clause 2.1)**

**1 PROJECT FACILITIES**

**I Project Facilities<sup>3</sup>**

1.1 The Appointed Agency shall construct the Project Facilities in accordance with the provisions of this Agreement. Such Project Facilities shall include:

- 1) Street furniture;
- 2) Street Lighting;
- 3) Arboriculture;
- 4) Bus-bays and bus shelters;
- 5) Fully equipped Command and Control Centre;

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<sup>3</sup>This template is applicable to highway projects. It may be suitably revised in case of other projects.

## **Annex – I**

### **(Schedule-C)**

#### **Project Facilities<sup>4</sup>**

#### **1 Project Facilities**

The Appointed Agency shall construct the Project Facilities described in this Annex-I to form part of the [Six-Lane] Project. The Project Facilities shall include:

- 1) Street furniture;
- 2) Street Lighting;
- 3) Arboriculture;
- 4) Bus-bays and bus shelters;
- 5) Fully equipped Command and Control Centre;

#### **2 Description of Project Facilities**

Each of the Project Facilities is briefly described below:

**(a) Street Furniture;**

As stipulated in the Volume II and III of Tender Documents.

**(b) Street Lighting;**

As stipulated in the Volume II and III of Tender Documents.

**(c) Arboriculture;**

As stipulated in the Volume II and III of Tender Documents.

**(d) Bus-Bays and Bus Shelters;**

As stipulated in the Volume II and III of Tender Documents.

**(e) Fully equipped Command and Control Centre;**

The appointed agency shall, construct central control building not exceeding 500 (Five Hundred) square meters of plinth area, and hand them over to the Authority no later than 30 (thirty) days prior to the Scheduled Completion Date.

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<sup>4</sup>This template is applicable to highway projects. It may be suitably revised in case of other projects.

## **1.2 Construction Methodology**

- 1.2.1 Tenderer shall submit the detailed construction methodology along the clear programme of works while submitting the tender. The methodology shall include the safety measures to be adopted in the execution of work. Tenderer shall express in detail the methodology for addressing the Social & Environment factors during the execution of work.

## **1.3 Site Order Book**

- 1.3.1 The Contractor shall maintain an identical pair of Site Order Books (one marked original and the other marked duplicate), at the Site at all times during the execution of the Works for the use of the Engineer and the Contractor. All instructions issued by the Engineer to the Contractor shall be recorded in both sets of the Site Order Book and shall be signed by the issuer and countersigned by the Contractor. After compliance with the instruction, the Contractor shall record the same in both sets of the Site Order Book duly signed and countersigned by the Engineer. Acceptance of any part of the work executed by the Contractor shall be subject to verification with respect to compliance of respective instructions of the Engineer through the Site Order Book. The Engineer shall retain the original copy of the Site Order Book, while the Contractor shall retain the duplicate one.

## **1.4 Quarry Materials**

- 1.4.1 The Contractor shall be wholly responsible to identify the suitable sources for quarry materials required for the Works, such as earth, sand, stone, murum, etc., and to make his own arrangements for collection and transportation of the materials irrespective of the leads and lifts required. The quarry thus identified by the Contractor should have proper license from the Government of Karnataka. All materials supplied by the Contractor shall satisfy the requirements set forth in the Specifications and shall be subject to the approval of the Engineer. The Contractor shall take this into account while offering his rates and no claims whatsoever shall be entertained for extra costs on this account.
- 1.4.2 **Royalties:** The Employer shall deduct Royalties on materials used in the Works from the progress payments to the Contractor at the rates specified in the most recent "Amendment to the Karnataka Minor Minerals Concession Rules - 1969" as published by the Commerce and Industries Department (Mines)

## **1.5 Inspection and testing**

- 1.5.1 Inspection of Material to be procured

Inspection and certification of all materials used on the works such as DI Pipes and Specials , Valves, Cement, Size Stones, Sand aggregate, Lead, Rubber gaskets etc., for conformity with specifications of BIS. If insisted, inspection of

materials at the manufacture place shall be arranged by the contractor at his cost including the travelling and accommodation of the inspecting officer.

**1.5.2 Inspection and certification of the various components of works.**

Construction of DI pipeline with all fixtures, construction of Valve Chamber including back filling of trench in layers with compaction as specified to ensure that all components of works are carried out as per specification and to required standards.

Inspection & Certification of Hydraulic Test on Completed pipe line in reaches and as a whole network as specified shall be carried out. The hydraulic testing of the pipelines is to be certified by the Quality assurance zone of the Board.

**1.6 Technical Specifications**

1.6.1 Engineer shall have the right to modify/alter the Particular Specifications and/or Standard Specifications at any time which promise to confer equal or better quality than the standard specified in the tender document. Such modification or alteration shall be acceptable to the Contractor subject to no additional financial burden to either the Contractor or the Employer.

**1.7 Storage of Materials and Plant**

1.7.1 The Contractor shall provide appropriate storage facilities for materials like cement, steel, aggregates, consumable supplies, equipment, mechanical and electrical items, etc., and shall take all safety and security measures against theft and deterioration in quality, at his own cost.

**1.8 Procurement of Materials:**

**1.8.1 CEMENT:**

The Contractor shall use only 43 grade cement conforming to IS 8112 / 89 with latest amendments with ISI mark. The Contractor should furnish the manufacturer test certificate for the above brand of cement for having manufactured the cement as per relevant BIS and guarantee certificate before using the cement.

**1.8.2 STEEL:**

The Contractor shall procure the steel from VISL / SAIL / VSP / TISCO and manufacturers' test certificate is to be produced.

**1.9 Equivalency of Standards and** be procured, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise stated in the Contract. Where such standards and codes are national, or relate to a particular country or region, other authoritative standards which ensure an equal or higher quality than the standards and codes specified will be acceptable subject to the Engineer's prior review and

written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval. In the event the Engineer determines that such proposed deviations do not ensure equal or higher quality, the Contractor shall comply with the standards specified in the documents.

#### **1.10 Sign Board**

1.10.1 The Contractor shall provide a sign board at the site of the Works of approved size and design which provides (i) the name of the Project (ii) the names and addresses of the Employer, the Contractor and the Consultant; (iii) the name and short description of the Project, (iv) the amount of the Contract Price ; and (v) the starting and completion dates.

#### **1.11 Samples and Tests**

1.11.1 The Contractor shall be responsible to develop a quality control program and to provide all necessary materials, apparatus, instruments, equipment, facilities and qualified staff for sampling, testing and quality control of the materials and the works under the Contract. Without limiting the generality of the foregoing, the Contractor shall either

(i) establish a testing laboratory at the site of Works which is adequately equipped and staffed to carry out all sampling and testing in accordance with the requirement set out in the General Specifications and/or these Special Specifications and provide all field equipment and apparatus as necessary to conduct all specified in-situ tests and/or any Tests on Completion, provided the correctness of the equipment's are ensured or

(ii) arrange for routine sampling, testing and reporting, as required, through a certified independent testing laboratory acceptable to the Engineer. All costs of such sampling, testing and reporting of test results will be borne by the Contractor, and the Contractor shall include sufficient provisions in his tendered rates to allow for independent sampling and laboratory testing under the direction of the Engineer up to 5% of the required tests at no additional cost. The Contractor shall furnish certified copies of all test reports to the Engineer within 3 days of completion of the specified tests.

1.11.2 The Contractor shall, within 14 days after the date of the Letter of Acceptance, submit to the Engineer for his consent a detailed description of the arrangements for conducting the quality control programme during execution of the Works, including details of his testing laboratory, equipment, staff and general procedures. If following submission, or at any time during the progress of Works, it appears to the Engineer that the Contractor's quality control programme is not adequate to



ensure the quality of the Works, the Contractor shall produce a revised programme which will be adequate to ensure satisfactory quality control.

#### **1.12 Protection of Utilities**

1.12.1 The Contractor is required to carefully examine the location of the Works and their alignments and to make special enquiries with all authorities concerning all utility lines such as water, sewers, gas pipe, telephone (underground and/or overhead) lines, electric cable (underground and/or overhead) lines, etc.; and to determine and verify to his own satisfaction the character, sizes, position and lengths of such utilities from authentic records. The Contractor shall be wholly responsible for the protection and/or facilitating relocation of such utilities as may be required, and shall not make any claim for extra work or extra time that may be required to protect or facilitate relocating such utilities. If any major shifting or realignment of water, sewers, gas pipes, electric and telephone lines is necessary due to their interference with the proposed Works, the same may be done by the Employer. The cost of such relocation will be borne by the Employer. In case the alignment of the pipeline crosses high tension electrical transmission lines belonging to the Karnataka Power Transmission Corporation Ltd. (KPTCL) or other authorities, the Contractor shall take all precautions necessary to see that the work is carried out with care and safety, without disturbing such transmission lines. The Contractor will be responsible to carry out all construction activities in such reaches in consultation with the owners of such facilities. However, satisfactory completion of the entire work will be the responsibility of the Contractor.

#### **1.13 Applicable Standards, Codes & Specifications**

- Code of Practice for Design of Urban Roads (Part 1, 2, 3 & 4) published by Ministry of Urban Development (MoUD)
- Street Design Guidelines published by UTTIPEC, New Delhi
- Codes and Practices Issued by Indian Roads Congress

The following specifications, standards and codes, including all official amendments / revisions and other specifications & codes referred to therein, should be considered a part of this specification. In all cases the latest issue/edition/revision shall apply.

## **2. LIST OF APPLICABLE STANDARDS, CODES & SPECIFICATIONS**

**IRC Publications**

| <b>S.No.</b> | <b>Code No.</b> | <b>Title of the Publication.</b>                                                                                                          |
|--------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 1.           | IRC:1-          | Type Designs for Highway Miles Stone.                                                                                                     |
| 2.           | IRC:2-1968      | Route Marker Signs for National Highways (First Revision).                                                                                |
| 3.           | IRC:3-1983      | Dimensions & Weights of Road Design Vehicles (First Revision).                                                                            |
| 4.           | IRC:4-1955      | Type Designs for Furlong and Boundary Stones.                                                                                             |
| 5.           | IRC:5-1985      | Standard Specifications & Code of Practice for Road Bridges, Section I- General Features of design (Sixth Revision)                       |
| 6.           | IRC:6-1966      | Standard Specifications & code of Practice for Road Bridges, Section II – Loads and Stresses (Third Revision)                             |
| 7.           | IRC:7-1971      | Recommended Practice for Numbering Bridges and culverts (First Revision)                                                                  |
| 8.           | IRC:8-1980      | Type Designs for Highway Kilometer Stones (Second Revision).                                                                              |
| 9.           | IRC:9-1972      | Traffic Census on Non-Urban Roads (First Revision).                                                                                       |
| 10.          | IRC:10-1961     | Recommended Practice for Borrowpits for Road Embankments Constructed by Manual Operation.                                                 |
| 11.          | IRC:11-1962     | Recommended Practice for the Design and Layout of Cycle Tracks.                                                                           |
| 12.          | IRC:12-1983     | Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling and Motor-Fuel Filling-cum-Service Stations (Second Revision) |
| 13.          | IRC:14-1977     | Recommended Practice for 2 cm Thick Bitumen and Tar Carpets (Second Revision).                                                            |
| 14.          | IRC:15-1981     | Standard Specifications & code of Practice for Construction of Concrete Roads (Second Revision).                                          |
| 15.          | IRC:16-1989     | Specification for Priming of Base Course with Bituminous Primers (First Revision).                                                        |
| 16.          | IRC:17-1965     | Tentative Specification for Single Coat Bituminous Surface Dressing.                                                                      |
| 17.          | IRC:18-1985     | Design criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (Second Revision)                                         |
| 18.          | IRC:19-1977     | Standard Specification and Code of Practice for Water Bound Macadam (Second Revision)                                                     |
| 19.          | IRC:20-1966     | Recommended Practice for Bituminous Penetration Macadam (Full Grout).                                                                     |
| 20.          | IRC:21-1987     | Standard Specifications and Code of Practice for Road Bridges, Section III- Cement Concrete (Plain and Reinforced) (Second Revision)      |
| 21.          | IRC:22-1986     | Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (First Revision).                      |

| S.No. | Code No.    | Title of the Publication.                                                                                                                    |
|-------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| 22.   | IRC:23-1966 | Tentative Specification for Two Coat Bituminous Surface Dressing.                                                                            |
| 23.   | IRC:24-1967 | Standard Specifications and Code of Practice for Road Bridges, Section V – Steel Road Bridges.                                               |
| 24.   | IRC:25-1967 | Type Designs for Boundary Stones.                                                                                                            |
| 25.   | IRC:26-1967 | Type Design for 200-Metre Stones.                                                                                                            |
| 26.   | IRC:27-1967 | Tentative Specifications for Bituminous Macadam (Base & Binder Course)                                                                       |
| 27.   | IRC:28-1967 | Tentative Specifications for the Construction of Stabilized Soil Roads with Soft Aggregate in Areas of Moderate and High Rainfall.           |
| 28.   | IRC:29-1988 | Specification for Bituminous Concrete (Asphaltic Concrete) for Road Pavement (First Revision)                                                |
| 29.   | IRC:30-1968 | Standard Letters and Numerals of Different Heights for Use of Highway Signs.                                                                 |
| 30.   | IRC:31-1969 | Route Marker Signs for State routes.                                                                                                         |
| 31.   | IRC:32-1969 | Standard for Vertical and Horizontal Clearances of Overhead Electric Power and telecommunication Lines as Related to Roads.                  |
| 32.   | IRC:33-1969 | Standard Procedure for Evaluation and Condition Surveys of Stabilised Soil Roads.                                                            |
| 33.   | IRC:34-1970 | Recommendations for Road Construction in Waterlogged Areas.                                                                                  |
| 34.   | IRC:35-1970 | Code of Practice for Road Markings (with Paints)                                                                                             |
| 35.   | IRC:36-1970 | Recommended Practice for the Construction of Earth Embankments for Road Works.                                                               |
| 36.   | IRC:37-1984 | Guidelines for the Designs of Flexible Pavements (First Revision)                                                                            |
| 37.   | IRC:38-1988 | Guidelines for Design on Horizontal Curves for Highways and Design Tables (First Revision)                                                   |
| 38.   | IRC:39-1986 | Standards for Road-Rail Level Crossing (First Revision)                                                                                      |
| 39.   | IRC:40-1995 | Standard Specifications and Code of Practice for Road Bridges, Section IV-Brick, Stone and Block Masonry (First Revision)                    |
| 40.   | IRC:41-1972 | Type Designs for Check Barriers.                                                                                                             |
| 41.   | IRC:42-1972 | Proforma for Record of Test Values of Locally Available Pavement Construction Materials.                                                     |
| 42.   | IRC:43-1972 | Recommended Practice for Tools, Equipment and Appliances for Concrete Pavement Construction.                                                 |
| 43.   | IRC:44-1976 | Tentative Guidelines for Cement Concrete Mix Design for Pavements (for Non-Air Entrained and Continuously Graded Concrete) (First Revision). |

| S.No. | Code No.    | Title of the Publication.                                                                                                         |
|-------|-------------|-----------------------------------------------------------------------------------------------------------------------------------|
| 44.   | IRC:45-1972 | Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges. |
| 45.   | IRC:46-1972 | A Policy on Roadside Advertisements (First Revision).                                                                             |
| 46.   | IRC:47-1972 | Tentative Specification for Built-up Spray Grout.                                                                                 |
| 47.   | IRC:48-1972 | Tentative Specification for Bituminous Surface Dressing Using Pre-coated Aggregates.                                              |
| 48.   | IRC:49-1973 | Recommended Practice for the Pulverization of Black Cotton Soils for Lime Stabilisation.                                          |
| 49.   | IRC:50-1973 | Recommended Design Criteria for the Use of Cement-Modified Soil in Road Construction.                                             |
| 50.   | IRC:51-1992 | Guidelines for the Use of Soil Lime Mixes in Road Construction (First Revision)                                                   |
| 51.   | IRC:52-1981 | Recommendations About the Alignment Survey and geometric Design of Hill Roads (First Revision)                                    |
| 52.   | IRC:53-1982 | Road Accident Forms A-1 and 4 (First Revision)                                                                                    |
| 53.   | IRC:54-1974 | Lateral and vertical Clearances at Underpasses for Vehicular Traffic.                                                             |
| 54.   | IRC:55-1974 | Recommended Practice for Sand-Bitumen Base courses.                                                                               |
| 55.   | IRC:56-1974 | Recommended Practice for Treatment of Embankment Slopes for Erosion Control.                                                      |
| 56.   | IRC:57-1974 | Recommended Practice for Sealing of Joints in Concrete Pavements.                                                                 |
| 57.   | IRC:58-1988 | Guidelines for the Design of Rigid Pavements for Highways (First Revision)                                                        |
| 58.   | IRC:59-1976 | Tentative Guidelines for the Design of Gap Graded Cement Concrete Mixes for Road Pavements.                                       |
| 59.   | IRC:60-1976 | Tentative Guidelines for the Use of Lime-Fly Ash Concrete as Pavement Base or Sub-Base.                                           |
| 60.   | IRC:61-1976 | Tentative Guidelines for the Construction of cement Concrete Pavements in Hot Weather.                                            |
| 61.   | IRC:62-1976 | Guidelines for Control of Access on Highways.                                                                                     |
| 62.   | IRC:63-1976 | Tentative Guidelines for the Use of Low Grade Aggregates and Soil Aggregate Mixtures in Road Pavement Construction.               |
| 63.   | IRC:64-1990 | Guidelines for Capacity of Roads in Rural Areas (First Revision)                                                                  |
| 64.   | IRC:65-1976 | Recommended Practice for Traffic Rotaries.                                                                                        |
| 65.   | IRC:66-1976 | Recommended Practice for Sight Distance on Rural Highways.                                                                        |

| S.No. | Code No.                 | Title of the Publication.                                                                                                   |
|-------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| 66.   | IRC:67-1977              | Code of Practice for Road Signs.                                                                                            |
| 67.   | IRC:68-1976              | Tentative Guidelines on Cement-Fly Ash Concrete for Rigid Pavement Construction.                                            |
| 68.   | IRC:69-1977              | Space Standards for Roads in Urban Areas.                                                                                   |
| 69.   | IRC:70-1977              | Guidelines on Regulation and Control of Mixed Traffic in Urban Areas.                                                       |
| 70.   | IRC:71-1977              | Recommended Practice for Preparation of Notations.                                                                          |
| 71.   | IRC:72-1978              | Recommended Practice for Use and Upkeep of Equipment, Tools and Appliances for Bituminous Pavement Construction.            |
| 72.   | IRC:73-1980              | Geometric Design Standards for Rural (Non-Urban) Highways.                                                                  |
| 73.   | IRC:74-1979              | Tentative Guidelines for Lean-Cement Concrete and Lean Cement-Fly Ash Concrete as a Pavement Base or Sub-Base.              |
| 74.   | IRC:75-1979              | Guidelines for the Design of High Embankments.                                                                              |
| 75.   | IRC:76-1979              | Tentative Guidelines for Structural Strength Evaluation of Rigid Airfield Pavements.                                        |
| 76.   | IRC:77-1979              | Tentative Guidelines for Repair of Concrete Pavements Using Synthetic Resins.                                               |
| 77.   | IRC:78-1983              | Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure (First Revision). |
| 78.   | IRC:79-1981              | Recommended Practice for Road delineators.                                                                                  |
| 79.   | IRC:80-1981              | Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways.                                                     |
| 80.   | IRC:81-1981              | Tentative Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique.                |
| 81.   | IRC:82-1982              | Code of Practice for Maintenance of Bituminous Surfaces of Highways.                                                        |
| 82.   | IRC:83-1982              | Standard Specifications and Code of Practice for Road bridges, Section IX – Bearings, Part I: Metallic Bearings.            |
| 83.   | IRC:83-1987<br>(Part-II) | Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearing, Part II : Elastomeric Bearings.        |
| 84.   | IRC:84-1983              | Code of Practice for Curing of Cement Concrete Pavements.                                                                   |
| 85.   | IRC:85-1983              | Recommended Practice for Accelerated Strength Testing & Evaluation of Concrete for Road and Airfield Constructions.         |
| 86.   | IRC:86-1983              | Geometric Design Standard for Urban Roads in Plains.                                                                        |
| 87.   | IRC:87-1984              | Guidelines for the Design & Erection of False work for Road Bridges.                                                        |

| S.No. | Code No.     | Title of the Publication.                                                                               |
|-------|--------------|---------------------------------------------------------------------------------------------------------|
| 88.   | IRC:88-1984  | Recommended Practice for Lime Flyash Stabilised Soil Base / Sub-Base in Pavement Construction.          |
| 89.   | IRC:89-1985  | Guidelines for Design & Construction of River Training & Control Works for Road Bridges.                |
| 90.   | IRC:90-1985  | Guidelines of Selection, Operation and Maintenance of Bituminous Hot Mix Plant.                         |
| 91.   | IRC:91-1985  | Tentative Guidelines for Construction of Cement Concrete Pavements in Cold Weather.                     |
| 92.   | IRC:92-1986  | Guidelines for the Design of Inter-changes in Urban Areas.                                              |
| 93.   | IRC:93-1985  | Guidelines on Design and Installation of Road Traffic Signals.                                          |
| 94.   | IRC:94-1986  | Specification for Dense Bituminous Macadam.                                                             |
| 95.   | IRC:95-1987  | Specification for Semi-Dense Bituminous Concrete.                                                       |
| 96.   | IRC:96-1987  | Tentative Specification for Two-Coat Surface Dressing Using Cationic Bitumen Emulsion.                  |
| 97.   | IRC:97-1987  | Tentative Specification for 20 mm Thick Premix Carpet Using Cationic Bitumen Emulsion.                  |
| 98.   | IRC:98-1988  | Guidelines on Accommodation of Underground Utility Services Along and Across Roads in urban Areas.      |
| 99.   | IRC:99-1988  | Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads. |
| 100.  | IRC:100-1988 | Tentative Specification for Single Coat Surface Dressing Using Cationic Bitumen Emulsion.               |
| 101.  | IRC:101-1988 | Guidelines for Design of Continuously Reinforced Concrete Pavement with Elastic Joints.                 |
| 102.  | IRC:102-1988 | Traffic Studies for Planning By-passes Around Towns.                                                    |
| 103.  | IRC:103-1988 | Guidelines for Pedestrian Facilities.                                                                   |
| 104.  | IRC:104-1988 | Guidelines for Environmental Impact Assessment of Highway Projects.                                     |
| 105.  | IRC:105-1988 | Tentative Specification for Bituminous concrete (Asphaltic Concrete) for Airfield Pavements.            |
| 106.  | IRC:106-1990 | Guidelines for Capacity of Urban Roads in Plain Areas.                                                  |
| 107.  | IRC:107-1992 | Tentative Specifications for Bitumen Mastic Wearing courses.                                            |
| 108.  | IRC:108-1996 | Guidelines for Traffic Prediction on Rural Highways.                                                    |
| 109.  | IRC:109-1997 | Guidelines for Wet Mix Macadam.                                                                         |

**IRC Special publications**

| <b>S.No.</b> | <b>Code No.</b> | <b>Title of the Publication.</b>                                                                                     |
|--------------|-----------------|----------------------------------------------------------------------------------------------------------------------|
| 1.           | IRC:SP:1-1971   | Bridging India's Rivers, Vol.I                                                                                       |
| 2.           | IRC:SP:2-1961   | Report on Road Transport Operation on Various types on Surface in Plains.                                            |
| 3.           | IRC:SP:3-1966   | Geometric Roads.                                                                                                     |
| 4.           | IRC:SP:4-1966   | Bridge Loading Round the World.                                                                                      |
| 5.           | IRC:SP:5-1967   | Road Drainage Practices Around the World.                                                                            |
| 6.           | IRC:SP:6-1966   | Modern Trends in the Design and Construction of Prestressed Concrete Bridges Around the World.                       |
| 7.           | IRC:SP:7-1971   | Report on Road Transport Operation Cost on Various Type of Road Surfaces in Hilly Regions.                           |
| 8.           | IRC:SP:8-1972   | Methodology of Flexible Pavement Design Around the World.                                                            |
| 9.           | IRC:SP:9-1972   | Rating of Bridges.                                                                                                   |
| 10.          | IRC:SP:10-1972  | Bridging India's Rivers, Vol. II                                                                                     |
| 11.          | IRC:SP:11-1988  | Handbook of Quality Control for Construction of Roads and Runways (Second Revision)                                  |
| 12.          | IRC:SP:12-1973  | Tentative Recommendations on the Provision of Parking Spaces for Urban Areas                                         |
| 13.          | IRC:SP:13-1973  | Guidelines for the Design of Small Bridges & Culverts.                                                               |
| 14.          | IRC:SP:14-1973  | A Manual for the Application of the Critical Path Method to Highway Projects in India.                               |
| 15.          | IRC:SP:15-1996  | Ribbon Development Along Highways and its Prevention.                                                                |
| 16.          | IRC:SP:16-1977  | Surface Evenness of Highways Pavement.                                                                               |
| 17.          | IRC:SP:17-1977  | Recommendations About Overlays on Cement Concrete Pavements.                                                         |
| 18.          | IRC:SP:18-1978  | Manual for Highway Bridge Maintenance Inspection.                                                                    |
| 19.          | IRC:SP:19-1977  | Manual for Survey, Investigation and Preparation of Road Projects.                                                   |
| 20.          | IRC:SP:20-1979  | Manual on Route Location, Design, Construction and Maintenance of Rural Roads (Other District Roads & Village Roads) |



|     |                |                                                                                                                              |
|-----|----------------|------------------------------------------------------------------------------------------------------------------------------|
| 21. | IRC:SP:21-1979 | Manual on Landscaping of Roads.                                                                                              |
| 22. | IRC:SP:22-1980 | Recommendations for the Sizes for each Type of Road Making Machinery to Cater to the General Demand of Road Works.           |
| 23. | IRC:SP:23-1983 | Vertical Curves for Highways.                                                                                                |
| 24. | IRC:SP:24-1984 | Guidelines on the Choice & Planning of Appropriate Technology in Road Construction.                                          |
| 25. | IRC:SP:25-1984 | Gopi and his Road Roller-Guidelines on Maintenance of Road Rollers.                                                          |
| 26. | IRC:SP:26-1984 | Report Containing Recommendations of IRC Regional Workshops on Rural Road Development (with Supplementary Notes).            |
| 27. | IRC:SP:27-1984 | Report Containing Recommendation of IRC Regional Workshops on Highway Safety.                                                |
| 28. | IRC:SP:28-1995 | Road Transport and Energy (First Revision)                                                                                   |
| 29. | IRC:SP:29-1994 | Directory of Indigenous Manufacturers of Road / Bridge Construction Machinery & Important Bridge Components (First Revision) |
| 30. | IRC:SP:30-1993 | Manual on Economic Evaluation of Highway Projects in India (First Revision)                                                  |
| 31. | IRC:SP:31-1992 | New Traffic Signs.                                                                                                           |
| 32. | IRC:SP:32-1988 | Road Safety for Children (5-12 Years Old).                                                                                   |
| 33. | IRC:SP:33-1989 | Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structures.                       |
| 34. | IRC:SP:34-1989 | General Guidelines About the Equipment for Bituminous Surface Dressing.                                                      |
| 35. | IRC:SP:35-1990 | Guidelines for Inspection and Maintenance of Bridges.                                                                        |
| 36. | IRC:SP:36-1991 | Guidelines on Format for IRC Standards.                                                                                      |
| 37. | IRC:SP:37-1991 | Guidelines for Evaluation of Load Carrying Capacity of Bridges.                                                              |
| 38. | IRC:SP:38-1992 | Manual for Road Investment Decision Model (with Floppy Disk)                                                                 |
| 39. | IRC:SP:39-1992 | Guidelines on Bulk Bitumen Transportation & Storage Equipment.                                                               |
| 40. | IRC:SP:40-1993 | Guidelines on Techniques for Strengthening and Rehabilitation of Bridges.                                                    |
| 41. | IRC:SP:41-1994 | Guidelines on Design of At-Grade Intersections in Rural & Urban Areas                                                        |

|     |                 |                                                                                                        |
|-----|-----------------|--------------------------------------------------------------------------------------------------------|
| 42. | IRC:SP:42-1994  | Guidelines on Road Drainage.                                                                           |
| 43. | IRC:SP:43-1994  | Guidelines on Low-Cost Traffic Management Techniques for Urban Areas.                                  |
| 44. | IRC:SP:44-1994  | Highway Safety Code.                                                                                   |
| 45. | IRC:SP:45-1996  | Time Series Data on Road Transport Passenger and Freight Movement (1951-1991)                          |
| 46. | IRC:SP:46-1997  | Steel Fibre Reinforced Concrete For Pavements                                                          |
| 47. | IRC:SP:47-1998  | Guidelines on Quality Systems for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete) |
| 48. | IRC:SP:48-1998  | Hill Road Manual                                                                                       |
| 49. | IRC:SP:49-1988  | Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement                             |
| 50. | IRC:SP:50- 1999 | Guidelines on Urban Drainage                                                                           |
| 51. | IRC:SP:51-1999  | Guidelines for Load Testing of Bridges                                                                 |
| 52. | IRC:SP:52-1999  | Bridge Inspection's Reference Manual                                                                   |
| 53. | IRC:SP:53-1999  | Tentative Guidelines on Use of Rubber and Ploymer Modified Bitumen in Road Construction                |
| 54. | IRC:SP:54-2000  | Project Preparation Manual for Bridges                                                                 |
| 55. | IRC:SP:56-2000  | Guidelines for Steel Pedestrian Bridges                                                                |

**Ministry of Surface Transport publications**

| S.No. | Title of the Publication.                                                                                                                                                                        |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.    | MOST Manual for Maintenance of Roads, 1983.                                                                                                                                                      |
| 2.    | MOST Road Development Plan for India (1981-2001), 1984.                                                                                                                                          |
| 3.    | MOST Pocketbook for Bridge Engineers, 1984                                                                                                                                                       |
| 4.    | MOST Pocketbook for Highway Engineer.                                                                                                                                                            |
| 5.    | MOST Handbook on Road Construction Machinery, 1985                                                                                                                                               |
| 6.    | MOST Specifications for Road and Bridge Works, 1994 (Third Revision)                                                                                                                             |
| 7.    | MOST Addendum to Technical Circulars & Directives on National Highways & Centrally Sponsored Road & Bridge Works, 1989                                                                           |
| 8.    | MOST Standard Plans for 3.0 m to 10.0 m Span Reinforced Cement Concrete Solid Slab Superstructure with and without Footpaths for Highways, 1991                                                  |
| 9.    | MOST Standard Plans for Highway Bridges R.C.C. T –Beam & Slab Superstructure – Span from 10 m to 24 m with 12 m width, 1991                                                                      |
| 10.   | MOST Standard Plans for Highway Bridges PSC Girder and RC Slab Composite Superstructure for 30 m Span with and without Footpaths, 35 m Span with Footpaths and 40 m Span without Footpaths, 1991 |
| 11.   | MOST Standard Drawings for Road Bridges – R.C.C. Solid Slab Superstructure (15° & 30° SKEW) Span 4.0 m to 10.0 m (with and without Footpaths), 1992                                              |
| 12.   | MOST Type Designs for Intersections on National Highways, 1992                                                                                                                                   |
| 13.   | MOST Prequalification Document for Central Sector Road and Bridge Projects (Under Local Competitive Bidding), 1993.                                                                              |
| 14.   | MOST Computer Aided Design System for High Embankment Problems, 1993.                                                                                                                            |
| 15.   | MOST Standard of Data Book for Analysis of Rates, 1993                                                                                                                                           |
| 16.   | MOST Addendum to Ministry's Technical Circulars and Directives on National Highways and Centrally Sponsored Road & Bridge Projects (Aug.88 to Dec.92), 1993.                                     |
| 17.   | MOST Standard Drawing for Road Bridges R.C.C. Solid Slab Superstructure (22.5° SKEW) R.E. Span 4M to 10 M (With and Without Footpath), 1996.                                                     |
| 18.   | MOST Addendum to Ministry's Technical Circulars and Directives on National                                                                                                                       |

|     |                                                                                                                                                  |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------|
|     | Highways and centrally Sponsored Roads & Bridge Projects (Jan. 93 to Dec. 94), 1996.                                                             |
| 19. | Standard Plan for Highway Bridges-Prestressed Concrete Beam & RCC Type Superstructure - Volume-II                                                |
| 20. | MOST Addendum to Technical Circulars & Directives on National Highways & Centrally Sponsored Road & Bridge Works Projects (Jan.1995 to Dec.1997) |
| 21. | Model Concession Agreement for Small Road Projects                                                                                               |
| 22. | MOST Standard Plans for Single , Double and Triple Cell Box Culverts with and without Earth Cushion                                              |

### Materials

|    |             |   |                                                                                                                                  |
|----|-------------|---|----------------------------------------------------------------------------------------------------------------------------------|
| 1  | IS:455      | - | Specification for Portland slag cement.                                                                                          |
| 2  | IS:1489     | - | Specification for Portland-pozzolana cement.                                                                                     |
| 3  | IS:8112     | - | Specification for 43-grade ordinary Portland cement.                                                                             |
| 4  | IS:12330    | - | Specification for sulphate resisting Portland cement.                                                                            |
| 5  | IS:383      | - | Specification for coarse and fine aggregates from natural sources for concrete.                                                  |
| 6  | IS: IS: 432 | - | Specification for mild steel and medium tensile steel (Parts-I & II) bars and hard-drawn steel wires for concrete reinforcement. |
| 7  | IS:1786     | - | Specification for high strength deformed steel bars and wires for concrete reinforcement.                                        |
| 8  | IS:1566     | - | Specification for hard-drawn steel wire fabric for (Part-I) concrete reinforcement.                                              |
| 9  | IS:9103     | - | Specification for admixtures for concrete.                                                                                       |
| 10 | IS:2645     | - | Specification for integral cement waterproofing compounds.                                                                       |
| 11 | IS:4990     | - | Specification for plywood for concrete shuttering work.                                                                          |

### Material Testing

|   |         |   |                                                                                      |
|---|---------|---|--------------------------------------------------------------------------------------|
| 1 | IS:4021 | - | Methods of physical tests for hydraulic cement. (Parts-1 to 13)                      |
| 2 | IS:4032 | - | Method of chemical analysis of hydraulic cement.                                     |
| 3 | IS:650  | - | Specification for standard sand for testing of cement.                               |
| 4 | IS:2430 | - | Methods for sampling of aggregates for concrete.                                     |
| 5 | IS:2386 | - | Methods of test for aggregates for concrete. (parts-I to VIII).                      |
| 6 | IS:3025 | - | Methods of sampling and test (physical and chemical) w used in industry.             |
| 7 | IS:6925 | - | Methods of test for determination of water-soluble chlorides in concrete admixtures. |

### Materials Storage

|   |          |   |                                                                            |
|---|----------|---|----------------------------------------------------------------------------|
| 1 | IS: 4082 | - | Recommendations on stacking and storing of construction materials at site. |
|---|----------|---|----------------------------------------------------------------------------|

### Concrete Mix Design

|   |           |   |                                                 |
|---|-----------|---|-------------------------------------------------|
| 1 | IS: 10262 | - | Recommended guidelines for concrete mix design. |
| 2 | SP:23     | - | Handbook on Concrete Mixes (S & T).             |

### Concrete Testing

|   |          |   |                                                                                                             |
|---|----------|---|-------------------------------------------------------------------------------------------------------------|
| 1 | IS:1199  | - | Method of sampling and analysis of concrete.                                                                |
| 2 | IS:516   | - | Method of test for strength of concrete.                                                                    |
| 3 | IS:9013  | - | Method of making, curing and determining compressive strength of accelerated cured concrete test specimens. |
| 4 | IS: 8142 | - | Method of test for determining setting time of concrete by penetration resistance.                          |
| 5 | IS: 9284 | - | Method of test for abrasion resistance of concrete.                                                         |
| 6 | IS: 2770 | - | Methods of testing bond in reinforced concrete.                                                             |

### Equipment

|   |          |   |                                                              |
|---|----------|---|--------------------------------------------------------------|
| 1 | IS: 1791 | - | Specification for batch type concrete mixers.                |
| 2 | IS: 2438 | - | Specification for roller pan mixer.                          |
| 3 | IS: 4925 | - | Specification for concrete batching and mixing plant.        |
| 4 | IS: 5892 | - | Specification for concrete transit mixer and agitator.       |
| 5 | IS: 7242 | - | Specification for concrete spreaders.                        |
| 6 | IS: 2505 | - | General Requirements for concrete vibrators: Immersion type. |
| 7 | IS: 2506 | - | General Requirements for screed board concrete vibrators.    |
| 8 | IS: 2514 | - | Specification for concrete vibrating tables.                 |
| 9 | IS: 3366 | - | Specification for pan vibrators.                             |

|    |           |   |                                                                                               |
|----|-----------|---|-----------------------------------------------------------------------------------------------|
| 10 | IS: 4656  | - | Specification for form vibrators for concrete.                                                |
| 11 | IS: 11993 | - | Code of practice for use of screed board concrete vibrators.                                  |
| 12 | IS: 7251  | - | Specification for concrete finishers.                                                         |
| 13 | IS: 2722  | - | Specification for portable swing weigh batchers for concrete (single and double bucket type). |
| 14 | IS: 2750  | - | Specification for steel scaffoldings.                                                         |

**Codes of Practice**

|    |          |   |                                                                                                                   |
|----|----------|---|-------------------------------------------------------------------------------------------------------------------|
| 1  | IS:456   | - | Code of practice for plain and reinforced concrete.                                                               |
| 2  | IS:457   | - | Code of practice for general construction of plain and reinforced concrete for dams and other massive structures. |
| 3  | IS:3370  | - | Code of practice for concrete structures for storage of liquids. (parts-I to IV)                                  |
| 4  | IS:3935  | - | Code of practice for composite construction.                                                                      |
| 5  | IS:2204  | - | Code of practice for construction of reinforced concrete shell roof.                                              |
| 6  | IS:2210  | - | Criteria for the design of reinforced concrete shell structures and folded plates.                                |
| 7  | IS:2502  | - | Code of practice for bending and fixing of bars for concrete reinforcement.                                       |
| 8  | IS:5525  | - | Recommendation for detailing of reinforcement in reinforced concrete works.                                       |
| 9  | IS:2751  | - | Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.     |
| 10 | IS: 9417 | - | Specification for welding cold worked bars for reinforced concrete construction.                                  |
| 11 | IS: 3558 | - | Code of practice for use of immersion vibrators for consolidating concrete.                                       |

|    |                   |   |                                                                                                                                                                                |
|----|-------------------|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12 | IS: 3414          | - | Code of practice for design and installation of joints in building.                                                                                                            |
| 13 | IS: 4326          | - | Code of practice for earthquake resistant construction of building.                                                                                                            |
| 14 | IS:4014           | - | Code of practice for steel tubular scaffolding. (parts-I & II).                                                                                                                |
| 15 | IS: 2571          | - | Code of practice for laying in-situ cement concrete flooring.                                                                                                                  |
| 16 | IS: 7861          | - | Code of practice for extreme weather concreting.<br><br>Part-I: Recommended practice for hot weather concreting.<br>Part-II: Recommended practice for cold weather concreting. |
| 17 | IS: 13920         | - | Ductile Detailing of Reinforced Concrete Structure subjected to seismic forces. 1993                                                                                           |
| 18 | SP-16(S&T) - 1980 | - | Design Aids for Reinforcement Concrete to IS:456-1978.                                                                                                                         |
| 19 | SP-24             | - | Explanatory Handbook on IS:456-1978.                                                                                                                                           |
| 20 | SP-34(S&T) - 1987 | - | Handbook on Concrete Reinforcement and Detailing.                                                                                                                              |

#### **Construction Safety**

|   |         |   |                                                            |
|---|---------|---|------------------------------------------------------------|
| 1 | IS:3696 | - | Safety code for scaffolds and ladders.(Parts-I & II)       |
| 2 | IS:7969 | - | Safety code for handling and storage of building materials |
| 3 | IS:8989 | - | Safety code for erection of concrete framed structures     |

#### **Measurement**

|   |         |   |                                                              |
|---|---------|---|--------------------------------------------------------------|
| 1 | IS:1200 | - | Method of measurement of building and engineering works.     |
| 2 | IS:3385 | - | Code of practice for measurement of civil engineering works. |



**APPLICABLE BUREAU OF INDIAN STANDARDS (BIS) for Water Supply, Drainage and Sanitation**

**(1) BIS Standards for Valves and Gates for water supply Standards**

| S.NO | IS.NO                          | TITLE                                                                                               | REVISION NO. | CATEGORY              | REAFFIRMED     |
|------|--------------------------------|-----------------------------------------------------------------------------------------------------|--------------|-----------------------|----------------|
| 1    | <u>IS 778 : 1984</u>           | Copper Alloy Gate, Globe and Check Valves for Waterworks Purposes                                   | Fourth       | Product Specification | November, 2015 |
| 2    | <u>IS 781 : 1984</u>           | Cast Copper Alloy Screw Down Bib Taps And Stop Valves for Water Services                            | Third        | Product Specification | November, 2015 |
| 3    | <u>IS 2685 : 1971</u>          | Code of practice for selection, installation and maintenance of sluice valves                       | First        | Code of Practice      | 2012           |
| 4    | <u>IS 3042 : 1965</u>          | single faced sluice gates (200 to 1200 mm size)                                                     |              | Product Specification | 2013           |
| 5    | <u>IS 3950 : 1979</u>          | surface boxes for sluice valves                                                                     | First        | Product Specification | 2012           |
| 6    | <u>IS 4038 : 1986</u>          | Foot Valves For Water Works Purposes                                                                | Second       | Product Specification | November, 2015 |
| 7    | <u>IS 5312 : Part 1 : 2004</u> | Swing Check Type Reflux (Non-Return] Valves for Water Works Purposes - Part 1 : Single-Door Pattern | Second       | Product Specification | 2014           |

| S.NO | IS.NO                          | TITLE                                                                                           | REVISION NO. | CATEGORY              | REAFFIRMED     |
|------|--------------------------------|-------------------------------------------------------------------------------------------------|--------------|-----------------------|----------------|
| 8    | <u>IS 5312 : Part 2 : 2013</u> | Swing Check Type Reflux (Non-Return) Valves for Water Works Purpose Part 2 : Multi-Door Pattern | First        | Product Specification | 0              |
| 9    | <u>IS 8931 : 1993/</u>         | copper alloy fancy single taps, combination tap assembly and stop valves for water services     | First        | Product Specification | 0              |
| 10   | <u>IS 9739 : 1981</u>          | pressure reducing valves for domestic water supply systems                                      |              | Product Specification | 2012           |
| 11   | <u>IS 9763 : 2000</u>          | Plastics Bib Taps, Pillar Taps, Angle Valves and Stop Valves for Hot and Cold Water Services -  | Second       | Product Specification | November, 2015 |
| 12   | <u>IS 14845 : 2000</u>         | Resilient Seated Cast Iron Air Relief Valves for Water Works Purposes -                         |              | Product Specification | November, 2015 |
| 13   | <u>IS 14846 : 2000</u>         | Sluice Valve for Water Works Purposes (50 to 1200 mm Size) -                                    |              | Product Specification | November, 2015 |

**(2) BIS Standards for Water Handling Standards**

| S.NO | IS.NO                         | TITLE                                                                                                | REVISION NO. | CATEGORY         | REAFFIRMED     |
|------|-------------------------------|------------------------------------------------------------------------------------------------------|--------------|------------------|----------------|
| 1    | <u>SP 35 (S&amp;T) : 1987</u> | Handbook on Water Supply and Drainage (with Special Emphasis on Plumbing)                            |              | Others           | 2014           |
| 2    | <u>SP 57 (QAWSM) : 1993</u>   | Handbook on Pipes and Fittings for Drinking Water Supply                                             |              | Code of Practice | March, 2016    |
| 3    | <u>IS 1172 : 1993</u>         | Code of Basic Requirements for Water Supply, Drainage and Sanitation                                 | Fourth       | Code of Practice | November, 2016 |
| 4    | <u>IS 2065 : 1983</u>         | Code of practice for water supply in buildings                                                       | Second       | Code of Practice | February, 2017 |
| 5    | <u>IS 3114 : 1994</u>         | Code of practice for laying of cast iron pipes                                                       | Second       | Code of Practice | August, 2014   |
| 6    | <u>IS 4127 : 1983</u>         | Code of practice for laying of glazed stoneware pipes                                                | First        | Code of Practice | February, 2017 |
| 7    | <u>IS 5822 : 1994</u>         | Code of Practice for Laying of Electrically Welded Steel Pipes for Water Supply                      | Second       | Code of Practice | August, 2014   |
| 8    | <u>IS 6295 : 1986</u>         | Code of practice for water supply and drainage in high altitudes and/or sub-zero temperature regions | First        | Code of Practice | February, 2017 |
| 9    | <u>IS 7558 : 1974</u>         | Code of practice for domestic hot water installations                                                |              | Code of Practice | February, 2017 |

| S.NO | IS.NO                           | TITLE                                                                                                                                                             | REVISION NO. | CATEGORY              | REAFFIRMED     |
|------|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------|----------------|
| 10   | <u>IS 9110 : 1979</u>           | Hand Operated Augers for Cleaning Water-closets, Pipes and Sewers                                                                                                 |              | Product Specification | February, 2016 |
| 11   | <u>IS 9222 : Part 1 : 1990</u>  | Recommendations for handling and dosing devices for chemicals for water treatment: Part I Coagulants                                                              | First        | Code of Practice      | February, 2016 |
| 12   | <u>IS 10053 : 1981</u>          | Requirements For Equipment For Jackson Candle Turbidimeter And Determination Of Turbidity                                                                         |              | Others                | November, 2012 |
| 13   | <u>IS 10313 : 1982</u>          | Requirements for settling tank (clarifier equipment) for water treatment plant                                                                                    |              | Others                | February, 2016 |
| 14   | <u>IS 10446 : 1983</u>          | Glossary of terms relating to water supply and sanitation                                                                                                         |              | Terminology           | February, 2017 |
| 15   | <u>IS 10553 : Part 1 : 1983</u> | Requirements for chlorination equipment: Part I General guidelines for chlorination plants including handling, storage and safety of chlorine cylinders and drums |              | Others                | November, 2012 |
| 16   | <u>IS 10553 : Part 2 : 1983</u> | Requirements for chlorination equipment: Part 2 Vacuum feed type chlorinators                                                                                     |              | Others                | February, 2016 |
| 17   | <u>IS 10553 :</u>               | Requirements for                                                                                                                                                  |              | Others                | February,      |

| S.NO | IS.NO                           | TITLE                                                                                                                             | REVISION NO. | CATEGORY              | REAFFIRMED     |
|------|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------|----------------|
|      | <u>Part 4 : 1983</u>            | chlorination equipment: Part 4 Gravity feed type gaseous chlorinators                                                             |              |                       | 2016           |
| 18   | <u>IS 10553 : Part 5 : 1987</u> | Requirements of chlorination equipment: Part 5 Bleaching powder solution feeder displacement type chlorinator                     |              | Others                | November, 2012 |
| 19   | <u>IS 11208 : 1985</u>          | Guidelines for registration of plumbers                                                                                           |              | Code of Practice      | February, 2017 |
| 20   | <u>IS 11401 : Part 1 : 1985</u> | Requirements for slow sand filters: Part 1 General guidelines                                                                     |              | Others                | November, 2012 |
| 21   | <u>IS 11401 : Part 2 : 1990</u> | General requirements for slow sand filters Part 2 Design, construction, operation and maintenance                                 |              | Others                | August, 2014   |
| 22   | <u>IS 11906 : 1986</u>          | Recommendations For Cement Mortar Lining For Cast Iron Mild Steel And Ductile-iron Pipes And Fittings For Transportation Of Water |              | Code of Practice      | November, 2012 |
| 23   | <u>IS 11925 : 1986</u>          | Pitch-impregnated Fibre Pipes and Fittings for Drainage Purposes                                                                  |              | Product Specification | November, 2012 |
| 24   | <u>IS 12183 : Part 1 : 1987</u> | Code of Practice for Plumbing in Multi-storeyed Buildings: Part 1 Water Supply                                                    |              | Code of Practice      | August, 2014   |

| S.NO | IS.NO                  | TITLE                                                           | REVISION NO. | CATEGORY         | REAFFIRMED     |
|------|------------------------|-----------------------------------------------------------------|--------------|------------------|----------------|
| 25   | <u>IS 12251 : 1987</u> | Code of practice for drainage of building basements             |              | Code of Practice | August, 2014   |
| 26   | <u>IS 12288 : 1987</u> | Code of Practice for Use and Laying of Ductile Iron Pipes       |              | Code of Practice | November, 2012 |
| 27   | <u>IS 13166 : 1992</u> | mechanical surface aerators-cuidlines for evluation and testing |              | Code of Practice | February, 2017 |

| S.NO | IS.NO                         | TITLE                                                                     | REVISION NO. | CATEGORY         | REAFFIRMED     |
|------|-------------------------------|---------------------------------------------------------------------------|--------------|------------------|----------------|
| 1    | <u>SP 35 (S&amp;T) : 1987</u> | Handbook on Water Supply and Drainage (with Special Emphasis on Plumbing) |              | Others           | 2014           |
| 2    | <u>SP 57 (QAWSM) : 1993</u>   | Handbook on Pipes and Fittings for Drinking Water Supply                  |              | Code of Practice | March, 2016    |
| 3    | <u>IS 1172 : 1993</u>         | Code of Basic Requirements for Water Supply, Drainage and Sanitation      | Fourth       | Code of Practice | November, 2016 |
| 4    | <u>IS 2065 : 1983</u>         | Code of practice for water supply in buildings                            | Second       | Code of Practice | February, 2017 |
| 5    | <u>IS 3114 : 1994</u>         | Code of practice for laying of cast iron pipes                            | Second       | Code of Practice | August, 2014   |
| 6    | <u>IS 4127 : 1983</u>         | Code of practice for laying of glazed stoneware pipes                     | First        | Code of Practice | February, 2017 |

**(3) BIS Standards for Waste Water Handling and Related Issues Standards**

| S.NO | IS.NO                          | TITLE                                                                                                               | REVISION NO. | CATEGORY      | of | REAFFIRMED     |
|------|--------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------|---------------|----|----------------|
| 1    | <u>IS 1742 : 1983</u>          | Code of practice for building drainage                                                                              | Second       | Code Practice | of | November, 2012 |
| 2    | <u>IS 2064 : 1993</u>          | Code of practice for selection, installation and maintenance of sanitary appliances                                 | Second       | Code Practice | of | November, 2012 |
| 3    | <u>IS 2470 : Part 1 : 1985</u> | Code of practice for installation of septic tanks: Part I design, criteria and construction                         | Second       | Code Practice | of | February, 2017 |
| 4    | <u>IS 2470 : Part 2 : 1985</u> | Code of practice for installation of septic tanks: Part II Secondary treatment and disposal of septic tank effluent | Second       | Code Practice | of | February, 2017 |
| 5    | <u>IS 4111 : Part 1 : 1986</u> | Code of practice for ancillary structures in sewerage system: Part I Manholes                                       | First        | Code Practice | of | February, 2017 |
| 6    | <u>IS 4111 : Part 2 : 1985</u> | Code of practice for ancillary structures in sewerage system: Part II Flusing tanks                                 | First        | Code Practice | of | February, 2017 |
| 7    | <u>IS 4111 : Part 3 : 1985</u> | Code of practice for ancillary structures in sewerage system: Part III Inverted syphon                              | First        | Code Practice | of | February, 2017 |
| 8    | <u>IS 4111 : Part 4</u>        | Code of Practice for Ancillary Structures in Sewerage System -                                                      |              | Code Practice | of | February, 2017 |

| S.NO | IS.NO                          | TITLE                                                                               | REVISION NO. | CATEGORY              | REAFFIRMED     |
|------|--------------------------------|-------------------------------------------------------------------------------------|--------------|-----------------------|----------------|
|      | <u>: 1968</u>                  | Part IV : Pumping Stations and Pumping Mains (Rising mains)                         |              |                       |                |
| 9    | <u>IS 4111 : Part 5 : 1993</u> | Code of practice for ancillary structures in sewerage system: Part 5 Tidal outfalls |              | Code Practice of      | August, 2014   |
| 10   | <u>IS 5329 : 1983</u>          | Code of practice for sanitary pipe work above ground for buildings                  | First        | Code Practice of      | February, 2017 |
| 11   | <u>IS 5611 : 1987</u>          | Code of Practice for Construction of Waste Stabilization Ponds (Faculative Type)    | First        | Code Practice of      | November, 2012 |
| 12   | <u>IS 6279 : 1971</u>          | equipment for grit removal devices                                                  |              | Product Specification | February, 2016 |
| 13   | <u>IS 6280 : 1971</u>          | Sewage Screens                                                                      |              | Product Specification | February, 2016 |
| 14   | <u>IS 6924 : 1973</u>          | Code of Practice for the Construction of Refuse Chutes in Multistoreyed Buildings   |              | Code Practice of      | February, 2017 |
| 15   | <u>IS 7090 : 1985</u>          | Guidelines for rapid mixing devices                                                 | First        | Code Practice of      | February, 2016 |
| 16   | <u>IS 7208 : 1992</u>          | Guidelines For Flocculator Devices                                                  | First        | Code Practice of      | February, 2017 |
| 17   | <u>IS 7232 : 1974</u>          | Method for imhoff cone test                                                         |              | Methods tests of      | November, 2012 |



| S.NO | IS.NO                           | TITLE                                                                                                      | REVISION NO. | CATEGORY         | REAFFIRMED     |
|------|---------------------------------|------------------------------------------------------------------------------------------------------------|--------------|------------------|----------------|
| 18   | <u>IS 7740 : 1985</u>           | Code of practice for construction and maintenance of road gullies                                          | First        | Code of Practice | February, 2017 |
| 19   | <u>IS 8413 : Part 1 : 1977</u>  | Requirements for biological treatment equipment: Part 1 Trickling filters                                  |              | Others           | February, 2016 |
| 20   | <u>IS 8413 : Part 2 : 1982</u>  | Requirements for biological treatment end equipment: Part 2 Activated sludge process and its modifications |              | Others           | February, 2016 |
| 21   | <u>IS 8419 : Part 1 : 1977</u>  | Requirements for filtration equipment : Part 1 Filtration media - sand and gravel                          |              | Others           | February, 2016 |
| 22   | <u>IS 8419 : Part 2 : 1984</u>  | Requirements for rapid sand gravity filtration equipment: Part 2 Under drainage system                     |              | Others           | February, 2016 |
| 23   | <u>IS 10037 : Part 1 : 1981</u> | Requirements for sludge dewatering equipment: Part 1 Sludge drying beds-sand, gravel and underdrains       |              | Others           | November, 2012 |
| 24   | <u>IS 10037 : Part 2 : 1983</u> | Requirements for sludge de-watering equipment: Part 2 Vacuum filtration equipment                          |              | Others           | February, 2016 |

| S.NO | IS.NO                           | TITLE                                                                                         | REVISION NO. | CATEGORY              | REAFFIRMED     |
|------|---------------------------------|-----------------------------------------------------------------------------------------------|--------------|-----------------------|----------------|
| 25   | <u>IS 10037 : Part 3 : 1983</u> | Requirements for sludge de-watering equipment: Part 3 Centrifugal equipment (Solid bowl type) |              | Others                | February, 2016 |
| 26   | <u>IS 10261 : 1982</u>          | Requirements for settling tank (clarifier equipment) for waste water treatment                |              | Others                | February, 2016 |
| 27   | <u>IS 10552 : 1983</u>          | buckets to be used in power driven bucket type sewer cleaning machine                         |              | Product Specification | February, 2016 |
| 28   | <u>IS 10595 : 1983</u>          | Requirements for power driven bucket-type sewer cleaning machine                              |              | Others                | February, 2016 |
| 29   | <u>IS 11117 : 1984</u>          | Requirements for power driven rodding machine for sewers                                      |              | Others                | February, 2016 |
| 30   | <u>IS 11387 : 1985</u>          | Requirements for high pressure jetting machine for sewer cleaning                             |              | Others                | February, 2016 |
| 31   | <u>IS 11397 : 1985</u>          | Attachment Tools For Power Driven Rodding Machine For Sewers                                  |              | Product Specification | February, 2016 |
| 32   | <u>IS 11931 : 1987</u>          | Sewer Cleaning Metal Rods                                                                     |              | Product Specification | November, 2012 |
| 33   | <u>IS 11972 :</u>               | Code of Practice for Safety Precautions to                                                    |              | Code of               | November,      |

| S.NO | IS.NO                  | TITLE                                                                                                                                               | REVISION NO. | CATEGORY         | REAFFIRMED     |
|------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------------------|----------------|
|      | <u>1987</u>            | be Taken When Entering a Sewerage System                                                                                                            |              | Practice         | 2012           |
| 34   | <u>IS 12314 : 1987</u> | Code of practice for sanitation with leaching pits for rural community                                                                              |              | Code Practice of | November, 2012 |
| 35   | <u>IS 13496 : 1992</u> | General Requirements of Suction Machine for Cleaning Sewers, Manholes and Ancillary Structures Provided on Sewer Line and Closed Storm Water Drains |              | Others           | November, 2012 |

**APPLICABLE BUREAU OF INDIAN STANDARDS (BIS) FOR CIVIL ENGINEERING DESIGN AND CONSTRUCTION**

**Special Structures Standards**

| S.NO | IS.NO                                       | TITLE                                                                        | COMMITTEE | NO. OF LICENCES | REVISION NO. | CATEGORY         | REAFFIRMED    |
|------|---------------------------------------------|------------------------------------------------------------------------------|-----------|-----------------|--------------|------------------|---------------|
| 7    | <u>IS 1138</u><br><u>4</u> :<br><u>1985</u> | Code of Practice for Composite Construction in Structural Steel and Concrete | CED 38    | 0               |              | Code of Practice | October, 2017 |
| 9    | <u>IS 1168</u><br><u>2</u> :<br><u>1985</u> | Criteria for design of RCC staging for overhead water tanks                  | CED 38    | 0               |              | Code of Practice | October, 2017 |

The following codes shall be used for the engineering and design.

Dead Load : IS 875 Part-I

Imposed / Live Load : IS 875 Part –II

Wind Load : IS 875-Part III

Seismic Load : IS 1893 (Part 1,2 & 4)

Concrete Design: IS 456:2000 (Non-liquid retaining structures)

IS 3370:2009 (Liquid retaining structures-limit state method with limiting crack width of 0.2mm)

Steel Design : IS 800:1984 (Working stress method)

## KARNATAKA BUILDINGS SPECIFICATIONS (KBS)

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**GOVERNMENT OF KARNATAKA**

**PUBLIC WORKS DEPARTMENT**

**KARNATAKA ROADS AND BRIDGES SPECIFICATIONS (KRBS)**

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1.-Ribbon development in India, 2.-Effects of ribbon development, 3.-Review of the measures that are possible for controlling ribbon development, 4.-How other countries have tackled the menace, 5.-Existing laws in India, their deficiencies and suggestions for improvement,

**Appendix-23-Highway safety [235-268]**

1.-Introduction, 1.1.-Engineering measures to improve road safety, 1.2.-Traffic enforcement, 1.3.-Traffic education, 1.4.-Accident investigation, 1.5.-General recommendations.

**2.-Guidelines for implementation of highway safety measures [241-268],** 2.1.-Road condition and traffic safety, 2.2.-Geometric design for improved safety, 2.3.-Road intersections, 2.4.-Roadside developments, roadside hazards and road appurtenances, 2.5.-Road surface characteristics, 2.6.-Traffic regulation and control, 2.7.-Accident recording and analysis, 2.8.-Education, 2.9. - Enforcement.

**TECHNICAL SPECIFICATIONS  
FOR  
ROADS & BRIDGE WORKS**

**Published by the Indian Road Congress on Behalf of the Govt. of India Ministry of  
Road Transport & Highways**

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## DRAFT ESCROW ACCOUNT- AGREEMENT

THIS AGREEMENT (the "**Agreement**") is entered into on this the [ ] day of [ ], 2017

Amongst:

<Name of special purpose vehicle >, a company incorporated under the provisions of the Companies Act 1956 promoted by Preferred bidder and its shareholders as per shareholding agreement as per letter of tender accepted by the employer, and having its registered office at <Address of special purpose vehicle >, hereinafter referred to as the "**The Contractor**" or "**Company**" which expression shall, include its successors in interest and permitted assigns;

**AND**

[Name of Employers ' Representative], or [description of Employers' representative], or any other person nominated by <Name of Employer> having its registered office at <Name of employers address> acting for and on behalf of the Employer (hereinafter referred to as the "**Employer's Representative**" which expression shall include its successors in interest and permitted assigns);

**AND**

(Name of the Bank), [description of bank] and having its registered office at ..... , (hereinafter referred to as the "**Bank**" which expression shall include its successors in interest and permitted assigns);

**AND**

[Name of the escrow agent], [description of escrow agent] and having its registered office at ..... (hereinafter referred to as the "**Escrow Agent**" which expression shall include its successors in interest and permitted assigns);

WHEREAS:

- A. The Contractor has been granted a contract by <Name of employer > ("**EMPLOYER**") for the project for "**Name of project**" in Karnataka ("**Project**");
- B. The Company has entered into a Contract Agreement dated .....2017 with employer ("**Contract Agreement**") wherein Employer has granted the contract to The Contractor for implementation of the Project subject to the terms and conditions set out there under;
- C. One of the terms of the Contract Agreement and the Financing Documents is that the Company is required to establish an Escrow Account, inter alia, on terms and conditions satisfactory to Lenders.

NOW IN CONSIDERATION OF THE PREMISES IT IS AGREED BY THE PARTIES AS FOLLOWS:

**1. DEFINITIONS AND INTERPRETATION**

**1.1 Definitions**

In addition to terms defined elsewhere in this Agreement, capitalized terms and expressions used herein shall, unless the context otherwise provides, have the meanings ascribed hereunder:

**"Account"** means the Escrow Account to be opened by the Company in accordance with this Agreement;

**"Business Day"** means any day on which banks are open for business in Mumbai or in relation to any notice or communication to be made under this Agreement, a day on which banks are open for business in the place of receipt of such notice or communication;

**"Company Account"** shall mean any bank account of the Company, other than the Escrow Account.

**"Enforcement Notice"** means any enforcement procedure commenced by the Employer' Representative under any of the Security Documents;

**"Escrow Account-** means an escrow account established by the Company in terms of and under this Agreement;

**"Event of Default"** means an event of default as defined and detailed in the Financing Documents;

**"INR"** means the lawful currency of India;

**"Payment Date"** means in relation to any Permitted Payment, the date(s) specified for such payment;

**"Permitted Payment"** means the Payments agreed to in this Agreement excluding payment to the Company Accounts as more particularly given in Clause 3.3.1;

**"Required Balance"** means on any Date in relation to the Escrow Account, an amount in INR which if proportionately, would be sufficient to meet Permitted Payment on the Payment Date(s);

**"Security Documents"** means all or any of the documents executed, delivered or furnished to secure the financial assistance under the Financing Documents including but not limited to the Deed of Hypothecation, Mortgage Deed,

Equitable Mortgage, Deed of Guarantee, Pledge Agreement, Undertakings, Negative Lien and other incidental or supplemental documents related thereto;

"Year" means each twelve month period commencing from April 1 and ending on March 31 of the succeeding year.

## **1.2 Construction**

In this Agreement, unless the context otherwise requires:

- (a) reference to the singular includes the plural and vice versa; words importing a particular gender includes all genders;
- (b) Headings and the use of bold typeface shall be ignored in its construction;
- (c) A reference to a Clause or Schedule is, unless indicated to the contrary, a reference to a clause of or schedule to this Agreement;
- (d) References to this Agreement shall be construed as references also to any separate or independent stipulation or agreement contained in it;
- (e) The words "other", or "otherwise" and "whatsoever" shall not be construed to be as any limitation upon the generality of any preceding words or matters specifically referred to;
- (f) References to the word "includes" or "including" are to be construed without limitation;
- (g) All references to agreements, documents or other instruments include (subject to all relevant approvals) a reference to that agreement, document or instrument as amended, supplemented, substituted, novated or assigned from time to time;
- (h) The words "herein", "hereto" and "hereunder" refer to this Agreement as a whole and not to the particular Clause in which such word may be used;
- (i) Reference to "person" includes any individual, partnership, firm, trust, body corporate, government, governmental body, authority, agency, unincorporated body of persons or association;
- (j) References to "Party" means a party to this Agreement and references to "Parties" shall be construed accordingly; and

- (k) References to any law shall include references to such law as it may, after the date of this Agreement, from time to time be amended, supplemented or re-enacted; and
- (l) Capitalized terms and expressions used but not defined herein shall, unless the context otherwise requires, have the meanings ascribed to them under the Contract Agreement.

## **2. ESCROW ACCOUNT**

### **2.1 Acceptance of Appointment of Escrow Agent**

- 2.1.1 The Escrow Agent hereby agrees to act as such and to accept all payments and other amounts to be delivered to or held by the Escrow Agent pursuant to the terms of this Escrow Agreement. Escrow Agent shall hold and safeguard the Escrow Account during the term of this Escrow Agreement and shall treat the amount in the Escrow Account as monies deposited by Company / EMPLOYER with the Escrow Agent, as agent for the benefit of the Employer's Representative, or its nominee, successors or assigns, in trust in accordance with the provisions of this Escrow Agreement. In performing its functions and duties under this Escrow Agreement, the Escrow Agent shall act as agent for the Employer's Representative and the Company.
- 2.1.2 The Company also hereby declares that all right, title and interest in and to the Escrow Account, 'the Authorized Investments and Permitted Payments made from the Escrow Accounts shall be vested in the Escrow Agent and held in trust by the Bank, The Contractor and the Employer's in accordance with the terms of this Agreement and as their respective interests are provided for herein. Amounts deposited in the Escrow Account from time to time shall be held by the Escrow Agent in trust and received and applied as provided in and in accordance with the Agreement. No person other than the Company and the Employer's Representative shall have any rights hereunder as the beneficiaries of or as third party beneficiaries under this Agreement.
- 2.1.3 The rights of Company and the Employer acting through the Employer's Representative in the monies held in Escrow Account are set forth in their entirety in this Escrow Agreement and Company and/ or the employer acting through the Employer' Representative shall have no other rights against or to the monies in the Escrow Account;

### **2.2 Establishment of Escrow Account**

At least 30 (thirty) days prior to the Contractor seeking any disbursement , the Company shall establish the Escrow Account with the Escrow Agent.

### **2.3 Maintenance of the Account**

The shall maintain the Escrow Account in accordance with the terms of this Agreement and its usual practices and applicable regulations and pay the maximum rate of interest payable to its customers on the balance in the said account from time to time.

### **2.4 Operating Procedures**

The Escrow Agent, the Company and The Contractor shall agree, in consultation with the employer on the detailed mandates, terms and conditions and operating procedures for the Escrow Account but in the event of any inconsistency between this Agreement and such mandates, terms and conditions or procedures, this Agreement shall prevail.

## **3. OPERATION OF ESCROW ACCOUNT**

3.1 The Escrow Account shall be established with the [ ] branch of the Escrow Agent. The Escrow Account shall be denominated in INR.

### **3.2 Deposits**

#### **3.2.1 Both the parties**

(a) Agrees, confirms and undertakes that it shall deposit and/or credit the Escrow Account with:

- (i) All Project Revenues and User charges and any other revenues from or in respect of the project, including the proceeds of any rentals, deposits, capital receipts and pursuant to this project;
- (ii) All proceeds received pursuant to any insurance claims; and
- (iii) All monies received from any other sources in relation to and in respect of the Project.

(b) May make deposits of any other funds into the Escrow Account at any time. Provided however that the terms of this Agreement shall apply to such other funds deposited in the Escrow Account by the Company.

3.2.2 EMPLOYER agrees, confirms and undertakes that it shall deposit and/or credit the Escrow Account with employer is paying interim payments and Final payment as certified by employer's representative in accordance to terms and conditions of contract agreement, Maintenance retention funds, termination payments and other monies paid or disbursed in accordance with the provisions of the Contract Agreement.

- 3.2.3 The Escrow Agent shall ensure that all interest, if any, on the balances of the Escrow Accounts and interest on Authorized Investments made from the Escrow Account shall be credited to or deposited in the Escrow Account.

### **3.3 Withdrawals**

- 3.3.1 The Escrow Agent shall allow withdrawal amounts from the Escrow Account as certified by Employer's representative and appropriate in the following order of priority after each interim payment given below on the Payment Date(s):

- (ii) All Taxes due and payable by The Contractor for the Project;
- (iii) All payments made to Debt Service;
- (iii) Salaries of contractor personnel
- (iv) All expenses in connection with and relevant to the construction of Project by way of payment to the sub-Contractor , Approved Vendors and such other persons as may be certified by employers representative.
- (v) O&M Expenses;
- (vi) All funds reserved for major maintenance reserve up to 5% of interim payment;
- (vii) Any payments and Damages due and payable by The Contractor to EMPLOYER pursuant to this Agreement; and
- (viii) Balance in accordance with the instructions of The Contractor.

The amounts specified in Clause 3.3.1 (i) to (viii) constitute the Permitted Payments.

- 3.3.2** Notwithstanding anything to the contrary contained in this Agreement upon the earlier of

- (a) Issue of Termination Notice;
- (b) Termination of Contract Agreement; or
- (c) The expiry of Contract Period;

all amounts standing to the credit of the Escrow Account shall be appropriated and dealt with in the following order of priority:

- (a) All Taxes due and payable by the Contractor for the Project;
- (b) All accrued Debt Service Payment;
- (c) Any payments and Damages due and payable by The Contractor to EMPLOYER pursuant to this Agreement, including Termination Claims;
- (d) All accrued O&M Expenses;
- (e) Any other payments required to be made under the Contract Agreement as certified by employer's engineers; and
- (f) Balance, if any, on the instructions of the Contractor;

### **3.4 Application of Insufficient Funds**

As provided in Clause 3.3, the application of funds in the Escrow Account shall be in the serial order of priority set forth therein. If the funds available are sufficient to pay a portion, but not all, of the amounts required to be paid, the Escrow Agent shall apply such funds in the serial order of priority set forth in Clause 3.3, until exhaustion thereof.

## **4. WITHDRAWALS FOLLOWING EVENT OF DEFAULT**

- 4.1 If the Employer's Representative notifies the Escrow Agent that an Event of Default is likely to occur or has occurred, and is continuing, then, until such time as the Employer's Representative has notified the Escrow Agent that the Event of Default has been cured or waived under the Financing Documents, the Escrow Agent shall permit only make withdrawals from the Escrow Account which constitute Permitted Payment and shall not make any payments from the Escrow Account to the Company Accounts.

## **5. ESCROW AGENT PROVISIONS**

### **5.1 Escrow Agent**

The Company hereby appoints the Escrow Agent to act as trustee for the Employer's Representative, the Company and the Bank in connection herewith and authorizes the Escrow Agent to exercise such rights, powers, authorities and discretion as are specifically delegated to the Escrow Agent by the terms hereof together with all such rights, powers, authorities and discretion as are reasonably incidental hereto, and the Escrow Agent accepts such appointment pursuant to the terms hereof.

### **5.2 Particular Duties of the Escrow Agent**

The Escrow Agent:

- (a) May, in the absence of bad faith or gross negligence on its part, rely as to any matters of fact which might reasonably be expected to be within the knowledge of the Company upon a certificate signed by or on behalf of the Company;
- (b) May, in the absence of bad faith or gross negligence on its part, rely upon the authenticity of any communication or documents believed by it to be authentic;
- (c) Shall, within 5 (five) Business Days after receipt, deliver a copy to the Employer's Representative and the Contractor of any notice or document received by the Escrow Agent in its capacity as the Escrow Agent from the Company or any other person hereunder or in connection herewith; and

- (d) Shall, within 5 (five) Business Days after receipt, deliver a copy to the Company of any notice or document received by the Escrow Agent from the Employer's' Representative or the Contractor or the Bank in connection herewith.

### **5.3 Segregation of Funds**

Monies and other property received by the Escrow Agent under this Agreement shall, until used or applied in accordance with this Agreement, be held by the Escrow Agent in trust for the purposes for which they were received, and shall be segregated from other funds and property of the Escrow Agent.

### **5.4 Termination**

This Agreement shall remain in full force and effect so long as amounts remain outstanding from the Company in respect of the payments received by it from the Employer, unless terminated earlier by the mutual consent of the parties.

### **5.5 Substitution of Escrow Agent**

The Company may, by not less than 60 (Sixty) days prior notice to the Escrow Agent, EMPLOYER and the Employer's Representative, substitute the Escrow Agent with a new escrow agent, provided that the new escrow agent is acceptable to the Employer's Representative and arrangements are made satisfactory to the Employer's Representative for transfer of amounts deposited in the Escrow Account to a new escrow account established with the successor escrow agent.

### **5.6 Fees**

The Company shall pay the Escrow Agent fees in an amount and at such times as may be agreed between the Escrow Agent and the Company.

## **6. ESCROW AGREEMENT DEFAULTS**

**6.1** If the Company is in breach of any of its obligations under this Agreement then, following a notice of default from the Employer's' Representative, the Company shall remedy the same:

- (a) In the case of a failure to deposit funds received by the Company in the Escrow Account by depositing the same in the Escrow Account within 5 (five) Business Days of receipt of such notice;
- (b) In the case of a breach consisting of causing the Escrow Agent to transfer funds to any Company Account in breach of the terms of this Agreement, by depositing the relevant funds in the Escrow Account in which such transfer should have been made within 5 (five) Business Days of receipt of such notice;



- (c) In the case of a breach of the Company's obligations under Clause 4, by instructing the Escrow Agent to realize any investment made in breach of Clause 4 within 5 (five) Business Days of receipt of such notice; or
- (d) In the case of any other breach, by remedying the same within five (5) Business Days to the satisfaction of the Employer's Representative.

**6.2** The Company and the Escrow Agent agree and confirm that any default by either the Company or the Escrow Agent in the performance of their respective obligations under this Agreement resulting, in the opinion of the Employer's Representative, in a breach of this Agreement (and provided such breach is not remedied in terms hereof), shall qualify as an Event of Default under the Financing Documents/Security Documents;

## **7. MISCELLANEOUS**

### **7.1 Closure of Accounts**

The Escrow Agent shall, upon receipt of amounts pursuant to Clause 3.3.2 in the Escrow Account, transfer all such amounts to a Company account designated by the Company and upon confirmation of receipt of such amounts to such designated Company account, close the Escrow Account.

### **7.2 Successors and Assigns**

This Agreement shall be binding on and shall ensure to the benefit of the Parties and their respective successors and permitted assigns.

### **7.3 No Set Off**

The Escrow Agent agrees not to claim or exercise any right of set off, banker's lien or other right or remedy with respect to amounts standing to the credit of the Escrow Account. For the avoidance of doubt, it is declared by the Escrow Agent that the monies and properties held by the Escrow Agent shall not be considered as part of the assets of the Escrow Agent and being trust property, shall in the case of bankruptcy or liquidation of the Escrow Agent be wholly excluded from the assets of the Escrow Agent in such bankruptcy or liquidation.

### **7.4 Notices**

7.4.1 All notices or other communications to be given or made under this Agreement shall be in writing, shall either be delivered personally or sent by courier, registered or certified mail or facsimile or electronic mail. The address for service of each Party and its facsimile number and e-mail address is set out under its name on the signing pages hereto. All notices shall be effective upon actual receipt save that where a notice is received

after 5.30 p.m. on a Business Day or on a day that is not a Business Day, such notice shall be deemed to be received on the first Business Day following the date of actual receipt. Without prejudice to the foregoing a Party giving or making a notice or communication by facsimile shall promptly deliver a copy of such notice or communication personally, by courier or mail to the addressee of such notice or communication.

7.4.2 Any party may by notice change the addresses and/or addresses to which such notices and communications to it are to be delivered or mailed. Such change shall be effective when all the Parties have notice of it.

## **7.5 Waiver**

Failure by any Party at any time to enforce any provision of this Agreement or to require performance by other Parties of any provision of this Agreement shall not be construed as a waiver of such provision and shall not affect the validity of this Agreement or any part of it or the right of the relevant Party to enforce any provision in accordance with its terms.

## **7.6 Severability**

If any condition, Clause or provision of this Agreement not being of a fundamental nature, is held to be illegal or unenforceable: the validity or enforceability of the remainder of this Agreement shall not be affected thereby.

## **7.7 Amendments**

No amendment to this Agreement shall be binding unless in writing and signed by the duly authorized representatives of the Parties.

## **7.8 Governing Law**

This Agreement shall be governed by and construed in accordance with the laws of India.

## **7.9 Regulatory Approvals**

The Escrow Agent shall use its best efforts to procure and shall thereafter maintain and comply with all regulatory approvals required for it to establish and operate the Escrow Account. The Escrow Agent represents and warrants that it is not aware of any reason why such regulatory approvals will not be ordinarily granted to the Escrow Agent.

## **7.10 Notification of Balances**

7 (seven) Business Days prior to each Payment Date (and for this purpose the Escrow Agent shall be entitled to rely on an affirmation by the Company and/or

the Employer's' Representative as to the relevant Payment Dates), the Escrow Agent shall notify the Employer's' Representative, Bank and the Contractor of the balance of the Escrow Account as at the close of business on the immediately preceding Business Day.

IN WITNESS whereof the Company Escrow Agent, Company, the Employer's' Representative and the Bank have caused this Agreement to be executed by the hand of an authorized representative.

SIGNED AND DELIVERED BY

.....Within named Escrow Agent  
By the hand of an authorized representative

Address:

Fax Number:

Attention: .....

SIGNED AND DELIVERED BY

.....Within named Bank  
By the hand of an authorized representative

Address:

Fax Number:

Attention: .....

SIGNED AND DELIVERED BY

.....Within named Company  
By the hand of an authorized representative

Address:

Fax Number:

Attention: .....

SIGNED AND DELIVERED BY

.....Within named Employer's' Representative  
By the hand of an authorized representative

Address:

Fax Number:

Attention: .....

**NAME OF WORK: DEVELOPMENT OF MAJOR ARTERIAL ROAD (PHASE-1) IN NADAPRABHU KEMPEGOWDA LAYOUT, BANGALORE****LIST OF SPECIFICATIONS FOR CIVIL WORKS**

| <b>Item No.</b> | <b>Description</b>                                                                                                                                                                                                                                                                                                                      | <b>Unit</b> | <b>Reference Specifications</b>                                                |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------------------------------------------------|
| 1               | SITE CLEARANCE WORK<br>KSRRB M200-6.1 Cutting of trees girth from 300mm to 600mm including cutting of trunks, branches and removal of stumps, roots stacking of serviceable materials with all lifts and up to a lead of 1 000m and earth filling in the depressions / pit, complete as per specifications. MORTH Specification No. 201 | No          | KSRRB M200-6.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 2               | KSRRB M200-6.2 : - Cutting of trees girth from 600mm to 900mm including cutting of trunks, branches and removal of stumps, roots stacking of serviceable materials with all lifts and up to a lead of 1 000m and earth filling in the depressions / pit, complete as per specifications. MORTH Specification No. 201.                   | No          | KSRRB M200-6.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 3               | KSRRB M200-6.3 : Cutting of trees girth from 900mm to 1800mm including cutting of trunks, branches and removal of stumps, roots stacking of serviceable materials with all lifts and up to a lead of 1 000m and earth filling in the depressions / pit, complete as per specifications. MORTH Specification No. 201.                    | No          | KSRRB M200-6.3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 4               | KSRRB M200-6.4 : Cutting of trees girth from 1800mm to 2700mm including cutting of trunks, branches and removal of stumps, roots stacking of serviceable materials with all lifts and up to a lead of 1 000m and earth filling in the depressions / pit, complete as per specifications. MORTH Specification No. 201.                   | No          | KSRRB M200-6.4 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 5               | KSRRB M200-6.4 : Cutting of trees girth from 2700mm to 3600mm including cutting of trunks, branches and removal of stumps, roots stacking of serviceable materials with all lifts and up to a lead of 1 000m and earth filling in the depressions / pit, complete as per specifications. MORTH Specification No. 201.                   | No          | KSRRB M200-6.4 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 6               | KSRRB M300-9. Replantation of Trees being cut in 0.60 m dia holes, 1 m deep dug in the ground, mixing the soil with decayed farm yard/sludge manure, planting the saplings, backfilling the trench, watering, fixing the tree guard and maintaining the plants for one year complete as per specifications.                             | No          | KSRRB M300-9 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Unit | Reference Specifications                                                        |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------------------------------------------------------------------------------|
| 7        | KSRRB M200-11.1. Clearing and grubbing road land including uprooting rank vegetation, grass, bushes, shrubs, saplings and trees girth up to 300 mm, removal of stumps of trees cut earlier and disposal of unserviceable materials and stacking of serviceable material to be used or auctioned, including removal and disposal of top organic soil not exceeding 150 mm in thickness complete as per specifications. II. By Mechanical Means: A. In area of light jungle. MORTH Specification No. 201                          | Ha   | KSRRB M200-11.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 8        | KSRRB M200-11.1. Clearing and grubbing road land including uprooting rank vegetation, grass, bushes, shrubs, saplings and trees girth up to 300 mm, removal of stumps of trees cut earlier and disposal of unserviceable materials and stacking of serviceable material to be used or auctioned, including removal and disposal of top organic soil not exceeding 150 mm in thickness complete as per specifications. II. By Mechanical Means: A. In area of light jungle. MORTH Specification No. 201 In area of thorny jungle | Ha   | KSRRB M200-11.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 9        | KSRRB M300-1 1. Excavation for road way in all types of soil by mechanical means including cutting and pushing the earth to site of embankment including trimming bottom and side slopes in accordance with requirements of lines, grades and cross sections complete as per specifications. MORTH Specification No. 301 (disposal upto a lead of 500m as per note 4 page no 152)                                                                                                                                               | Cum  | KSRRB M300-1 1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 10       | KSRRB 300-5. Excavation in soft rock without blasting for formation of roads including stacking neatly, to uniform line and level including cost of explosives, labour, HOM of machineries and equipments complete as per specifications. (with all lead and lift) MORTH / Chapter 3                                                                                                                                                                                                                                            | Cum  | KSRRB 300-5 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications     |
| 11       | KSRRB 300-8. Excavation in hard rock by chiselling and / or wedging where blasting is prohibited for formation of roads including stacking to uniform line and level including cost of all labour complete as per specifications. (with all lead and lift) MORTH / Chapter 3                                                                                                                                                                                                                                                    | Cum  | KSRRB 300-8 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications     |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Unit | Reference Specifications                                                       |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------------------------------------------------------------------|
| 12       | KSRRB M300-53. Construction of embankment with approved material Gravel/Murum with all lifts and leads, transporting to site, spreading, grading to required slope and compacting to meet requirement Table 300-2 complete as per specifications, including cost of gravel / murum, watering charges & compaction by vibratory roller to 95% of proctors density. MORTH Specification No. 305                                                                                                                                                     | Cum  | KSRRB M300-53 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 13       | KSRRB M300-54. Construction of embankment with approved material deposited at site from roadway cutting and excavation from drain and foundation of other structures graded and compacted to meet requirement of Table 300-2 complete as per specifications. which includes , watering charges & compaction by vibratory roller) MORTH Specification No. 305                                                                                                                                                                                      | Cum  | KSRRB M300-54 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 14       | KSRRB M300-55. Construction of sub-grade and earthen shoulders with approved material Gravel/Murum with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of Table No. 300-2 complete as per specifications, including cost of earth, watering charges & compaction by vibratory roller to 97% of proctors density) MORTH Specification No. 305                                                                                                                                     | Cum  | KSRRB M300-55 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 15       | PAVEMENT WORKS, ROAD SIDE DRAIN & UTILITY DUCT<br>KSRRB M400-6.1. Construction of granular sub-base by providing close graded crushed stone aggregates of granite / trap / basalt material, mixing in a mechanical mix plant at OMC, carriage of mixed material to work site, spreading in uniform layers with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per specifications. A. Plant Mix Method. Close graded granular sub-base material as per 400-1 - Grading II | Cum  | KSRRB M400-6.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 16       | KSRRB M400-7. Construction of granular sub-base by providing Coarse graded crushed stone aggregates of granite / trap / basalt material, spreading in uniform layers with motor grader on prepared surface, mixing by mix in place method with rotavator at OMC, and compacting with vibratory roller to achieve the desired density, complete as per specifications. By mix in place method. For Coarse graded granular sub-base material as per 400-2 - Grading II                                                                              | Cum  | KSRRB M400-7 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Unit | Reference Specifications                                                      |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------------------------------------------------------------|
| 17       | KSRRB M400-17. Providing, laying, spreading and compacting cushioned stone aggregates of granite / trap / basalt to wet mix macadam specifications including pre mixing the material with water at OMC in mechanical mix plant carriage of mixed materials by tipper to site, laying in uniform layers with paver in sub-base/base course on well prepared surface and compacting with vibratory roller to achieve the desired density complete as per specifications. MORTH Specification No. 406 | Cum  | KSRRB M400-17 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 18       | KSRRB M500-6. Providing and applying primer coat with S.S.bitumen emulsion on prepared surface of granular base such as WMM including cleaning of road surface and spraying primer at the rate of 0.60 kg/sqm using mechanical means complete as per specifications. MORTH Specification No.502                                                                                                                                                                                                    | Sqm  | KSRRB M500-6 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 19       | KSRRB 500-7. Providing and applying tack coat using 80/100 grade bitumen(VG10) on the prepared black topped surfaces at 2.5 kg per 10 sqm, heating bitumen in boiler fitted with spray set (excluding cleaning of road surface) including cost of all materials, labour, HOM of machineries complete as per specifications. MORTH Chapter 5                                                                                                                                                        | Sqm  | KSRRB 500-7 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 20       | KSRRB 500-9. Providing and applying tack coat using 80/100 grade bitumen(VG10) on granular base such as WBM surfaces hot bitumen primed at 4 kg per 10 sqm, heating bitumen in boiler fitted with spray set (excluding cleaning of road surface) including cost of all materials, labour, HOM of machineries complete as per specifications. MORTH Chapter 5                                                                                                                                       | Sqm  | KSRRB 500-9 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 21       | KSRRB M500-17. Providing and laying dense graded bituminous macadam using 100/120 TPH capacity H.M.P. with sensor paver Gr-II (50 mm to 75 mm) with 4.5 % VG-30 Bitumen , premixed with VG30 grade bituminous binder and, transporting the hot mix to work site, laying to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH table 500-10 complete in all respects complete as per specifications. | Cum  | KSRRB M500-17 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Unit | Reference Specifications                                                      |
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| 22       | KSRRB M500-18. Providing and laying semi dense bituminous concrete using crushed aggregates of specified grading, premixed with bituminous binder and filler, transporting the hot mix to work site, laying with a paver finisher to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 508 complete in all respects complete as per specifications. using 100/120 TPH capacity H.M.P. with sensor paver Gr-II (25 mm to 30 mm) with 5 % VG-30 Bitumen      | Cum  | KSRRB M500-18 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 23       | KSRRB M500-19. Providing and laying bituminous concrete 40 mm thick with hot mix plant, using 100/120 TPH capacity H.M.P. with sensor paver Gr-II (30 mm to 45 mm) with 6 % VG-30 Bitumen, premixed with bituminous binder and filler, transporting the hot mix to work site, laying with a paver finisher to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 500.9 complete in all respects complete as per specifications. MORTH Specification No. 509 | Cum  | KSRRB M500-19 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 24       | Kerb Stones: Providing and fixing Pre cast solid concrete kerb stones made out of CC 1:2:4 and finished with CM 1:3 Plastering and finishing cutting etc., complete of size 450X200X400 mm.                                                                                                                                                                                                                                                                                                                                                                                         | No   | MORT&H Specification No. 408                                                  |
| 25       | KSRB 15-19.1 : Providing and applying ready mix priming coat over concrete / masonry / asbestos cement sheet / plastered surfaces including preparing the surface after thoroughly cleaning of oil, grease, dirt and other foreign matter, and sand papering including cost of materials, labour, complete as per specifications.                                                                                                                                                                                                                                                   | Sqm  | KSRB 15-19.1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |
| 26       | KSRRB M800-6. Painting two coats on New Concrete Surface:- Painting two coats after filling the surface with synthetic enamel paint in all shades on new plastered concrete surfaces complete as per specifications.                                                                                                                                                                                                                                                                                                                                                                | Sqm  | KSRRB M800-6 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |



| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Unit | Reference Specifications                                                      |
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| 27       | KSRRB M400-21. Construction of footpath/separator by providing a 150mm compacted granular subbase as per clause 401 & 25mm thick cement concrete grade M-15, overlaid with precast concrete tiles in cement mortar 1:3 including provision of all drainage arrangements but excluding kerb channel complete as per specifications. MORTH specification No.409                                                                                                                                                                                                                                                                                                                                                                                            | Sqm  | KSRRB M400-21 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 28       | KSRRB M 800-14.2. KSRRB M800-23.1. Metal Beam Crash Barrier:-Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m centre to centre, 1.8 m high, 1.1 m below ground/road level, all steel parts and fitments to be galvanised by hot dip process, all fittings to conform to IS:1367 and IS:1364, metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per clause 800.10 complete as per specifications. Excluding cost of earth work excavation and pcc for fixing. A. Type - A, "W" MORTH Specification No. 810 | Rmt  | KSRRB M800-23.1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 29       | KSRB 2.8 : Providing and Filling in foundation with granite / trap broken metal 100mm. and down size, with approved sand including hand packing, ramming, watering, including cost of all materials and labour with all lead and lift. complete as per specifications. specification. No. KBS                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Cum  | KSRB 2.8 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications        |
| 30       | KSRB 4-1.1: Providing and laying in position plain cement concrete of mix 1:2:4 with OPC cement @ 240kgs, with 40mm and down size graded granite metal coarse aggregates @0.878cum and fine aggregates @0.459cum machine mixed, concrete laid in layers not exceeding 15 cms. thick, well compacted, in foundation, including cost of all materials, labour, HOM of machinery, curing complete as per specifications Specification No. KBS 4.1, 4.2                                                                                                                                                                                                                                                                                                      | Cum  | KSRB 4-1.1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications      |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Unit | Reference Specifications                                                       |
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| 31       | Providing laying plain /reinforced cement concrete for side Drains using M20 nominal mix concrete with OPC cement at 300 kgs. With 20mm and down size granite metal coarse aggregates at 0.69 cum and fine aggregates at 0.43 cum machine mixed, well compacted for walls and bottom including centering, shhuttering, cost of materials, HOM of machinery, curing etc, complete excluding cost of steel as per MORTH Specification No. 1500,1700,2200 - For wall & bottom thickness 15cm.     | cum  | KSRB 37.59.2 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications     |
| 32       | KSRRB M2200-5.12 Design Mix M25 with OPC cement @ 340 kgs, with 20mm and down size graded granite metal coarse aggregates @ 0.70 cum and fine aggregates @ 0.47 cum.with superplastisiser @3lts upto 5m ht ,confirming to IS9103-1999 Reaffirmed-2008, Upto 5 mtr Ht (inclusive of form work -refer general note no.17 page no. d of SR 2012-13)                                                                                                                                               | Cum  | KSRRB M2200-5.12 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 33       | KSRB 4-6.4 : Providing and removing centering, shuttering, strutting, propping etc., and removal of form work for vertical surface such as walls at any thickness, including attached pilasters, buttresses, plinth cills and string courses cost of all materials, labour complete as per specifications. Specification No. KBS 4.6.2                                                                                                                                                         | Sqm  | KSRB 4-6.4 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications       |
| 34       | KSRB 4-6.4 : Providing and removing centering, shuttering, strutting, propping etc., and removal of form work for flat surface such as roofs,landing, balconies and likes,thickness upto 200mm including cost of all materials, labour complete as per specifications. Specification upto 3.5m from ground level No. KBS 4.6.2                                                                                                                                                                 | sqm  | KSRB 4-6.4 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications       |
| 35       | KSRRB M2200-6. Supplying, fitting and placing TMT bar reinforcement in sub-structure complete as per drawing and Technical Specifications complete as per specifications MORH Specification No.1600 & 2200                                                                                                                                                                                                                                                                                     | MT   | KSRRB M2200-6 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |
| 36       | KSRB 7.9 : Providing and fixing M.S.grill work for windows and ventilators using M.S. flats, or M.S. square rods, or combination of M.S. flats and square rods as per approved design, drawing including cutting steel sections and welding the same to required pattern with a coat of red lead primer, cost of materials, fixtures, labour and HOM of machinery complete as per specifications. Specification No. KBS 7.12. For Cable trays fixing (flat 50x6x2000mm) at spacing of 1.5m c/c | Kgs  | KSRB 7.9 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications         |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Unit | Reference Specifications                                                       |
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| 37       | Providing and laying reinforced cement concrete pipe NP2 for culverts including pointing ends, and fixing collars with cement mortar 1:2 including cost of all materials, labour, curing complete as per specifications. Specifications. No. KSRB 1000, 2300 MOST Specification No.1000 / 2300; 150mm dia spaced at 30m c/c                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Rmt  | KSRB 1000, 2300 MORTH Specification No. 1000/2300                              |
| 38       | KSRRB M800-29.2. Providing and laying of a reinforced cement concrete pipe duct, 300mm dia, across the road (new construction), extending from drain to drain in cuts and toe of slope to toe of slope in fills, constructing head walls at both ends, providing as minimum fill of granular material over top and sides of RCC pipe as per IRC:98-1997, bedded on 0.3 thick layer of granular materia free of rock pieces, outer to outer distance of pipe at least half dia of pipe subject to minimum 450mm in case of double and triple row ducts, joints to be made leak proof, invert level of duct to be above heigher than ground level to prevent entry of water and dirt, all as per IRC: 98-1997 and approved drawings complete as per specifications. Case-II: Double row for two utility services. | Rmt  | KSRRB M800-29.2 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 39       | KSRRB M 800-14.2. Reinforced cement concrete M-15 Grade kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc complete as per specifications. li) Ordinary kilometre stone (precast) including additional M-15 concrete pedestal of 0.2 mtr. height above G.L. MORTH Specification No. 804                                                                                                                                                                                                                                                                                                                                                                                                                                                               | No   | KSRRB M 800-14.2 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 40       | <b>LANDSCAPING WORKS</b><br>KSRRB M300-1. Spreading of sludge farm yard manure or/ and good earth in required thickness (cost of sludge, farm yard manure or/and good earth to be paid for separately) complete as per specifications. MORTH Specification No. 307                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Cum  | KSRRB M300-1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications     |
| 41       | KSRRB M300- 8.1. Planting and Maintaining of Flowering Plants and Shrubs A) Planting flowering plants and shrubs in central verge MORTH Specification No. 307                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Rmt  | KSRRB M300- 8.1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 42       | KSRRB M300- 8.2. Planting and Maintaining of Flowering Plants and Shrubs B) Maintenance of flowering plants and shrubs in central verge for one year.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Km   | KSRRB M300- 8.2 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                     | Unit | Reference Specifications                                                     |
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| 43       | KSRRB M300-9. Planting of trees by the road side (Avenue trees) in 0.60 m dia holes, 1 m deep dug in the ground, mixing the soil with decayed farm yard/sludge manure, planting the saplings, backfilling the trench, watering, fixing the tree guard and maintaining the plants for one year complete as per specifications. spacing - 20m c/c.                | No   | KSRRB M300-9 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 44       | KSRRB M300-7.1. Planting permanent hedges including digging of trenches, 60 cm wide and 45 cm deep, refilling the excavated earth mixed with farmyard manure, supplied at the rate of 4.65 cum per 100 metres and supplying and planting hedge plants at 30 cm apart complete as per specifications. A) Planting permanent hedges including digging of trenches | Rmt  | KSRRB M300-7.1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 45       | "KSRRB M300-7.2. Planting permanent hedges including digging of trenches, 60 cm wide and 45 cm deep, refilling the excavated earth mixed with farmyard manure, supplied at the rate of 4.65 cum per 100 metres and supplying and planting hedge plants at 30 cm apart complete as per specifications. B) Maintenance of hedge for one year                      | Rmt  | KSRRB M300-7.2 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 46       | KSRB 6-1.1 :Providing and constructing burnt brick masonry with approved quality of non-modular bricks of standard size of class designation 3.5 Newton per sqmm with mud mortar for basement and superstructure including cost of materials, labour charges, scaffolding, curing complete as per specifications. (Plantation box size: 6.5m x 2.4m)            | Cum  | KSRB 6-1.1                                                                   |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Unit | Reference Specifications                                                 |
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| 47       | <p>ELECTRICAL WORKS</p> <p>LED FLOOD LIGHTS (FOR HIGH MAST)</p> <p>'Fabrication Supplying erection testing &amp; Commissioning for 25 Mtr long Polygn high Mast with Single / multiple telescopic section having ( minimum overlap distance of 1.5 times of top section) thickness as per BSEN 10025 grade S 355 JO/ ASTM A572-50 steel sheet plate for shaft suitable to withstand a wind velocity of 47 m/sec as per IS 875 part 3 . Base plate as per IS 2062/ASTM A572-50. The mast shall be galvanized in singlehot dip as pe BSEZN ISO 1461/ ASTM A123 with an average 70 microns as per IS2629, and welded as per rBS 5135 Single L-Seam joint. The mast shall have 2 way head frame with die cast LM-6 Puleys, Stainless steel axle, Phosphorus Bronze bearing bush press-fitted with separated guides for 2 runs of 5mm dia stainless steel wire rope of AISI 304 grade 7/19 -core(Factor of Safety as per TR no.-7) 2.5 sqmm EPR insulated PCP sheathed trailing power cable housed inside the bottom shaft of mast with door having locking arrangement. The mast shall have power tool operating on 230/415 V. 50z, 1/3 phases reversible geared motor, The mast shall have latern of 2 segments, suitable dia with max load carring capacity as per IS 1239. The mast shall be erected on existing RCC footing. The mast shall be supplied with</p> | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications            |
| 48       | <p>KSRB 2-2.2 : Earthwork excavation for foundation of buildings, water supply, sanitary lines and electrical conduits either in pits or in trenches 1.5m and above in width, in hard soil not exceeding 1.5 m. in depth including dressing the bottom and sides of pits and trenches, stacking the excavated soil clear from edges of excavation with lead upto 50 m. after breaking of clods complete as per specifications. specification. No. KBS 2.1(b) / 2.3.5. (P.No. 5/I.No. 2.4 of CSR 2015-16)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Cum  | KSRB 2-2.2 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Unit | Reference Specifications                                                 |
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| 49       | KSRB 4.2.1 : Providing and laying in position reinforced cement concrete of Design mix M25 with OPC cement @ 340kgs, with 20mm and down size graded granite metal coarse aggregates @0.70 cum and fine aggregates @ 0.47cum, with super plasticisers @ 3 liters confirming to IS 9103-1999 reaffirmed-2008 at machine mixed, concrete laid in layers not exceeding 15 cms thick, vibrated for all works in foundation for footings, pedestals, retaining walls, return walls, walls (any thickness) including attached pilasters, column pillars, posts, struts, buttresses, bed blocks, anchor blocks & plinths etc., including cost of all materials, labour, HOM of machinery, curing, complete but excluding cost of reinforcement as per specifications. Specification No. KBS 4.1, 4.6 | Cum  | KSRB 4.2.1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 50       | KSRB 4-1.2 : Providing and laying in position plain cement concrete of mix 1:3:6 with OPC cement @ 220kgs, with 40mm and down size graded granite metal coarse aggregates @0.892cum and fine aggregates @ 0.465cum machine mixed, machine mixed, concrete laid in layers not exceeding 15 cms. thick, well compacted, in foundation including cost of all materials, labour, HOM of machinery, curing complete as per specifications. Specification No. KBS 4.1, 4.2. (P.No. 12/I.No. 4.2 of CSR 2015-16)                                                                                                                                                                                                                                                                                    | Cum  | KSRB 4-1.2 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 51       | KSRB 4-6.1 : Providing and removing centering, shuttering, strutting, propping etc., and removal of form work for foundations, footings, bases of columns for mass concrete including cost of all materials, labour complete as per specifications. Specification No. KBS 4.6.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Sqm  | KSRB 4-6.1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Unit | Reference Specifications                                      |
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| 52       | 'Supplying of LED Flood Lights of 150 W system power consumption pressure diecast aluminium housing with powder coating with IP 65 protection. 1, 200-275 V voltage with electronic Driver, PF>0.9 should meet ANSI 24 Vibration test, Compliance to UL/CE with Class I. System rating shall be 50 K hrs.@ Lumen maintenance of 701% system efficacy >80lm/w. Over load & Short circuit protection ensures reliable operation in spite of problem in output side. Compliance to IS 10322/IEC 60598, LM 79 & LM 80 Adherence with RoHS. UL approved MCPCB. Top access street light with single screw to ensure ease of maintenance at the sight site location with minimised minimal tools. LED lights fixture with .... W system power consumption . LED Efficiency>130lm/w at 1 W & Fixture Efficiency >80lm/w with Nominal CRI>75. Muninaire manufacture should have in-house facility accredited by NABL/CPRI & any Government certificate agency & Design & Development facility certified by ISO 9001:2008. Housing with supplier word mark /name shall be Engraved/Embossing on the die cast housing /Body Part. Warranty of 5 years against any manufacturing defect working under standard electrical conditions as mentioned above should be given by LED manufacturer. | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 53       | LIGHTING POLES - 10 Mtr - Octagonal Poles<br>Fabricating, supplying and erection of 10 mtrs long hot dip galvanised octagonal pole with BSEN 10025 grade S 355 JO steel plate for shaft, IS 2062 for base plate with door opening arrangements including suitable boards, bakelite sheet and MCBs as per IS specifications suitable to withstand a wind speed of 47 m/sec for 12 mtrs pole in single section and single joint welded as per IS 9595 / IS 10178 AWS having dimensions bottom 240mm dia, top 90mm with 3mm thick, suitable base plate and 4 nos. of .. long J bolt along with template and the pole shall be hot dip galvanised in single dipping with not less than 65micron as per ASTM-A123 and 153 etc. (excluding foundation) as per drawing appended.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 54       | SINGLE ARM SWORD TYPE BRACKET 1500 mm<br>'Supplying, and fixing of Hot dip Galvanized M.S.Bracket suitable for out door luminaries and mounted on Octagonal pole using necessary bolts, nuts etc., complete.<br>single arm bracket with 1500mm standard 40/50 MM dia                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Unit | Reference Specifications                                                     |
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| 55       | Double ARM SWORD TYPE BRACKET 2000 mm<br>'Supplying, and fixing of Hot dip Galvanized M.S.Bracket suitable for out door luminaries and mounted on Octagonal pole using necessary bolts, nuts etc., complete.<br>Double arm bracket with 2000mm standard 40/50 MM dia                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |
| 56       | Casting of M-25 cement concrete foundation, etc.complete.<br>KSRRB M300-1 1. Excavation for road way in all types of soil by mechanical means including cutting and pushing the earth to site of embankment including trimming bottom and side slopes in accordance with requirements of lines, grades and cross sections complete as per specifications. MORTH Specification No. 301<br>(disposal upto a lead of 500m as per note 4 page no 152)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Cum  | KSRRB M300-1 1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 57       | KSRRB M2900-1. Plain cement concrete M10 mix with crushed stone aggregate 40 mm nominal size mechanically mixed, placed in foundation and compacted by vibration specifications including curing for 14 days complete as per MORTH Specification No. 408                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Cum  | KSRRB M2900-1 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 58       | STREET LIGHT -180 W LED LAMP<br>'Supply of LED Streetlight with pressure die cast aluminium housing body with optimal heat sink for better thermal dissipation. Diffuser with Injection moulded & is made of polycarbonate material with high transmission index, delivering superior light output. Rated life Burning Hrs 50000 hr @ Lumen Maintenance of 70%. COT > 5500K; IP 66 optical and electrical compartment & impact resistance of complete luminaire > IK08. Power Factor >0.9 with mains Current should not be greater than 0.1A to 0.7A & Surge Protection- Min 4KV along with Over voltage/Overload, short circuit/ miswiring protection. Compatible for pole mounting with outer dia of 40mm to 50mm. Universal Voltage driver to operate wide voltage range from 100V to 270V 50/60Hz application. Over load & Short circuit protection ensures reliable operation in spite of problem in output side. Compliance to I.S 10322/IEC 60598, LM 79 & LM 80 Adherence with RoHS. UL approved MCPCB. Tap access street light with single screw to ensure ease of maintenance at the sight site location with minimized minimal tools. LED Light fixture with..150 W System Power consumption. LED Efficiency>130lm/w at 1W & Fixture Efficiency >80lm/w with nominal CRI> 75. Luminaire | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |



| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Unit | Reference Specifications                                      |
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| 59       | <b>FEEDER PILLERS</b><br>Supply and installation/ fixing/ provision of outdoor type thermoplastic moduler panel encloser with transparant polycarbonate lid shock proof IP65 (weather proof) rust proof dust proof water proof corrosion proof having internally emedded gasket on both lid and flap suitable to fix single phaswe /three phase energy meter in suitable base plate and having provision for fuse/MCB cutou with transparent hinged flap opening for operating MCB along with complete tamper proof SEALING facility | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 60       | <b>MCB</b><br>Supply and fixing Moulded Case Circuit Breakers (MCCB) Over existing wood/panel bourd using necessary screws bolts nuts wiring complete. Protection of overload amd schort circuit with thermal magnetic/ Microprocessor release and earth fault as per IS-13947                                                                                                                                                                                                                                                       | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 61       | <b>Astronomical timers</b><br>Supplying and fixiing microprocessor based Astronomical Timer Switch with necessary screws bolts nuts wiring complete                                                                                                                                                                                                                                                                                                                                                                                  | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 62       | <b>PIPE EARTHING</b><br>Earthing with GI Rod: Rod type of earthing using 40 mm dia 3 mtr long MS/GI as ground rod in earth pit of 300 mm width and 3300 mm depth as using 50x6 mm flat welded to ground rod as terminal & connected to equipment ground terminal using PVC Al wire as specified with 'Bentonite clay slurry for earthing in 50 kg bags (3 Nos Per Pit)                                                                                                                                                               | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 63       | <b>ENERGY METER</b><br>Suplying of Multi Functional Digital meter three line backlight LCD type for voltage current frequency. Power Power factor KVA KWH KVAR suitable for 3 Phase 4 wire LT network with IP54 degree of protection and completely wired as required with communication port and class 0.5s accuracy.                                                                                                                                                                                                               | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Unit | Reference Specifications                                                     |
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| 64       | <b>CABLES</b><br>Supplying of 1.1 KV LT UG cable having alluminium conductor PVC insulated extruded inner sheathed galvanized steel strip confirming to IS-3975:1990 ( No of strip indicated to GTP) and exstruded PVC outer sheathed armoured cable with specified IS-1554 Part 1-1988 and Confirming to GTP and group A<br>3.5 Core 35 Sqmm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |
| 65       | Labour Charges for 1.1 KV class UG cables<br>'25 sqmm to 75 sqmm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |
| 66       | <b>TRENCH</b><br>Diging of trench of 0.6 m deep x 0.5 m wide refilling the trench to the required ground level and consolidating etc. complete ( CC Cutting road Surface )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |
| 67       | Supply and installaing Multi strand Multi Core PVC insulated unarmoured copper cable of<br>'2.5 sqmm 3 core                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |
| 68       | <b>ROAD FURNITURE WORKS</b><br>KSRRB M800-2. Retro-Reflectorised Traffic Signs - Manufacturing, Supply and installation of retro-reflective Cautionary, Mandatory & Informatory signboards made out of cube corner micro prismatic grade sheeting confirming to Type XI Standards of IRC:67:2012 specification & fixed over 4mm thick Aluminium Composite Panel sheet having minimum 0.30mm thick Aluminum skin on both sides & fixed over a support frame of 25x25x3mm MS angle and mounted on 75mm dia OR 75x75x6mm Mild steel angle of Total height 2.70M with clear height of not less than 2.10 M from the ground level to the bottom of the sign board & 60cm below ground level. The sign post should be painted with one coat of red oxide paint and two coats of synthetic enamel paint of black and white colour with bands of 30 cm height alternatively firmly fixed to the ground by means of foundation with M20 grade cement concrete of 45cm x 45cm x 60cm including cost & conveyance of all materials, equipment, machinery & Labour with all leads and lifts, Loading charges necessary for satisfactory completion of the work as directed by engineer in-charge. 10 years warranty for Retro Reflective Sheeting from the original sheeting manufacturer as per clause 6.9 in IRC | No   | KSRRB M800-2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Unit | Reference Specifications                                                     |
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| 69       | KSRRB M800-2. Retro-Reflectorised Traffic Signs - Manufacturing, Supply and installation of retro-reflective Cautionary, Mandatory & Informatory signboards made out of cube corner micro prismatic grade sheeting confirming to Type XI Standards of IRC:67:2012 specification & fixed over 4mm thick Aluminium Composite Panel sheet having minimum 0.30mm thick Aluminum skin on both sides & fixed over a support frame of 25x25x3mm MS angle and mounted on 75mm dia OR 75x75x6mm Mild steel angle of Total height 2.70M with clear height of not less than 2.10 M from the ground level to the bottom of the sign board & 60cm below ground level. The sign post should be painted with one coat of red oxide paint and two coats of synthetic enamel paint of black and white colour with bands of 30 cm height alternatively firmly fixed to the ground by means of foundation with M20 grade cement concrete of 45cm x 45cm x 60cm including cost & conveyance of all materials, equipment, machinery & Labour with all leads and lifts, Loading charges necessary for satisfactory completion of the work as directed by engineer in-charge. 10 years warranty for Retro Reflective Sheeting from the original sheeting manufacturer as per clause 6.9 in IRC 2012 & a certified copy of three years outdoor exposure report from an independent test lab | No   | KSRRB M800-2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 70       | KSRRB M800-2. Retro-Reflectorised Traffic Signs - Manufacturing, Supply and installation of retro-reflective Cautionary, Mandatory & Informatory signboards made out of cube corner micro prismatic grade sheeting confirming to Type XI Standards of IRC:67:2012 specification & fixed over 4mm thick Aluminium Composite Panel sheet having minimum 0.30mm thick Aluminum skin on both sides & fixed over a support frame of 25x25x3mm MS angle and mounted on 75mm dia OR 75x75x6mm Mild steel angle of Total height 2.70M with clear height of not less than 2.10 M from the ground level to the bottom of the sign board & 60cm below ground level. The sign post should be painted with one coat of red oxide paint and two coats of synthetic enamel paint of black and white colour with bands of 30 cm height alternatively firmly fixed to the ground by means of foundation with M20 grade cement concrete of 45cm x 45cm x 60cm including cost & conveyance of all materials, equipment, machinery & Labour with all leads and lifts, Loading charges necessary for satisfactory completion of the work as directed by engineer in-charge. 10 years warranty for Retro Reflective Sheeting from the original sheeting manufacturer as per clause 6.9 in IRC 2012 & a certified copy of three years outdoor exposure report from an independent test lab | No   | KSRRB M800-2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Unit | Reference Specifications                                                        |
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| 71       | KSRRB M800-2. Retro-Reflectorised Traffic Signs - Manufacturing, Supply and installation of retro-reflective Cautionary, Mandatory & Informatory signboards made out of cube corner micro prismatic grade sheeting confirming to Type XI Standards of IRC:67:2012 specification & fixed over 4mm thick Aluminium Composite Panel sheet having minimum 0.30mm thick Aluminum skin on both sides & fixed over a support frame of 25x25x3mm MS angle and mounted on 75mm dia OR 75x75x6mm Mild steel angle of Total height 2.70M with clear height of not less than 2.10 M from the ground level to the bottom of the sign board & 60cm below ground level. The sign post should be painted with one coat of red oxide paint and two coats of synthetic enamel paint of black and white colour with bands of 30 cm height alternatively firmly fixed to the ground by means of foundation with M20 grade cement concrete of 45cm x 45cm x 60cm including cost & conveyance of all materials, equipment, machinery & Labour with all leads and lifts, Loading charges necessary for satisfactory completion of the work as directed by engineer in-charge. 10 years warranty for Retro Reflective Sheeting from the original sheeting manufacturer as per clause 6.9 in IRC 2012 & a certified copy of three years outdoor exposure report from an independent test lab | No   | KSRRB M800-2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |
| 72       | KSRRB M 800-5.1 Over head Signs (Truss and Vertical Support): Manufacturing, Suppl and installation of retro- reflective Over Head Gantry signboards made out of cube corner micro prismatic grade sheeting confirming to type XI standards of irc:67:2012 fixed over 4mm thick Aluminium Composite Panel sheet, excluding the cost of type XI retro reflective sheeting and 4mm Thick ACP sheet with suitable back support frame over a designed support frame over a designed support system of aluminium alloy or galvanised steel trestles and trusses of section type as per structural design requirements and approved plans complete as per specifications. Vertical and Lateral clearance of the Gantry shall be as per IRC 67 2012 and as per clause 800.2.2 and 800.2.3 and installed as per clause 800.2.7. 10 years warranty for Retro effective sheeting from the original sheeting supplier as per clause 6.9 in IRC 2012 & a certified copy of three years outdoor exposure report from an independent test lab for the product offered shall be obtained from the supplier.                                                                                                                                                                                                                                                                        | MT   | KSRRB M 800-5.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Unit | Reference Specifications                                                      |
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| 73       | KSRRB M800-13.Road Marking with Hot Applied Thermoplastic Compound with Reflectrising Glass Beads on Bituminous Surface:- Providing and laying of hot applied thermoplastic compound 2.5 mm thick including reflectorising glass beads at 250 gms per sqm area, thickness of 2.5 mm is exclusive of surface applied glass beads as per IRC:35. The finished surface to be level, uniform and free from streaks and holes complete as per specifications. MORTH Specification No. 803                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Sqm  | KSRRB M800-13 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 74       | Direction and place Identification Signs with size more than 0.9 sqm size Board: Manufacturing, Supply and installation of retro reflective Cautionary, mandatory, Informatory signboards made out of cube corner micro prismatic grade sheeting confirming of Type XI standards of IRC:67:2012 specification & fixed over 4mm thick Aluminium composite panel sheet having minimum 0.30 mm thick aluminium skin on both sides & fixed over a support frame of 25 x 25 x3 mm MS angle and mounted on 75mm dia OR 75 x 75 x6 MM mild steel angle of total height 2.70 M with clear height of not less than 2.10 M from the ground level to the bottom of the sign board & 60 cm below ground level. The sign post should be painted with one coat of red oxide paint and two coats of synthetic enamel paint of black and white colour with bands of 30cm height alternatively firmly fixed to the ground by means of foundation with M20 grade cement concrete of 45 cm x 45 cm x 60 cm including cost & conveyance of all materials , equipments, machinery & labour with all leads and lifts, loading charges necessary for satisfactory completion of the work as directed by engineer in-charge. 10 years warranty for retro reflective sheeting from the original sheeting | Sqm  | KSRRB M800-3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 75       | Road Humps / Speed breakers for control of vehicular speeds on roads Providing road humps for the entire formation width, using bituminous premix materials and heavy duty cobble stones 60 mm thick, having road hump dimension of 1.00 mtr. (width) X 0.15 mtr (height) rectangular sections and ramp on either side of road hump of 0.85 mtr (wide), including providing WBM (2 layers) for shoulder portion 1.7mts in length on either side, completing with road marking paint with applied thermoplastic compound with reflecting glass beads on bituminous surface and providing 2 Nos.. retro reflective traffic signs as per IRC SP67 2010 (for details refer IRC 99-1988) - lane for formation width of 12 mtrs. using SDBC mix material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Unit | KSRRB 38.39 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Unit | Reference Specifications                                                        |
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| 76       | Supply & INSTALLATION OF Solar Raised Pavement Makers made of polycarbonate molded body with circular shape, solar powered, LED self illumination in active mode, 360 degree illumination and reflective panels with micro prismatic lens in passive mode. The marker shall support a load of 20000 kg tested in accordance to IRC 37 and shall be resistant to dust and water ingress according to IP 65 (Ingress Protection 65 is a test which is conducted to check if solar road stud is protected from total dust and Ingress and low pressure water jets from any direction) standards and should withstand temperatures in the range of 0 C to 70 C. Colour of lighting could be provided in red or yellow (amber) as per requirement and typical frequency of blinking is 1 Hz. There should be current losses of less than 20 micro-ampress at V in sleep-charging mode to enhance the life of the maker and a full charge should provide for minimum autonomy of hours. The height, width and length of the marker shall not be less than mm x mm x mm. Also the surface diameter of the maker shall not be less than mm respectively. the weight of the marker shall not exceed kilograms. Fixing will be by drilling holes on the road for the shanks to go inside, without | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                   |
| 77       | CULVERTS<br>"KSRRB M2100-2.1. Earth work in excavation for foundation of structures as per drawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. B. Mechanical Means (i) Depth upto 3 m" MORTH Specification No. 304                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Cum  | KSRRB M2100-2.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 78       | "KSRRB M2100-3.2. Excavation in Ordinary Rock with blasting KSRRB M2100-3.1. Earth work in excavation for foundation of structures as per drawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. (ii) Ordinary rock (not requiring blasting) " B. Mechanical Means Depth upto 3m MORTH Specification No. 304                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Cum  | KSRRB M2100-3.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Unit    | Reference Specifications                                                          |
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| 79       | KSRRB M2100 Excavation in Hard Rock without Blasting KSRRB M2100-4.2. Earth work in excavation for foundation of structures as per drawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. "III. Hard rock - (blasting prohibited ) A. Mechanical Means MORTH Specification No. 304 | Cum     | KSRRB M2100 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications         |
| 80       | KSRB 2.3 : Filling available excavated earth (excluding rock) in sides of foundations upto plinth in layers not exceeding 20 cms. in depth, compacting each deposited layer by ramming after watering with lead upto 50 m. and lift upto 1.5 m. including cost of all labour complete as per specifications. specification. No. KBS 2.9                                                                                                                                           | Cum     | KSRB 2.9 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications          |
| 81       | Providing and laying Plain Cement Concrete in sub-structure M15 with OPC cement @ 240kgs, with 40mm and down size graded granite metal coarse aggregates @0.63cum and fine aggregates @ 0.42cum<br>a) upto 5mtr height                                                                                                                                                                                                                                                            | Cum     | MORT&H Specification No. 1500, 1700 & 2200                                        |
| 82       | Plain reinforced cement concrete in open foundation with OPC cement design mix M30 @360kgs, with 20mm and down size graded granite metal coarse aggregates @ 0.69cum and fine aggregates @ 0.46cum, with superplastisiser @3lts confirming to IS9103-1999 Reaffirmed -2008 complete as per drawing and Technical Specifications. Substructure (Design Mix) - upto 5m                                                                                                              | Cum     | KRBS Section 1700 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 83       | Providing weep holes in Brick masnory / Plain / Reinforced concrete abutment, wing wall / return wall with 100mm dia AC pipe, extending through the full width of the structure with slope of 1V:20H towards drawing face. Complete as per drawing and Technical Specifications complete as per Specifications MORTH Specification No. 2706 & 2200                                                                                                                                | No./Mtr | MORT&H Specification No. 2706 & 2200                                              |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Unit | Reference Specifications |
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| 84       | KSRRB M2700- Painting on Concrete Surface<br>KSRRB M2700-12. Providing and applying 2 coats of water based cement paint to unplastered concrete surface after cleaning the surface of dirt, dust, oil, grease, efflorescence and applying paint at of 1 litre for 2 sqm complete as per specifications MORTH Specification No. 800                                                                                                                                                                                                                                                                                                                                           | Sqm  | MORT&H 800               |
| 85       | Provision of an Reinforced cement concrete crash barrier Barrier at the edges of the road approaches to bridge structures and medium constructed with M20 grade concrete with HYSD reinforcement confirming to IRC 21 and dowel bars 25mm dia,450mm long at expansion joints filled with pre moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the engineer all as specified complete as per specifications> MORTH specification No. 809                   | Rmt  | MORT&H 809               |
| 86       | KSRRB M800-11.2.Painting lines, dashes, arrows etc.,on Roads in two coats on New Work:- Painting lines, dashes, arrows etc on roads in two coats on new work with ready mixed road marking paint conforming to IS:164 on bituminous surface, including cleaning the surface of all dirt, dust and other foreign matter, demarcation at site and traffic control complete as per specifications, i) Upto 10 cm in width. MORTH Specification No. 803                                                                                                                                                                                                                          | Sqm  | MORT&H 803               |
| 87       | KSRRB M500-41. Providing and laying 25 mm thick mastic asphalt wearing course with paving grade bitumen meeting the requirements given in table 500-29, prepared by using mastic cooker and laid to required level and slope after cleaning the surface, including providing antiskid surface with bitumen precoated fine grained hard stone chipping of 13.2 mm nominal size at the rate of 0.005cum per 10 sqm and at an approximate spacing of 10 cm center to center in both directions, pressed into surface when the temperature of surfaces is not less than 100°C, protruding 1 mm to 4 mm over mastic surface, complete as per clause 500.15 as per specifications. | Sqm  | MORT&H 515               |



| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Unit | Reference Specifications                                                        |
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| 88       | KSRRB M2200-9. Providing and laying of Filter media with granular materials /stone crushed aggregates satisfying the requirements laid down in clause 2500.4.2.2. of MORTH specifications to a thickness of not less than 600 mm with smaller size towards the soil and bigger size towards the wall and provided over the entire surface behind abutment, wing wall and return wall to the full height compacted to a firm condition complete as per drawing and Technical Specification complete as per specifications<br>MORTH Specification No. 710.1.4 of IRC:78 & 2200 | Cum  | MORT&H 710.1.4 of IRC:78 & 2200                                                 |
| 89       | KSRRB M2500-1.1. Providing and laying boulders apron on river bed for protection against scour with stone boulders weighing not less than 40 kg each complete as per drawing and Technical specification complete as per specifications. A. Boulder Laid Dry Without Wire Crates MORTH Specification No. 2503                                                                                                                                                                                                                                                                | Cum  | MORT&H 2503                                                                     |
| 90       | KSRRB M2500-4.1. Providing and laying Pitching on slopes laid over prepared filter media including boulder apron laid dry in front of toe of embankment complete as per drawing and technical specifications                                                                                                                                                                                                                                                                                                                                                                 | Cum  | KSRRB M2500-4.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 91       | KSRRB M300-31. Turfing with Sods-Furnishing and laying of the live sods of perennial turf forming grass on embankment slope, verges or other locations shown on the drawing or as directed by the Engineer including preparation of ground, fetching of sods and watering. complete as per specifications. MORTH Specification No. 307                                                                                                                                                                                                                                       | Sqm  | MORT&H 307                                                                      |
| 92       | KSRRB M300-32. Preparation of seed bed on previously laid top soil, furnishing and placing of seeds, fertilizer, mulching material, applying bituminous emulsion at the rate of 0.23 litres per sqm and laying and fixing jute netting, including watering for .3 months all as per Clause 308 complete as per specifications. MORTH Specification No. 308                                                                                                                                                                                                                   | Sqm  | MORT&H 308                                                                      |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Unit | Reference Specifications                                                        |
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| 93       | Supplying and fixing in position new guard stones of granite/trap/sand stone/shahabad roughly dressed, of size 700mm x 200mm x 200mm including excavation, painting with white and black paint 15cm wide strip alternatively etc., complete.                                                                                                                                                                                                                                                                                                     | Each | KSRB 24.50 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications      |
| 94       | KSRRB M2200-8.1. Back filling behind abutment, wing wall and return wall complete as per drawing and Technical Specification complete as per specifications. A. Granular material MORTH Specification No. 710.1.4 of IRC.78 & 2200                                                                                                                                                                                                                                                                                                               | Cum  | MORT&H 710.1.4 of IRC:78 & 2200                                                 |
| 95       | KSRRB M2500-2. Providing and laying of apron with cement concrete blocks of size 0.5x0.5x0.5 m cast in-situ and made with nominal mix of M-15 grade cement concrete with a minimum cement content of 240 kg / cum as per IRC: 21-2000 complete as per specificationsMORTH Specification No. 2503                                                                                                                                                                                                                                                 | Cum  | MORT&H 2503                                                                     |
| 96       | MINOR BRIDGES<br>KSRRB M200-12.1. Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of masonry, cement concrete, wood work, steel work, including T&P and scaffolding wherever necessary, sorting the dismantled material, disposal of unserviceable material and stacking the serviceable material with all lifts complete as per specification<br>i) Lime /Cement Concrete. I. By Manual Means :A. Lime Concrete, cement concrete grade M-10 and below.<br>MORTH Specification No. 202 | Cum  | KSRRB M200-12.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 97       | KSRRB M200-12.3. Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of masonry, cement concrete, wood work, steel work, including T&P and scaffolding wherever necessary, sorting the dismantled material, disposal of unserviceable material and stacking the serviceable material with all lifts complete as per specification . Prestressed / Reinforced cement concrete grade M-20 & above.                                                                                           | Cum  | KSRRB M200-12.3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                | Unit | Reference Specifications                                                        |
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| 98       | KSRRB M200-14.2. Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of masonry, cement concrete, wood work, steel work, including T&P and scaffolding wherever necessary, sorting the dismantled material, disposal of unserviceable material and stacking the serviceable material with all lifts complete as per specifications. Dismantling brick/Tile work B. In cement mortar. | Cum  | KSRRB M200-14.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 99       | KSRRB M200-15.2. Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of masonry, cement concrete, wood work, steel work, including T&P and scaffolding wherever necessary, sorting the dismantled material, disposal of unserviceable material and stacking the serviceable material with all lifts complete as per specification Rubble stone masonry in cement mortar              | Cum  | KSRRB M200-15.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 100      | KSRRB M800-35. Providing and fixing of road stud 100x 100 mm, die-cast in aluminium, resistant to corrosive effect of salt and grit, fitted with lense reflectors, installed in concrete or asphaltic surface by drilling hole 30 mm upto a depth of 60 mm and bedded in a suitable bituminous grout or epoxy mortar, all as per BS: 873 part 4:1973 complete as per specifications                                                        | Each | KSRRB M800-35 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 101      | KSRRB 1100-1. Bored / Cast-in-situ R.C.C. 1000mm dia. piles with OPC cement design mix M35 @ 390kgs, with 20mm and down size graded granite metal coarse aggregates @0.69cum and fine aggregates @ 0.45cum, with superplasticiser @31ts confirming to IS9103-1999 Reaffirmed-2008 excluding reinforcement as per drawings including cost of all materials, labour, HOM of machineries complete as per specifications. MORTH /Chapter 12    | Rm   | KSRRB 1100-1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Unit | Reference Specifications                                                         |
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| 102      | KSRRB M1100-11.2. Cement Concrete for Reinforced Concrete in Pile Cap complete as per Drawing and Technical Specification complete as per specifications. D. RCC with OPC cement design mix M35 @ 390kgs, with 20mm and down size graded granite metal coarse aggregates @0.68cum and fine aggregates @ 0.45cum, with superplasticiser @31ts confirming to IS9103-1999 Reaffirmed-2008. Case-II: Using Batching Plant, Transit Mixer and Concrete Pump<br>MORTH Specification No.1100, 1500 & 1700                                                                                                                                                                                          | Cum  | KSRRB M1100-11.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 103      | "KSRRB M2100-1.1. Earth work in excavation for foundation of structures such as culverts, bridges etc., as per drawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. I Ordinary soil A. Manual Means (i) Depth upto 3 m"<br>MORTH Specification No. 304                                                                                                                                                                                                                                     | Cum  | KSRRB M2100-1.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 104      | KSRRB M2200-15. Supplying, fitting and fixing in position true to line and level POT-PTFE bearing consisting of a metal piston supported by a disc or unreinforced elastomer confined within a metal cylinder, sealing rings, dust seals, PTFE surface sliding against stainless steel mating surface, complete assembly to be of cast steel/fabricated structural steel, metal and elastomer elements to be as per IRC: 83 part-I & II respectively and other parts conforming to BS: 5400, section 9.1 & 9.2 and clause 2000.6 of MORTH Specifications complete as per drawing and approved Technical Specifications complete as per specifications<br>MORTH Specification No.2000 & 2200 | MT   | KSRRB M2200-15 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Unit | Reference Specifications                                                         |
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| 105      | KSRRB M2300-10.3. Furnishing and Placing Reinforced / Prestressed cement concrete in super-structure as per drawing and Technical Specification complete as per specifications. RCC with OPC cement design mix M40 @ 420kgs, with 20mm and down size graded granite metal coarse aggregates @0.67cum and fine aggregates @ 0.44cum, with superplastisiser @3lts confirming to IS9103-1999 Reaffirmed-2008 Case - II: Using Batching Plant, Transit Mixer & Concrete Pump MORTH Specification No. 1500,1600 & 1700<br>Height upto 5 m    | Cum  | KSRRB M2300-10.3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 106      | KSRRB M2300-10.3. Furnishing and Placing Reinforced / Prestressed cement concrete in super-structure as per drawing and Technical Specification complete as per specifications. RCC with OPC cement design mix M40 @ 420kgs, with 20mm and down size graded granite metal coarse aggregates @0.67cum and fine aggregates @ 0.44cum, with superplastisiser @3lts confirming to IS9103-1999 Reaffirmed-2008 Case - II: Using Batching Plant, Transit Mixer & Concrete Pump MORTH Specification No. 1500,1600 & 1700<br>Height 5 m to 10 m | Cum  | KSRRB M2300-10.3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 107      | KSRRB M2200-6. Supplying, fitting and placing TMT bars Fe 500 reinforcement in super-structure complete as per drawing and Technical Specifications complete as per specificationsMORTH Specification No.1600                                                                                                                                                                                                                                                                                                                           | MT   | KSRRB M2200-6 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |
| 108      | KSRRB M2300 - High tensile wires KSRRB M2300-15. High tensile steel wires / strands including all accessories for stressing, stressing operations and grouting complete as per drawing and Technical Specifications complete as per specifications MORTH Specification No. 1800 SOLID SLAB                                                                                                                                                                                                                                              | Ton  | KSRRB M2300 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications      |
| 109      | KSRRB M2600-9. Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/ supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation complete as per specifications MORTH Specification No. 2607                                                                                                                              | Rm   | KSRRB M2600-9 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Unit | Reference Specifications                                                        |
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| 110      | KSRRB M2700-1. Providing and laying 12 mm thick mastic asphalt wearing course on top of deck slab excluding prime coat with paving grade bitumen meeting the requirements given in table 500-29, prepared by using mastic cooker and laid to required level and slope after cleaning the surface, including providing antiskid surface with bitumen precoated fine grained hard stone chipping of 9.5 mm nominal size at the rate of 0.005cum per 10 sqm and at an approximate spacing of 10 cm center to center in both directions, pressed into surface when the temperature. of surfaces not less than 100 deg. C, protruding 1 mm to 4 mm over mastic surface, all complete as per clause 5100.5 complete as per specifications. MORTH Specification No. 515 & 2702 | Sqm  | KSRRB M2700-1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 111      | Solid slab super structure KSRRB M2300-9.1. Furnishing and Placing Reinforced / Prestressed cement concrete in super-structure as per drawing and Technical Specification complete as per specifications. E. PSC with OPC cement design mix M40 @ 420kgs, with 20mm and down size graded granite metal coarse aggregates @0.67cum and fine aggregates @ 0.44cum, with superplasticiser @3lts confirming to IS9103-1999 Reaffirmed-2008, Case - I : Using Concrete Mixer MORTH Specification No. 1500,1600 & 1700 - Height 5 m to 10 m                                                                                                                                                                                                                                   | Cum  | KSRRB M2300-9.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 112      | KSRRB M2300-16. Providing and laying Cement concrete wearing coat with OPC cement design mix M30 @ 360kgs, with 20mm and down size graded granite metal coarse aggregates @0.69cum and fine aggregates @ 0.46cum, and reinforcement at 75 kg/cum with superplasticiser @3lts confirming to IS9103-1999 Reaffirmed-2008 including cost of reinforcement complete as per drawing and Technical Specifications complete as per specifications MORTH Specification No. 2702                                                                                                                                                                                                                                                                                                 | Cum  | KSRRB M2300-16 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 113      | KSRRB M2700-9. Providing, precasting, transportation and placing in position precast pretensioned concrete girders as per drawing and technical specifications including the cost high tensiled strands complete as per specifications MORTH Specification No.1800 & 2300                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Cum  | KSRRB M2700-9 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                         | Unit | Reference Specifications                                                              |
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| 114      | KSRRB M2700-5. Drainage Spouts complete as per drawing and Technical specification complete as per specifications MORTH Specification No. 2705.                                                                                                                                                                                                                                                                                     | No   | KSRRB M2700-5 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications         |
| 115      | Providing, fabricating and fixing GI Gratings using Structural Steel over the Cutouts /spouts including fabrication, finishing the joints smooth, all labours, hire charges of machinery such as welding machine, gas cutter, materials, with all leads and lifts, loading and unloading, stacking, hire charges of machinery complete as per Drawing and MORT&H technical specification and as directed by the Engineer in Charge. | MT   | KSRRB SECTION 1900 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |
| 116      | Providing steel liner 10 mm thick for curbs and 6 mm thick for seining of wells including fabricating and setting out as per detailed drawing complete as per specifications<br>6 mm thk plate for piles                                                                                                                                                                                                                            | Tone | KSRRB M1200-47 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications        |
| 117      | Painting with black anti-corrosive bitumastic paint of approved brand and manufacture to give an even shade. Two or more coats on new work for Piling Work.                                                                                                                                                                                                                                                                         | Sqm  | KSRRB SECTION 1100.8 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 118      | Pile load test on single vertical pile in accordance with IS:2911(Part IV)<br>a) Initial and routine load test                                                                                                                                                                                                                                                                                                                      | MT   | KSRRB SECTION 1100.17 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 119      | Pile load test on single vertical pile in accordance with IS:2911(Part IV)<br>b) Lateral load test                                                                                                                                                                                                                                                                                                                                  | MT   | CPWD SECTION 20.5.5 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 120      | KSRRB M2800-3. Guniting concrete surface with cement mortar applied with compressor after cleaning surface and spraying with epoxy complete as per Technical Specification. MORTH Specification No.2807                                                                                                                                                                                                                             | sqm  | CPWD SECTION 13.22 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Unit | Reference Specifications                                                        |
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| 121      | <p>TUNNEL WORKS Providing temporary barricade of 2m height of plain MS sheet 16 Gauge fixed with steel frame as per drawing, Painting (including primer of approved quality) with synthetic enamel paint of approved colour, quality and brand , writing lettering and logo of metro including maintenance of the same duly cleaningthe same on fortnightly basis and painting it required, arrangement for blinker lights on barricades during night as per requirement and as per the instruction of the engineer. Barricading should be rugged. During the Construction, barricading has to be kept continuously. Nothing extra will be paid for dismantling and re-erecting the barricades at the same place. There should not be any opening at the end of barricade except at locations approved by Engineer.</p> <p>Note:</p> <p>i) Barricades on either side shall be measured induvidually.</p> <p>ii) Once barricade has been provided and work started, removal of barricade is not permitted till completion of pile, pile cap, pier and pier cap, portal beams, segment erection, I girder erection, till completion of entire superstructure.</p> <p>iii) While erecting barricade, the bottom gap between barricade and road should be plugged with cement concrete from inside.</p> <p>iv) There should be minimum openings at the end of barricade to allow access of trucks / lorries and machines to sitework area. Even these spacing should have proper opening &amp; closing arrangements.</p> <p>v) Adequate blinking lights on barricade during night time must be ensured. The cost of item should include provision for power pack / Genset etc. So as to ensure the blinking of lights</p> | Rmt  | As per BMRCL Spec's                                                             |
| 122      | <p>"KSRRB M2100-2.3.Earth work in excavation for foundation of structures as perdrawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. B. Mechanical Means (i ) Depth upto 3 m" MORTH Specification No. 304 B.Mechanical Means (iii ) Depth above 6 m MORTH Specification No. 304</p> <p>Note: Including Dewatering Charges</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Cum  | KSRRB M2100-2.3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |



| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Unit | Reference Specifications                                                        |
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| 123      | “KSRRB M2100-3.2. Excavation in Ordinary Rock with blasting KSRRB M2100-3.1. Earth work in excavation for foundation of structures as per drawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. (ii) Ordinary rock (not requiring blasting) “ B. Mechanical Means Depth upto 3m MORTH Specification No. 304<br>Note: Including Dewatering Charges | Cum  | KSRRB M2100-3.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 124      | KSRRB M2100 Excavation in Hard Rock without Blasting KSRRB M2100-4.2. Earth work in excavation for foundation of structures as per drawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. “III. Hard rock - (blasting prohibited ) A. Mechanical Means MORTH Specification No. 304<br>Note: Including Dewatering Charges                           | Cum  | KSRRB M2100 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications     |
| 125      | “KSRRB M2100-5.2. Earth work in excavation for foundation of structures as per drawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. “V. Marshy soil - B. Mechanical Means MORTH Specification No. 304<br>Note: Including Dewatering Charges                                                                                                      | Cum  | KSRRB M2100-5.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 126      | KSRRB M2100 Back Filling of abutments using wing wall & Returns<br>KSRRB M2100-7. Earth work in excavation for foundation of structures as per drawing and technical specifications, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material complete as per specifications. VI. Backfilling in Marshy Foundation Pits.” MORTH Specification No. 304                                                                      | Cum  | KSRRB M2100-7 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Unit | Reference Specifications                                                                                                   |
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| 127      | <p>WATER PROOFING TO CONCRETE SURFACES Using Membrane Technology For raft &amp; retaining wall Providing &amp; applying water proofing to concrete surfaces using high quality polymer-modified bituminous compounds (confirming to ASTM D 5147) reinforced with non woven polyester fabric, weighing 180gm/sqm granular finish 4mm thick by torch on application method confirming to the properties indicated below. It shall be provided after priming the surface using bitumen primer at 0.2 ltr /sqm.</p> <p>Detailed specification &amp; Methodology</p> <ol style="list-style-type: none"> <li>1. Membrane thickness 4mm (+ or – 5%)</li> <li>2. Tensile strength – Longitudinal 790 N/5cm Transverse 730 N/5cm</li> <li>3. Elongation of Membrane - Longitudinal 65% Transverse 69%</li> <li>4. Tear Resistance - Longitudinal 180 N Transverse 190 N</li> <li>5. Lap joint strength - Longitudinal 750 N/5cm Transverse 550 N/5cm</li> <li>6. Puncture Resistance – Static 1.4 Dynamic 1.3</li> <li>7. Water absorption - &lt; 0.15%</li> <li>8. Water permeability - Nil</li> <li>9. Chemical resistance – Chloride, sulphate and Nitrate</li> </ol> <p>The area to be water proofed shall be free from loose aggregate, dust free and in dry condition. Primer must be applied to the surface and allowed to dry prior to application of membrane. The membrane shall be applied within 6 hours after application of primer. The membrane comes in a roll form shall be unrolled and placed in the correct position where it</p> | Sqm  | Sr. No. 38.1, SOR 2016-17 PW & P&IWTD South Zone Bangalore / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 128      | <p>For roof slab &amp; terraces Providing &amp; applying water proofing to roof slab, terraces, landscape area, podium etc., using modified polyurethane cures (conforming to ASTM C836-84) to give a tough elastomeric waterproof membrane on the surface. The surface shall be cleaned free from dust and other particle before usage. standards &amp; methodology :</p> <p>This compound has a medium viscosity grade with 620% of elongation and shall be done either by roller application/brush application/ spray. This will be applied for a thickness of 1.3mm first layer 0.5mm &amp; 2nd layer 0.8mm. After applying the 2nd layer sand sprinkle shall be done to provide mechanical key.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Sqm  | Sr. No. 38.2, SOR 2016-17 PW & P&IWTD South Zone Bangalore / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Unit | Reference Specifications                                                         |
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| 129      | KSRRB M2200-5.19. Design mix M35 with OPC cement @ 390kgs, with 20mm and down size graded granite metal coarse aggregates @0.68cum and fine aggregates @ 0.45cum, with superplastisiser @31ts confirming to IS9103-1999 Reaffirmed-2008 - ii) For height, upto 10m,cement @ 390kgs,                                                                                                                                                                                                                                                       | Cum  | KSRRB M2200-5.19 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 130      | KSRRB M2300-11.1. Furnishing and Placing Reinforced / Prestressed cement concrete in super-structure as per drawing and technical specification complete as per specifications. F. PSC with OPC cement design mix M40 @ 420 Kgs, with 20mm and down size graded granite metal coarse aggregates @ 0.67 cum and fine aggregates @ 0.44 cum, with superplastisiser @ 3 lts confirming to IS 9103-1999 Reaffirmed -2008 MORTH specification NO. 1500, 1600 & 1700. ii) For height from 5m to 10m.                                            | Cum  | KSRRB M2300-11.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 131      | KSRB 4-1.4 : Providing and laying in position plain cement concrete of mix 1:5:10 with OPC cement @ 160kgs, with 40mm and down size graded granite metal coarse aggregates @0.86cum and fine aggregates @ 0.58cum machine mixed, machine mixed, concrete laid in layers not exceeding 15 cms. thick, well compacted, in foundation, including cost of all materials, labour, HOM of machinery, curing complete as per specifications. Specification No. KBS 4.1, 4.2. (P.No.12, I.No. 4.4 of PWD SR 2015-16) - Plum Concrete below Tunnel | Cum  | KSRB 4-1.4 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications       |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Unit | Reference Specifications |
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| 132      | Providing and installing cast -in-situ vertical bored piles of depth as per drawing with M35/20 grade of reinforced cement concrete using portland siag cement ,including all operations such as mobilisation,installation and shifting of piling rig etc, in all soil strata,road,footpath including boulders and kankar and soft rock/weathered rock,empty boring required.The cost shall also include built up of piles up to the required level. Pile measurement shall be from cut-off level to founding level.The item includes disposal of earth,muck,slush released from piles,at contractor's dumping ground with all leads and lifts as per approved methods&specifications. The cost shall also include the cost of empty boring whatever required.Reinforcement shall be paid seperately under relevant item. Rate shall be include the cost of required dosage of admixture in concrete for obtaining required workability as per approval of Engineer.Drilling shall be done by use of hydraulic rig using temporary casing required depth (min of 4.5m), Using polymer slurry and as directed by the Engineer.(Use of bentonite slurry is not permitted). Socketing shall be as per specification and the decision of Engineer shall be final. Payment foe socketing shall be made as shown in drawing of actual , whichever is lesser. | Rmt  | As per BMRCL Spec's      |
| 133      | Carrying out initial vertical load tests on piles as per relevant IS Codes including all arrangements for measuring settlement/ defelections and submitting reports. This includes,cost of all the piles (including test pile,and reaction piles, If required). reinforcement , making of pile head ready for testing at the desired level, supporting /reaction arrangement (including reaction piles/solid/rod anchors, if any) for the kentledge load 2.5 times the theoretical design vertical load capacity.The test arrangements designed shall cater for additional 2.5% above test load.<br>For 600 mm dia Pile , having pile capacity of 120 MT to 200 MT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | No   | As per BMRCL Spec's      |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Unit | Reference Specifications                                                   |
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| 134      | Providing and fixing M.S. Hand railing for Balcony with 50mm dia. M.S. hollow pipe of 14 gauge, welded to 20mmx20mm M.S. square rod placed vertically, spaced at 100mm at regular intervals of 600mm. These vertical rods laterally tied to 3 horizontal rods spaced at equal interval. These assembly is fixed to concrete by using expansion bolts and welding the same to reinforcement bars and making good the surface. All the joints and sections should be cut to length, welded and grinded wherever necessary etc., complete. The work includes cost of all materials, labour charges for all items of work, hire charges for welding, cutting and grinding equipment, and electricity charges, etc., complete as per specification and drawing. | Rmt  | Sr. No. 7.35, SOR 2016-17 PW, P&IWTD South Zone Bangalore                  |
| 135      | Providing and fixing polycarbonate sheet manufactured out of 2mm thick (lexan) from GE plastics material or equivalent of same profile of galvalume sheeting fixed including steel superstructure with self drilling fasteners.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Sqm  | As per BMRCL Spec's                                                        |
| 136      | <b>Control Room</b><br>KSRB 2-1.1 : Earthwork in surface excavation in ordinary soil for leveling and lowering the ground manually (other than foundation of buildings, culverts, road drains and trenches of pipe lines and cables) and removing the excavated stuff to a distance not exceeding 50m and lift up to 1.5m, excavated surface levelled and neatly dressed as per specification No. KBS 2.1(a)/2.3.1                                                                                                                                                                                                                                                                                                                                         | Cum  | KSRB 2-1.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 137      | KSRB 2-2.3 : Excavation in soft rock without blasting by manual means foundation of buildings, water supply and sanitary lines and electrical conduits etc., either in pits or in trenches 1.50m and above in width, in soft rock not exceeding 1.50m in depth including stacking the excavated stuff clear from edges of excavation with lead upto 50m including cost of explosives, labour, HOM of equipment complete as per specifications. specification. No.KBS 2.1C/2.9.4/2.18/2.18                                                                                                                                                                                                                                                                  | Cum  | KSRB 2-2.3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 138      | KSRB 2.2.6 : Excavation for foundation of buildings, water supply & sanitary lines & electrical conduits etc., either in pits or in trenches 1.50m & above in width in hard rock by chiselling and or wedging where blasting is prohibited, not excluding 1.50m depth including stacking the excavated stuff clear from edges of excavation with lead upto 50m including cost of explosives, labour HOM of equipment complete as per specifications.                                                                                                                                                                                                                                                                                                       | Cum  | KSRB 2.2.6 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Unit | Reference Specifications                                                    |
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| 139      | RCC Work: Above GL - Columns, Beams & Slab<br>KSRB 4.2.7: Providing and laying in position reinforced cement concrete of design mix M25 with OPC cement @ 340kgs, with 20mm and down size graded granite metal coarse aggregates @ 0.70cum and fine aggregates @ 0.47cum, with superplasticiser @ 31ts confirming to IS9103- 1999 Reaffirmed-2008, machine mixed, concrete laid in layers not exceeding 15 cms thick, vibrated for all works in ground floor level for roof slabs, staircase, lintels and beams retaining walls, return walls, walls (any thickness) including attached pilasters, columns, pillars, posts, struts, buttresses, string or lacing courses, parapets, coping, bed blocks, anchor blocks, plain window cills, fillets etc., including cost of all materials, labour, HOM of machinery, curing, complete as per specifications.<br>Specification No. KBS 4.1, 4.6 | Cum  | KSRB 4.2.7 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 140      | KSRB 4-6.5 : Providing and removing centering, shuttering, strutting, propping etc., <b>for columns</b> , pillars, post and struts, square / rectangular/ polygon in plan including cost of all materials, labour complete as per specifications. Specification No. KBS 4.6.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Sqm  | KSRB 4-6.5 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 141      | KSRB 4-6.8 : Providing and removing centering, shuttering, strutting, propping etc., and removal of form work for <b>sides and soffits of beams, beams haunchings</b> , cantilever, girders, bressumers and lintels exceeding 1 m in depth including cost of all materials, labour complete as per specifications.<br>Specification No. KBS 4.6.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Sqm  | KSRB 4-6.8 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 142      | KSRB 4-6.10 :Providing and removing centering, shuttering, strutting, propping etc., <b>for chajjas</b> , corbels etc., including edges including cost of all materials, labour complete as per specifications.<br>Specification No. KBS 4.6.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Sqm  | KSRB 4-6.10 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Unit | Reference Specifications                                                   |
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| 143      | KSRB 4.9.2 : Providing <b>T.M.T steel reinforcement of Fe 500</b> for R.C.C work including straightening, cutting, bending, hooking, placing in position, lapping and / or welding wherever required, tying with binding wire and anchoring to the adjoining members wherever necessary complete as per design (laps, hooks and wastage shall not be measured and paid) cost of materials, labour, HOM of machinery complete as per specifications. Specification No. KBS 4.6.3                                                                                                                                                                                               | MT   | KSRB 4.9.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 144      | KSRB 5-14 : Providing and constructing precast concrete solid blocks with compressive strength not less than 3.5 Newton per sqm with cement mortar 1:4 masonry (quoin, Jamb, closer blocks) with solid concrete blocks of size 40x15x20 cms conforming to I.S: 2185/1965 in superstructure including cost of materials, labour charges, scaffolding, curing complete as per specifications.                                                                                                                                                                                                                                                                                   | Sqm  | KSRB 5-14 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 145      | uPVC Sliding Window<br>Providing & fixing of glazed 2 Track-2 Panel Sliding Windows made out of multi Chamered uPVC sections with TPV gaskets having Isolated drainage and reinforced with Galvanized iron profiles through out the window. The outer frame having a overall size of 60x45 mm with reinforcement of 1 mm thickness and sash with overall size of 39x58 mm with reinforcement of 1.5mm thickness. Glazing bead for fixing of glass shall be of size 20x18mm and coextruded with gasket. Windows shall be provided with 5mm plain float glass, standard hardware & single point locking system of flush lock, Wall thickness of frame & sash shall be 2-2.2 mm. | Sqm  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications              |
| 146      | Door Shutter<br>KSRB 7.4 : Providing and fixing 1mm thick M.S. sheet garage door with frame and diagonal braces of size 40x40x6 mm angle Iron, using M.S. flats 30x6 mm for diagonal braces and central cross pieces 3.15mm thick M.S. Gusset plates at the junctions and corners, with handles, stoppers and locking arrangements etc., including applying a priming coat of red lead paint cost of materials, labour, HOM of machinery complete as per specifications. 1 double leaf door of size 2.4x2.4m. Specification No. KBS 7.9 / 7.12. (P.No. 31, I.No. 7.4 of CSR 2015-16                                                                                           | Sqm  | KSRB 7.4 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Unit | Reference Specifications                                                     |
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| 147      | <p>Terrace Waterproofing</p> <p>KSRB 10-3 : Providing and laying integral cement based waterproofing treatment including preparation of surface as required for treatment of roofs ,balconies, terraces etc., consiting of following application .(A) Applying and grouting a slurry coat of neat cement using 2.75 kg/ sqm of cement admixed with proprietary water proofing compound conforming to IS: 2645 over the RCC slab after cleaning the surface before treatment to</p> <p>.(b) laying cement concrete using broken brick bats 25mm to 100mm size with 50% of cement mortar 1:5 admixed with proprietary water proofing compound conformating IS:2645 over 20mm thick layer of cement mortar 1:5 admixed with proprietary water proofing compound to reqired slope and treating similarly the adjoining walls upto 300mm height including rounding off junction of walls and slabs . (c)After two days of proper curing , apppyling a second coat of cement lurry surface with 20mm thick jointless cement mortar of mix 1:4 admixed with proprietary water proofing compound and finally finishing the surface with trowel and neat cement slurry and making of 300X300 mm square . (e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for finial test including coat of materials, labour</p> | Sqm  | KSRB 10-3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications    |
| 148      | <p>Flooring &amp; Skirting</p> <p>KSRB 14.10-1: Flooring with 25mm thick polished tandur blue stone slabs using cement mortar 1:6, 25mm thick over existing cement concrete bed or top of roof laid to line and level and jointed with cement slurry mixed with pigment to match the shade of the slab, including cost of materials, labour, curing, polishing complete as per specifications. Specification No. KBS</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Sqm  | KSRB 14.10-1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 149      | <p>Granite for Steps</p> <p>Providing and laying Hassan Green granite flooring for staircase, treads and rises using pre polished 20 mm thick water cut green Granite slab laid over existing cement concrete bed in CM 1:3, average 20mm thick including full rounding for nosing , cutting 3 line grooves not more than 2 mm wide for antiskidding, curing etc.,complete.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Sqm  | / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications              |



| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                     | Unit | Reference Specifications                                                     |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------------------------------------------|
| 150      | Internal Wall Plaster<br>KSRB 15-3.2: Providing 12mm thick cement plaster in single coat with cement mortar 1:4 (with lime rendering) to brick masonry including rounding off corners wherever required smooth rendering, Providing and removing scaffolding, including cost of materials, labour, curing complete as per specifications.                                                                                       | Sqm  | KSRB 15-3.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 151      | External Wall Plaster<br>KSRB 15-3.11: Providing 20mm thick <b>cement plaster in single coat</b> with <b>cement mortar 1:4</b> to stone masonry & concrete surface including rounding off corners wherever required smooth rendering, Providing and removing scaffolding, including cost of materials, labour, curing complete as per specifications.                                                                           | Sqm  | KSRB 15-3.11 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 152      | Celing Plaster<br>KSRB 15-3.14: Providing 12mm thick cement plaster in single coat with cement mortar 1:4 to ceiling(with lime rendering) including & rounded off corners wherever required smooth rendering Providing & removing scaffolding, including cost of materials, labour curing complete as per specification                                                                                                         | Sqm  | KSRB 15-3.14 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 153      | Internal Wall Painting<br>KSRB 15-14.1 : Providing and applying two coats with <b>oil bound washable distemper</b> of approved brand and shade on wall surface including priming coat with distemper primer after thoroughly brooming the surface free from mortar drops and other foreign matter including preparing the surface even and sand paper smooth, cost of materials, labour, complete as per specifications.        | Sqm  | KSRB 15-14.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 154      | Celing Paint<br>KSRB 15-14.1 : Providing and applying two coats with <b>oil bound washable distemper</b> of approved brand and shade on ceiling and / or sloping roof including priming coat with distemper primer after thoroughly brooming the surface free from mortar drops and other foreign matter including preparing the surface even and sand paper smooth, cost of materials, labour, complete as per specifications. | Sqm  | KSRB 15-14.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Unit | Reference Specifications                                                     |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------------------------------------------|
| 155      | External Wall Painting<br>Providing and finishing external walls in two coats with Apex Paint of approved brand and shade to give an even shade after thoroughly brooming the surface to remove all dirt and loose powdered material, free from mortar drops and other foreign matter cost of materials, labour, complete as per specifications. (with primer) ( Two or more coats applied @ 3.28 litres / 10Sqm) over & including base coat of water proofing cement paint "Snowcem plus" or equivalent applies @ 2.20 kg/10 sqm. | Sqm  | / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications              |
| 156      | Painting For Door<br>KSRB 15-17.4: Providing and applying painting two coats (including priming coat) on new wood surface and /or wood based surface with enamel paint to give an even shade, cleaning the surface of all dirt, dust and foreign matter, sand papering including cost of materials, labour, complete as per specifications.                                                                                                                                                                                        | Sqm  | KSRB 15-17.4 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 157      | Painting For Window Grill<br>KSRB 15-18.2 : Providing and applying enamel metal paint two coats (excluding priming coat) over new steel or other metal surface brushing to give an even shade after cleaning oil, grease, dirt and other foreign matter, including cost of materials, labour, complete as per specifications.                                                                                                                                                                                                      | Sqm  | KSRB 15-18.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 158      | PVC laminated false ceiling;Supply & installation of PVC laminated false ceiling size of 600x600mmx9mm as per the following specification:- Panels are PVC laminated on the finish side and backed with aluminum foil (behind). It shall be suspended with the frame work and accessories completed from roof slabs, beams etc., by means of 4mm dia galvanized rods, J bolt, Tee runner, Ultra look Tee Runner and edge trim etc.                                                                                                 | Sqm  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |
| 159      | KSRB 14.14-5: Providing Non skid Ceramic tiles of approved make,shade and size300x300 6mm thk for flooring, laid on a bed of 12mm thick, cement mortar 1:3 mix, flush pointing with white cement using colour pigment , including cost of materials, labour, curing, complete as per specifications. specification No. KBS                                                                                                                                                                                                         | Sqm  | KSRB 14.14-5 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Unit | Reference Specifications                                                     |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------------------------------------------|
| 160      | KSRB 14-17.2: Dadoing with glazed tiles Providing skirting, dado, rise of steps with <b>colour glazed tiles 15x15 cms</b> 6mm thick on 10mm thick cement plaster 1:3 & jointed with white cement slurry over rough plaster surface( excluding cost of rough plastered surface which should be measured & paid seperately) using glazed tiles of approved make & size including cost of materials, labour, complete as per specification Specification no.14,16,14,17                                                                                                                                                   | Sqm  | KSRB 14-17.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 161      | INTERNAL PLUMBING & SANITARY WORK<br>Providing and fixing Chlorinated Poly Vinyl Chloride (CPVC) pipes, 15mm nominal OD pipes conforming to IS 15778, having thermal stability for hot and cold water supply including all CPVC plain and brass threaded fittings including fixing the pipe with clamp at 1.00 mtr spacing. This includes jointing of pipes and fittings with one step CPVC solvent cement & the cost of cutting chases & making good the same including testing of joints complete. (Concealed work including cutting chases and good the walls etc.)<br>Wash Basin +WC+Urinals (Vertical+Horizontal) | Rmt  | / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications              |
| 162      | Providing and fixing <b>Chlorinated Poly Vinyl Chloride (CPVC) pipes, 20mm nominal OD pipes</b> conforming to IS 15778, having thermal stability for hot and cold water supply including all CPVC plain and brass threaded fittings including fixing the pipe with clamp at 1.00 mtr spacing. This includes jointing of pipes and fittings with one step CPVC solvent cement & the cost of cutting chases & making good the same including testing of joints complete. (Concealed work including cutting chases and good the walls etc.)                                                                               | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |
| 163      | Providing and fixing <b>Chlorinated Poly Vinyl Chloride (CPVC) pipes, 25mm nominal OD pipes</b> conforming to IS 15778, having thermal stability for hot and cold water supply including all CPVC plain and brass threaded fittings including fixing the pipe with clamp at 1.00 mtr spacing. This includes jointing of pipes and fittings with one step CPVC solvent cement & the cost of cutting chases & making good the same including testing of joints complete. (Concealed work including cutting chases and good the walls etc.)                                                                               | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Unit | Reference Specifications                                                 |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------------------------------------------------------------|
| 164      | Providing and fixing <b>unplasticised PVC pipes with 90mm outer dia 10.00 kg/sq.cm working pressure chemp plast / Wavin or equivalent make with pipe fittings, clips, making good the floor, including cost of all materials, labour charges, HOM of equipment and testing complete as per specifications.</b><br>Urinals +Washbasin                                                                                                                                                                                                                                                                                                                                                       | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications            |
| 165      | Providing and fixing <b>unplasticised PVC pipes with 110mm outer dia 10.00 kg/sq.cm working pressure chemp plast / Wavin or equivalent make with pipe fittings, clips, making good the floor, including cost of all materials, labour charges, HOM of equipment and testing complete as per specifications.</b>                                                                                                                                                                                                                                                                                                                                                                            | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications            |
| 166      | Providing pedestal for <b>wash basin</b> of approved 1st quality and make conforming to ISI Specifications and fixing for low down cistern as directed Rate includes cost of materials and conveyance to work spot.<br>Toilet+outside                                                                                                                                                                                                                                                                                                                                                                                                                                                      | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications            |
| 167      | KSRB 11 -6 : Providing and fixing <b>white vitreous china clay, water closet European type ( Pedestal type, S-trap )</b> with black solid plastic seat and lid, C.P brass hinges, rubber buffers. 10 litre white glazed / vitreous china clay low level, flushing cistern ( all are approved make ) with fittings, C.I / M.S brackets, 40mm diameter flush bend with fittings and clamps, overflow arrangements with specials and 25mm mosquito proof coupling of approved design, painting of fittings and brackets, cutting and making good the wall and floor wherever required, including cost of materials, labour complete as per specifications. Specification No. KBS 11<br>Toilet | No   | KSRB 11 -6 IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 168      | Providing and fixing white <b>vitreous china clay urinals</b> with flat back of approved make fixed to wooden plugs including bends, painting white to exposed pipes etc., complete as per directions.(rate includes cost of all materials and lead).A grade.                                                                                                                                                                                                                                                                                                                                                                                                                              | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications            |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                              | Unit | Reference Specifications                                                       |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------------------------------------------------------------------|
| 169      | KSRB 11-17-1 : Providing and <b>fixing C.P. brass towel rail 740mm length, 20mm dia with C.P brackets, fixed to wooden cleats</b> with C.P. brass screws including cost of materials, labour complete as per specifications.<br>Washbasin                                                                                                                | No   | KSRB 11-17-1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 170      | KSRB 11-18-5.1 : Providing and fixing unplasticised PVC single equal junction of required degree with access door 100x100x100mm, including cost of materials, labour, testing complete as per specifications. KBS 11-1.10                                                                                                                                | No   | KSRB 11-18-5.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 171      | Providing and fixing 10 cm dia. <b>uPVC Nahani Trap</b> fixed with UPVC grating, UPVC plug bend and piece of UPVC pipe upto plug bend, scaffolding etc. complete.<br>WC+Washbasin Area                                                                                                                                                                   | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                  |
| 172      | Providing and fixing in position 15 mm dia ,nominal bore CP Brass bib tap of approved quality including cost of all materials, labour and HOM of equipments with all leads complete as per specifications. (Make Parriware/Jaquar/ Hindware)                                                                                                             | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                  |
| 173      | Providing and fixing Chorinated Poly Venyl Chloride (CPVC) pipes 32mm nominal OD pipes conforming to IS 15778, having thermal stability for hot and cold water supply including all CPVC plain and brass threaded fittings including fixing the pipe with clamp at 1.00 mtr spacing. This includes jointing of pipes and fittings<br>From ground to tank | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                  |
| 174      | KSRB13-7.2-1 - Providing and fixing in position 32 mm nominal bore non-return valve vertical type of approved make including cost of all materials, labour and HOM of equipments with all leads complete as per specifications. Specification No.KBS 13.2.10 /13.13<br>Toilet                                                                            | No   | KSRB13-7.2-1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 175      | Providing and fixing Chorinated Poly Venyl Chloride (CPVC) pipes 40mm nominal OD pipes conforming to IS 15778, having thermal stability for hot and cold water supply including all CPVC plain and brass threaded fittings including fixing the pipe with clamp at 1.00 mtr spacing. This includes jointing of pipes and fittings                        | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                  |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Unit | Reference Specifications                                                     |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------------------------------------------|
| 176      | KSRB13-6.2-1 : Providing and fixing in position <b>brass stop cock</b> of approved quality <b>15mm</b> nominal bore including cost of all materials, labour and HOM of equipments with all leads complete as per specifications.Specification No.KBS 13.2.2/13.3 washbasin outside                                                                                                                                                                                                                    | No   | KSRB13-6.2-1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 177      | KSRB13-6.3-3 Providing and fixing in position brass gate valve with C.I wheel of approved quality ( screwed end ) 25mm nominal bore including cost of all materials, labour and HOM of equipments with all leads complete as per specifications. Specification No.KBS 13.2.6/13.3                                                                                                                                                                                                                     | No   | KSRB13-6.3-3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 178      | KSRB13-6.3-3 Providing and fixing in position brass gate valve with C.I wheel of approved quality ( screwed end ) 32mm nominal bore including cost of all materials, labour and HOM of equipments with all leads complete as per specifications. Specification No.KBS 13.2.6/13.3 Outside                                                                                                                                                                                                             | No   | KSRB13-6.3-3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 179      | KSRB 6-8.1 :Construction of partition wall 10 cms thick with ground moulded modular burnt bricks of class designation 3.5 Newton per sqmm with cement mortar 1:4 including providing and fixing plaster mesh manufactured out of hot dipped galvanized iron of nominal thickness 0.35 mm. 100 mm. wide as per I.S. 2212/1991 at 7.5 m. c to c including cost of materials, labour charges, scaffolding, curing complete as per specifications. Specification No. KBS 6.2 Partition Wall               | Sqm  | KSRB 6-8.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications   |
| 180      | Providing & of Fixed Louvered Ventilator made out of multi chambered uPVC sections with TPv gaskets having isolated drainage and reinforced with Galvanized Iron profiles through out the window. The outer frame having a overall size of 60x55mm with reinforcement of 1 mm thickness and Mullion with overall size of 74x60mm with reinforcement of 1 mm thickness. Ventilator shall be provided with 4.5 mm Pin Head glass, standard hardware, Wall thickness of frame Mullion shall be 2-2.2 mm. | Sqm  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications                |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                | Unit | Reference Specifications                                                    |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----------------------------------------------------------------------------|
| 181      | KSRB 9-15-3 : Providing and fixing in position shutters for doors made out of Honne wood styles and rails of 30mm. thick with bottom and lock rails 180mm wide top rail and styles 100mm wide as per drawing and panels of 18mm thick of exterior grade Plain particle board including cost of materials, labour, HOM of machineries complete as per specifications.(excluding cost of fixtures ) Specification No. KBS 9.34, 9.26.3       | Sqm  | KSRB 9-15-3 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 182      | KSRB13-8.9 : Providing and fixing to wall, ceiling and floor, high density polyethylene pipes 6.00 kgf/sq.cm working pressure, 110 mm outside diameter with special flange, compression type fittings, wall clips, making good the wall, ceiling and floor including cost of all materials, labour charges, HOM of equipments and testing complete as per specifications.<br>Specification No.KBS 13.2.15.1 /13.9<br>Toilet                | Rmt  | KSRB13-8.9 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |
| 183      | Providing and fixing to wall, ceiling and floor, high density polyethylene pipes 6.00 kgf/sq.cm working pressure, 200 mm outside diameter with special flange, compression type fittings, wall clips, making good the wall, ceiling and floor including cost of all materials, labour charges, HOM of equipments and testing complete as per specifications. Specification No.KBS 13.2.15.1 /13.9<br>Toilet                                | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications               |
| 184      | KSRB13-8.9 : Providing and fixing to wall, ceiling and floor, high density polyethylene pipes 6.00 kgf/sq.cm working pressure, 90 mm outside diameter with special flange, compression type fittings, wall clips,making good the wall, ceiling and floor including cost of all materials, labour charges, HOM of equipments and testing complete as per specifications. Specification No.KBS 13.2.15.1 /13.9<br>Rain water collection pipe | Rmt  | KSRB13-8.9 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications  |

| Item No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Unit | Reference Specifications                                                    |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----------------------------------------------------------------------------|
| 185      | Providing and fixing 15 x 10 cm of approved quality salt glazed stoneware gully trap in cement concrete 1:4:8 outside the building including symet C.I. medium duty cover in the sink, connecting glazed stoneware pipe, brick masonry chamber with R.C.C. lid and Symet C.I. cover for the gully trap, testing etc. complete. Washbasin+urinals                                                                                                                      | No   | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications               |
| 186      | KSRB 12-8.1 : Constructing brick masonry inspection chamber 450X450 mm and 450mm depth, ( clear inside dimension ) for single pipeline, using table moulded non-modular bricks of class designation 50 in cement mortar 1:5, C.I cover withframe (light duty) 455x610mm internal dimensions, total weight of cover with Toilet                                                                                                                                        | No   | KSRB 12-8.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 187      | KSRB 12-8.1 : Constructing brick masonry inspection chamber 600X850mm and 450mm depth, ( clear inside dimension ) for single pipeline, using table moulded non-modular bricks of class designation 50 in cement mortar 1:5, C.I cover withframe (light duty) 455x610mm internal dimensions, total weight of cover with Toilet                                                                                                                                         | No   | KSRB 12-8.1 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 188      | KSRB 12-3.2 : Providing and laying in position plain cement concrete of mix 1:4:8 ( as per design) using 40mm and down size graded granite / trap metal for haunching of 150mm internal diameter stoneware pipes, concrete machine mixed laid in layers not exceeding 15 cms thick, well compacted, including cost of materials, labour charges, form work, HOM of machinery, curing complete as per specifications. Specification No. KBS 4.1 / 4.2 150 mm main line | Rmt  | KSRB 12-3.2 / IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications |
| 189      | Providing and laying reinforced cement concrete pipe NP2 for culverts, including pointing ends & fixing collars with Cement mortar 1:2,including cost of material labour curing, complete as per specification, MOST Specfication KSRB 1000,2300 150 mm FOR Trunk main line (As per Sewer CAD)                                                                                                                                                                        | Rmt  | IS / IRC / MORTH / BESCOM / CPWD / NBC Codes & Specifications               |



## **7 B 1. SUB-SECTION**

### **ELECTRICAL EQUIPMENT SPECIFICATION**

## **Contents**

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## **1 GENERAL REQUIREMENTS - ELECTRICAL EQUIPMENT**

### **1.1 INTRODUCTION**

This scope of this specification consists of general requirements of Design, manufacture, inspection and testing at manufacturer's works, supply, packing, forwarding and delivery to site, unloading, handling and storing the equipment at site, assembly, installation, testing and commissioning at site of the equipment/ system listed below as per Specifications, data sheets & Single Line Diagram. Particular requirements of all electrical equipments are covered under „Part 12: Particular Requirements - Electrical" of this Specification.

- a) Oil cooled Transformers
- b) HT Switchgear Panels
- c) HT Capacitor Banks & Panel
- d) FCMA Neutral Soft Start Panel
- e) 415V Metal enclosed switchboards (MCCs/PCCs)
- f) 415 V Power capacitor and control panel
- g) Bus Duct
- h) Diesel Generator Set with Acoustic Enclosure
- i) UPS
- j) Battery, Battery charger and DC Distribution board
- k) Cabling System: HV, LV, Control and Telecommunications
- l) Cable carrier system,
- m) Lighting
- n) Lighting System Equipment
- o) Earthing & Lightning protection system.
- p) Fire MCC Panel (Emergency DB)
- q) Fire Alarm and Protection System

The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, tested, Commissioned successfully and should be working satisfactorily since at least last 5 years continuously. Certificates from the end users, regarding their satisfactory Performances, shall have to be submitted in this regard.

Various equipment /items shall conform to latest applicable standards specified. In case of Conflict between standards and this specification, this specification shall govern.

### **1.2 TRANSFORMERS**

Transformer system shall have provision such that inter-opera ability with instrumentation controls system.

**A. Applicable Standards**

The transformers shall conform to the latest applicable standards specified below

|                                                       |                                |         |
|-------------------------------------------------------|--------------------------------|---------|
| Power Transformer                                     | IS:2026/ BS:171/ IEC:60076/    | IS11171 |
| Fittings and Accessories                              | IS:3639                        |         |
| Outdoor type Oil immersed distribution transformers   | IS:1180-2014                   |         |
| Up to 2500 kVA, 11 kV Transformer                     |                                |         |
| Loading of oil immersed transformer                   | IS:6600/BS:CP.1010/IEC:60354   |         |
| Transformer Oil                                       | IS: 335/BS 148/IEC: 60296      |         |
| Bushings for > 1000V, AC                              | IS: 2099/BS:223/IEC:60137      |         |
| Bushings for > 1000V, AC                              | IS:7421                        |         |
| Degree of Protection                                  | IS:13947 (Part 1)/ IEC:60947-1 |         |
| Double float type Buchholz Relay                      | IS:3637                        |         |
| Electrical insulation classified by thermal stability | IS1271/BS:2757/IEC:60085       |         |
| Climate Proofing                                      | BS:CP1014                      |         |
| Code of Practice for selection, installation and      | IS - 10028                     |         |
| Maintenance of transformers                           |                                |         |
| Manual on Transformers                                | CBIP Publication No.295        |         |

**B. Features of Construction**

- a) The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections.
- b) All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded.
- c) The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat resistant, oil insoluble paint.
- d) Adequately sized manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be galvanized.
- e) The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.
- f) Lifting lugs and eyebolts shall be so located that a safe clearance is obtained without the use of a spreader, between the sling and transformer bushings.
- g) Transformers shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.
- h) The transformer core shall be constructed from high grade, non-ageing, cold-rolled, grain Oriented, Silicon Steel Laminations. The steel laminations shall be of "core" type. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connection to the tank.

- i) Windings shall be of insulated copper wire or copper strip. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core. The windings shall be fully shrunk under vacuum before assembly. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.
- j) The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.
- k) Transformer shall operate without injurious heating at the rated KVA and at any voltage up to + 10 % of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstanding capability.
- l) Transformer shall be provided with Zero sequence / earth fault current protection on LV side transformer feeder protection. (Neutral CT to be provided in case of solid grounding)

**C. Winding connections**

Windings shall be of HV: Delta & LV: Star, vector group Dyn 11.

**D. D. Rating**

The rating of transformers shall be as per standard ratings shown in IS 1180:2014 or relevant standard.

**E. E.Type of cooling**

The transformers shall be oil immersed with natural oil circulation, type ONAN. With the provision for radiator cooling with fans for forced cooling, if required will be added in future.

The rating of the transformer with ONAF shall be specified.

**F. F.Impedance and losses**

The percentage impedance, no load & load losses shall be as per IS 1180: 2014 or relevant standard.

**G. Performance requirements**

- (a) The transformers shall be suitable for operation without danger on to any particular tapping at the rated kVA provided that the voltage does not vary by more than  $\pm 10\%$  of the voltage corresponding to the tapping.
- (b) The transformers shall be suitable for continuous operation with a frequency variation of  $\pm 5\%$  of rated frequency, combined voltage and frequency variation should not exceed 10%.
- (c) All transformers shall be capable of withstanding external short circuit without damage as per IS 2026.
- (d) The transformers shall be capable of continuous operation in accordance with relevant IS for loading of oil immersed transformers.
- (e) The neutral terminal of star windings shall be designed for the highest over current that can flow through this terminal.
- (f) The temperature rise of oil & windings over the specified ambient temperature shall not exceed the limits given below with air as cooling medium when tested in accordance with IS 2026 (Part-2).

Top oil (measured by thermometer) : 40° C

Winding (measured by resistance) : 45° C

- (g) Noise level of transformers shall be less than 80 dB at a distance of 1 metre.

#### **H. H.Tap Changer**

- (a) The standard tapping range shall be +5% to -10% of HV in terms of 2.5 % with taps on HV Side. (consider as per IS 1180-2014, Part - 1)
- (b) For transformer of rating less than or equal to 500 kVA, tap changing shall be carried out by means of an off circuit externally operated self positioning switch when the transformer is in de-energized condition. Off circuit tapping arrangement shall be either by means of an externally operated switch with mechanically locking device and a position indicator. Arrangement for pad-locking shall be provided.
- (c) On Load Tap Changing Gear for Transformer (above 500kVA) The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e. 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.
- (d) When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.
- (e) Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.
- (f) Oil in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.
- (g) OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weather-proof cabinet with IP 55 protection which shall include:
- (i) Driving motor (415V, 3-phase, 50 Hz. AC squirrel cage).
  - (ii) Motor starting contactor with thermal overload relays, isolating switch and HRC fuses.
  - (iii) Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa.
  - (iv) Control switch: Raise/off/lower (spring return to normal type).
  - (v) Remote/local selector switch (maintained contact type).
  - (vi) Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.

- (vii) Limit switches to prevent motor over-travel in either direction or final mechanical stops.
- (viii) Brake or clutch to permit only one taps change at a time on manual operation.
- (ix) Emergency manual operating device (hand crank or hand wheel).
- (x) A five digit operation counter.
- (xi) Electrically interlocked reversing contactors (preferably also mechanically interlocked).
- (xii) 240V, 50 Hz. AC space heater with switch and HRC fuses. (xiii) Interior lighting fixture with lamp door switch and HRC fuses.
- (xiii) Gasketed and hinged door with locking arrangement.
- (xiv) Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
- (xv) Necessary relays, contactors, current transformers etc.

(h) Control Requirements for OLTC

The following electrical control features shall be provided:

- (i) Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
- (ii) Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.
- (iii) Cut-off of electrical control when manual control is resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
- (iv) Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

(i) Automatic Control of OLTC

Automatic OLTC control shall include the following items:

- (i) Voltage setting device
  - (ii) Voltage sensing and voltage regulating devices.
  - (iii) Line drop compensator with adjustable R and X elements.
  - (iv) Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation
  - (v) Adjustable dead band for voltage variation
- (j) The OLTC remote control equipment shall be housed in an indoor sheet steel cubicle to be located in a remote control room. It shall conform to degree of enclosure protection IP42 or better and shall comprise the following.
- (k) The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary.

- (l) All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP54, colour of finish shade for interior and exterior shall be glassy white and light grey semi glossy shade 631 of IS-5 respectively.
  - (m) Earthing bus shall be of 25 x 6 mm copper.
  - (n) The OLTC remote control equipment shall comprise of the following
    - (i) Control switch: Raise/Off/Lower (spring return to normal type)
    - (ii) Auto/manual selector switch (maintained contact type)
    - (iii) Tap position indicator
    - (iv) Facia type alarm Annunciators with “accept” and “lamp test” facilities.
      - A.C. supply failure
      - Drive motor auto tripped
      - Tap change delayed
    - (v) Necessary auxiliary relays
    - (vi) Lamp indications for :
      - Tap change in progress
      - Lower limit reached
      - Upper limit reached
    - (vii) Cable glands for power and control cables.
    - (viii) 240 V rated panel space heater with ON-OFF switch.
    - (ix) Fluorescent type interior lighting fixture with lamp and door switch.
    - (x) HRC fuses.
    - (xi) Terminal blocks.
    - (xii) Internal wiring.
    - (xiii) Earthing terminal.
  - (o) Fittings and Accessories
- The following fittings and accessories shall be provided for transformer:
- (a) Inspection manhole(s) with cover(s) on the top cover of the transformer.
  - (b) Lifting lugs or eyes for lifting of fully assembled transformer by crane.
  - (c) Jacking pads, at least four in number, at suitable height, for lifting the complete transformer filled with oil.
  - (d) Lifting arrangements for
    - (i) Complete transformer filled with oil
    - (ii) For the assembly of core and coils and
    - (iii) For lifting the tank of large transformers whenever specified.
  - (e) Hauling eyes on each face of the transformer (for transformer rated 10000 KVA and above).
  - (f) Skids at the base of the transformer.
  - (g) A ladder assembly shall be provided to reach the top of the transformer for maintenance work. It shall be possible to padlock the ladder to the transformer tank so



- that ladder cannot be removed. Usage of transformer structure / marshalling boxes etc as means to climb transformer are not acceptable.
- (h) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the Employer's earthing conductors. Suitable earthing terminals on cable boxes and separately mounted radiator banks shall also be provided.
  - (i) Neutral earthing bar of copper of specified section installed from the neutral bushing to ground level suitably supported along its run on porcelain insulators, together with clamping arrangements at neutral bushing and for two Employer's earth conductors. The supporting insulators shall be tank mounted.
  - (j) Terminal marking and rating plates shall be as per the specified standard and shall also give the following additional information:
    - (i) Connection diagram showing the internal connections.
    - (ii) Guaranteed Temperature rise of winding and oil.
    - (iii) Insulation levels of the windings, including neutral end of windings with uniform insulation.
    - (iv) Transportation weight.
    - (v) Un-tanking weight.
    - (vi) Core and winding weight.
    - (vii) Table giving the tapping voltage, tapping current and tapping power factor for each tap. Values of short circuit impedance on the extreme tapplings and on the principal tapping and indication of the winding to which the impedance is relates.
  - (k) The transformer shall also be provided with the following non-corrodible plates, indelibly marked showing:
    - (i) Location and function of all valves and plugs and indication of the maintenance instrument reference for applying vacuum of drying and oil filling.
    - (ii) Valves connection diagram
  - (l) The conservator shall be provided with the following accessories:
    - (i) Filling plug, sump and drain valve of 15 mm size for conservator of size 650 mm and 25 mm size for conservator above 650 mm diameter.
    - (ii) 150 mm diameter magnetic type oil level gauge with low oil level alarm contacts and a prismatic oil sight gauge, both as specified in Data Sheet and provided with markings for minimum oil level and oil level at rated temperature rise.
    - (iii) A bolted cover at one end for cleaning.
    - (iv) Valve for shutting off oil to the transformers.
    - (v) Weather proof dehydrating breather with silica gel and oil seal to eliminate constant contact with the atmosphere, mounted at a level of about 1400 mm above ground level.
  - (m) Gas and Oil Actuated Relay (Buchholz Relay)
  - (n) Temperature Indicators
  - (o) Dial Type Thermometer
  - (p) Winding Temperature Indicator

**I. Cable Terminations / Cabling Requirement**

11kV air insulated cable box with air insulated disconnecting chamber shall be provided with supporting brackets and structure to facilitate their support from ground level. The disconnecting chamber and terminal box shall be air insulated and complete with seal-off bushings, removable flexible connectors/links and removable covers. LT terminal box shall be suitable for connecting LT air insulated bus duct.

All transformers shall be provided with lockable emergency Push Button station near the transformer to trip the transformer as per IER. All transformers shall be provided with alarm annunciation on breaker control panel.

**J. Tolerance on Losses**

The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2026. Cost loading shall be done for capitalization of losses at time of bid evaluation for all transformers as per CBIP Manual on transformers.

**K. Rejection**

- (a) The Employer or Employer's Representative reserves the right to reject the transformer if the same does not meet the specification requirement, subject to tolerances as per IS 2026.
- (b) The impedance values difference and temperature rise values shall not exceed from the guaranteed specified values.
- (c) The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost. If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Employer's Representative reserves the right to accept the rejected transformer until the replacement transformer is made available.
- (d) Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost.

**1.3 HT METAL ENCLOSED SWITCHBOARDS & SWITCHGEARS**

HT/MV metal enclosed Switchboards and Switchgear system shall have provision such that inter-operation ability with instrumentation control system.

The HT/MV switchboard is proposed with "FORM 4 -B" enclosure as per the Indian Standard. All indoor boards/ panel are proposed with a degree of protection of IP54 while all outdoor equipment above ground are proposed with a degree of protection of IP65 and above as per site condition.

**A. Applicable Standards**

The switchgear and its components shall conform to the latest applicable standards specified below:

|                                                                                                  |                                                         |
|--------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| Circuit Breakers                                                                                 | IS : 13118 / BS : 5311 / IEC: 60056,60694,IEC 62271-100 |
| Metal Enclosed switchgear                                                                        | IS:3427/ BSEN:60298 / IEC:60298,IEC 62271-200           |
| Current Transformers                                                                             | IS : 2705 / BS : 7626                                   |
| Voltage Transformers                                                                             | IS : 3156 / BS : 7625 / IEC : 60186 IS : 5578, 11353    |
| Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring                        | IS : 2544 / BS : 3297 / IEC :60 273                     |
| Busbar Support insulators Degree of Protection                                                   | IS : 13947 (Part 1) / IEC : 60947-1/ BSEN : 60529       |
| Electrical Relays for Power system protection                                                    | IS : 3231, 3842 / BS : 142 / IEC : 60255                |
| Electrical Indicating Instruments                                                                | IS : 1248 / BS : 89 / IEC :60051                        |
| High Voltage Fuses                                                                               | IS : 9385 / BS : 2692 / IEC : 60282                     |
| AC Electricity Meters                                                                            | IS : 722, 8530 / BS : 5685 / IEC :60145,60211           |
| Specification for copper rods and bars for electrical purposes                                   | IS : 613                                                |
| Code of practice for phosphate iron and steel                                                    | IS : 6005 / BS : 3189                                   |
| Alternating current Switches for voltages above 1000 V                                           | IS : 9920 / IEC : 60129,60265 & 60298                   |
| Low voltage fuses                                                                                | IS : 13703 / BS 1362 / IEC 60269                        |
| Toggle switches                                                                                  | IS : 3452 / BS : 3676                                   |
| Code of practice for selection, installation and maintenance of switchgear and control gear      | IS : 10118                                              |
| Control switches                                                                                 | IS:6875 / BSEN 60947/IEC: 60947                         |
| Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation | IS 5572, IS 5571                                        |
| Electrical apparatus for explosive gas atmospheres-General Requirements                          | IEC 60079                                               |
| Fault level calculation                                                                          | IS: 2026                                                |

## **B. Constructional Features**

- a) Switchgear design shall be of metal enclosed, single front, free standing, floor mounted and fully compartmental execution having separate sections for each circuit. Each Circuit shall have a separate vertical panel with distinct compartments for main bus bars, circuit breaker, cable termination and auxiliary devices.
- b) The adjacent panels shall be completely separated by steel sheets except in bus bar sheet compartments where insulated barriers shall be provided to segregate

- adjacent panels. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits.
- c) Switchgear cubicle shall be provided with hinged door on the front with facility for locking door handle.
  - d) Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP4X and the relay and meter compartments shall have a degree of Protection not less than IP 52.
  - e) All removable covers shall be gasketed all around with neoprene or superior gaskets.
  - f) Instruments, relays and control devices shall be flush-mounted on hinged door of the metering compartment located in the front portion of cubicle. The metering compartment shall be properly shielded to prevent mal-operation of electronic equipment such as numerical / static relays due to electro-magnetic fields.
  - g) All transformers shall be provided with alarm annunciation on breaker control panel
  - h) Each switchgear cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with label indicating the switchboard designation, rating and duty.
  - i) Each relay, instrument, switch, fuse and other devices shall be provided with separate label.
  - j) The fully draw-out modules shall have all the circuit components mounted on withdraw able type steel chassis.
  - k) All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.
  - l) In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers such that no live parts are accessible.
  - m) External cable connections shall be through separate cable compartments for power and control cables. Safety shutters shall be provided to cover up the fixed high voltage contacts on busbars when the circuit breaker carriage is moved to "test" and "isolated" positions.
  - n) One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the bus bars and adjacent circuits alive.
  - o) All sheet steel work shall be phosphate in accordance with the following procedure and in accordance with IS: 6005 "Code of Practice for Phosphate Iron and Steel". Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
  - p) After phosphate, thorough rinsing shall be clean water followed by final rinsing with dilute dichromate solution and even drying. The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved. After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of

tests. The final finished thickness of paint film on steel shall not be less than 100 microns and shall not be more than 150 microns. Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface. A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

**C. Circuit Breaker**

- a) Circuit breakers shall be vacuum type with three separate single pole interrupting units, operated through a common shaft by a sturdy operating mechanism. Surge Arrestors shall be provided for each motor / transformer feeder.
- b) Circuit Breakers shall be re strike free, stored energy operated and trip free type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.
- c) Anti pumping relay and trip coil suspension relay shall be provided.
- d) There shall be „Service“, „Test“ „Fully withdrawn“ positions for the breakers. In the „Test“ position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected.
- e) Separate limit switches, each having a minimum of 2NO+ 2NC contacts, shall be provided for both „Service“ and „Test“ positions of the circuit breakers. All these service, test, fully withdrawn, spring charge and also breaker ON / OFF shall be visible mechanically from outside the breaker panel when the front door is closed.
- f) Electrical closing & tripping shall be performed by shunt trip & close coils both in Local & Remote mode. Selector switch lockable in “Local” position shall be provided on the cubicle door. „Red“ and „Green“ indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker “Service”, “Test” and breaker readiness positions shall be indicated by separate indicating lamps on the cubicle door.
- g) Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.
- h) 10% spare feeders with at least one for each type of highest rating shall be provided in each switch gear.
- i) Surge arrestors shall be provided for all motors / transformer feeders and shall be metal oxide gapped or gapless type generally in accordance with IEC 60099-1 and suitable for indoor only.
- j) Core balance CTs (CBCT) shall be provided on outgoing motor and transformer feeders having CT Ratio 50 / 1A or more. These CBCTs shall be mounted inside the switch gear panel.

**D. Operating Mechanism Control**

- a) Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.

- b) Operating mechanism shall normally be operated from the breaker cubicle itself.
- c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.
- d) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.
- e) The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.
- f) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.
- g) Circuit breaker control shall be on 110 V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 80-110 % of the control voltage. Trip coils shall operate satisfactorily between 50 -110 % the rated control voltage.

**E. Safety Interlocks and Features**

- a) Withdrawal or engagement of a circuit breaker shall not be possible unless it is in the open position.
- b) All circuit breaker shall have lockable local / remote selector switch, for closing the breaker from local shall be possible only in TEST position. Whereas as closing from remote shall be possible in either SERVICE and TEST position. For opening breaker from local shall be possible only when local remote selector switch shall be in local position. Opening breaker from remote shall be either breaker in service position or selector switch being in remote position.
- c) All Motors and Service Transformers feeder breaker shall have lockable emergency push button (openable only with key) near motor and service transformer, hard wired to circuit breaker panel emergency push button.
- d) Operation of a circuit breaker shall not be possible unless it is in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.
- e) Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts



when the breaker is withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.

- f) The circuit breaker carriage shall be earthed before the breaker reaches the test position from fully withdrawn position. In case of breakers with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage earthing shall break only after the auxiliary disconnects break.
- g) Caution nameplate, "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

**F. Earthing**

- a) Copper earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board.
- b) The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher without exceeding maximum allowable temperature rise.
- c) The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.
- d) Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.
- e) Hinged doors shall be earthed through flexible earthing braid of adequate cross section.
- f) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.
- g) Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.
- h) All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

**G. Circuit / Busbar Earthing Facility**

- a) It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches.
- b) Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers to prevent accidental earthing of live circuit or bus bars. In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker.
- c) The earthing facilities proposed to be provided by the Bidder shall be clearly detailed in the Bid and shall be subject to Employer's approval. Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

#### **H. Annunciators**

- a) Annunciators shall be of fascia type with translucent plastic window for each alarm point.
- b) Annunciated fascia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective fascia LED light is lighted.
- c) Each annunciation window shall be provided with two LED Lights to provide redundancy against LED light failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.
- d) All fascia annunciated points shall be suitable to accept external contacts of either „NO“ or „NC“ self or hand reset type for initiating the annunciation sequence shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds.
- e) For static Annunciator schemes, special precaution shall be taken by the Contractor to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels / desks.
- f) A “Lamp Test” push button shall be provided for each individual panels group of Annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible electronics alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.
- g) Annunciator shall have following features:
  - Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.
  - During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the “lamp test” circuit and shall start flashing.
  - Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.
  - “Alarm Supply Failure” Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply
  - Alarm annunciates having provision to integrate all alarm / trip signals to PLC.
  - Alarm annunciation shall be provided for transformers, Chlorination system and surge vessel system where ever discrete local automation is envisaged.
  - All Annunciations shall have interfacing facilities for communication for SCADA.

#### **I. Indicating Instruments & Meters**

- a) The instruments shall be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

##### **Metering Instruments**

- Multi Function Meter (MFM) with the facility to measure A, V, KW, KWh, KVA<sub>r</sub>, PF, Hz with communication port.
  - Multi-Function Meters shall be of the accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits.
- b) MFM shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire type test blocks for the testing of the



meters without disturbing the CT and VT secondary connections.

- c) The instruments can be electronic / digital type with LCD display & RS 485 connectivity for remote reading of parameters in SCADA. These instruments should have high performance ratio and can be equipped with digital output (for alarms).

**J. Control and Selector Switches**

- a) Control and instrument switches shall be heavy duty rotary type, provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust tight removable covers.
- b) The control switches shall be 3 positions, spring return to neutral type. They shall be provided with contacts to close in „normal after close“ and „normal after trip“ position.
- c) Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In addition, a semaphore indicator shall be provided for earthing switch. Local / Remote selector switch shall be stay put 2 /3 position with lockable provision.
- d) Contacts of the switches shall be spring assisted and contact faces shall be of silver / silver alloy. Springs shall not be used as current carrying parts. Contact rating and configurations of the switches shall be adequate for the functions desired. Lockable type switches, which can be locked in a particular position, shall be provided, if required. Emergency stop buttons, if any, shall incorporate „stay-put“ features with independent reset facilities.

**K. Indicating Lights / Pilot Lights**

- a) Indicating light shall be rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lights shall be provided with translucent light covers.
- b) Clustered LED type lamps shall be provided. Lenses shall be glass or plastic in standard colours, red, green, blue, white and amber, in accordance with IEC 60073. Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.
- c) The basis of colours shall be as follows:

Red: Flow of energy.

Green: No flow of energy.

White: Supervision of power available, relay coil healthy, etc.

Amber : For all alarm conditions such as pressure low, overload,

Disagreement with original condition,, „ abnormal“ condition or,, „ sequence-on“ condition also for service and test position.

Blue: For all healthy conditions such as control supply, spring charged and lockout relay coil healthy.

Yellow : For R, Y, B indication light, yellow as one of the light.

**L. Push Buttons**

- a) Push buttons shall be of momentary contact type with rear terminal connections. The colour of the push button actuator shall be red for „OPEN / STOP“ and green for „CLOSE / START“. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.
- b) Normal stop push button shall be mushroom type latchable in red colour, after pressing and it is latched, the latch can be removed by clockwise rotation. (Motor stops automatically after pre determined conditions such as delivery valve close in case of pumps.) This may replace stop push button.
- c) Emergency stop push button red in colour shall be lockable by pressing the push button and can be opening only with key and with shrouding. (Motor stopped immediately irrespective of predetermined conditions required) Emergency Push button with shrouding shall be provided near transformer and motors for remote tripping.
- d) Reset push button shall be either for resetting the flag and OLR or LEDs with push button for resetting.
- e) All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 5A at 110V DC.
- f) All push button shall have additional NO/NC potential free for hard wiring to instrumentation control panel.

**M. Space Heaters**

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle, bus ducts and Motors above 7.5 kW. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a RTD thermostat to cut off the heaters at 35 degree C.

**Note: space heaters shall be provided for all motors above 30 KW**

**N. Cubicle Lighting / Receptacle**

Each cubicle shall be provided with interior lighting by means of 18 W energy efficient (lumen per watt shall be indicated) fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240 V, 1 ph, 50 Hz, AC supply. A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

**O. Power and Control Cable Termination**

- a) Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable aluminium solder less crimping type of lugs for terminating the cables and control cables lugs and ferrules shall be tinned copper conforming to IS 8309. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of termination provide on the equipment.
- b) Double compression type glands with armour and bonding clamps for the termination of

all solid dielectric multicore cables shall be provided and shall confirm to BS: 6121. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.

- c) Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high voltage for one minute.
- d) Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds / bolts shall be provided at connections to completely cover the terminations.
- e) Where core-balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

**P. Wiring For Control and Protective Circuits**

- a) All low voltage wiring for control, protection and indication circuits shall be carried out with 1100 V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm.
- b) All wiring shall be run on the sides of panels and shall be neatly bunched and cleatted without affecting access to equipment mounted in the panel. The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping will not be accepted. Wire ways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one re-stripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire resistant material.
- c) Wiring shall only be jointed or tied at terminals. Terminals of the clamp type shall not have more than two wires connected.

**Q. Termination and Ferrules**

- a) Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels.
- b) Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire is removed.
- c) All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

**R. Control Wiring Terminal Blocks**

- a) Terminal blocks (TBs) shall be of 1000 V grade, 10A and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link

- between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.
- b) Terminals shall be numbered for identification, grouped according to function. Engraved „black on-white“ labels shall be provided on the terminal blocks describing the function of the circuit.
  - c) Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled. Terminals used for connecting current transformer secondary leads shall be „disconnecting and shorting“ type with a facility for earthing the secondary.
  - d) Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.
  - e) At least 20 % cores shall be kept spare in multicore control cables. At least 10% spare terminals shall be provided and space for adding another 10% spares terminals shall also available in each set of TBs.

**S. Bus Bars**

- a) The Bus bars shall be of electrical grade, high conductivity, copper and shall be provided with minimum clearances as per relevant IS. Bus bar cross section shall be uniform throughout the length of the switchgear.
- b) All bus bars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases.
- c) The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.
- d) Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint.
- e) Direct access to, or accidental contact with busbars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.
- f) Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.
- g) End terminations at transformer end and MV panel end shall be flexible bus bar such that no load / force / weight of the bus bar act on the terminal studs.

**T. Current & Voltage Transformers**

- a) Current transformers shall be of cast resin, bar-primary type unless specified otherwise, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure and shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block. The class of insulation shall be Class E or better.

- b) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear. For wound-primary type CTs, the short time current rating shall not be less than 0.5 sec. CT core laminations shall be of high grade silicon steel. Where multi-ratio current transformers are specified, a label shall be provided, clearly indicating the connections required for the alternative ratios.
- c) These connections shall also be shown on panel wiring diagrams. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboard.
- d) Magnetization characteristics, calculated performance and protective settings shall be provided by the Contractor. All Voltage Transformers shall be of Single Phase type. The bus VT's shall be housed in a separate panel in a truck so as to be fully withdrawable. All Voltage transformers shall have HRC fuses on Primary and Secondary Side. There shall be provision for changeover on secondary side of Voltage Transformers to have alternate arrangement in case one Voltage Transformer fails.

**U. Relays**

- (i) All Protective relays shall be numerical type. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity.
- (ii) All numerical protective relays shall be flush mounted at the front with connections at the rear. Shall have communication port for remote, metering and monitoring facility, suitable for electrical measurement including voltage, current, power (active / reactive) and energy parameters.
- (iii) All numerical relays shall have keypad to allow relay settings from relay front. Resetting knobs shall be accessible from the front on removing the external cover and shall be external to the case.
- (iv) All numerical relays and timers shall be rated for control supply voltage specified and be capable of satisfactory continuous operation between 70 % and 110 % of the rated voltage. Making, Carrying and Breaking Current ratings of the relay Contacts shall be adequate for the circuits in which they are used.
- (v) The numerical relays shall have communication, Metering and Monitoring Facility. The communication facility shall have two Ports local front port (RJ45/USB) for laptop communication and the second port (Rear RS485) for SCADA.
- (vi) The numerical processor shall be capable of measuring and sharing values of a wide range of quantities, events, faults and disturbance recordings with time stamping using internal real time clock. Battery backup for real time clock in the event of power failure shall be provided.
- (vii) Numerical Relays shall have diagnostic feature with self check for power failure, Programmable routines, memory and main CPU Failures etc.
- (viii) The Protective relays shall have adequate number of potential free contacts (Programmable). The Contacts shall be suitable for directly wiring in the breaker closing and tripping circuits operating from 110 V DC Control Voltage.

- (ix) The current operated relays shall have provision for 4 Sets of CT Inputs and Voltage operated relays shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current suitable for CT Secondary current of 1 A / 5 A selectable at Site.
- (x) Numerical Relays shall be immune to any kind of electromagnetic interference and capacitance effect due to length of connected control cables.
- (xi) Timer function shall be programmable for ON/OFF delays.
- (xii) Numerical Relays shall be able to provide supervisory function such as trip circuit monitoring, circuit breaker monitoring, PT & CT supervisions and recording facilities with post fault analysis.
- (xiii) All relays shall withstand minimum test voltage of 2 KV AC RMS for oneminute.
- (xiv) Numerical relays shall have two level password protections, one for read only and otherfor authorization for modifying the setting etc.

**V. Energy monitoring and power supply management**

- a) Necessary Provisions & features shall be incorporated to enable energy monitoring /energy management for the installation. Energy Metering shall meet the requirement of guaranteed specific energy consumption specified by the contractor through instrumentation control system.
- b) In case, Numerical relays having built in features of energy measurement of requisite accuracy and provided in switch gear, separate energy meter is not required.
- c) Necessary provision & features shall be incorporated to under voltage monitoring/ relay for incomer feeder, bus bar chamber and control supply.

**W. I / O signal for Instrumentation, Control & Automation System from Electrical panels.**

- a) I/O signals from instruments shall be separately wired to a marshalling box such that instrumentation engineers will not enter in to power panel that are not familiar with them.
- b) Necessary provisions shall be incorporated to meet the requirements indicated in
  - (i) I/O Schedules - ACB/VCB, Command Open & Close, Feedback trip, Breaker healthy (Ready to close), Local /Remote, Breaker Opened / Closed.
  - (ii) Data Transfer Schedule
  - (iii) Alarm Schedule of Particular requirement of Instrumentation, Control & Automation System, Part-13, and Volume 2 of the Bid document.

**X. Drawings and Data**

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates etc.

**1.4 FCMA NEUTRAL SOFT START PANEL**



#### **A. Applicable Standards**

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

|                                                                              |   |                                            |
|------------------------------------------------------------------------------|---|--------------------------------------------|
| Metal enclosed switchgear                                                    | : | IS: 3427                                   |
| Current transformers                                                         | : | IS: 2705/BS: 7626                          |
| Arrangement for switchgear busbars,<br>Main connections and auxiliary wiring |   | IS: 5578/IS: 11353                         |
| Busbar support insulators                                                    | : | IS: 2544/BS: 3297/IEC: 273                 |
| Degree of protection                                                         | : | IS: 13947 (Part I) /BSEN: 60529/ IEC:947-1 |
| Electrical relays for power system                                           | : | IS: 3231/BS: 142/IEC: 255                  |
| Protection                                                                   |   |                                            |
| Electrical indicating instruments                                            | : | IS: 1248/BS: 89/IEC: 51                    |
| A.C. electricity meters                                                      | : | IS: 722/BS: 2692                           |
| Specification for copper rods and bars<br>for electrical purposes            | : | IS: 613                                    |
| Code of practice for phosphating iron<br>And steel                           | : | IS: 6005/BS: 3189                          |

#### **B. Constructional and Performance Features**

- (a) Flux Compensated Magnetic Amplifier (FCMA) neutral soft start panel shall be indoor, metal clad with separate metal enclosed compartments for (i) control, metering and current transformers for differential protection (ii) shorting switch (iii) busbars (iv) power cable terminations (v) push buttons with indicating lamps.
- (b) FCMA shall achieve smooth starting by torque control for gradual acceleration of the drive system thus preventing jerks and extending the life of equipment.
- (c) Starting current shall be limited to 3.0 times the full load current of the motor.
- (d) Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.
- (e) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer plant. After application of the primer, two coats of finishing synthetic enamel paint oven baked/ stoved, shall be applied.
- (f) The cable compartment shall house all power cable connections along with associated cable terminations.
- (g) Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.
- (h) Caution name plate with inscription "Caution - Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals of main disconnecting switch.
- (i) Starting of motor shall be from either FCMA panel located near to motor or shall be from 11 kV motor modules or from PLC. Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

**C. Main Busbars**

- (a) Busbars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protecting all joints.
- (b) Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.
- (c) Busbars shall be of copper conductor of hand drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

**D. Earthing**

- (a) An earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted/ welded to the frame work.
- (b) All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

**E. Panel Accessories and Wiring**

- (a) Panel shall be supplied completely wired internally upto equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided.
- (b) All auxiliary wiring shall be carried out with 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 mm<sup>2</sup>.
- (c) Terminal blocks shall be of stud type, 650 volts grade 10 amps rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.
- (d) All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.
- (e) Accuracy class for indicating instruments shall be 2.0 or better. Instruments shall be 110 mm square, 240V scale for flush mounting with only flanges projecting.
- (f) Relays shall be suitable for flush mounting with only flanges projecting.
- (g) All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose and shall be included. All auxiliary relays and timers shall be supplied in non-draw-out cases. Externally operated hand reset flow indicators shall be provided on all relays and timers. Timers shall be of electromagnetic or electronic type only.
- (h) Push buttons shall be provided with inscription plates engraved with their functions.
- (i) Indicating lamps shall be panel mounting type with series resistors. The wattage of lamps shall be 5 to 10 watts.
- (j) Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 240 V, 1 ph, 50 Hz supply. They shall be complete with HRC fuses, isolating switches and thermostat.
- (k) Each panel shall be provided with 240 Volts, 1 phase, 50 Hz, 5 amps, 3 pin receptacle with switch located in a convenient position. An interior illuminating lamp together with the operating door switch and protective fuses shall be provided.
- (l) Provision shall be made for receiving, distribution, isolating and fusing of auxiliary D.C. and A.C. supplies for controls, space heating etc. The fuse ratings shall be so chosen



as to ensure selective clearance of sub circuit faults.

- (m) Fuses shall be HRC cartridge type mounted on plug in type fuse base.
- (n) The D.C. and A.C. auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit fuses as required.

**F. Cable Termination**

- (a) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc.
- (b) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solderless crimping type .
- (c) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc. shall be supplied.

**1.5 415 V METAL ENCLOSED SWITCHGEARS / MCC**

**A. Applicable Standards**

The switchgear and its components shall conform to the latest applicable standards specified below. .

|                                                                                                      |                                         |
|------------------------------------------------------------------------------------------------------|-----------------------------------------|
| Switchgear General Requirements                                                                      | IS:13947/BS:5486/IEC:60947              |
| Factory Built Assemblies of SWGR and Controlgear for Voltages upto and including 1000V AC & 1200V DC | IS:8623/BS:5486/IEC:60439               |
| Air Break Switches                                                                                   | IS:13947-P3 /BSEN60947 /IEC:60947-3     |
| Moulded Case Circuit Breaker                                                                         | IS 2516 / IEC 60947-2/ BS EN 60947-2    |
| Miniature Circuit Breakers                                                                           | IS:8828/BSEN:60898                      |
| Low voltage Fuses                                                                                    | IS:13703/BS:1362/IEC:60269-1            |
| Contactors                                                                                           | IS:13947/BS EN60947-4 /IEC:60947-1      |
| Starters                                                                                             | IS:13947/BS EN60947-4/IEC:60292-1TO 4   |
| Control Switches / Push buttons                                                                      | IS:6875 / BSEN 60947                    |
| Current Transformers                                                                                 | IS:2705/BS:7626                         |
| Voltage Transformers                                                                                 | IS:3156/BS:7625/IEC:60044, 60186        |
| Indicating instruments                                                                               | IS:1248/BS:89/IEC:60051                 |
| Marking and Identification of Conductors and Apparatus Terminals                                     | IS:11353/BS:159                         |
| A.C. Electricity Meters                                                                              | IS:722, 8530/BS:5685 / IEC 60145,60 211 |
| Degree of Protection                                                                                 | IS:13947/IEC:60947-P1                   |
| Selection installation and maintenance of switchgear and controlgear                                 | IS:10118                                |

|                                                                                    |                 |
|------------------------------------------------------------------------------------|-----------------|
| Code of practice for phosphating iron and steel                                    | IS:6005/BS:3189 |
| Specification for copper rods and bars for electrical purposes                     | IS:613          |
| Control transformers for switchgear and controlgear voltage not exceeding 1000V AC | IS:12021        |

## **B. Features of Construction**

The LV switchboard is proposed with "FORM 4 –B" enclosure as per the Indian Standard. All indoor boards/ panel are proposed with a degree of protection of IP54 while all outdoor equipment above ground are proposed with a degree of protection of IP65 and above as per site condition.

- (a) The switchgear shall be metal enclosed, dust proof, modular type, suitable for indoor floor mounting and shall have following features.
  - (i) Total height of switchgear shall not exceed 2300 mm. Height of Switches; Pushbuttons shall not exceed 1800 mm and shall not be less than 700 mm.
  - (ii) Shall be double front execution and fixed type
  - (iii) Shall have designation labels both on front and rear sides
  - (iv) Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.
  - (v) Degree of Protection shall be IP54.
  - (vi) Thickness of CRCA Sheet is 2mm.
- (b) Switchgear shall be divided into distinct vertical sections each comprising :
  - (i) A completely enclosed busbar compartment running horizontally
  - (ii) Enclosed vertical busbars serving all modules in vertical section
  - (iii) A separate horizontal enclosure for all auxiliary power and control buses if required
  - (iv) Vertical cable alley of 250mm wide covering entire height
- (c) Operating devices shall be incorporated only in the front of switchgear
- (d) Each shipping section shall have metal sheets at both ends.
- (e) Cable alley shall be provided with suitable hinged doors.
- (f) GS/GI Earth bus of size 50mm x 10 mm shall be provided at the bottom.
- (g) Rear of Single Front Switchgear shall be provided with removable panels with screws.
- (h) All doors shall be with concealed type hinges and captive screws.
- (i) Each vertical section shall be equipped with 240 V, 1 Phase, 50 Hz space heater controlled by thermostat.
- (j) A 240 V, 1 phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for correction of head lamps.
- (k) Interchange ability  
All identical equipment and corresponding parts be fully interchangeable without any modifications.
- (l) Main and Auxiliary Buses
  - (i) Switchgear busbars shall be of uniform cross section throughout the length and made of high conductivity, electrical grade hard drawn copper conductor.
  - (ii) Busbar shall be fully insulated by encapsulation in epoxy resin with moulded caps

protecting all joints and shall be adequately supported to withstand stresses developed due to short circuits. Supports shall be of glass reinforced phenolic material or cast resin.

- (iii) Busbar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts and Belleville washers and nuts.

**C. Air Circuit Breaker (ACB)**

- (a) Air circuit breaker shall be selected for feeders for load current equal to and more than 630A.
- (b) Circuit breakers shall be operated by a motor spring charging type of mechanism. The motor operated spring charged mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.
- (c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.
- (d) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.
- (e) The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.
- (f) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.
- (g) All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication.
- (h) Closing coils and other auxiliary devices shall operate satisfactorily at all voltages  
between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.
- (i) The Breaker shall be provided with Microprocessor based releases for Inverse-time delayed overload releases for the phases, Short-time delayed short-circuit releases and earth-fault releases.
- (j) The breaker service Short Circuit breaking capacity (ICS) shall be equal to ultimate Short Circuit capacity (ICU) and shall be equal to short time withstand current of Breaker (ICW)

**D. Moulded Case Circuit Breaker (MCCB)**

- (i) MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, moulded, insulating material housing. MCCBs shall have an ultimate short circuit capacity not less than the short circuit current Specified .MCCBs shall have a service short circuit breaking capacity ( $I_{CS}$ ) equal to the ultimate short-circuit capacity ( $I_{CU}$ ).
- (ii) Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.
- (iii) The MCCBs shall be provided with the following features.
  - (i) Common trip bar for simultaneous tripping of all poles
  - (ii) Shrouded terminals
  - (iii) Time for clearing short circuit current of 20 msec.
  - (iv) 2 NO + 2 NC auxiliary contacts

**E. Switches and Fuses**

- (a) 415 V air-break switched shall be of the load break, fault make, group operated type. For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral wire. For use on single phase system and d-c systems, the switches shall be of the two pole type.
- (b) Switches shall be of the heavy duty, quick make and quick break type. Switch contacts shall be silver plated, and contract springs shall be of stainless steel. Switch handles shall have provision for locking in both fully open and fully closed positions. Mechanical ON-OFF indication shall be provided on the switches.
- (c) Switches for controlling motor circuits shall be of the load break, fault make type, and shall be capable of breaking locked rotor current of the associated motor.
- (d) 415 V switches and fuses shall be provided with the following interlocks so that :  
The fuses are not accessible unless the switch is in fully open condition  
It is not possible to close the switch when the fuse cover is open, but an authorised person may override the interlock and operate the switch. After such an operation, the cover shall be prevented from closing if the switch is left in the „ON“ position.
- (e) All fuses shall be of the HRC cartridge type, mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated.
- (f) Earthing and neutral lines in main supply circuits shall be of solid silver plated copper and be of the bolted pattern.
- (g) Fuses and links functionally associated with the same circuit shall be mounted side by side.

**F. Miniature Circuit Breaker (MCB)**

- (a) MCB shall be hand operated, air break, quick make, quick break type.
- (b) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

- (c) Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Where this is not specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

**G. Contactors**

- (a) The power contactors used in the switchboard shall be of, air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947.
- (b) Operating coils of all contactors shall be suitable for operation on 240 V, single phase, 50 Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70 % of coil rated voltage. Contactors shall be provided with a three element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings.  
The hand reset button shall be flush with the front door of the control module, and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactor shall all be provided with single phasing preventer (SPP).
- (c) Motor starters shall be complete with auxiliary relays, timers and necessary indications.

**H. Current Transformers**

- (a) Current Transformers shall be Cast Resin type.
- (b) Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block.
- (c) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear, as indicated in the Technical Specification.
- (d) CT core laminations shall be of high grade silicon steel.
- (e) Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

**I. Voltage Transformers**

- (a) Voltage Transformers shall be Cast Resin type.
- (b) Secondary and tertiary windings of voltage transformers shall be rated for a three phase line to line voltage of 110 V.
- (c) It shall be possible to replace voltage transformer fuses easily without having to de energise the main bus-bars.

**J. Indicating Instruments & Meters**

- (a) Electrical indicating instruments shall be 110 mm square with 240° scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers. Instrument dials shall be white with black

numbers and lettering.

- (b) Normal maximum meter reading shall be of the order of 60 % normal full scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current. Watt hour meters shall be of the induction type and shall be provided with reverse running stops. Instruments shall have an accuracy of Class 1.0.

**K. Indicating Lamps**

Indicating lamps shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 240 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers. Bulbs and lenses shall be interchangeable and easily replaceable from the front.

**L. Push Buttons**

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head.

**M. Space Heaters**

Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 350 °C.

**N. Safety Arrangements**

All terminals, connections and other components, which may be "live" when front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door is opened. Components within the cubicles shall be labelled to facilitate testing.

**O. Earthing of Switchboards / Panels**

- (a) Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.
- (b) Earth bus bars shall be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth bus bars shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated switchboard/panel.
- (c) Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.



- (d) All instrument and relay cases shall be connected to earth bus bar by means of 1100 V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

**P. Internal Wiring**

The internal wiring shall be carried out with 650/1100V grade, PVC insulated, stranded conductor wires. The minimum size of conductor for power circuits shall be 4 Sq.mm copper or equivalent size aluminium conductor. Control circuits shall be wired with copper conductor of atleast 1.5 Sq.mm.

**Q. I / O & Other Data for Instrumentation, Control & Automation System**

Necessary provisions shall be incorporated to meet the requirements indicated in

- (a) I / O Schedules
- (b) Data Transfer Schedule
- (c) Alarm Schedule

**1.6 415 V POWER CAPACITOR AND CONTROL PANEL**

**A. Applicable Standards**

The capacitor and control panel conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern

|                                                                             |                                     |
|-----------------------------------------------------------------------------|-------------------------------------|
| Shunt capacitors for power systems                                          | IS : 13340                          |
| Internal fuses and internal overpressure disconnectors for shunt capacitors | IS : 12672                          |
| Metal enclosed switchgear                                                   | IS : 3427 / BSEN 60298/ IEC : 60298 |
| Code of practice for phosphating iron and steel                             | IS : 6005/BS : 3189                 |
| Specification for copper rods and bars for electrical purpose               | IS : 613                            |

**B. Design Features**

- (a) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.
- (b) The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanised.
- (c) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which will result in the failure of the parallel units.

- (d) The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free standing type.
- (e) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer paint. After application of primer, two coats of finishing synthetic enamel paint oven baked/stoved shall be applied.
- (f) The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers may be provided in the cubicle to ensure proper ventilation.
- (g) Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS : 2834.
- (h) Capacitors shall be of Mixed Dielectric of polypropylene and paper with internal element fuses. The impregnant shall be non PCB (poly chlorinated biphenyl) oil.
- (i) Each unit shall satisfactorily operate at 135% of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage upto a maximum of 10% above the rated voltage, excluding transients.
- (j) **Unit Protection**  
Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse braking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

**C. Power Capacitor and Control Panel**

- (a) Power capacitor and control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.
- (b) The control equipment including capacitors shall be mounted in a panel of cold rolled sheet steel. The panel shall be of indoor type and shall consist of :
- (c) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity
- (d) Isolating switch
- (e) Contactor with overload element
- (f) Relays responsive to current/voltage/KVAR/PF as specified for automatic switching
- (g) Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.
- (h) Auto-manual selector switches
- (i) Push button for opening and closing the power circuit.
- (j) Red and green lamps for capacitors ON/OFF indication.
- (k) Protective relays to protect the healthy capacitor units when one unit fails in a series connection.
- (l) Space heater and cubicle lighting as per the requirements.



**D. Drawings and Data**

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified,

**1.7 415V BUS-DUCT**

- (a) All bus-ducts will be of non-segregated metal enclosed phase with cross over chamber (if required), all bends and accessories like flexible expansion joints, terminal connectors and flanges, wall frame assembly etc.
- (b) The Bus-bar shall be
  - (i) Electrolytic grade copper
  - (ii) 99% purity
  - (iii) 97% Conductivity
- (c) The metal enclosed bus duct shall be designed to operate continuously under the conditions specified in Data Sheet.
- (d) The material of the enclosure shall be CRCA with minimum thickness of 2 mm.
- (e) Bus-duct enclosure will be of MS epoxy painted with outer shade of Siemens grey RAL 7032 & black matt paint on the inside. Paint thickness shall be 140 microns or above.
- (f) Wall frame assembly shall be provided if required.
- (g) The enclosure shall be totally enclosed, dust & vermin proof with ventilation louvers.
- (h) All nuts, bolts, hardware used for Bus-duct shall be of M12 size, grade 8.8 & of cadmium.
- (i) All joints in the enclosure shall have neoprene gaskets.
- (j) The Bus-duct shall comply with the technical parameters of the latest version of the IS/IEC
- (k) The bus duct shall be inclusive of the following:
  - i. Straight run of the duct
  - ii. 90 deg bends
  - iii. Copper flexible at Transformer end
  - iv. Copper flexible at LT DG end
  - v. Copper flexible at LT panels end.
  - vi. Wall frame assembly and seal off bushing
  - vii. Phase crossover chamber
- (l) The bidder shall submit type test certificates along with the bid for Bus duct for The following:
  - i) S.C. withstand capacity for 1 second.
  - ii) Degree of protection.
  - iii) Temperature rise.

## **1.8 DIESEL STANDBY GENERATOR**

### **A. Applicable Standards**

The Diesel Standby Generator and its components shall conform to the latest applicable Standards specified below:

|                                                                                                                                                                 |                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| Diesel Engines for General Purposes                                                                                                                             | : BS 5514 / ISO 3046                                  |
| The Electrical Performance of                                                                                                                                   | : BS 5000                                             |
| Rotating Electrical Machinery                                                                                                                                   |                                                       |
| Rotating Electrical Machines                                                                                                                                    | : IS 4722                                             |
| Circuit breakers                                                                                                                                                | : IS-13118, BS-5311, IEC-56 & 694,                    |
| BSEN-60942 (P-2)                                                                                                                                                |                                                       |
| Air break switches air break disconnectors,<br>air break switch disconnectors and fuse<br>combination units for voltage not exceeding<br>1000 V AC or 1200 V DC | : IS-13947 (P-3), BS-EN60947, IEC-<br>60947-3         |
| Current transformer                                                                                                                                             | : IS-2705/BS-7626, IEC-60185                          |
| Voltage transformer                                                                                                                                             | : IS-3156/BS-7625/IEC 60186                           |
| Electrical Relays                                                                                                                                               | : IS-3231,3842/BS-142/IEC-60255                       |
| Contactors for voltage not<br>exceeding 1000 V ac or 1200 VDC                                                                                                   | : IS-13947 Part-IV/ BSEN-60947-4-<br>1/ IEC-60947-4-1 |
| Control Switches                                                                                                                                                | : IS-6875/BSEN-60947 /                                |
| IEC-60947-4-1                                                                                                                                                   |                                                       |
| High Voltage Fuse                                                                                                                                               | IS-9385/BS-2692/ IEC-60282                            |
| Low Voltage Fuse                                                                                                                                                | : IS-13703/BS-1362 IEC-269-1                          |
| Electrical direct acting indicating<br>Instruments                                                                                                              | : IS-1248/BS-89/IEC-60051                             |
| A.C. electricity metres of induction<br>type voltage greater than 1000 volts                                                                                    | : IS722, 8530/BS-5685 / IEC-60145,<br>60211           |
| Resistance wire, tapes and stripes<br>for heating elements                                                                                                      | : IS-3725                                             |
| Wrought aluminium and aluminium<br>alloy bars, rods, tubes and sections<br>for electrical purposes                                                              | : IS-5082                                             |
| Specification for copper rods and<br>bars for electrical purposes                                                                                               | : IS-613                                              |
| Toggle switches                                                                                                                                                 | : IS-3452/BS-3676                                     |
| Control switches/push buttons                                                                                                                                   | : IS-6875/BSEN 60947                                  |
| Noise and Emission Limit<br>of Environment and Forests                                                                                                          | : As per latest notification of ministry              |

**B. General Requirements**

- (a) The diesel engine shall draw cooling air directly from outside the room through a weather proof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel. The exhaust system pipe shall be 2 Meters above the nearest building as per CPCB. The exhaust pipe line diameter shall be suitably designed to avoid back pressure when discharged at higher elevation. The silencer shall be of the „residential“ type and be located externally.
- (b) The generation voltage shall be 415V for D.G capacity less than 2 MVA and generation voltage shall be 11kV for D.G capacity more than 2 MVA. Even if one D.G set is required for achieving the required capacity they shall be operated in parallel with necessary synchronizing arrangement with LCD.
- (c) At no point D.G sets will be operating parallel with grid. The diesel engine fuel shall be stored in an above ground bulk storage steel tank to be located adjacent to the generator room at a site accessible for filling to local road tankers.
- (d) The storage tank shall be sized to store fuel for 1 day running of the engine at full load. The tank shall be provided with fittings to permit the visual observation of fuel level and filling by local tanker operators. A level sensor shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.
- (e) The fuel storage tank shall be located in a bund capable of holding not less than 125% of the maximum storage tank contents. Fuel transfer pumps shall be provided to automatically transfer fuel from the bulk storage tank to a high level 990 litres day tank located in the generator room or generator skid mounted day fuel tank. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump.
- (f) Any leakage from the pumps shall be routed to the bund. A system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally) and if a high level day tank is used, to automatically dump the day fuel back to the bulk storage tank.
- (g) The Fuel system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm. Adequate sensors shall be provided to detect the fault and shall be wired to control panel.
- (h) The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.
- (i) All alarms shall be conveyed to the central HMI through the PLC.

**C. Diesel Generating Set Automatic Control**

- (a) AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting during mains power failure.
- (b) Diesel generating set for use in auto mains failure mode shall have a three position automatic /off /manual selection and shall operate as follows:
  - (i) Automatic mode :

On occurrence of mains failure the following sequence shall be followed.

a) Mains to Generator changeover

- mains failure detected
- delay of 10 seconds
- generator is started and run up to speed
- time delay of 50 seconds
- mains supply is switched off
- generator supply is switched on

b) Generator to Mains changeover

- mains healthy detected
- manual changeover signal received,
- generator supply is switched off
- mains supply is switched on
- generator runs for 2 minutes and stops

All timer settings shall be adjustable.

- (c) If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after their attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:

- (d) The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

**D. Alternator for Diesel Generating Set & Biogas Generator Set**

- (a) The generation voltage shall be 415V for capacity less than 2 MVA and generation voltage shall be 11kV for capacity more than 2 MVA.
- (b) Alternator shall be 4 pole, 3 phase, 50 Hz, 0.8 P.F, salient pole, revolving field, Brush less type, self-regulating continuously rated and manufactured in accordance with IS 4722, BS 5000: Part 99 or IEC 60034-1. They shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 43.
- (c) The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects.

- (d) The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved.
- (e) Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12 hour Period under the specified conditions of temperature, humidity and atmospheric pressure. Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised.
- (f) The alternator shall have pre-packed grease lubricated ball or roller bearing and provided with facilities for degreasing whilst in service. The alternator shall be foot mounted on a common bed frame with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW.
- (g) The alternator vibration level shall not exceed the values defined in IS 12075. The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds. The alternator shall be fitted with an anti-condensation Alternator shall have 6 Nos. duplex RTDs inside the stator winding. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%.
- (h) The alternator, its neutral and control panel shall be earthed as per relevant standards. Alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier, surge protection device and salient pole rotating field system. The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within  $\pm 2.5\%$  for a power factor of 0.8 to unity, including hot to cold variations.
- (i) The steady state frequency droop between no load and full load shall not exceed 5%. Transient voltage deviation following a step load of 60% of rated at a power factor of between 0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5 second.
- (j) The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within  $\pm 5\%$  of rated. Alternator shall have sensors for alternator protection and shall be wired to control panel.
- (k) The alternator shall be provided with class F insulation with temperature rise limited to that of class B insulation.

**E. Diesel Engine for Generating Set**

- (a) Engine shall be four-stroke, direct injection, and turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.
- (b) Engines shall be rated for continuous duty at site ambient conditions with an inherent O/ L Capacity of 10% for 1 hour in any 12 hours.
- (c) The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10,000 hours between major overhauls. The maximum operating speed shall be 1500 rpm. The range of manual adjustment shall not be less than  $\pm 5\%$  of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.
- (d) Engine governors shall be suitable for remote control load sharing between identical

- engine units. In addition to any electrical over speed trips, there shall be a mechanical over speed device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only.
- (e) The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2.
  - (f) Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by-pass valve shall be incorporated.
  - (g) Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer.
  - (h) The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0°C. An engine driven alternator and charging system shall be provided. An automatic mains energized battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to full fill the starting requirements.
  - (i) Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine is inhibited whilst the hand turning equipment is connected.
  - (j) Twin heavy duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbo charger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.
  - (k) Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), and water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion. Engine shall be provided with sensors for engine protection and shall be wired to control panel.
  - (l) Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for levelling purpose and shall be designed to resist horizontal movement of the diesel set.

- (m) The fuel System shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all inter connecting pipe work , flexible engine connection pipe etc.

**F. Diesel Generator Control Panel:**

- (a) The control panel shall have provision such that inter-opera ability with instrumentation control system. The control panel with communication facility shall be separately mounted on anti vibration mountings and shall comprise the following:

(i) Breaker incorporating short circuit and overload trip

(ii) Earth fault protection for the Alternator

(iii) Alternator Over & Under Voltage Protection

(iv) Voltage Controlled Over Current Relay

(v) Voltmeter with built in selector switch /( digital)

- ammeter with built in selector switch / (digital)
- frequency meter
- Power Factor Meter
- KWH Meter (Multifunction meter)
- engine temperature and oil pressure gauge
- service hours run indicator
- key switch start and stop control
- operational status indicator
- anti-condensation heater and thermostat
- alternator anti-condensation heater controls
- mains fed battery charger
- Auto start on mains power supply failure facility
- Fails to Start (Alarm )
- Over / Under Voltage (Alarm)
- Battery Charger Fault (Alarm)
- Low fuel Oil Level (Alarm)
- Over Load (Alarm)
- Low Lube Oil Pressure (Trip)
- High Water Temperature(Trip)
- High Lube Oil Temperature (Trip)
- Electrical Protection Relays (Trip).

- (b) A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting.

- (c) Simple operating instructions shall be detailed on the fascia of the control panel. All alarm and trip status signals from diesel supply system, engine control panel and alternator protection shall be hard wired to a marshalling box for instrumentation control system.



**G. Synchronising Panel**

Whenever two or more sets are required to operate together, necessary synchronizing panel complete with circuit breaker, synchroscope, numeric relays, digital meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

**H. Acoustic Enclosure**

- (i) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.
- (ii) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam/glass wool as acoustic material.
- (iii) The sound level shall be restricted to 75dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.
- (iv) The acoustic enclosure shall be certified to meet the emission norms.

**I. Bulk Fuel Storage Tanks**

- (i) Bulk fuel storage shall be in accordance with the explosives norms and necessary approval shall be obtained by the contractor.
- (ii) Tanks and fittings, etc shall conform to IS 803 or BS 799: Part 5The tank shall be constructed in mild steel and the fittings in materials other than:
  - (iii) Yellow brass, including low grade alloys of copper and zinc.
  - (iv) Lead and zinc.
  - (v) Galvanized metals.
  - (vi) Natural rubber.
- (vii) The maximum fuel surface level below the point of entry of the vent shall not be less than 100 mm. The internal surface shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment.
- (viii) The following fittings shall be included:
  - (a) 600 mm diameter manhole complete with portable cover situated in the top of the tank complete with ladder to the interior.
  - (b) Dipstick, calibrated in litres with guide tube and striker plate.
  - (c) Local indication of fuel level to be given at a position where it can be easily read during fuel delivery.
  - (d) Filling pipe work and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning.
  - (e) Outlet pipe situated at the raised end of the tank not less than 150 mm above tank bottom, complete with check valve, isolating valve and end cap.
  - (f) Drain pipe situated at lowest point in tank complete with isolating valve and captive end cap.
  - (g) Inlet fittings for overflow pipe from daily service tank or tanks (where specified).
  - (h) Vent pipe situated at high level in the tank. The pipe shall rise continuously from the tank and terminate with an inverted 'U' bend and vermin screen.
  - (i) External ladder for horizontal tanks more than 2 m diameter.



- (j) Level sensors shall be included which are connected to Low fuel oil level.

## **1.9 UPS SYSTEM**

- (a) UPS shall be supplied as per Instrumentation specification. UPS shall be three phase incoming supply with breaker.
- (b) All UPS shall have IGBT technology for rectifier and inverter.
- (c) The system shall be complete with all mounting stands, insulators, interconnecting accessories etc all as per enclosed specifications and data sheets.

## **1.10 BATTERY, BATTERY CHARGER & DCDB**

- a) Battery, Battery Charger shall be three phase incoming supply with breaker. DCEquipment shall comply with IEC 60896 including those standards referred to therein.
- b) General Requirements

Following items shall be covered in the Contract:

- (i) 110 V Value Regulated Lead Acid Battery (VRLA)
  - (ii) Float-cum-boost charger for 110 V batteries
  - (iii) DC distribution board.
  - (iv) Min. 30 minutes backup for batteries
- c) All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.
  - d) The system shall be complete with all mounting stands, insulators, interconnecting accessories etc all as per enclosed specifications and data sheets.

### **A. Valve Regulated Lead Acid Battery**

#### **Design Features**

Battery offered shall be Value Regulated Lead Acid Battery (VRLA) Type. The battery shall conform to the latest applicable standards specified below:

Stationary Value Regulated Lead Acid Batteries Specification : IS 15549-2005

- a) The equipment offered shall be complete with all parts that are necessary or usual for the efficient operation of the equipment, whether specifically mentioned or not.
- b) The VRLA batteries shall be starved electrolyte type to allow recombining of generated oxygen internally. The battery shall be completely explosion resistant, shall tolerate freezing and shall not allow gases to escape during normal charging conditions. The battery shall not require any topping and be maintenance free.
- c) All inter cell, inter modules and inter stack connectors shall be covered with heat shrunk FR/FRLS sleeves.
- d) Containers, cell lids, safety vents, separators, connectors, electrolyte, shall conform to the relevant IS/IEC and safety standards. The cell containers shall conform to the safety requirements of UL 94 HB or equivalent safety standard. The safety vent shall

be self resealing pressure regulating with flame arrestor. In case the batteries are proposed to be housed in a sheet metal or polymeric enclosure, the same is deemed to be included in the scope of the bidder. The enclosure for battery shall conform to the safety provisions of UL 1778 or equivalent standard.

e) The battery shall be complete with accessories and devices, including but not limited to the following:

i) Battery racks

ii) Set of intercell, inter- module and inter stack connectors as required for the complete installation.

iii) Accessories for testing and maintenance

f) Battery racks shall be constructed from steel. Metallic stands shall be painted with acid resistant paint after 2 coats of primer. The racks shall be rigid, mechanically strong, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form continuous row. Insulators shall be provided below the legs of the stands (h)1 set of accessories for testing and maintenance shall also be provided suitable for all the three battery banks.

i. One- -3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.

iii. Two -PVC aprons

iv. Two -Cell lifting straps

v. One set -Terminals and cable boxes with glands for connecting cable as required.

Each of

Spare connectors

Spare vent plugs

Spare nuts and bolts

Suitable set of spanners

## **B. Battery Charger and D.C. Distribution Board**

### Applicable Standards

The battery charger and D.C. Distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability : IS: 9000  
tests for components for electronic and electrical equipment

Environmental tests for electronic and electrical : IS: 9000  
equipments

|                                                                                                                 |                                               |
|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| Metal clad base material for printed circuits for use in electronic and telecommunication equipment             | : IS: 5921                                    |
| Transformers and inductors (power audio, pulse and switching) for electronic equipment                          | : IS: 6297                                    |
| Printed wiring boards                                                                                           | : IS: 7405                                    |
| Environmental requirements for semi-conductor devices and integrated circuits                                   | : IS: 6553                                    |
| Terminals for electronic equipment                                                                              | : IS: 4007                                    |
| Factory built assemblies of switchgear and control gear for voltages upto and including 1000 V AC and 1200 V DC | : IS:8623/BS:5486 / IEC:60439                 |
| Air break switches                                                                                              | : IS: 13947(Part-3) BSEN 60947-3              |
| Miniature circuit breakers                                                                                      | : IS 8828/BSEN: 60898                         |
| HRC cartridge fuses                                                                                             | : IS: 9224/BS: 88                             |
| Contactors                                                                                                      | : IS: 13947 (Part - 3) /BS: 775/ IEC: 60158-1 |
| Control switches/push buttons                                                                                   | : IS: 6875                                    |
| Indicating instruments                                                                                          | : IS: 1248/BC: 89/ EC:51                      |
| Degree of Protection                                                                                            | : IS: 13947-(Part 1) /IEC: 60947-1            |
| Climate-proofing of electrical equipment                                                                        | : BSCP: 1014                                  |
| Code of practice for phosphating iron and steel                                                                 | : IS: 6005/BS: 3189                           |
| Semi-conductor converters                                                                                       | : IEC: 60146                                  |
| Semi-conductor rectifier equipment safety code                                                                  | : IS: 6619                                    |
| Specification for copper rods and bars for Electrical purposes                                                  | : IS: 613                                     |

#### **Battery Charger**

- (a) Battery charger shall be combined float-cum-boost type.
- (b) The charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit.
- (c) The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The BIDDER shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.
- (d) The float charger shall be designed for supplying :
  - (i) The D.C. loads specified under Sr. No. 8.19.2 of Vol II, Part-8 i.e. continuous load and short-time overload.
  - (ii) The trickle charging current of the battery.
- (e) The boost charger shall be designed for supplying the boost charging current of the battery.
- (f) If the battery and charger are to be supplied by separate contractors, the charger Contractor shall coordinate with the battery contractor regarding float /trickle boost charging current & voltages required for the battery.
- (g) Battery Charger shall be provided with facility for both automatic and manual control

of output voltage and current and necessary selector switch shall be provided. Contractor regarding the float/trickle and boost charging current and voltages required by the battery,

- (h) Performance
- (i) Float Charger

The D.C. output voltage during float charging shall be stabilised within

- (i) 1% of the set DC bus voltage. Manual control shall be used if auto mode fails.
- (ii) Boost Charger  
For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. After a specified number of hours (adjustable) when the rated cell voltage is reached, the charger shall be returned to float charge status.
  - In case of combined float-cum-boost charger, the switching and control of high rate charge and return to float charge shall be by automatic controller/regulator.
  - Manual control shall be used if auto-mode fails.
  - During boost charging following emergency measures shall be provided:
  - If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.
  - If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.
- (j) Suitable filter Circuits shall be provided in the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of D.C Loads.
- (k) The D.C System shall be unearthed.

#### **Charger Panel and D.C. Distribution Board**

- (a) Battery charger panel and D.C. distribution board shall be sheet metal enclosure free standing type with cable entry from bottom.
- (b) Indications, controls and output voltage setting adjustments shall be on front panel. The Contractor shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.
- (c) The components shall be liberally rated and housed in a well ventilated sheet metal cubicle complete with input and output terminals. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.
- (d) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.
- (e) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins.
- (f) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.
- (g) All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.

- (h) All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring will be 1.5 mm<sup>2</sup> and for power wiring shall be 2.5 mm<sup>2</sup>.
- (i) Ground terminals with isolating links shall be provided.
- (j) Cable glands shall be provided to suit the incoming and outgoing cables.

**Components/Accessories**

- (a) The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the Contractor's scope. Instead of incoming ON/OFF switches, stricker fuses and contactors, the Contractor may provide suitably rated 3 pole MCBs with overload and short circuit protection and auxiliary contacts.
- (i) One (1) set - Three phase full wave full controlled bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor/ capacitor network for surge protection. The diodes/SCRs shall be individually protected by fuses with fuse fail indication.
- (ii) One (1) Double wound, dry type, three phase suitably rated mains transformer.
- (iii) One (1) set of suitably rated control transformers for electronic controller.
- (iv) One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of <1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.

The electronic controller shall be provided with following features.

- Boost current stabilisation of  $\pm 2\%$  with AC input variation of voltage and frequency variation of  $\pm 10\%$  and  $\pm 5\%$  respectively.
- Boost charge current limiter with potentiometer to adjust the setting.

- (v) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.
- (vi) One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.
- (vii) One (1) Auto/Manual selector switch for selecting the mode of operation of the controller.
- (viii) One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto mode.
- (ix) One (1) front panel mounted potentiometer for manual adjustment of voltage in manual mode.
- (x) One (1) TP AC ON/OFF switch for float charger incoming.
- (xi) One (1) set of HRC fuses complete with fuse fittings for AC input with suitable ratings and with trip indication.
- (xii) One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains, "ON" condition.

- (xiii) One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch.
- (xiv) One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.
- (xv) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current.
- (xvi) One (1) Double pole DC ON/OFF rotary switch for float charger output.
- (xvii) One (1) pilot lamp with series resistor to indicate float charger DC „ON“ condition.
- (xviii) Annunciation System for the following
  - (a) AC Supply Failure.
  - (b) Rectifier Fuse Failure.
  - (c) Surge Circuit Fuse Failure.
  - (d) Filter Fuse Failure.
  - (e) Load Limiter Operated.
  - (f) Charger Trip.
  - (g) Battery on Float.
  - (h) Battery on Boost.

#### **Power Electronic Components**

- (a) Diode and thyristors shall be of monocrystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.
- (b) If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care should be taken to select matched pairs of rectifier heat sink units.
- (c) Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.
- (d) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.
- (e) The diodes or thyristor banks shall be natural air cooled.
- (f) The diodes or thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varistor). It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of busbars and as near as possible identical contact resistance in each current path.

### **1.11 CABLING SYSTEM: HV, LV, CONTROL AND TELECOMMUNICATIONS**

#### **A. Applicable Standards**

The cables shall conform to the latest applicable standards specified below.

PVC insulated cables : IS: 694

(For voltage upto 1100 V)

|                                                                   |                                 |
|-------------------------------------------------------------------|---------------------------------|
| HRPVC & PVC insulated cables<br>heavy duty                        | : IS: 1554                      |
| Crosslinked polyethelen insulated<br>PVC sheathed cables          | : IS: 7098                      |
| Low frequency cables and wires with<br>PVC insulation and sheath  | : IEC: 60189-1 &<br>IEC-60189-2 |
| PVC insulation and sheath of electric<br>cables                   | : IS: 5831                      |
| Polyethylene insulation and sheath for<br>electric cables         | : IS: 6474                      |
| Conductors for insulated electric cables                          | : IS: 8130                      |
| Methods of test for cables                                        | : IS: 10810                     |
| Specification for drums of electric cables                        | : IS: 10418                     |
| Specification for PVC insulated cables<br>for electricity supply  | : BS: 6346                      |
| Specification for PVC insulation and<br>sheath of electric cables | : BS: 6746                      |

## **B. Features of Construction**

### **a) XLPE Insulated HV Power Cables :**

The Cables shall be 11 KV/ 11 KV (Un earthed) grade, heavy duty, stranded aluminium Conductor, XLPE Insulated, Conductor Screening by extruded Semiconducting Compound, insulation screening through Combination of semi conducting compound and non magnetic tape( Copper tape), inner sheath over laid up cores, galvanised steel wire /strip armoured (Aluminium wire armouring for single core cables), outer sheath of extruded black PVC Compound type ST-2. Core Identification shall be by printed numerals.

### **b) LT Power Cables**

#### **(i) PVC Insulated Cables:**

The Cables shall be 1.1 KV Grade, heavy duty, Stranded Aluminium/ Copper Conductor, PVC Compound type A insulated, inner sheathed, galvanised steel wire /strip armoured, black PVC compound type ST1 outer sheathed.

#### **(ii) XLPE Insulated Cables:**

The Cable shall be 1.1 KV Grade, heavy duty, stranded aluminium/ Copper Conductor, XLPE insulated, inner sheathed, galvanised steel wire/ strip armoured ,extruded black PVC Compound type ST2 outer sheathed.

### **c) Control Cables:**



The Cables shall be 1.1 KV grade, heavy duty, stranded copper conductor, PVC Compound type A Insulated, galvanised steel wire/ strip armoured extruded PVC type ST1 outer sheathed.

d) Telecommunication Cables:

The cables shall meet the following requirements:

- (i) Conductor : Solid, tinned, annealed copper
- (ii) Insulation : PVC insulation Type-A as per IS:5831
- (iii) Twisting : The insulated conductors shall be twisted together to form twisted pairs or quads, these shall be stranded in concentric layers to form the cable core. The cable thus formed shall be tightly lapped with outer wrapping tapes.  
The interstices of insulated cable core shall be completely filled with viscose compound
- (iv) Overall screening : With 0.075 mm Aluminium tape or 0.013 mm melinex tape, overlap not less than 30%
- (v) Other details : A suitable non-magnetic rip cord shall be laid longitudinally under the sheath. The armouring shall be of galvanised steel wires or galvanised single steel strip. The inner PVC sheath shall be of Type-A. The outer PVC sheath shall be of Type ST-1.

**C. Cable Rating**

- a) The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.
- b) In assessing the rating of any cable or wire, the following factors shall be taken into account:
  - Supply voltage and frequency
  - Maximum voltage drop permissible
  - Type and magnitude of load
  - Fault level and duration related to circuit protection relays and fuses
  - Circuit over current protection
  - Route length and disposition of cables
  - Ambient temperature
  - Method of installation
- c) All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 45 °C. The design current of any circuit shall exceed the full load current of the supplied device by at least 10%. Power cables shall be sized to limit the maximum voltage drop to no more than 3 %.
- d) Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the



remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation. HV and LV cables shall be sized for a fault clearance time of 0.5 seconds for the incoming feeders and 0.16 seconds for switchboard feeders controlled by circuit breaker.

**D. Cable Colours**

All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

The colour coding should be as follows:

|                    |                      |
|--------------------|----------------------|
| 3 Phase            | Red, Yellow And Blue |
| Single phase or DC | Red And Black        |
| Earth              | Green/Yellow         |
| Control            | Blue (DC), Red (AC)  |

**E. Cable Conductors**

Copper conductors shall be used for cables of sizes upto 6 Sq.mm. Aluminium conductors shall be used for cables of size 10 Sq. mm and above. Cores of cross-sectional area greater than 1.5 mm<sup>2</sup> shall be stranded. Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm<sup>2</sup>. Power cables shall be of a minimum cross-section of 2.5 mm<sup>2</sup>. Internal wiring of control panels shall be of a minimum cross-section of 1.0 mm<sup>2</sup> flexible and stranded. Control cables shall be of a minimum cross-section 1.5 mm<sup>2</sup> for external use and 1.0 mm<sup>2</sup> for internal use.

**F. Cable Numbering**

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three digit numbers.

|                   |          |
|-------------------|----------|
| HV power          | HV-P__ _ |
| LV power          | P__ _    |
| Control           | C__ _    |
| Instrumentation   | I__ _    |
| Protection        | PR__ _   |
| Telecommunication | T__ _    |

**G. Cable Drums**

Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

The Bidder shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within

tolerance limit of < 5% without any tolerance on total ordered quantity of each size of cable. However before winding the cables on drums. Contractor shall obtain Employer's approval for the drum lengths.

Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size, and number of cores, length, result and date of tests as required in the Employer's Requirements. Cables manufactured more than 12 months before delivery will not be accepted. All cables shall be delivered with cable ends effectively sealed by hygroscopic scaling caps. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

**H. Drawings and Data**

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, Test certificates etc shall be submitted along with the bid/ after award of contract as specified, " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

**1.12 CABLE CARRIER SYSTEM**

**A. General**

The cable carrier system covers the supply of cable racks, cable trays and its supporting accessories.

**B. Applicable Standards**

|                                                                     |            |
|---------------------------------------------------------------------|------------|
| Steel for general structural purposes                               | : IS: 2062 |
| Dimensions for hot rolled steel beam                                | : IS: 808  |
| Column channel and angle sections                                   |            |
| Code of practice for use of metal arc                               | : IS: 816  |
| Welding for general construction in Mild steel                      |            |
| Hot deep galvanising of iron & steel                                | : IS: 2629 |
| Methods of testing uniformity of coating Of zinc coated articles    | : IS: 2633 |
| Hot dip zinc coatings on structural Steel and other allied products | : IS: 4759 |

**C. Cable Racks and Trays**

- (a) All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanised.

- (b) Cable trays shall either be run in concrete trenches or run overhead supported from building steel, floor slab, cable racks, cable cum pipe racks, etc.,.
- (c) Vertical trays/raceways and outdoor cable trays shall be covered by removable 16 gauge GS sheet covers.
- (d) The size of ladder/perforated cable trays to be supplied and installed shall be 150, 300, 450, 600 and 800 mm wide.
- (e) The mounting structures/cable racks shall be fabricated from standard structural steel members (channels, plates, angles and flats).
- (f) The cable racks and supports shall be painted after installation with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint

**D. Galvanising**

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below;

**(a) Fabricated Steel**

Thickness less than 2 mm, but not less than 1.2 mm      340 gms/sq.m

Thickness less than 5 mm, but not less than 2 mm      460 gms/sq.m

Thickness 5 mm and over      610 gms/sq.m

**(b) Fasteners**

Upto nominal size M10      270 gms/sq.m

Over M10      300 gms/sq.m

Galvanising shall be carried out after all drilling; punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

**1.13 LIGHTING SYSTEM**

**A. General Requirements**

- (a) Refer Part 12- Particular Requirements, Volume-2 of Bid Documents for the requirements of lighting system.
- (b) LED lighting shall be considered for indoor and outdoor lighting. Conventional lighting shall be considered subject to the requirement and approval of Employer. However general requirements of conventional lighting along with LED lighting have been described in the following sections.
- (c) The Lighting system includes the following items.

- (i) Lighting fixtures complete with Lamps and accessories.
- (ii) Lighting system equipment
  - Light control switches, receptacle units with control switch units, lighting wires, conduits and other similar items necessary to complete lighting system.
  - Lighting fixture supports, street lighting poles and flood light towers.
  - Main Lighting distribution board, lighting panels.
  - Multi core cables for street, boundary and flood lighting.
- (d) All Lighting Fixtures, luminaries shall be considered for Emergency Lighting and fed from Main Lighting Board supplied by both mains supply normally and DG Set during power failure.
- (e) DC Emergency Lighting shall be provided for Control rooms of Switchyards SCADA room, Switchgear and Control room of Pump houses.

**B. Applicable Standards**

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

|                                                                               |   |                                         |
|-------------------------------------------------------------------------------|---|-----------------------------------------|
| Lighting Fixtures & Accessories Electrical                                    | : | IS: 1913/ BS: 4533                      |
| lighting fittings general and Safety requirements                             |   |                                         |
| Code of practice for industrial lighting                                      | : | IS: 6665                                |
| Calculation of co-efficient of utilisation                                    | : | IS: 3646 (Part - III)                   |
| Industrial lighting fittings with metal Reflectors                            | : | IS: 1777                                |
| Decorative lighting outfits                                                   | : | IS: 5077                                |
| Dust proof electric lighting fittings                                         | : | IS: 4012                                |
| Dust tight electric lighting fittings                                         | : | IS: 4013                                |
| Flood lights                                                                  | : | IS: 10322/BS: 4533                      |
| Luminaires for street lighting                                                | : | IS: 10322 Part 5                        |
| Water tight electric lighting fittings                                        | : | IS: 3553/ BS: 4533, 5225(I)             |
|                                                                               | : | IS:1258/BSEN                            |
| Bayonet lamp holders                                                          |   | 61184IEC:60061                          |
| Edision screw lamp holders                                                    | : | IS: 10276/BSEN 60238                    |
| Bi-Pin lamp holders for tubular fluorescent lamps                             | : | IS: 3323                                |
| Starters for fluorescent lamp                                                 | : | IS: 2215/BSEN 60155                     |
| Holders for starters for tubular fluorescent Lamps                            | : | IS: 3324/ BSEN 60400                    |
|                                                                               | : | IS: 1534 (Part 1)/BSEN                  |
| Ballast for use in fluorescent lighting fitting                               |   | 60920& 60921                            |
| Transistorised ballast for fluorescent lamps                                  | : | IS: 7027                                |
| Ballast for HP mercury vapour lamp                                            | : | IS: 6616                                |
| Capacitors for use in fluorescent, HPMV & LP sodium vapour discharge Circuits | : | IS:1569/ BSEN 61048 & 61049 /IEC: 60586 |

|                                                                          |                                             |
|--------------------------------------------------------------------------|---------------------------------------------|
| Vitreous enamel reflector for tungsten :<br>Filament lamp                | IS: 8017                                    |
|                                                                          | : IS: 2418 (Part -1) /BSEN 60081 IEC: 60081 |
| Tubular fluorescent lamps                                                |                                             |
| High pressure mercury vapour lamps                                       | : IS: 9900/BS: 3677/ IEC: 60188             |
| Tungsten filament general electric lamps                                 | : IS: 418/IEC: 60432                        |
| Cast acrylic sheets for use in Luminaries                                | : IS: 7569                                  |
| Screwless terminal and electrical connections :<br>for lighting fittings | IS: 10322                                   |
| High pressure sodium vapour lamps                                        | : IS: 9974                                  |
| Emergency lighting units                                                 | : IS: 9583                                  |
| Ignition proof enclosures, dust-tight for Elect. :<br>Equipment          | IS: 11005                                   |
| Luminaires                                                               | : IS: 10322 (Part I to V)                   |

### **Lighting System Equipment**

|                                                                                                                         |                                        |
|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| Arrangement for busbars, main connections :<br>and auxiliary wiring and marking                                         | IS: 5578/ 11353/BS: 159                |
| Enclosed distribution fuse boards and cutouts :<br>for voltages not exceeding 1000V                                     | IS: 2675/ BSEN 60439                   |
| General requirements for switchgear and :<br>control gear for voltages not exceeding 1000<br>V                          | IS: 13947                              |
| Code of practice - installation and :<br>maintenance of switchgear                                                      | IS: 10118/BS: 6423 BS 6626,<br>BS 6867 |
| Factory built assemblies of switchgear and :<br>control gear for voltages upto and Including<br>1000 V AC and 1200 V DC | IS: 8623/BS-5486/ IEC: 60439           |
| Miniature air break circuit breakers for AC :<br>circuits                                                               | IS: 8828/ BSEN 60898                   |
| HRC cartridge fuse links upto 650 V                                                                                     | : IS: 9224/BS: 88/ IEC: 60269          |
| „D“ Type fuses                                                                                                          | : IS: 8187                             |
| Current transformers                                                                                                    | : IS: 2705/BS: 7626/ IEC: 60185        |
| Voltage transformers                                                                                                    | : IS: 3156/BS: 7625/ IEC:60186         |
| Direct acting electrical indicating Instruments                                                                         | : IS: 1248/BS: 89/ IEC: 60051          |
| A.C. electricity meters                                                                                                 | : IS: 722/BS 5685                      |
| Electrical relays for power system protection                                                                           | : IS: 3231/BS: 142/ IEC: 60255         |
| Switches for domestic and similar purposes                                                                              | : IS: 3854/BS: 3676                    |
| Three pin plugs and socket outlets                                                                                      | : IS: 1293/BS: 546                     |
| Boxes for enclosure of electrical accessories                                                                           | : IS: 5133(1)                          |
| Rigid steel conduits for electrical wiring                                                                              | : IS: 9537/BS: 31                      |
| Accessories for rigid steel conduits for :<br>electrical wiring                                                         | IS: 3837/BS-31                         |
| Flexible steel conduits for electrical wiring                                                                           | : IS: 3480                             |
| Rigid non-metallic conduits for electrical                                                                              | : IS: 9537/BS: 4607(2)                 |

Installations

|                                                                                         |   |                      |
|-----------------------------------------------------------------------------------------|---|----------------------|
| Fittings for rigid non-metallic conduits                                                | : | IS: 3419/BS: 4607(2) |
| PVC insulated cables for working voltages upto and including 1100 V Tubular steel poles | : | IS: 694              |
| Specification for copper rods and bars for electrical purposes                          | : | IS: 2713             |
| Code of practice for phosphating iron and steel                                         | : | IS: 613              |
| Fittings for rigid steel conduits for Electrical wiring                                 | : | IS: 6005/ BS: 3189   |
|                                                                                         |   | IS: 2667             |

**C. Lighting Fixtures (Luminaries)**

- (a) Luminaries shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.
- (b) The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.
- (c) Connections between different components shall be made in such a way that they will not work loose by small vibration.
- (d) For each type of Luminaires the Contractor shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.
- (e) All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage with the variation in supply voltage, frequency and combined voltage and frequency of  $\pm 10\%$ ,  $\pm 5\%$  and  $\pm 10\%$  respectively.
- (f) The Luminaires and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.
- (g) Fluorescent type, metal halide type luminaires shall be complete with accessories like lamps, ballasts, power factor improvement capacitors, starters, re-wirable fuse and fuse base. These shall be mounted as far as possible in the luminaire housing only. If these cannot be accommodated integral with the Luminaires then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box.
- (h) Fluorescent type Luminaires with more than one lamp shall be provided with capacitors connected in lead-lag circuit for correction of stroboscopic effect.
- (i) Each luminaire shall have a terminal block suitable for loop-in, loop-out and T-off connection by 250/400 V, 1 core, PVC insulated copper/aluminium conductor wires upto 4 sq.mm in size. In outdoor areas the termination at the luminaire shall be suitable for 1100 V, PVC insulated, copper/aluminium conductor, armoured cables of sizes upto 6 sq.mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by means of standard copper wire of minimum 1 sq.mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

- (j) Mounting facility and conduit knock-outs for the luminaries shall be provided.
- (k) Earthing
  - (i) Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.
  - (ii) Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.
  - (iii) All metal or metal enclosed parts of the luminaire/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.
- (l) Painting/Finish
  - (i) All surfaces of the Luminaire/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.
  - (ii) When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.
  - (iii) The luminaire housing shall be stove-enamelled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings.
  - (iv) The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 1/2" dia. mandrel.
  - (v) The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection.
  - (vi) External control gear box provided for housing accessories shall be painted or galvanised.

**D. LED Lighting**

- (i) High Power White LEDs used in the luminaries shall have wattage greater than ONE watt.
- (ii) LED shall be operated at a forward current of less than 90% of the rated current.
- (iii) Colour Rendering Index (CRI) of the LEDs used in the luminaire shall be greater than 70.
- (iv) The illumination of the luminaire shall be uniform without dark bands or abrupt variations and soothing to the eye.
- (v) Light Uniformity Ratio ( $E_{min} / E_{avg}$ ) would be  $> 0.4$ .
- (vi) Luminary Body Temperature would be less than 30 °C above the ambient, even after continuous burning of Luminary for 24 Hrs.
- (vii) The Luminaire works on single phase three wire system (Phase, Neutral & Earth).
- (viii) The luminaire housing is made up of Corrosion free High Pressure Aluminum die cast thus confirming the luminaire to IP-68 protection and safety as per IEC 60598-1.
- (ix) The Luminaire is equipped with distortion free, clear, Heat Resistant toughened, UV stabilized glass cover in the front fixed to the die cast Aluminum frame which would be fixed to the housing by means of stainless steel screws.
- (x) The minimum technical specifications for LED lighting will be as follows:
  - a. Powered by the latest bright LEDs with high efficiency and meeting LM-80 standard.



- b. Average rated life span of 50000 hrs.
- c. LED efficacy shall be greater than 125 Lumens/watt.
- d. Luminaire efficacy of at least 80 Lumens/watt.
- e. Input voltage range 90-300 V.
- f. Power factor > 0.9.
- g. THD < 15%.
- h. Ingress protection as per IP 68 for outdoor luminaires
- i. Operating temperature -5°C to 50°C
- j. Storage temperature -5° to 70°C
- k. Humidity 10% - 100%
- l. LEDs shall be operated at a forward current less than 90% of its rated current.
- m. The LEDs used in the luminaire shall have minimum angle of 120 degree.
- n. Colour rendering index (CRI) of the LEDs shall be greater than 70.
- o. Conform to Photo Biological Safety for the LEDs as per IEC 62471.
- p. Free replacement warranties of 5 years for technical defects.

#### **E. Decorative Luminaries**

- (a) These luminaires shall be generally indoor type provided with cold rolled cold annealed (CRCA) sheet steel channel/rail cum reflector housing complete with all electrical control accessories mounted on it. The finish shall be stove enamelled.
- (b) Decorative fluorescent type luminaires shall be either open type, provided with translucent white opal acrylic diffusers, polystyrene lens prismatic or square polystyrene louvers.
- (c) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column pendant mounting or for recess mounting in false ceiling.
- (d) Decorative luminaires with mirror optic reflectors shall be of the wide angle dispersion type. Where these luminaires are mounted in control rooms and computer rooms, clip-on type adjustable reflectors which can be attached onto the tube shall be provided to direct the light output in the desired direction. This is mainly to reduce reflection of the light source from TV/monitor screens.
- (e) Luminaires mounted recessed in false ceiling shall be with reflector housing and spring loaded fixing arrangement for the diffuser/louver frame. It shall be possible to have access to the lamp and other accessories from below.

#### **F. Industrial Luminaries**

- (a) The luminaire shall be provided with CRCA sheet steel mounting rail with reflector of minimum 20 SWG thicknesses and complete with all control accessories mounted on it.  
The finish shall be vitreous enamelled.
- (b) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column/pendent mounting.
- (c) The distribution of light shall be such that at least 80% of the total luminous flux from the luminaire shall be in the lower hemisphere.
- (d) The luminous output of the luminaire with reflector shall not be less than 75% irrespective of type of reflector used.



**G. Bulk Head / High Bay luminaires**

**Bulk Head Luminaire**

- (a) The luminaire shall be of robust construction, with cast aluminium/vitreous enamelled housing, heat and shock resistant prismatic or clear glass cover fixed with neoprene gaskets for sealing. For mechanical protection to the glass cover, round steel wire-guard with vitreous enamelled finish shall be provided.
- (b) The luminaire shall be suitable LED lamp upto 150 watts, for direct mounting to ceiling/wall/column and used for general purpose indoor lighting.

**High and Medium Bay Luminaries**

- (a) High and medium bay luminaires shall be with cast aluminium housing, anodised aluminium mirror polished reflector canopy with eye bolt for suspension, cooling fins and glass cover.
  - (i) The luminaire shall be suitable for LED/ Magnetic Induction lamps upto 1000 watts. The control gear accessories shall be mounted integral with the luminaire.
  - (ii) High bay luminaires shall be used when the mounting height is above 8 metres while medium bay luminaires shall be used when the mounting height is around 6 to 8metres.

**H. Flood Light Luminaire**

**General purpose flood light luminaire**

- (a) Flood light luminaires shall be of weather proof construction with cast aluminium housing, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.
- (b) The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.
- (c) For focussing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.
- (d) The Luminaires shall be suitable for LED /Magnetic Induction lamps upto 400 watts, incandescent lamps upto 1000 watts.
- (e) The luminaire shall be provided with cable gland on the canopy in down ward direction for cable connection.
- (f) It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.
- (g) It shall be possible to replace the lamp from the canopy without opening the front glass.

**I. Outdoor Lantern Luminaries**

**Post top Lantern**

- (a) Post top lantern Luminaires shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.

- (b) The luminaire shall have cast aluminium spigot of 50/60 diameter finished with corrosion proof paint for mounting, opal acrylic or high density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.
- (c) The luminaire shall be suitable LED Lamps.

**J. Sub-station Lantern**

- (a) Sub-station lantern shall be generally outdoor weather proof type for illumination of switchyard equipment.
- (b) The luminaire shall have cast aluminium housing finished with corrosion proof paint, spigot for mounting on pole, prismatic glass refractor dome to give distribution of light in horizontal plane, anodised aluminium reflector to give light distribution at an angle 20 to 40 degrees, above the horizontal plane, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.
- (c) The Luminaires shall be suitable LED/ Magnetic Induction lamps of suitable wattages.

**K. Portable Emergency LED Light Luminaire**

- (a) Emergency light of Installite luminaire shall be indoor type for providing emergency light during failure of normal AC supply.
- (b) The luminaire shall be with CRCA sheet steel enclosure, complete with metallised mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two metre length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.
- (c) The luminaire shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminaire shall pick-up automatically and on restoration of A.C. supply the luminaire shall switch off automatically.
- (d) The luminaire shall be suitable for LED lamps of suitable wattages.

**L. Accessories for Luminaries**

**Reflectors**

- (a) The reflectors shall be made of CRCA sheet steel/aluminium/silvered glass/chromium plated sheet copper as indicated for above mentioned luminaries.
- (b) The thickness of steel/aluminium shall comply with relevant standards. Reflectors made of steel shall have vitreous enamelled finish. Aluminium used for reflectors shall be anodized/epoxy stove enamelled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.
- (c) Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient so as to ensure the overall light output specified by the Contractor.
- (d) Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

**M. Lamp/Starter Holders**

- (a) Lamp holders shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with under normal installation and use.
- (b) Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamps holder shall not be exposed during insertion or removal of lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position.
- (c) Lamp holders for incandescent, mercury vapour and sodium vapour lamps shall be of Edison Screw (E.S.) type.
- (d) The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

**1.14 LIGHTING SYSTEM EQUIPMENT**

**A. Main Lighting Distribution Board and Lighting Panels (AC & DC)**

**(a) Constructional Features**

- (i) Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 52. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP 55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.
- (ii) All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets. For the main floor mounted distribution boards with the switch fuse units arranged in tier formation, the hinged door of each unit shall be interlocked so as to prevent opening of the door when the switch is ON and to prevent closing of the switch with the door not fully closed.

However, a device for by-passing the door interlock shall be provided to enable the operation of the switch with the door open, when necessary, for examination /maintenance. For wall mounting 1-phase ways lighting panels when provided with MCBs, a hinged, latched front door shall be provided with key-locking facility and a slotted bakelite sheet shall be provided inside. Only the MCBs operating knobs or the fuse cap covers shall project out of the bakelite sheet slots for safe operation and neat appearance. Incoming to lighting panels shall be provided with TPN MCB with ELCB.

- (iii) All accessible live connections/metals shall be shrouded and it shall be possible to change individual fuses, switches, MCBs from the front of the boards/panels without danger of contact with live metal.
- (iv) For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.

- (v) Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.
- (vi) Two earthing terminals shall be provided to suit the earthing conductor.
- (vii) All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognised phosphating process. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final stove-enamelled finish paint of specified colour.

**(b) Busbars**

- (i) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.
- (ii) Busbars shall be provided with at least the minimum clearances in air as per applicable standards for 500 V, 3 phase system.
- (iii) Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers and contacts does not exceed 85°C under site reference ambient temperature.
- (iv) The busbars, busbar connections and busbar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the fuse/MCB's let through/cut-off current associated with the specified short-circuit level of the system.
- (v) Busbar supports shall be made from suitable insulating material such as Hylam sheets; glass reinforced moulded plastic materials, permali wood or cast resin. Separate supports shall be provided for each phase of the busbars. If a common support is provided for all three phases, anti-tracking barriers shall be incorporated.
- (vi) The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase busbars. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase busbars. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

**B. Panels/Boards" Component Equipment**

- (a) Switches/Miniature Circuit Breakers (MCB)
  - (i) Switches/MCBs shall be hand operated, air break, quick make, quick break type conforming to applicable standards.
  - (ii) The switch shall be protected by fuse and the MCB shall be provided with overload/short-circuit protective device for protection under overload and short-circuit conditions. The minimum breaking capacity of MCBs shall be 6 kA R.M.S.at 415 V/220 V D.C.
  - (iii) Switch shall have provision for locking in both fully open and closed positions. MCBs shall be provided with locking facility.
  - (iv) The connections between switch and fuse shall be insulated and all live connections shall be shrouded.

(b) Fuses

- (i) Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of 80 kA at 440 V. Fuses upto 63A for distribution systems of medium short circuit levels may be of HRC cartridge screw-cap, D type, having a certified rupturing capacity of not less than 46 kA at 440 V and 16 kA at 250 V D.C.
- (ii) Fuses shall be provided with visible indication to show that they have operated.
- (iii) Cartridge fuses shall preferably be mounted in moulded plastic carriers. If fuse- carriers are not provided, insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

(c) Indicating Instruments and Meters

- (i) Whenever required, instruments and meters shall be of the flush mounting type. They shall be suitably mounted so as to provide for easy access to CTs and small wiring.
- (ii) Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.
- (iii) Watt-hour meters shall be of direct reading electro-dynamometer type complete with cyclometer type dials and reverse running stops.
- (iv) Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.
- (v) Potential fuses shall be provided at the tap-off point from the busbars for the voltmeters.

(d) Instrument Transformers

- (i) Current and voltage transformers shall be of the dry type, of metering accuracy class 1.0. Unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.
- (ii) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for shortcircuiting and grounding the CTs at the terminal blocks.
- (iii) Voltage transformers shall be provided with suitably rated primary and secondary fuses.

(e) Indicating Lamps

Indicating lamps shall be of the filament type and low watt consumption. Lamps shall be provided with series resistors.

(f) Internal Wiring

- (i) Panels/boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 650/1100V grade, PVC insulated, stranded aluminium/copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.
- (ii) Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

- (iii) All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20 A.
- (iv) Terminals for circuits with voltage exceeding 125 V shall be shrouded.
- (v) Terminals shall be numbered and provided with identification strip for identification of the circuit.
- (vi) Terminal blocks for C.T. secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

**C. Labels & Diagram Plate**

- (a) All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/panel.
- (b) Labels shall be made of non-rusting metal, 3-ply lamicaid or engraved PVC.
- (c) Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

**D. Light Control Switches**

- (a) Light control switches of ratings and types, i.e. decorative/industrial shall be supplied as required. The switches shall be suitable for use on 240 V, 1 Ph, 50 Hz supply.
- (b) Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure.  
The switch box/enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.
- (c) The size of enclosure boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 18 gauge sheet steel galvanised.  
The enclosure box shall be covered with perspex/insulating cover. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

**E. Receptacle Units**

- (a) Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch or MCB shall be flush mounted within galvanised 18 gauge steel enclosure with insulation cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.
- (b) The receptacle units shall be suitable for 240 V, 1 ph - N, 50 Hz/415 V, 3 Ph - N, 50 Hz supply as required.
- (c) Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in "ON" position.



- (d) Three phase receptacles shall be associated with a TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch is in "ON" position.
- (e) The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

**F. Lighting Wires**

- (a) The wires for wiring in lighting system shall be 250/440 V, 1/C, PVC insulated, unarmoured with stranded copper conductors.
- (b) The minimum area of conductors shall be 2.5 sq.mm. for light fittings and 5A Receptacles and 4 sq.mm for receptacles rated 15 A and above.
- (c) The wires shall be coaded white for phase/positive of D.C. and black for neutral/negative of D.C.

**G. Conduits**

- (a) Rigid steel/non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.
- (b) Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5 m.
- (c) Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

**H. Junction Boxes**

- (a) Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.
- (b) The junction boxes shall be dust and vermin proof and shall be fabricated from 14 gauge sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.
- (c) The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, HRC fuses as required.
- (d) The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.
- (e) The boxes shall be painted with one shop coat of Red oxide zinc chromate primer followed by a finishing coat of paint.

**I. Lighting Poles and Flood Light Pole Mounting**

- (a) Lighting poles for street lights and flood lights shall be of stepped tubular steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface.

Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied.

- (b) Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. A steel ladder shall be provided. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.
- (c) The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes. The required sizes of poles and the junction box shall be as indicated in the attached drawings.

### **1.15 EARTHING AND LIGHTNING PROTECTION SYSTEM**

#### **A. General**

- (i) The earthing and lightning protection system covers earthing conductors, earth electrodes and accessories.
- (ii) Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system. Crane rails, tracks, metal pipes and conduits also shall be earthed at two points.
- (iii) Steel RCC Columns, metallic stairs and rails of the building housing electrical equipment also shall be connected to nearby earthing grid conductor. Metallic sheaths/ screens and armour of multicore cables shall be earthed at both ends. Metallic sheaths and armour of single core cables shall be earthed at the switchgear end only.
- (iv) Every alternate post of switchyard fence shall be connected to the earth grid by GS flat and gates by flexible lead to earthed post.
- (v) Each Continuous laid length of cable tray shall be earthed at minimum two places by GS/GI Flats to earthing system, the distance between the earthing points shall not exceed 30m.
- (vi) Lightning Protection System shall comprise vertical / horizontal air terminations, down conductors, test limits and earth electrodes. Air terminations, down conductors and test links shall be of galvanised steel conductors and earth connection below the ground level shall be of mild steel.
- (vii) Lightning Protection System down conductors shall not be connected to other earthing conductors above the ground level.

#### **B. Applicable Standards**

The earthing and lightning protection system shall conform to the Indian Electricity rules, and the latest applicable standards indicated below:

Code of Practice for Earthing : IS: 3043

Code of Practice for the Protection of : IS/IEC: 62305



Building and allied structure against lightning

Hot dip galvanising : IS: 2629, 2633, 4759

Structural steel : IS: 2062 & 808

Welding : IS: 816

**C. Earthing Conductor**

- (i) The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor. The material used for the earthing conductor shall be as follows:
  - (a) Conductors above ground shall be galvanised steel flat;
  - (b) Conductor buried in the ground or embedded in concrete shall be mild Steel, rod /flat.
- (ii) Allowance shall be made for reduction in the cross section of the steel over the design life of the earthing system;
- (iii) The earth electrode system shall comprise one or more earth electrodes, earthing network, mesh or a combination of these in order to obtain the required earth electrode resistance.
- (iv) Earth electrodes where used shall be of heavy duty galvanised mild steel of not less than 40 mm NB and 3000 mm long. Where multiple electrodes are used they shall be separated by a distance of not less than the driven length.
- (v) Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing tapes shall be connected. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked 'Electrical Earth'.
- (vi) All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Employer's Representative.
- (vii) Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.
- (viii) After the earth installation has been completed the Contractor shall demonstrate to the Employer's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.
- (ix) Marker posts and plates shall be provided to mark the route of buried tape or conductor electrodes. The markers shall be similar to those provided for cable routes.
- (x) Lightning Protection System
  - a) The need of lightning protection has been established by calculating the overall risk factor as per IS/IEC 62305.
  - b) Air termination system comprising of rods/mesh or combination of both will be provided and the methods used to determine the positioning of Air termination system will be as per IS 62305.

- c) Air termination system will be connected to the earthing system by down conductors fixed along the outer surface of building. Number & layout of the down conductors will be as per IS/IEC 62305.
- d) Each down comer will be terminated to a separate treated test earth electrode which in turn will be connected to station earthing system.
- e) Test link will be provided in the run of each down conductor at approximately 1000 mm above ground level.

**D. Main Equipotential Bonding Conductor**

- (i) Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.
- (ii) Equipotential bonding conductors shall have the following minimum sizes, the contractor shall specifically design the equipotential earthing for each site locations.

a) Main Equipotential Conductors

|                                                                                 |            |        |
|---------------------------------------------------------------------------------|------------|--------|
| -Main Earth Conductor buried in earth                                           | 40 mm dia. | MS Rod |
| -11/0.433 kV transformers, main switchboard and standby generator installation. | 50 x 10 mm | flat   |
| -interconnection to lightning protection system                                 | 50 x 10 mm | flat   |
| interconnection to MCC s                                                        | 50 x 10 mm | flat   |

b) Equipotential Conductors

|                                                                                                                  |                             |      |      |
|------------------------------------------------------------------------------------------------------------------|-----------------------------|------|------|
| - interconnection to CP s                                                                                        | 25 x 3 mm                   | flat |      |
| - power factor correction capacitor panel                                                                        | 25 x 3 mm                   | flat |      |
| - local push buttons                                                                                             | 14 SWG                      | wire |      |
| - lighting distribution board                                                                                    | 4 SWG                       | wire |      |
| - lighting and receptacle system                                                                                 | 12 SWG                      | wire |      |
| - outdoor street lighting                                                                                        | 8 SWG                       |      | wire |
| - ladder rack and cable tray at suitable points                                                                  | 25 x 3 mm                   | flat |      |
| - hand rails and metallic structures                                                                             | 25 x 3 mm                   | flat |      |
| - building reinforcement                                                                                         | 25 x 3 mm                   | flat |      |
| - incoming and outgoing process services                                                                         | 25 x 3 mm                   | flat |      |
| - steel structures comprising storage tanks, mezzanine platform, crane rails, air handling ductwork systems etc. | 25 x 3 mm                   | flat |      |
| - LV Motors                                                                                                      |                             |      |      |
| - up to 10 kW                                                                                                    | 8 SWG                       |      | wire |
| - 10 to 20 kW                                                                                                    | 4 SWG                       |      | wire |
| - 20 to 50 kW                                                                                                    | 25 x 3 mm                   |      | flat |
| - Earth electrode                                                                                                | 40mm dia 3000 mm long heavy |      |      |

Duty G.I. pipe electrode

**Notes:**

1. Equipotential conductors shall interconnect between the device to be bonded and the main equipotential conductor.
2. Connections to building structural steelwork or concrete reinforcement shall be made by a bolted connection to a tag welded to the steelwork or reinforcement bars. Unless otherwise specified at least two connections shall be made to the steelwork and reinforcement bars at the perimeter of each building at diagonally opposite locations.

**E. Circuit Protective Conductors**

- (i) An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:
  - a separate core within a multicore cable;
  - a separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor,
  - The metal sheath of an armoured cable. The sheath shall be bonded to the metalwork of the apparatus and to the apparatus earth bar if any;
  - the copper sheath of a mineral insulated copper sheathed cable;
  - an independent earthing conductor MS or GS conductor run adjacent to the circuit it protects.
- (ii) Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e. motors in excess of 75 kW shall form a separate core of a multicore cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.
- (iii) The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.
- (iv) Where the cable armouring or sheath is used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.
- (v) Instrumentation Earth

An instrumentation earth bus, if required shall be provided in each control panel. This shall comprise a **copper flat** of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the instrument earth. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before. In this fashion all instrument earths shall be connected radially from the same earth point.

- (vi) The earth pit for instrumentation system shall be separate. Electric earth pits shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.
- (vii) SPDs associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturers recommendations.

#### **F. Galvanising**

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

##### **a) Fabricated Steel**

Thickness less than 2 mm,

But not less than 1.2 mm 340 gms/sq.m

Thickness less than 5 mm, but not less than 2 mm 460 gms/sq.  
M

Thickness 5 mm and over 610 gm / sq.m

##### **b) Fasteners**

Upto nominal size M10 270 gms/sq.m

Over M10 300 gms/sq.m

Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

### **1.16 FIRE DETECTION AND ALARM SYSTEM**

- (a) Fire alarm system shall be provided for notification of fire alarm, supervisory and trouble condition and to control fire safety functions.
- (b) The design requirements are defined in the specifications. as part of design engineering, fire alarm scheme based on requirements of NFPA 72, National Fire Alarm Code (2002 edition) shall be developed for the areas given in the tender drawings.

- (c) The Fire Alarm and Detection system shall comply with NFPA 72 & IS 2189 for all applications.
- (d) The design is typically provided in compliance with the model building codes having jurisdiction in that area. NFPA 72, 2000 edition: The National fire Alarm code is usually used for the installation methods, testing and maintenance.
- (e) Connection conditions from relevant regional authorities & institutions shall be maintained (Police & Fire, emergency services).
  - a) National Building code of India (BIS)
  - b) BIS: Bureau of Indian standard (IS: 2189)
  - c) NFPA: National Fire Protection Association
  - d) IEC: International Electro technical commission
  - e) NEC: National Electric Code
  - f) NEMA: National Electrical Manufacturer"s Association
  - g) NBC: National Building Code
- (f) Fire Alarm system shall be designed to provide continuous surveillance against fire in the areas covered by the system under all conditions.
- (g) The Fire alarm control panel, detectors and other related devices used in the system shall conform to international Standards UL / LPCB / FM.
- (h) Fire Alarm Control Panel (FACP):
  - (a) The FACP shall be of microprocessor based design having the required number of outgoing loops (Minimum 8 loops per panel) to connect addressable type detectors and devices.
  - (b) Microprocessor based Control unit(Panel) at each local Fire alarm system shall have following Features:
    - The Panel shall confirm to FM /UL listed.
    - Each detector / device that is connected on the loop shall be identified by a unique address that shall be assigned to each device. This address shall indicate the individual device address as well as the address of the loop to which it is connected.
    - Check the status of the system at definite pre set intervals and give warning in case of system faults like open circuit, short circuit, dirty detector, removal of detector or any other faults.
    - In case of fire the panel shall give audio as well as alphanumeric display. From the display the zone and location of fire should be readily identified.
    - Power to detection devices and notification appliances shall be supplied from FACP.

**Characteristics of Main Display Unit of each FACP:**

- i. General display current date, time, last event, number of alarms, priority wise alarm list, and any other applicable information shall be displayed on each FACP.

- ii. Automatically display system messages, alarms. Vital information to operators concerning a fire situation.
- iii. Fire progression & evacuation details.

(c) Power Supply Requirement for FACP

Power Supply requirement for FACP (Fire Alarm & Control Panel). Primary supply - 230VAC, 50Hz.

1. Back-up/secondary supply - sealed, lead-acid batteries.
    - i. FDAS panel shall be backed up with its built in battery & battery charger. Battery shall have capacity to back up complete operation for 48 hrs. Battery shall have sufficient capacity to power the fire alarm system for not less than 48 hours plus 30 minutes of alarm to an end voltage of 1.14volts per cell, upon a normal AC power failure.
    - ii. The power supply unit shall accept 230 V AC mains power. The power supply unit shall supply DC power to all the interface cards/modules within the FAP as well as to all the devices wired on all the FAP loops.
    - iii. Simply monitoring the battery voltage level shall not be accepted as battery supervision.
    - iv. Batteries shall be rechargeable, sealed maintenance-free type. Battery capacity shall be sized to provide backup power to the FAP for supervision and alarm.
  2. Both mains failure as well as low battery level troubles shall be annunciated by the FAP.
  3. Battery Charger:
    - i. The power supply shall supervise the standby batteries and provide a dual rate constant current battery charger featuring automatic temperature compensation. It shall be completely automatic, constant current charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 230V, 50 Hz power source.
    - ii. It shall have protection to prevent discharge through the charger.
    - iii. It shall have protection for overloads and short circuits on both AC and DC sides. A trouble condition shall actuate the charger signal.
    - iv. Charger shall have automatic AC line voltage regulation, automatic Current limiting features, and adjustable voltage controls.
- (i) Manual Call Points (MCPs) shall be mounted at exit points of all areas (at operating height of 1.2 M) with operating instruction (IN CASE OF FIRE BREAK GLASS”) printed on the facia housed in a suitable housing to avoid inadvertent operation.
- (j) The FAP shall have the facility to monitor & process all the input signals received andalso have the facility to control all the output signals connected to various devices in the field through any of the loop interface modules/cards.
- (k) Fire fighting system shall contain but not to limited to, the items listed below -
- i) Portable fire extinguishers

ii) Nitrogen injection fire prevention method for transformer

iii) Sand & Water Bucket

**1.17 PREFERRED MAKES/ MANUFACTURERS:**

The list of preferred Makes/ Manufacturers is given below:

| SL NO | DESCRIPTION                           | MANUFACTURER/MAKE                                                                                                                                  |
|-------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | Power transformers                    | M/s ABB<br>M/s BHEL<br>M/s Siemens<br>M/s Areva T&D<br>M/s Crompton Greaves Limited                                                                |
| 2     | Auxiliary transformers                | M/s ABB<br>M/s BHEL<br>M/s Siemens<br>M/s Areva T&D<br>M/s Crompton Greaves Limited<br>M/S Volt Amp<br>M/S Bharat Bijlee<br>M/s Kirloskar Electric |
|       |                                       | M/s Siemens<br>M/s ABB                                                                                                                             |
| 3     | 11 kV Metal enclosed switchgears /MCC | M/s Siemens<br><br>M/s Areva<br>M/s BHEL<br>M/s Mitsubishi                                                                                         |
| 4     | HV Vacuum Circuit Breaker             | M/s Siemens<br>M/s ABB<br>M/s Crompton Greaves Limited<br>M/s Areva<br>M/s BHEL                                                                    |
| 5     | Protective Relays                     | M/s ABB<br>M/s Schneider Electric<br>M/s L&T<br>M/s GE<br>M/s Siemens<br>M/s Areva T&D                                                             |
| 6     | H.T & L.T Current Transformers        | M/s ABB<br>M/s Areva T&D<br>M/s CGL<br>M/s BHEL                                                                                                    |
| 7     | Neutral earthing resistors            | M/s Bharatia Cutler Hammer (I). Ltd<br>M/s Crompton Greaves Limited                                                                                |

| SL NO | DESCRIPTION                       | MANUFACTURER/MAKE                                                                                                                 |
|-------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
|       |                                   | M/s Indcoil Mfg Company Limited                                                                                                   |
| 8     | LV Switchgears /MCC               | M/s Schneider Electric<br>M/s ABB                                                                                                 |
|       |                                   | M/s. Siemens<br>M/s GE<br>M/s L&T<br>M/s Mitsubishi                                                                               |
| 9     | Lighting Fixtures and Accessories | M/s Philips<br>M/s ABB<br>M/s Crompton Greaves Limited<br>M/s Wipro<br>M/s Bajaj Electricals                                      |
| 10    | L.T Power Capacitors              | M/s BHEL<br>M/s ABB,<br>M/s CG Power Systems<br>M/s Universal Cables                                                              |
| 11    | Alternators for DG Sets           | M/s Kirloskar Electric<br>M/s CGL<br>M/s BHEL<br>M/s Kirloskar                                                                    |
|       |                                   | M/s Stomford                                                                                                                      |
| 12    | Cables                            | M/s Universal Cables<br>M/s Polycab<br>M/s Havell"s                                                                               |
| 13    | Battery                           | M/s Exide Industries<br>M/s AMCO<br>M/s HBL-NIFE                                                                                  |
| 14    | Battery Chargers                  | M/s Universal Instruments<br>M/s Amara Raja<br>M/s Chabhi Electricals<br>M/s HBL-NIFE<br>M/s Caldine                              |
| 15    | Cable Termination Kits            | M/s Mahindra Engg and Chemical Products<br>M/s REPL<br>M/s Raychem                                                                |
| 16    | FCMA Starters                     | M/s. Innovative technomics<br>M/s. Sunshine controls<br>M/s. Sakthi power innovative<br>(or) Equivalent as per tender requirement |



**Note:**

Other Makes, if offered, are subject to Specific Approval by the Employer/ Employer's Representative based on the Submission of the following documents by the bidder:

- (i) Copies of Type Test Certificate for the items offered.
- (ii) List of Clients to whom already the items have been supplied along with the year of Supply and Value of Orders
- (iii) Copies of Performance Certificate from the User's for the items.
- (iv) Copy of latest ISO Certification for the Manufacturer
- (v) Details of Manufacturing Facilities
- (vi) Turn Over of the Manufacturer
- (vii) Copies of Approval for the items from reputed Consultants.

## **7 B 2. SUB-SECTION**

### **INSTRUMENTATION CONTROL AND AUTOMATION SPECIFICATION**

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## **2 GENERAL REQUIREMENTS -INSTRUMENTATION CONTROL AND AUTOMATION**

### **2.1 Introduction**

This part covers the general requirements for the design, supply, installation, inspection and testing of the instrumentation, Control and Automation (PLC based SCADA system inclusive of wired and wireless communication system) and associated plant and materials.

### **2.2 Reference Standards**

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

|                                                 |                                                                                                           |
|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| BS 89-2:1990, EN 60051-2:1989, IEC 60051-2:1984 | Direct acting indicating analogue electrical measuring Instruments and their accessories.                 |
| BS 1042 (Various)                               | Measurement of fluid flow in closed conduits.                                                             |
| BS 1646-1:1979, ISO 3511/I-1977                 | Symbolic representation for process measurement control Functions and instrumentation. Basic requirements |
| BS EN 837-1:1998                                | Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing            |
| BS EN 60751:1996, IEC 60751:1983                | Industrial platinum resistance thermometer sensors                                                        |
| BS 3680 (Various)                               | Measurement of liquid flow in open channels.                                                              |
| BS 3693:1992                                    | Recommendations for design of scales and indexes on analogue indicating instruments                       |
| BS EN 60770-1:1999, IEC 60770-1:1999            | Transmitters for use in industrial-process control systems. Methods for performance evaluation            |
| BS 4675-2:1978, ISO 2954-1975                   | Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity |
| BS EN 60584-1:1996, IEC 60584-1:1995            | Thermocouples. Reference tables                                                                           |
| BS 5308 (Various)                               | Instrumentation cables                                                                                    |
| BS EN 60529:1992                                | Specification for degrees of protection provided by enclosures (IP code)                                  |
| BS ISO 11631:1998                               | Measurement of fluid flow. Methods of specifying flowmeter performance                                    |
| BS 5863-1:1984, IEC 60381-1:1982                | Analogue signals for process control systems. Specification for direct current signals                    |
| BS 5863-2:1980, IEC 60381-2:1978                | Analogue signals for process control systems. Specification for direct voltage signals                    |

|                                      |                                                                                                                                   |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| BS EN 60654-1:1993, IEC 60654-1:1993 | Industrial-process measurement and control equipment. Operating conditions. Climatic conditions                                   |
| BS 6739:1986                         | Code of practice for instrumentation in process control systems: installation design and practice                                 |
| BS EN 60073:2002                     | Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators |
| BS 1553 (Various)                    | Specification for graphical symbols for general engineering                                                                       |
| ISA-5.1-1984 - (R1992)               | Instrumentation Symbols and Identification                                                                                        |
| ISA-5.4-1991                         | Instrument Loop Diagrams                                                                                                          |
| ANSI/ISA-7.0.01-1996                 | Quality Standard for Instrument Air                                                                                               |
| ANSI/ISA-18.1-1979 -(R1992)          | Annunciator Sequences and Specifications                                                                                          |
| ISA-26-1968                          | Dynamic Response Testing of Process Control Instrumentation                                                                       |
| ISA-37.1-1975 - (R1982)              | Electrical Transducer Nomenclature and Terminology                                                                                |
| ISA-37.3-1982 - (R1995)              | Specifications and Tests for Strain Gage Pressure Transducers                                                                     |
| ANSI/ISA-50.00.01-1975 (R2002)       | Compatibility of Analog Signals for Electronic Industrial Process Instruments                                                     |
| ANSI/ISA-51.1-1979 - (R1993)         | Process Instrumentation Terminology                                                                                               |
| ISO 9000 and 09004                   | Quality Systems                                                                                                                   |
| IEEE 60587                           | Power Supply Surge Protection                                                                                                     |
| IEC 61131-3                          | Programming Languages for Programmable Controllers.                                                                               |
| IEC 61158-2                          | Communication Protocols                                                                                                           |
| ISO 9075 (BS 6964)                   | Structured Query Language (SQL)                                                                                                   |
| BS 5515                              | Documentation of Computer Based Systems                                                                                           |
| BS 7165                              | Recommendation for Achievement of Quality in Software                                                                             |
| BS EN 50081                          | Electromagnetic Compatibility                                                                                                     |
| ISO 3511                             | Process measurement control functions-instrumentation symbolic representation.                                                    |
| ISO-OSI                              | 7 Layer Communication Model                                                                                                       |
| IEC-8705101                          | Modbus Protocol Conversion                                                                                                        |
| IEEE 472-1974                        | Surge protection.                                                                                                                 |
| NEMA                                 | National Electrical Manufacturers Association                                                                                     |

### **2.3 Statement of Compliance**

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during FDS submission once the contract has been awarded.

All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Engineer for consent before any design against that standard proceeds.

## **2.4 Qualification Criteria for Instrumentation Manufacturer, Automation System Manufacturer, and Automation System Integrator**

ISO 9001 or above accreditation shall be a minimum qualification for all Instrumentation and/or Automation System Manufacturers and all Automation System Integrators (System Integrators).

The complete Instrumentation, Control, and Automation works in this contract shall be executed by a single System Integrator with a minimum of 5 years of experience in automation projects. The System Integrator shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution.

The System Integrator shall submit evidence that they employ in excess of 25 personnel, including no less than 15 technical staff to include engineers, programmers, and field technicians. Qualifications and license details for a minimum of three professional engineers in the direct employ of the System Integrator, as well as resumes of all personnel assigned to this contract shall be submitted as part of the Contractor's technical bid.

The System Integrator shall be an authorized system integrator for the Automation System Manufacturer(s). Verification certificates shall be submitted directly from the manufacturer(s) of the Automation System. In addition, references shall be provided with the Contractor's technical bid for a minimum of five (5) locations where the proposed manufacturer's Automation System has been successfully installed by the proposed System Integrator within five (5) years prior to the bid date and has been successfully operating for at least two (2) years immediately prior to the bid date. References shall include name, address, and telephone number for the appropriate contact person.

The Instrumentation Manufacturer(s) shall have minimum 15 years of experience in India in the field of instrument supply and service and shall have a local service centre in Bangalore.

All hardware and software proposed shall have been successfully used in a similar sewage treatment plant application for a period of at least five (5) years and be from established and reputable suppliers.

## **2.5 Documents to be submitted during Bid Submission**

1. Include a complete Table of Conformance to each and every reference standards or part of the specifications. Use a chart format with specification part identified, indicate whether each part is in compliance, a deviation or an exception to the specific part. If an exception or deviation, include a narrative description as to how the deviation or exception can benefit the end-user of the system over that item specified.



2. Provide a block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.
3. Provide a written overview of the proposed SCADA system, instrumentation system describing the principal functions and capabilities of the system's PC, PLC's, system communications and general system capabilities (maximum number of network nodes, PLC's and I/O points, communication protocols available, etc.).
4. Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all major hardware items. List shall include as a minimum, the manufacturer, the quantity provided, and model numbers for each. Technical schedules for Instruments, PLC & SCADA shall be duly filled in with relevant details.
5. Provide an operating system and software applications list with descriptive literature for the proposed system. Include all major software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the owner. (No proprietary software shall be accepted).
6. Information is required for:
  - a) Name and version of the proposed PC's operating system.
  - b) Name and version of the proposed computer operator graphical user interface software package (SCADA).
  - c) Name and version of the PLC on-line/off-line programming software for all controllers
  - d) Name and version of any required communications software, firmware, etc.
  - e) Name and version of the specified report application software.
  - f) Name and version of the specified maintenance application software if any.
  - g) Describe how system data points are linked from the system database into various applications such as reporting or maintenance. If via DDE (Dynamic Data Exchange) describe specifically the steps required to import data automatically and on-line into the proposed software applications.
  - h) Briefly describe the required procedure for configuration and/or programming of the proposed system to add a simple remote PLC and additional I/O's to the system in the future. Describe in detail, specifically how communications are programmed for the future remote PLC and the necessary changes required at the main controller.
  - i) Provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system.
  - j) Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, radio communications licensing, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.
  - k) Describe the system supplier's provisions for service, technical assistance and replacement parts for the proposed system. Include the system supplier's 1-800-toll free number. Identify with resumes, all personnel who will be providing technical support services for the project after it is accepted.

The Contractor shall provide the above required details/documents during the bid submission. Failure to submit even one of the above will be treated as a non-responsive bid and lead to technical rejection of the bid. Contractor shall note the importance of this obligation.

### **2.5.1 General Submissions**

The Contractor shall make submissions to the Engineer of all design drawings, schedules and complete documentation on spare parts relating to instrumentation, control and Automation equipment and systems provided under this Contract.

These submissions shall include, where relevant, the following:

### **2.5.2 Functional design specification**

The Contractor shall submit a complete Functional Design Specification (FDS) for approval by the Engineer within 3 months of the award of contract. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Proposed SCADA screens shall form an integral part of FDS submissions.

The format of the program details may be chosen by the Contractor, however it is suggested that this format be chosen to satisfy the requirements of the software design documentation, if applicable, as described elsewhere.

The FDS shall describe the ‘fail-safe’ features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

The Contractor shall submit and obtain approval of the FDS from the Engineer before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

### **2.5.3 Drawings and schedules**

- (a) Process and instrumentation diagram which shall comply with BS 1646 and BS 1553/equivalent ISA standard.
- (b) General arrangement drawings of field-mounted instruments showing installation details.
- (c) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
- (d) Layout drawings of panel fascias showing instruments, controls and details of all labels.
- (e) Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
- (f) Annunciator arrangement and engraving details.
- (g) Internal circuit and wiring diagrams for instrument and control panels.
- (h) Schematic control diagrams.
- (i) Instrument loop diagrams.
- (j) Instrument wiring and piping diagrams.
- (k) Interconnection wiring diagrams.
- (l) Cable block diagrams, drawings and schedules.
- (m) Instrument system and panel power distribution diagrams.
- (n) Programmable-device functional design specifications which shall include hardware details, logic flow charts, ladder diagrams and program listings.
- (o) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
- (p) Labelling schedules.
- (q) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.

All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.

### **2.5.4 Data and calculations**

- (a) Manufacturers' catalogues and data sheets.
- (b) Calculations to support control system design.
- (c) Specification for protective coatings and painting.

### **2.5.5 Certificates**

- (a) Manufacturers' works tests.
- (b) Pre-installation checks.

- (c) Pressure-testing schedules.
- (d) Instrument loop test check sheets.
- (e) Installed instrument performance tests.
- (f) System tests.
- (g) Statutory certificates of compliance (such as hazardous area equipment).

#### **2.5.6 Operation and maintenance instructions**

- (a) Composite manual describing the functional and operation of each piece of equipment.
- (b) Composite manual for testing and servicing every system and individual item.

### **2.6 Design**

#### **2.6.1 Basic Features**

Instrumentation, Control, Automation system shall be designed, manufactured and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- to suit the abilities of the staff who will:
  - use the systems;
  - service the systems;
- to measure, indicate process, store and control the relevant parameters, as specified;
- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of operations and maintenance' personnel and plant and to store and collate the data, as required;
- to derive, present and utilize, as required, such additional data as required to facilitate:
  - the most efficient operation of the plant;
  - the routine maintenance of the plant

#### **2.6.2 Design Requirements for Instrumentation, Control and Automation Systems**

The instrumentation, control, automation installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years, unless otherwise approved by the Engineer.

## **2.7 Site Conditions**

- A. Temperature and Humidity Range.** The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (non condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.
- B. EMI/RFI Noise Immunity.** The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.
- C. Generated Interference.** The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1 or equivalent Indian Standard for noise emissions.
- D. Coordination.** The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.
- E. Sequencing.** The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

## **2.8 Enclosure/Panel Details**

### **2.8.1 Enclosures and mounting boards**

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

Enclosures mounted inside buildings shall have a minimum rating of protection to IP 54.

Enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles.

Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

## **2.8.2 Panel design and construction**

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified the height of panels shall be not greater than 2130 mm overall (excluding lifting devices) above finished floor level.

Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have antivibration mountings.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

### **2.8.3 Panels - Major**

Panels shall be constructed generally as specified in the preceding clause. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of center of gravity and method of fabrication, with the following minimum thickness:

- instrument bearing surfaces, gland plates and pneumatic distribution plates, 3mm;
- internal mounting plates, 3mm;
- doors, covers and filler panels, 2mm.

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

Each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.



A chequer-plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable.

Sufficient removable un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.

Panels containing instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces. If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections.

All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.

Provision shall be made for safe and easy handling during transit and installation.

If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

#### **2.8.4 Panels - Minor**



Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

**(a) Local control panel (LCP)**:- Local Control Panel shall be provided for each Motor near the drive and shall be Interconnected with MCC. The Local Control Panel shall have the following Provisions.

- 3 Push buttons START / STOP / EMERGENCY STOP
- Start / Stop push button operates when the switch on LCP is in — ANUAL position.
- Emergency Stop push button operates irrespective of the position of the switch.

When the selector switch on LCP is in — LOCAL position, the motor will be operated by push buttons on LCP and will take into account only the specific fail-safe controls of the equipment (electrical protections, low level for a pump). When the selector switch on LCP is in —REMOTE position the drive will be operated from PLC.

➤ **Motorized Valves for STP's (Field Type):-**

Motorized valves will use fully integrated control Actuator. The actuator comes with integrated:

- Selector switch —Remote/ Local
- P.B's for: OPEN / CLOSE/ STOP.

Note :- Necessary Field Indicating devices (Where-ever process Interlocks are applicable) and LED's (Motor's, Actuator's etc., of feedback Indications) shall be provided on LCP's for Manual control operations.

### **2.8.5 Panels - Composite**

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and, at the sole discretion of the Engineer, ICA equipment may be combined within a single enclosure subject to the following conditions:

- The observance of all other clauses herein relating to enclosures, mounting boards and minor panels;
- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component;
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities;
- The absence of any voltage exceeding 250vac or 50vdc from any compartment containing ICA equipment;
- The use of the full height of the panel (excluding the bus bar chamber and Cable space) for any ICA equipment compartment.

### **2.8.6 Panel protection**

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.

At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainders are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

### **2.8.7 Panel isolation**

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the off' position. The on' and off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labeled with suitable warning notices.

Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the free' plug and a socket mounted adjacent to the device.

The power supply connector shall be a socket.

### **2.8.8 Panel terminal blocks**

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analysers, resistance thermometers, retransmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than

230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanised. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type SAKC or equivalent which permit the connection of a test milliammeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.

Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalised where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimise the risk of accidental contact.

### **2.8.9 Panel internal wiring**

Panel circuits shall be segregated into the following categories:

#### **Group 1: Power control and very-high-level signal wiring (above 50V):**

- 1.1 ac power supplies;
- 1.2 dc power supplies;
- 1.3 ac current signals above 50mA (such as CT circuits);
- 1.4 ac voltage and control signals above 50V (such as PT circuits).

#### **Group 2: High-level signal wiring (6V to 50Vdc):**

- 2.1 signals from conventional electronic transmitters and controllers (such as digital or 4mA to 20mA);
- 2.2 circuits to alarm annunciators and other solid-state devices
- 2.3 digital signals;
- 2.4 emergency shut-down and tripping circuits;
- 2.5 on/off control circuits;
- 2.6 intrinsically safe circuits;

#### **Group 3: Low-level signal wiring (5V dc and below):**

- 3.1 signals from thermocouples;
- 3.2 signals from resistance thermometers and re-transmitting slide-wires;
- 3.3 signals from analytical equipment and strain gauges.

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

- (a) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;
- (b) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel. Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm<sup>2</sup> minimum copper conductor with HPDE or PVC-insulated cable of adequate grade and rating.

Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm<sup>2</sup> minimum copper conductor with 250V grade, PVC-insulated cable of adequate grade and rating.

Wiring sheath colors shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded.

Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

#### **2.8.10 Panel wiring identification and termination**

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.

The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.

Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

#### **2.8.11 Panel Earthing**

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals.

In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

SPD s associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

#### **2.8.12 Panel lighting**

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three metres of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

#### **2.8.13 Panel ventilation**

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably-labelled enclosed switch mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

#### **2.8.14 Panel labels**

All control gear shall be fully labelled with the KKS code identifying the equipment designation/ function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Engineer before manufacture. Each label shall be permanently secured to the



surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black. The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- To describe or identify circuits or circuit components;
- To identify dc polarity;
- To warn or remind about dangerous or potentially-dangerous circumstances;
- Wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high.

The minimum practicable number of different sizes shall be used. Manufacturers' nameplates shall not be fitted on panel external surfaces.

#### **2.8.15 Panel finish**

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Engineer. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanised or otherwise finished to an approved standard.



## **2.9 Instruments and ancillaries**

### **2.9.1 General**

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully tropicalised and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

Instruments mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish.

Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where applicable instruments shall be easily withdrawable from its housing for maintenance without interrupting its signal.

Unless otherwise specified, instruments shall be finished in the manufacturer's standard colour. Instrument dials shall be of such material that no peeling or discolouration will take place with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 150mm except where forming part of standard instruments and accessories such as air-sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770-1 or equivalent. For the important and critical processes the transmitting devices, such as pressure, temperature and level gauges, shall have a reference gauge installed locally for easy reference for the operation and maintenance staff. The transmitters shall be provided with LCD meters.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory configured ranges, measuring instruments shall have zero and span adjustment.

Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

In order that maintenance and inspection may be carried out safely and conveniently instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with sun shading.

## **2.9.2 Indicating Instruments and Meters**

### **General**

All instruments and meters shall be flush mounted and generally of the same pattern and appearance throughout and those which perform similar duties shall be of uniform type and manufacture.

Indicating instruments shall be fitted with an externally accessible zero adjuster. They shall have no parallax error and their normal maximum reading shall be approximately 60% full scale deflection.

Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The ammeter shall have an adjustable and sealable red pointer set to indicate normal full load current. The ammeter physical size shall be in keeping with the size of the starter concerned. The minimum size to be used is 0.25 DIN.

Indicating instruments shall comply with IS 1248, BS 89 or IEC 60051 and shall be of industrial grade accuracy.

(a) Panel Mounted Digital Indicators For Field Instruments

Digital panel indicators shall be microprocessor based and modular in design. It shall accept 4-20 mA DC isolated input. The digital panel indicator shall provide an output of 4-20 mA DC proportional to input signal for retransmission. It shall have RS 485 communication port for connectivity to PLC.

Technical Particulars

|                               |   |                                                                       |
|-------------------------------|---|-----------------------------------------------------------------------|
| <b>Type</b>                   | : | <b>Microprocessor based.</b>                                          |
| Mounting                      | : | Front facia of Instrument Control Panel (ICP)                         |
| Display                       | : | Back-lit LED                                                          |
| Digit height                  | : | 12.5 mm or higher                                                     |
| No. of digits                 | : | 4                                                                     |
| Input                         | : | 4-20 mA DC (isolated)                                                 |
| Zero & Span adjustment        | : | Required                                                              |
| Engineering units for display | : | As per site requirement                                               |
| Weather protection class      | : | IP-52 of IS 13947                                                     |
| Retransmission output         | : | 4-20 mA proportional to Process variables.                            |
| Relay outputs                 | : | Required 2NO+2NC for high level alarm and 2NO+2NC for low level alarm |
| Communication port            | : | RS-485 (With Modbus protocol)                                         |

(b) Kilowatt-hour meters.

Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy ( $\pm 2.5\%$ ). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

Quantity : 1 No. for each pump and incomers of 0.433 kV (or more)  
Switchboard (each motors) As per site conditions.

Purpose : Power and Energy Monitoring

It shall monitor voltage, current, kW, kVAr, kVA, power factor and frequency.

Technical Particulars

Data logging

Data storage and it shall be retrieved via RS 485 port Soft

Integration

The meter shall be integrated with SCADA system to provide remote display of all measured parameters and meter configurations. The metering shall be via RS 485 port.

#### Measurement

- True RMS measurement
- Instantaneous phase voltages, line voltages, phase currents and line currents
- Frequency
- Active, reactive, apparent powers and power factor per phase and line
- Energy-Import and Export
- Maximum demand kVA, kW, kVAr

#### Communications

- RS 485
- Baud rates minimum 9600

#### Accuracy Class

- 0.5 S

#### Accuracy Standards

- IS-14697:1999

#### Front Panel Display

- LED with back lighting
- Display for all basic power and energy parameters

#### - Specifications

- Password protection for setup parameters

#### Ratings

##### Voltage Inputs

- 50 to 347 VAC
- Accuracy VL-N: 0.25% reading
- Accuracy Hz : +/- 0.1 Hz
- Support 3 phase 3 wire, 3 phase 4 wire connections ☐ Standard screw in terminals

##### Current Inputs

- 5 Amp. Nominal
- Accuracy current: 0.25% reading
- 20% over range full accuracy

## Power Supply

- 110 V to 240 VAC & VDC

## Environmental Conditions

- As per process Requirement- Ambient Temperature.
- Humidity: upto 95% non condensing

Dimension: Appr. 96x96x96 mm

### (c) Microprocessor based Alarm Annunciator

- (1) Microprocessor based alarm annunciator shall be provided for generating audio-visual alarms for each abnormal condition. Alarms shall be initiated by the opening and closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exist. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple configuration after installation requiring no additional parts or special equipment. Each alarm shall initiate the operation of both visual and audible devices. The sound intensity (adjustable) of each audible device shall be suitable for the maximum sound level of its environment
- (2) Each alarm shall initiate a visible and audible indication of the specified condition. Unless otherwise specified, alarm indicators shall be grouped together in annunciator units each having at least 20% spare windows. Each alarm window shall consist of minimum 2 nos. of bulbs having cluster of LEDs and shall have screens engraved with legends approved by the Engineer's Representative.
- (3) When any alarm condition occurs, an audible device common to an alarm annunciator system shall sound and the appropriate indicator shall flash on and off. The flashing rate shall be selectable. Facility for selection of type of sequence shall be provided.
- (4) The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a future alarm condition occurs.
- (5) An integral 'test' pushbutton shall be provided to illuminate each lamp and to operate the audible device but shall not cause a spurious alarm condition.
- (6) Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds adjustable do not initiate any action.
- (7) Isolation facility shall be provided for the hooters.
- (8) Alarm annunciator/indicator legends or labels shall be arranged with three lines of text as follows:

|      |             |   |                     |
|------|-------------|---|---------------------|
| i.   | top line    | : | Location            |
| ii.  | middle line | : | Parameter           |
| iii. | bottom line | : | Status              |
| e.g. |             | : | RESERVOIR LEVEL LOW |

(9) Alarm annunciator shall have RS-485 communication port (Modbus protocol) for interfacing with the PLC system.

(10) A LED shall be provided to indicate the 'ON' status of the alarm annunciator.

### Technical Particulars

Alarm annunciator shall be provided on instrument control panel for annunciation of alarms in controlroom. The technical particulars of alarm annunciator are as follows:

|      |                                |   |                                                                                                                        |
|------|--------------------------------|---|------------------------------------------------------------------------------------------------------------------------|
| i.   | Type                           | : | Microprocessor based, split type with alarm windows mounted on the front door and electronic modules inside the panel. |
| ii.  | Mounting                       | : | Flush with panel                                                                                                       |
| iii. | Construction                   | : | Modular                                                                                                                |
| iv   | Inputs                         | : | Potential free, NO/NC contacts                                                                                         |
| v    | Size of windows                | : | 60 mm X 26 mm                                                                                                          |
| vi   | Operating sequences            | : | First up (user selectable dip switch)                                                                                  |
| vii  | Bulbs per channel              | : | 2 (Cluster LEDs)                                                                                                       |
| viii | Push Buttons                   | : | For Test, Mute, Acknowledge & Reset                                                                                    |
| ix   | Hooter                         | : | Required, electronic type                                                                                              |
| x    | Power supply                   | : | 24 V DC/240 V AC                                                                                                       |
| xi   | Power supply status Indication | : | Required                                                                                                               |
| xii  | Weather protection             | : | IP-52 of IS 13947                                                                                                      |
| xiii | No. of Windows                 | : | 8 / 12 / 24, As required with 20 % Spare                                                                               |
| xiv  | Quantity                       | : | As per process requirement                                                                                             |

### 2.9.3 Indicator Lights

Indicator lights shall be not less than 20 mm diameter and shall be panel mounted types with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lampholder or panel wiring. Lampholders shall be keyed into panels to prevent rotation. Lens colours shall comply with BS EN 60037 as follows:

|   |                              |        |
|---|------------------------------|--------|
| - | power on                     | white* |
| - | running -                    | green  |
| - | tripped/alarm                | red    |
| - | status (open, closed, etc)   | blue   |
| - | ready to start               | blue   |
| - | warning (no imminent danger) | amber  |

Note:\*white may be used where doubt exists as to which other colour to use.

The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.

The indicating lamps on control panel shall be cluster of LED's.

#### **2.9.4 Pushbuttons**

Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

|   |                                        |        |
|---|----------------------------------------|--------|
| - | stop, emergency stop                   | red    |
| - | start                                  | green  |
| - | jogging/inching                        | black  |
| - | reset (when not also acting as a stop) | blue   |
| - | lamp test                              | blue   |
| - | override/alarm accept                  | yellow |

#### **2.9.5 Specification For Junction Boxes:**

(A) Junction box (instrument)

|   |                       |   |                                                                                                                                                                                                                                     |
|---|-----------------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Construction          | : | 3mm sheet steel hot                                                                                                                                                                                                                 |
| 2 | Protection            | : | IP 65                                                                                                                                                                                                                               |
| 3 | Paint and shade       | : | One coat of red oxide primer Powder coated light grey as per shade 631 of is:5                                                                                                                                                      |
| 4 | Terminal strip        | : | Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted                                                                                                                                                       |
| 5 | No of terminal strips | : | 30/40/70                                                                                                                                                                                                                            |
| 6 | Conduit & cable entry | : | Rating: 600v 10 a ac                                                                                                                                                                                                                |
| 7 | Gland plant thickness | : | Lower side                                                                                                                                                                                                                          |
| 8 | Door of JB            | : | 3mm                                                                                                                                                                                                                                 |
|   |                       | : | Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lids When completely unscrewed (captive screws) |

|    |             |   |                                                                                                                                                             |
|----|-------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9  | Dimension   |   | Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry                                                           |
| 10 | Mounting    | : | Frame mounted                                                                                                                                               |
| 11 | Earthing    | : | Two no of earthing bolts for JB Earthing separate instrument Earth bus on insulating clits to be provided                                                   |
| 12 | Name plates | : | To be provided material: white Engraved letters on black Anodized aluminum sheet<br>Fixing: stainless steel screws<br>Lettering:- black with white Engraved |

(B) Junction box (power & control)

|    |                       |   |                                                                                                                                                                                                                                    |
|----|-----------------------|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Construction          | : | 3mm sheet steel hot                                                                                                                                                                                                                |
| 2  | Protection            | : | IP 65                                                                                                                                                                                                                              |
| 3  | Paint and shade       | : | Power coated light grey as per Shade 631 of is:5                                                                                                                                                                                   |
| 4  | Terminal strip        |   | Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted                                                                                                                                                      |
| 5  | No of terminal strips |   | 30/40/70                                                                                                                                                                                                                           |
| 6  | Conduit & cable entry |   | Lower side                                                                                                                                                                                                                         |
| 7  | Gland plate thickness |   | 3mm                                                                                                                                                                                                                                |
| 8  | Door of JB            |   | Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lid When completely unscrewed (captive screws) |
| 9  | Dimension             |   | Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry clearly specifying GA Drawing                                                                                                    |
| 10 | Mounting              |   | Frame mounted                                                                                                                                                                                                                      |
| 11 | Earthing              |   | Two no of earthling bolts for JB Earthing                                                                                                                                                                                          |
| 12 | Name plates           |   | To be provided material: white Engraved letters on black Anodized aluminium sheet<br>Fixing: stainless steel screws<br>Lettering:- black with white Engraved.                                                                      |



## **2.10 Cabling**

### **2.10.1 Instrumentation cabling**

Cables from conventional measuring transmitters and analogue process controllers, such as digital or 4mA to 20mA dc output from a constant-current source, (hereinafter referred to as high-level signals) shall be polyethylene or PVC insulated with stranded conductors and laid up as twisted pairs with one twist per 30mm approx. Each cable shall have an overall screen of braided copper or mylar backed aluminium foil giving a minimum coverage of 85%, a steel wire armouring insulated from the screen and from any ducting and an overall PVC sheath. For runs exceeding 30 metres or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or mylar-backed aluminium foil for each signal pair. The minimum conductor size shall be 24/0.2mm but shall be of greater cross-sectional area if required for the satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

Cables from strain gauges, analysers and the like, such as 0 to 100mV (hereinafter referred to as low level signals — see also below) shall be as specified above and shall have an individual screen for each signal pair.

Cables from indicating devices to alarm or tripping circuits shall be as specified above for high-level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

Cables for high-level signals, low-level signals, resistance thermometers and thermocouples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables run in the vicinity of instrumentation cables shall be twisted at the rate of one twist per 50mm approximately and shall be separated from instrumentation cables by a distance of not less than 300mm.

Initiating devices for plant protection and personnel safety shall be connected by individual cables direct to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay or similar. The outer sheaths of such cables shall be coloured orange.

Technical particulars:

(i) Contractor shall include in his scope the supply, laying of cables and associated civil/mechanical work.

(ii) Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.

(iii) Cable joints in instrument signals and power supply cables shall not be permitted.

(iv) Cables shall be capable of satisfactory performance when laid on trays, in trenches, conduits, ducts and when directly buried in the ground.

(v) Cables shall be capable of operating satisfactorily under the specified power supply system voltage and frequency variation.

a) Cables for analog signals

The cables shall comply with the following requirements:

Cables of 1100V grade, multi-pair/multi-triad cable, annealed, tinned, high conductivity, 1.5 sq. mm. stranded copper conductor, extruded PVC insulated two/three cores twisted into pair/triad, laid up collectively, individual pair/triad shielded and overall shielded with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armoured with galvanised steel wire and overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be used for analog signals.

b) Cables for digital signals

The cables shall comply with the following requirements:

Cables of 1100V grade, multi core cables, annealed, tinned, high conductivity, 1.5 sq. mm. stranded copper conductor, extruded PVC, overall shielded with aluminium mylar tape, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be used for digital signals.

c) Cables for Instrument/Equipment power supply

The cables shall comply with the following requirements:

Cables of 1100V grade, multicore cable, annealed, tinned, high conductivity, 2.5 sq. mm. stranded copper conductor, extruded PVC, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be provided for Instrument/Equipment power supply.

### **2.10.2 Telemetry cabling**

Telemetry cabling between a master station and an outstation, unless otherwise specified, shall consist of a minimum of 6 signal pairs, of which two pairs shall be allocated to the telemetry system, one pair shall be allocated to a speech circuit and three pairs shall be spare. Each conductor shall be multi-stranded with an equivalent diameter of not less than 0.9mm. Conductors shall be laid up in starquad formation. The dc resistance of any pair of conductors shall not exceed 88 ohms per loop mile at 10°C and the difference between the resistances of the conductors of any pair shall not exceed 0.5% of the loop resistance of that pair.

Telemetry cables shall be designed for burying in water-logged ground.

Conductors shall be plain annealed copper with aluminium/polythene laminate sheath moisture barrier, copper or brass tape pest barrier, single galvanised steel wire armour and overall polythene sheath. The cable shall have a solid filling of petroleum jelly.

The characteristic impedance of each signal circuit shall have a nominal value of 600 ohms at 800Hz and the circuits shall be suitable for signal input levels of between -30dbm to +4dbm (0dbm = 1mW into a load of 600 ohms). The overall attenuation between the terminations of any circuit at the mean frequency of the band width specified elsewhere shall not exceed 20dbm and the attenuation at any two frequencies within this band width shall not differ by more than 6dbm. The transmission time for any two frequencies within the band width specified elsewhere shall not differ by more than  $1 / (4 \% B)$  seconds, where B is the transmission speed in bauds, as specified elsewhere.

The signal-to-noise ratio within the bandwidth specified elsewhere shall be better than 12db. The frequency of any received signal shall not differ from the frequency of the corresponding transmitted frequency by more than 1% of the transmission speed in bauds specified elsewhere.

Loading coils as necessary to meet the performance requirements detailed herein shall be supplied and installed at equally-spaced points.

(a) Fiber optic cable

To facilitate the proper and efficient co-ordination of the Works the Contractor shall sublet all Cabling Works to one Sub-Contractor who has proven and successful experience in fiber optic cable installations on projects similar to the one now proposed.

If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on total end to end signal attenuation not to exceed 40 dB, including all splices and termination losses, and after taking into consideration.

- a) Type of fiber
- b) Ambient conditions
- c) Method of installation
- d) The disposition of each cable relative to others

All cables and wires shall be suitable for installation and continuous services in the ambient conditions described elsewhere in this document.

Shop Drawings and Product Data shall be submitted for the approval of the Engineers as follows;

- Submit full technical details of each type of cable proposed.
- Submit copy of test certificates from the manufacturer or an independent testing authority confirming that cables comply with the specification.
- Submit exact route of the cable run and relevant Sections in the shop drawings.

Each drum length of cable shall be allotted a distinct and separate reference number. This number shall appear on the test certificate covering the respective length of cable and shall also be clearly marked on the cable drum.

The Contractor shall advise the Engineer upon delivery to site of each drum length, quoting the reference number, the test certificates shall be handed to the Engineer for examination and approval. All cables shall be delivered to site with the manufacturer seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Engineer.

The Contractor shall be responsible for the off-loading and handling of the cables on site, and shall ensure that cables are delivered to site on drums and properly protected against mechanical damages. Where lengths are cut from cables, the open ends shall be sealed.

The contractor shall be aware of the need to supply and install all cables for this Contract which are most suitable for the special environmental conditions prevailing in this project.

The cable shall comprise 8 fibers, loose tube, two fibers per tube with central 1.5 mm nominal steel central strength member, moisture barrier, steel tape armored in continuous lengths up to a maximum of 6.0 km or as dictated by cable joint chamber locations and route survey.

|                             |                                                  |
|-----------------------------|--------------------------------------------------|
| <b>Single Mode</b>          |                                                  |
| Type of fiber               | Single mode, doped silica                        |
| Core Diameter               | 9.0 ± 0.5 micro m                                |
| Cladding Dia                | 125 ± 2.0 micro m                                |
| Coating (outer) Diameter    | 250 ± 15 micro m Material UV curable acrylate    |
| Numerical aperture          | 0.11 micro m                                     |
| Attenuation                 | <0.4 dB/km @ 1300 nm <0.2 dB/km @ 1500 nm        |
| Bandwidth                   | 1000 MHz @ 1300 nm                               |
| Chromatic Dispersion        | 3.5 ps/nm x km @ 1300 nm 20 ps/nm x km @ 1500 nm |
| Operating temperature range | -30 to +80 deg. C                                |
| Crush resistance            | >200N/cm                                         |
| Weight                      | 500 kg/km (maximum)                              |
| Tensile strength            | 2000 N (minimum)                                 |
| <b>Multi mode</b>           |                                                  |
| Type of fiber               | Multi mode, doped silica                         |
| Core Diameter               | 62.5 ± 3.0 micro m                               |
| Cladding Diameter           | 125 ± 2.0 micro m                                |
| Coating (outer) Dia         | 250 ± 15 micro m Material UV curable acrylate    |
| Numerical aperture          | 0.275 ± 0.15 micro m                             |
| Attenuation                 | <3.2 dB/km @ 1300 nm <0.9 dB/km @ 1500 nm        |
| Bandwidth                   | 500 Mhz x km @ 1300 nm                           |
| Operating temperature       | -30 to +80 deg. C                                |

|                  |                     |
|------------------|---------------------|
| range            |                     |
| Crush resistance | >200N/cm            |
| Weight           | 500 kg/km (maximum) |
| Tensile strength | 2000 N (minimum)    |

### **2.10.3 Cable termination boxes**

Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals so that the armouring may be earthed or isolated from earth, as circumstances dictate.

Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be cast steel or heavy gauge sheet steel construction giving protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, un-drilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collet. The numbering for a particular cable core shall be the same throughout its length.

Cable joints shall be at points approved by the Engineer.

Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands and, after installation and testing, shall be covered with Densomastic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided in excess of the minimum quantity specified. All materials and things of every kind required for the cabling jointing shall be provided by the Contractor.

### **2.10.4 Cable labeling**

At each end of each cable, in a uniform and visible position, a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Three-phase power cable cores shall be identified A, B, C or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

Each cable and core shall bear the same number at both ends of the cable and core respectively.

(a) Power terminations — colour, number or letter.

(b) Control terminations — letter or number or both.

#### **2.10.5 Cable terminations**

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant molded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system for one second.

All glands shall be provided with an earthing tag. For cables of 4mm<sup>2</sup> or less, a serrated washer may be used instead for earth continuity.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

Through joints shall be permitted only on long cable runs outside buildings. Where such joints are necessary; the cables shall be jointed with epoxy or acrylic resin Cold-setting compound which has been pre-measured and pre-packed ready for use.

The boxes shall be of a split moulded plastic type with filling vents for compound.

Bonding straps shall be fitted with armour clamps across the joint and inspected by the Engineer prior to filling the box with compound. Wrapped pressure type joints shall not be accepted.

Conductor cores shall be jointed number to number or color to color.

#### **2.10.6 Cable installation-general**

Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Engineer, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Cables shall not be installed in areas of direct sunlight.

Where this is unavoidable, approved sun shields shall be supplied and installed.

Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Engineer.

Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings, such as rawlplugs.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand Site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and fixing of each cable shall permit the removal and replacement of any cable without disturbance to any other cable or the fixings thereof.

When cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

Submissions which the Contractor shall submit the following in relation to cable installations in addition to submissions detailed elsewhere in the Specification.

#### **2.10.7 Drawings and schedules:**

- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings. For those items which are underground, these drawings shall include the following:
- Route plans and sectional views for all cable runs, cable trays, cable ducts and cable



trenches;

- The position of all marker posts, joints, draw pits and the like.
- Cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

#### **2.10.8 Data and calculations:**

- Manufacturers' catalogues and data sheets for all cables and fittings. Cable sizing Calculations.

#### **2.10.9 Test certificates:**

- Test certificates for all witnessed and routine tests carried out at the manufacturer's works and at Site (calibration).

#### **2.10.10 Cable trays and ladders**

Cable tray and cable-support ladders shall be of heavy-gauge galvanised steel and with an overall PVC coating when required to the approval of the Engineer.

Cable tray and ladder systems shall be installed using factory-made supports, joints and junction/bend pieces. Wherever tray and ladder sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanising compound or lead-based anti-corrosive paint.

Ladder systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

#### **2.10.11 Flexible conduits**

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium-plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment; the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.



### **2.10.12 PVC conduit**

Where galvanised conduit would be liable to corrosion, PVC conduit shall be installed.

PVC conduit shall be of the oval or round high impact non-flame-propagating type as specified and self-extinguishing, to BS EN 61386-21. Surface and concealed installations shall be generally as described for steel conduit.

PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories.

Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose-made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between  $-5^{\circ}\text{C}$  and  $+60^{\circ}\text{C}$  and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth-continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaires or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilise steel insert clips.

## **2.11 Cable installation methods**

### **2.11.1 General**

All cabling installation methods shall be subject to the approval of the Engineer.

### **2.11.2 Installation directly into the ground**

Where cables are buried in the earth, the bottom of the excavated trenches shall be freed of sharp stones and other projections and covered with sand to a depth of 50mm.

Cables shall be unrolled from drums without loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp projections.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100mm of compacted sand and shall have a layer of protective interlocking concrete cable tiles. The tiles shall be overlaid with marker tape.

When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.

ICA and communication cables shall be laid not closer than 1000mm to high voltage cables.

A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

### **2.11.3 Installation in underground ducts**

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100mm shall be laid at a minimum depth of 1000mm (to the duct centre). The ducts shall be encased by 150mm concrete on all sides.

When installing cables in ducts, the following measures shall be observed:

- Cables shall be pulled in a straight line;
- Rollers shall be positioned at the edges of drawpits both at the drawing-in and drawing-out points over which the cables shall be drawn;
- uPVC pipes and cable sheaths shall be coated with an approved lubricant;
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;
- The pulling rope shall be guided by rollers.

Only one power cable shall be drawn into each duct.

Whenever a duct is laid in the ground, a draw-wire shall be pulled through with at least 1000mm excess at each end and the draw-wire left in position if the duct is not to be used immediately.

### **2.11.4 Sealing cable entries into buildings**

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

All cable entries into a building shall be in ducts and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes.

### **2.11.5 Marking of underground cables**

The location of all underground cables shall be identified by:

- Brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;
- Marker posts in road verges and the like at intervals of not more than 100m and at all

junctions and changes of direction along the route;

- Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 200mm high above ground with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer.

#### **2.11.6 Installation in cable trunking**

Cable trunking shall be manufactured from mild steel of not less than 1.25mm and shall be hot-dip galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose-made by the manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m vertically. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking, the bared ends shall immediately be given a coat of zinc-rich cold galvanising paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Engineer before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

#### **2.11.7 Installation in troughs and trenches**

Where the building structure incorporates purpose-built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench. Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, not less than 1.25mm for trays from 100mm to 150mm width and not less than 1.5mm thickness for trays from 150mm to 300mm width.

Cable-tray supports shall be of sufficient strength to maintain rigid support to the fully-laden cable tray along its entire length. All brackets and tray work shall be suitable for withstanding a temporary weight of 125kg.

Wherever possible, cable trays shall be installed in full lengths without cutting.

Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc-rich cold galvanising paint. Similarly for PVC-coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose-made saddles, as approved by the Engineer, together with proprietary cable cleats.

#### **2.11.8 Installation in buildings**

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or simply at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.

Cables shall be located between 50mm pegs spaced at 40mm centres across a rung so that a 40mm or 80mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipework.

#### **2.11.9 Cable installation in conduits**

Conduits shall be either galvanised heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

A space factor of 40% shall not be exceeded and, in any case, conduit shall have a minimum diameter of 20mm. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm diameter, straight-through joint boxes shall be of the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

#### **1. Functional and Technical Specifications for Continuous Ambient Air Quality Monitoring System Specifications (CAAQMS)**

- a) Continuous Ambient Air Quality Monitoring System (CAAQMS) will gather data about pollution, ambient conditions (temperature and humidity), levels of gases in the city (pollution) and any other events on an hourly and subsequently daily basis. It is for information of citizens and administration to further take appropriate actions during the daily course / cause of any event.

- b) CAAQMS should have the following capabilities:

- They should be ruggedized enough to be deployed in open air areas, on streets and parks
- They should be able to read and report at least the following parameters: Temperature, Humidity, Ambient Light, Sound, Pressure, CO, NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub> and compulsorily PM 2.5 and PM 10.
- c) CAAQMS will inform and enable citizens and administrators to keep a check on their endeavors which impact environment and enable the city to take remedial action if required. These environmental sensors can also be connected via 3G or 4G wireless network or Wi-Fi networks. It is not mandatory to connect all sensors via MPLS fiber network.
- d) The data should be collected in a software platform that allows third party software applications to read that data. Various environment sensors shall sense the prevailing environment conditions and send the data to the integrated control system where real time data resides and the same shall be made available to various other departments and applications for decision making. It is preferred if the platform also includes intelligent analytical engines that makes information meaningful to all stakeholders and helps ease decision-making.
- e) Successful bidder can also make use of the nearby Variable messaging displays wherever possible (need to be finalized post detailed survey of locations).
- f) The sensor management platform should allow the configuration of the sensor to the network and also location details etc.
- g) The sensors should be able to be managed remotely. This includes sensors being updated with calibration parameters, software upgrades. Sensors must also provide updates and detect faults with self-diagnosis functionality.
- h) Apart from information provision, the sensors must ensure data is transmitted securely and have security measures from sensors to the software platform. It must also ensure tamper alerts are provided in cases of vandalism, security breaches, etc.

#### **2.11.10 Technical Specifications**

| <b>Sr.No.</b> | <b>Parameter</b>                                                                 | <b>Specification</b>                                                                                                                                                                                                                              |
|---------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.            | Measurement elements                                                             | Temperature, Humidity, Ambient Light, Sound, CO, NO <sub>2</sub> , O <sub>3</sub> , SO <sub>2</sub> , PM <sub>2.5</sub> , PM 10                                                                                                                   |
| 2.            | Measurement component<br>Measurement range<br><br>(must measure required ranges) | NO <sub>2</sub> : 0 – 220 ppb,<br>O <sub>3</sub> : 0 – 390 ppb<br>SO <sub>2</sub> : 0 – 630 ppb<br>CO : 0 – 31 ppm<br>PM 2.5: 0 to 250 micro gms / cu.m<br>PM 10: 0 to 450 micro gms / cu.m<br>Light: up to 10,000 Lux<br>Noise: up to 100 dB (A) |
| 3             | Temperature, Pressure and Humidity Sensor                                        | Real-time Temperature Range: outdoor                                                                                                                                                                                                              |

| Sr.No. | Parameter                        | Specification                                                                                                                             |
|--------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
|        |                                  | 0°C ~ 50°C<br>Real-time in Air Humidity Level Display<br>Real-Time Pressure Display (in Bars or millibars)                                |
| 4 .    | Connectivity (Minimum)           | Wifi, Ethernet or GSM (3G)<br><br>Sensors must have provision to interchange between WiFi or GSM systems easily                           |
| 5      | Software and Data backup         | Backup measurement data for upto 5 days in case of network failure or system maintenance cycles                                           |
| 6      | Mechanical Enclosure             | Single enclosure with all components inside or simplified mounting                                                                        |
| 7      | Data validity and stabilization  | Sensors must ensure data of sensors is valid and not require stabilization times in case of power outages less than 5 hours.              |
| 8      | Product origin and certification | Products must be <b>made in India</b><br><br>Must also qualify a minimum international standards on product certification such as CE, FCC |

## 2. Service Level Agreements

Service Level Agreement (SLA) shall become the part of contract between AUTHORITY and the Successful bidder. SLA defines the terms of the successful Bidder's responsibility in ensuring the timely delivery of the deliverables and the correctness of the same based on the agreed Performance Indicators as detailed in this section.

i. The successful bidder has to comply with Service Levels requirements to ensure adherence to project timelines, quality and availability of services, throughout the period of this contract i.e. during implementation phase and for a period of three (3) years. The successful bidder has to supply appropriate software/hardware/ automated tools as may be required to monitor and submit reports of all the SLAs mentioned in this section.

ii. For purposes of the SLA, the definitions and terms as specified in the document along with the following terms shall have the meanings set forth below:

a) "Total Time" - Total number of hours in the quarter (or the concerned period) being considered for evaluation of SLA performance.



b) "Uptime" – Time period for which the specified services/ outcomes are available in the period being considered for evaluation of SLA. Formulae for calculation of Uptime:  $\text{Uptime (\%)} = \{1 - [(\text{Downtime}) / (\text{Total time} - \text{scheduled maintenance time})]\} * 100$

c) "Downtime"- Time period for which the specified services/ components/ outcomes are not available in the concerned period, being considered for evaluation of SLA, which would exclude downtime owing to Force Majeure & Reasons beyond control of the successful bidder.

d) "Scheduled Maintenance Time" - Time period for which the specified services/ components with specified technical and service standards are not available due to scheduled maintenance activity. The successful bidder is required to take at least 10 days prior approval from AUTHORITY for any such activity. The scheduled maintenance should be carried out during non-peak hours (like post mid-night, and should not be for more than 4 hours. Such planned downtime would be granted max 4 times a year.

e) "Incident" - Any event / abnormalities in the service being rendered, that may lead to disruption in normal operations and services to the end user.

f) "Response Time" - Time elapsed from the moment an incident is reported in the Helpdesk over phone or by any applicable mode of communication, to the time when a resource is assigned for the resolution of the same.

g) "Resolution Time" - Time elapsed from the moment incident is reported to Helpdesk either in person or automatically through system, to the time by which the incident is resolved completely and services as promised are restored.

| SLA and Penalty for Sensors |                        |                                                                                                                                                                                   |
|-----------------------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| #                           | Uptime SLA (Quarterly) | Penalty Clause                                                                                                                                                                    |
| 1                           | Uptime $\geq 99\%$     | No Deduction                                                                                                                                                                      |
| 2                           | Uptime $< 99\%$        | (99%- Uptime %) of monthly Operational Expense for the component. For example if uptime of component is 95%, then penalty imposed will be 99%-95% i.e. 4% of operational expense. |

i. Uptime definition: All devices have to be working and deliver the desired results. The no. of hours that the particular device/ equipment does not work will be treated as down time. Uptime shall be calculated as  $\text{Uptime (\%)} = \{1 - [(\text{Downtime}) / (\text{Total time} - \text{scheduled maintenance time})]\} * 100$ . For ex, if 10 nos. of Sensors for Digital display are deployed at various locations, and 2 device/ units does not work for 5 Hrs, the total non-working device hours will be 10 unit hours ( and the uptime would be  $\{1 - (10 / (10 * 90 * 24))\}$ , 10 being the number of units, for 90 days on 24 hours basis.



ii. Penalty levied for non- performance as per SLA requirements will have to be paid by the successful bidder to AUTHORITY or can be deducted through subsequent payments due from AUTHORITY.

iii. The penalties would be levied for every unit down time hour– be it for non-availability of network or non- availability of power etc. because the successful bidder is responsible for supply of all enabling components on end to end basis.

**SLA for Change Requests (Applicable for changes in existing / already deployed modules)**

| SI No. | Service Metric Parameter              | Metric                                                                                                                          | Frequency             | Penalty                                                                                                                                                                                                                           |
|--------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1      | Criticality of Change – <b>Low</b>    | < T+2 weeks,<br>where T is the timeframe for completion of the Change request as agreed upon by AUTHORITY and successful bidder | Weekly per Occurrence | 0.1% of (Opex) value per week for the first two weeks for each occurrence,<br><br>0.5% of (Opex) value per week for every subsequent week, subject to a maximum of 1% post which AUTHORITY may invoke Annulment of the contract.  |
| 2      | Criticality of Change – <b>Medium</b> | < T+1 weeks,<br>where T is the timeframe for completion of the Change request as agreed upon by AUTHORITY and successful bidder | Weekly per Occurrence | 0.2% of (Opex) value per week for the first two weeks for each occurrence,<br><br>0.5 % of (Opex) value per week for every subsequent week, subject to a maximum of 1% post which AUTHORITY may invoke Annulment of the contract. |
| 3      | Criticality of Change – <b>High</b>   | < T,<br>where T is the timeframe for completion of the Change request as                                                        | Weekly per Occurrence | 0.5% of (Opex) value per week for the first two weeks for each occurrence,<br><br>1% of (Opex) value per                                                                                                                          |

| SI No. | Service Metric Parameter | Metric                                         | Frequency | Penalty                                                                                                               |
|--------|--------------------------|------------------------------------------------|-----------|-----------------------------------------------------------------------------------------------------------------------|
|        |                          | agreed upon by AUTHORITY and successful bidder |           | week for every subsequent week, subject to a maximum of 3% post which AUTHORITY may invoke Annulment of the contract. |

**Definitions:**

1. Severity 1: Monitoring system or application or mobile application down for 5 or more smart elements impacting critical business functions OR any module/ function deemed as highly critical by AUTHORITY
2. Severity 2: Monitoring system or application or mobile application down for 2 or more smart elements impacting functionality of smart elements as per mentioned SLAs
3. Severity 3: Monitoring system or application down for 1 smart element impacting functionality of smart elements sensor
4. Response Time: Response time is defined as the time the support vendor takes to respond from the time that ticket was raised.
5. Resolution Time: Resolution time is defined as the time the vendor takes to resolve the issue or provide acceptable workaround for the issue.

**SLA Reporting system**

- i. The successful bidder shall design, implement/customize, deploy the Enterprise Management System (EMS) and shall develop any additional tools required to monitor the performance indicators listed as per the SLAs mentioned in the RFP.
- ii. The Acceptance Testing and Certification agency shall verify the accuracy and completeness of the information captured by the SLA monitoring system implemented by the successful bidder and shall certify the same.
- iii. The EMS deployed for the project, based on SLAs, shall be configured by the successful bidder to calculate the payment to be paid by the PSCDCL, if any, after deducting the necessary penalties. EMS should be integrated with the toll free call center (established by the Bidder) for site fault reporting.

**2.11.11 Flow Measuring Systems**

Flow measuring system shall consist of flow sensor / transducers, flow computer and flow transmitter.

Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground pipelines.

To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow sensor shall be provided in accordance with the requirements of the flowmeter manufacturer.

The flow transmitter shall be suitable for field or panel mounting and shall accept an input from the flow sensor. It shall process the input signal and provide 4-20 mA dc output proportional to flow rate. The flow range shall be adjustable.

A zero span adjustment facility shall be provided for flow transmitter and indicator.

Flow measurement shall not be affected by physical properties of sewage viz., temperature, pressure, viscosity, density etc., within given limits. Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least  $\pm 1.0$  % of the measured value unless otherwise stated.

(a) Electromagnetic Flow Meter (Full Bore):

General

The Electromagnetic Flow Meters shall be installed in RCC chambers / open pits or buried for indication of flow rate and total consumption of water in a transmission or distribution pipe work of water supply system.

The Electromagnetic Flow Meters shall withstand maximum working temperature and working pressure shall be as per process requirement.

### **Electromagnetic Flow Meter**

Full bore electromagnetic flow meters shall be designed, manufactured and calibrated to ISO standard. The flow meter shall be capable of measuring bi-directional flow.

### **General Specification**

Electromagnetic Flow Meter shall be a velocity sensing electromagnetic type, microprocessor based signal converter, Flow Integrator and Totalizer sealed housing, flanged tube meter as per working pressure requirement. The meter shall be manufactured to highest standard available for mag-meters. The accuracy shall be inclusive of linearity, hysteresis, and repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 5 m/sec and pressure rating shall be as per process requirement to be constructed as follows

Meter tube shall have a constant nominal inside diameter offering no obstruction to the flow.

Signal Converter shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the meter.

The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and reverse directions.

The converter shall provide an isolated 4-20 mA output into minimum 600 ohm load and a frequency output of a maximum of 0-10 KHZ and a scaled pulse output.

The microprocessor based signal converter shall have a self-diagnostic test mode and backlit display that continuously displays ‘Rate of Flow’ and ‘Total Volume’.

The converter shall be compatible with Microsoft Windows and other software programs with built in terminal communication capabilities of RS 485, HART or other protocols for interface.

The converter shall be remotely mounted maximum upto 200 m from the sensor, and shall be supplied with all calibration complete for desired requirements.

The converter cum transmitter shall be fully programmable from the front facia. The programming shall be user friendly, self-prompting menu driven.

The length of the sensor shall be strictly as per ISO upto DN 600 mm and for other sizes it shall be as per the manufacturer's standard. Only, one manufacturer shall make all meter size and styles required for this contract.

#### (b)Open Channel Flow meter

Open channel flow measuring systems shall consist of level transducer, flow computer and flow transmitter. The level of the fluid in the flume shall be measured by the ultrasonic level transducer.

The level measured shall be used along with the physical characteristics of the flume to compute the flow rate.

The level transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected as per IP65. It shall have ambient temperature compensation and adjustable datum setting facilities.

The design and application of ultrasonic level meters shall take into account the channel construction, the material size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For application where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

The structure required for supporting the level sensor, platform, railings etc shall be in the Contractor's scope.

#### **2.11.12 Level Measuring System**

##### **(i) Ultrasonic Level Meters**

Ultrasonic level measuring devices applied for level measurement shall comprise a transducer, control unit and remote indicator.

The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected to IP 65. It shall have ambient temperature compensation, adjustable datum setting facilities.

The accuracy of the sensor shall be  $\pm 0.25\%$  or better.

It shall be programmable with an integral programming keyboard and provide a digital display of the measured variable. It shall be provided with diagnosis facilities and shall provide an isolated 4 to 20 mA dc output signal proportional to the range of measurement.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

##### **(ii) Conductivity Level Switches**

The electrodes used for conductivity level switches shall be stainless steel. Single electrode systems (one electrode per holder) shall be used (except where their use is impractical) with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

Where relay or control units are not mounted in control panels, they shall be provided with surface mounting enclosures with a degree of protection to IP 52 for indoor locations or IP 65 for outdoor locations.

### **2.11.13 Pressure gauges and transmitters**

Pressure gauges shall comply with BS EN 837-1 or equivalent and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used. Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed 0.1% of the span. Pressure transmitters shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP 65 standard or higher standard. For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP 68 standard and shall operate up to maximum submergence of 20 metres of water. Pressure transmitters shall provide a digital or 4mA to 20mA dc output proportional to the pressure range.

Pressure gauges and transmitters shall have primary isolating valves, 2 or 3 way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

### **2.11.14 Strain-gauge pressure transducers and transmitters**

Strain-gauge pressure transducers shall use thin film sensors without bonding.

Each instrument housing shall be of all-welded Grade X 4 CrNiMo 17 12 2 stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a noncorrodible barrier diaphragm. The mean time between failure for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below, or higher performance:

- Accuracy:  $\pm 0.1\%$  of calibrated span, including linearity hysteresis and repeatability;
- Repeatability:  $\pm 0.05\%$  at maximum span;
- Stability:  $\pm 0.1\%$  of upper range limit over 6-month period;

- Over-pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- Power-supply variation effect: 0.01% per volt variation.
- Load variation effect:  $\pm 0.0002\%$  per ohm of loop-resistance variation.
- Temperature:  $-29^{\circ}\text{C}$  to  $+82^{\circ}\text{C}$  range; total thermal error of  $\pm 0.75\%$  of span over  $0^{\circ}\text{C}$  to  $50^{\circ}\text{C}$ ;
- Protection: IP 65.

Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP 65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

Provision for transducer venting shall be provided.

#### **2.11.15 Temperature Monitoring System**

##### **Microprocessor Based Multi-Channel Temperature Scanner and Indicators**

Panel mounted microprocessor based multi-channel temperature scanner shall be provided to continuously monitor temperature at different positions in each pump-set. The scanner shall have provision of accepting RTD/ thermocouple inputs. Facility shall be provided for grouping of channels for generating alarm/trip signals. Each scanner shall generate two nos. of potential free contacts for each group. The scanner shall have facility for interfacing with Programmable Logic Controller (PLC).

##### **Technical Particulars**

###### **a) General:**

Service : As per Process requirement

Installation hardware and accessories : Required

Type : Microprocessor based

Mounting : Front facia of Instrument Control Panel (ICP)

|                               |   |                                                                         |
|-------------------------------|---|-------------------------------------------------------------------------|
| No. of channels               | : | 16 / 24- channels, As required with 20 % Spare.                         |
| Quantity                      | : | As per Process Requirement.                                             |
| Input                         | : | From Temperature measuring sensors                                      |
| Display                       | : | Separate LCD/LED displays for channel no. and corresponding temperature |
| Auxillary Outputs (Relay's)   | : | Two Nos. For each channel                                               |
| Digit height                  | : | 12.5 mm or higher                                                       |
| No. of digits                 | : | 2 nos. for channel no.<br>4 nos. (minimum) for process value display    |
| Zero & Span adjustment        | : | Required                                                                |
| Engineering units for display | : | Deg. Celsius                                                            |
| Accuracy                      | : | ± 0.2 % of span or better                                               |
| Weather protection class      | : | IP-52 of IS 13947                                                       |
| Relay outputs                 | : | Required 2NO+2NC for each group                                         |
| Communication port            | : | RS-485 (With Modbus protocol) for interfacing with PLC                  |

Bearing and winding temperature system shall be provided for HT/LT motors.

Nine (9) sensors shall be provided per pump set (pump 7 Motor) and blower motor.

## **2.12 Specifications for Online water Monitoring System**

### **2.12.1 Multi-parameter Controller System Specifications:**

It should be equipped with the following minimum features:

- USB-interface for data transfer, upgrading firmware etc.
- Backup controller function to increase reliability (in terminal mode)
- Control unit with keys and toggle switch for the quick selection of software functions
- With large graphic display with backlight
- With integrated backup controller function
- Input voltage 90 - 264 VAC 50/60 Hz
- Line power consumption approx. 25 VA
- Max. power delivery 18 Watt
- 6 Galvanically separated current outputs (0/4-20 mA) that can be assigned arbitrarily
- MODBUS communication protocol for the data integration with PLC and SCADA
- With Sensor ID recognition
- High EMC interference immunity
- Integrated lightning protection



- Should have the latest features of highly advanced Multiparameter Controller having capability of handling at least 18 sensors in a single controller configuration and more as and when required.
- Should have the capability to be operated as Controller (having programmability feature) or just a terminal (that can display the data without any way to make changes).
- Display should be with improved reading precision through special backlit graphic display
- Easy User Intuitive operating keys: including keys for functions such as: Measurement, calibration, set/system settings, additional keys for: confirmation/switching menu O.K. (OK), Escape (ESC) etc.
- Internal integrated Datalogger with minimum data memory for up to 500,000 data sets
- The Controller should be able to power all the sensors and terminals or accessories attached to it without having to need any additional power sources in the system for increased protection against lightening and possible electromagnetic interference.
- The system should start automatically after the power is reset to the system (in case of power failure).
- The controller should be low power consuming with consumption of less than 5W.
- Sensors connected to the system shall be automatically detected and initialized.
- No extra system configuration should be needed for substitute / replacement sensors.
- The system should have Service mode for cleaning/calibration/maintenance activities.
- It should be possible to download the data via the USB interface an extremely fast data exchange to USB memory stick.
- The system should be fully programmable with multiple levels of access control with help of Electronic-Key for data security and protection against non-authorized access to avoid any tampering or changes to the system configuration by unauthorized access.
- The controller should storage the sensor configurations and calibrations
- The controller should have Logbook to record the data
- The supplier should provide the firmware update free of cost as and when they are available for the life time of the system.
- The system should have a status LED that gives reliable and fast information regarding function and status of system. And the Controller/controller should show a LED for diagnostic purposes on the front. This LED should show normal and malfunctions of the system at a glance.
- Data Output to Control System: The System should have the capability to transmit the required 4-20 mA Analog Outputs as a minimum.
- In addition to above, the system should have ability to output Profibus, Modbus/RS 485, RS 232, LAN, GPRS, GSM compatible signals in future with addition of respective module as and when required.
- The system should be able to operate on AC Power (100-240 AC)
- Ambient Conditions Operating temperature: -4 °C ... +55 °C
- Storage temperature: -10 °C ... +65 °C
- Housing Material – Non corrosive e.g. Acrylonitrile-Styrene-Acryloesterpolymer or better
- Protection Rating IP 66 / equivalent to NEMA 4X for controller
- Electromagnetic Compatibility: EN 61326, Class B; FCC Class A, EMC for indispensable operation

- Integrated Lightning Protection: According to EN 61326 enhanced overvoltage protection for the entire system, implemented in each component

### **2.12.2 Communication and Data Presentation/Display**

The controller should be interfaced with a GSM/GPRS communication modem to seamlessly transmit the data from remote plants to a central location over a pre-defined interval.

The communication to the system should be two way for ability to view settings and make changes to the configuration over the air, as and when required.

The data should be received at a central location and should be displayed there in real-time in graphical and tabular format. The software as a minimum should have ability to print reports, archive data and make it available for export as a CSV file. The system should also have facility to generate alarm when set points are exceeded.

The Computer System to be supplied for this application should have enough configurations to accommodate data from at least 10 sites for at least 5 year duration with continuous monitoring of parameters every 15 min as minimum.

UPS of 2KVA capacity and internet connection with Static IP will be supplied along with the Computer.

## **2.13 Programmable Logic Controllers**

### **2.13.1 General**

Programmable Logic Controllers (PLC) shall be provided as a Hot Stand-by Controller to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be \_off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC shall be of an approved type from a major international manufacturer. PLC System (Panel) should be housed in a dust free environment.

Redundancy: hot redundant processor, redundant Power supply, non-redundant I/O's, redundant communication between Processor and I/O's and redundant FO communication shall be considered.

### **2.13.2 PLC Coding**

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation. PLC shall be coded using FBD language. The Contractor shall provide a suitable PC complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative based on the FDS submitted.

## **2.14 SCADA**

### **2.14.1 General :**

SCADA shall be provided at central monitoring Room, which shall be based in the administration building.

The SCADA system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring and controlling all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers workstation (EW), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

The HMI shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the Sewage Treatment Plant (STP).

SCADA system should be housed in an air-conditioned environment.

#### **2.14.2 System Integration & SCADA Automation Works:**

##### **The major prerequisites of efficient online analysers are:**

- ❖ Should be capable of operating unattended over prolonged period of time.
- ❖ Should produce analytically valid results with precision and repeatability
- ❖ The instrument/analyser should be robust and rugged, for optimal operation under extreme environmental conditions, while maintaining its calibrated status.
- ❖ The analyser should have inbuilt features for automatic water matrix change adaption.
- ❖ The instrument / analyser should have onboard library of calibration spectras for different industrial matrices with provision of accumulating further calibration matrices
- ❖ Should have data validation facility with features to transmit raw and validated data to central server.
- ❖ Should have Remote system access from central server provisioning log file access.
- ❖ Should have provision for Multi-server data transmission from each station without intermediate PC or plant server.
- ❖ Should have provision to send system alarm to central server in case any changes made in configuration or calibration.
- ❖ Should have provision to record all operation information in log file.
- ❖ For each parameter there should be provision for independent analysis, validation, calibration & data transmission.
- ❖ Must have provision of a system memory (non-volatile) to record data for at-least one year of continuous operation.
- ❖ Should have provision of Plant level data viewing and retrieval with selection of Ethernet, wireless, Mod-Bus & USB.
- ❖ In case of TOC analyser, the empirical relationship between TOC to COD or BOD must be authenticated for all industrial applications and the correlation calculation (for factor) provided.
- ❖ The software will give alarm, in case of the concentration of parameter exceeds the prescribed norms by 10% continuously.
- ❖ The correlation/interpretation factor for estimating COD and BOD using UV-Visible Absorption Technique shall be regularly authenticated/ validated and details provided.
- ❖ Record of calibration and validation should be available on real time basis on central server from each location/parameter.
- ❖ Record of online diagnostic features including sensor status should be available in database for user friendly maintenance.
- ❖ Expandable program to calculate parameter load daily, weekly or monthly basis for future evaluation with flow rate signal input.

- ❖ Must have low operation and maintenance requirements with low chemical consumption and recurring cost of consumables and spares.

#### **2.14.3 System Validation**

Online instrument operation will be evaluated using the known buffers, traceable standards and laboratory techniques.

By validating sensors and probes with known standards such as KHP (potassium hydrogen phthalate) for COD & TOC,  
Formazin equivalent standard for TSS & pH buffers have to be used to calculate a running variance of the measurements.

#### **2.14.4 Parameter validation**

Each parameter is validated with reference to standard laboratory analysis and known standards.

#### **1. Operation & maintenance:**

- **Daily Check** – GPS Transmission, System Diagnostic alarms.
- **Monthly Check** – Sensors & system cleaning, data backup, Parameter Calibration as specified in calibration schedule.
- **Periodic Check** – System validation with known standards, Laboratory & Online parameters Comparative

#### **2. Reporting :**

- ▶ The RT EQMS suppliers have to provide central server at CPCB and SPCB with latest software to view the data in graphical/ tabular format and also to compare the data features.
- ▶ One minute data average must be transmitted/retrieved to servers every 30 minutes. In the event of transmission loss the time stamped data in the data-logger memory must be transmitted to fill from the last transmission break with a stamp of time delay.
- ▶ The software should have two way communication, so that data from the system can be seen whenever desired and remote of controller/data logger can be taken to visualize the immediate status of the system.

#### **3. Functional capabilities of software**

- ✓ The system should be capable of collecting data on real time basis without any human intervention.
- ✓ The data generation, data pick up, data transmission; data integration at server end should be automatic.
- ✓ The submitted data shall be available to the Boards, SPCBs/PCCs and CPCB for immediate corrective action.
- ✓ Raw data should be transmitted simultaneously to SPCBs /PCCs and CPCB.

- ✓ In case of delay in collection of data due to any reason, the data transmission should be marked delayed data and reports of delayed data should be displayed on the portal
- ✓ At no point of time, manual data handling should be permitted. Data validation should be permitted only through the administrator and data changes recorded with date and time stampings.
- ✓ Configurations of the systems once set up (through remote procedure) and verified, should not be changed. In case any setting change is required it should be notified and recorded through the authorized representatives only.
- ✓ The data submitted electronically shall be available to the data generator through internet, so that corrective action if any required due to submission of erroneous data can be initiated by the industry.
- ✓ The software should be capable to verify the data correctness which means at any given point of time the regulatory authorities/data generator should be able to visualize the current data of any location's specific parameter.
- ✓ A system for data validation shall be incorporated in the software with two stage/three stage
- ✓ validation and fixed responsibilities of stakeholders as below;
  - a. Data Generator:**
  - b. SPCBs/PCCs:**
  - c. CPCB:**
- ✓ System should have capability to depict data at the actual location of industry over the map. CPCB and or SPCBs shall develop a map based system for data integration at a single location.

#### **4. Software Capabilities of Data Analyzing & Statistical Tools**

The software should be capable of analyzing the data with statistical tools and shall have the following capabilities:

- (i) Statistical data analysis (customizable) for average, min., max., diurnal variation.
  - (ii) Comparison of parameters of different locations in user selectable time formats i.e. in graphical and tabular formats compatible to MS Excel, MS Word, \*.txt etc.  
Ensuring access to every intricate detail and real time information has become a necessity for control room operators. With Security and Surveillance, Video walls, round-the-clock vigilance and Monitoring in real time has become convenient and manageable. Features like true cube redundancy and long life hours of light source in a video wall ensure a long term performance in mission critical application
  - (iii) Capability of comparison of data with respect to standards/threshold values.
  - (iv) Auto report and , auto mail generation etc.
  - (v) Providing calibration database for further validation/correction of data
  - (vi) Transmitting data to different locations as per EC, CTE/CTO, and other directives in force
  - (vii) Channel configuration for range, units etc.
  - (viii) Providing data in export format on continuous basis through central/station computer system to other system.
- Data transmission through different media like GPS, CDMA, Normal phone line, Datacards, Broadband, 3G etc. (at least any two media supported).

- Data Storage for next five years.

System should be connected to a backup power source with adequate capacity to avoid any power disruption

## **5. Video walls, round-the-clock vigilance and Monitoring in real time**

### **Scope of Work**

The specification provided in this document covers the requirements of Design, Supply of Components, Installation, Testing and Commissioning of Video Wall and the respective Audio Visual System Solutions.

Network Operating Center should be designed with user friendly technology to communicate with internal & external users with High Definition display solution and latest technology to create new benchmark in terms of Audio - Visual Solutions and should have the following features:

1. Video Wall Solution should have the provision of displaying contents over Large Display - Video Wall through different sources like PC, Laptop, Satellite TV Input, and other Video Source etc.
2. The Video Wall to be designed for 24 x 7 operation and should provide enhanced productivity and user friendly operation in terms of new product and technology.
3. Video Wall should have the video wall processor and engine which can have the flexibility to show or display the different - different sources with flexible layout, drag drop facility and desktop sharing features etc.
4. The Video Wall for network operating center is to be designed in such a way that the managed data received from various police stations should be display on it according to the requirement.
5. It can flip the video/ data randomly to get the better overview at NOC.
6. Video Wall Border for aesthetically good look.

### **Some of the brief activities as a part of scope of work for the bidder are:**

- The bidder should design, supply of components, installation, testing and commissioning of Audio Visual System with Video wall display solutions as required for the satisfactory operation of the entire solution.
- The field cabling with conduit installation for the power and LAN cabling at one location will be provided by client, and the same needs to be validated and confirmed by the bidder.
- The bidder will be responsible for providing the services for configuring the hardware and deploying system software as per the requirements testing/ integration of various hardware and software.
- Bidder will be back-end support agreement/arrangement for services including supply of spare parts, expertise requirements etc. with the Original Equipment Manufacturers (OEMs) of Servers which includes the post sales support activities for the entire project period. The OEM undertaking letter should be submitted along with the bid.



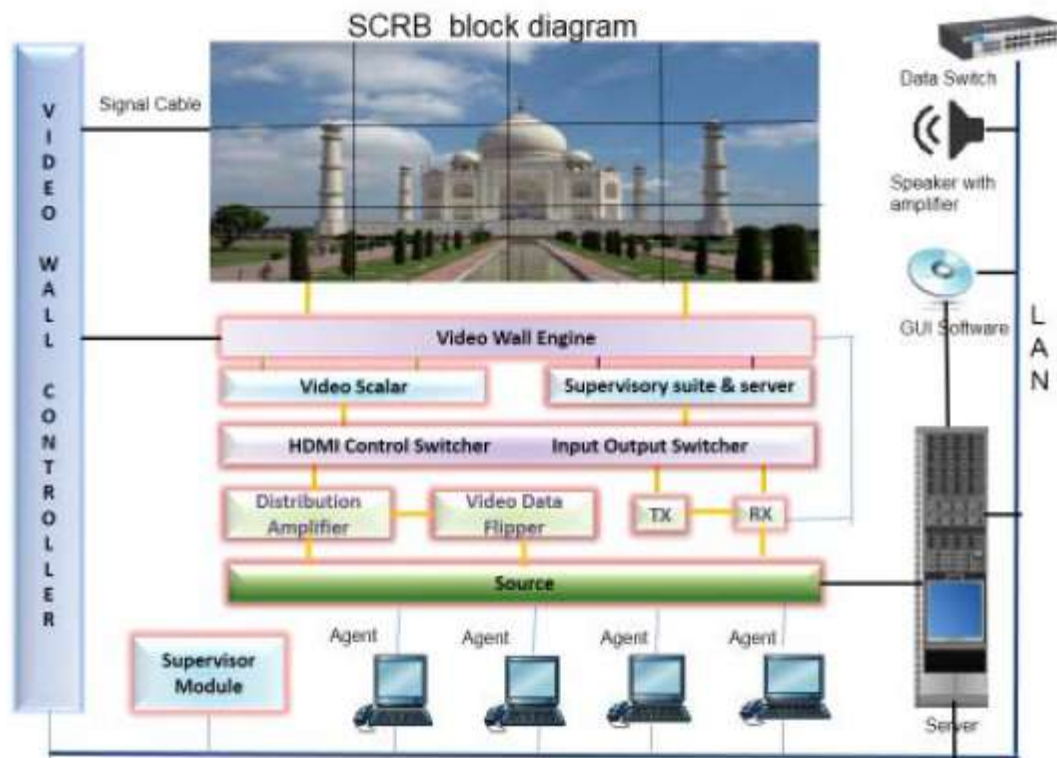
- Bidder need to submit the detailed bill of material along with the internal part nos for all quoted products inclusive of all licenses.
- The bidder has to conduct the site survey and present the detailed site inspection survey report including the pre installation checklist.
- Specifications for the power supply required for provisioning UPS/Power for the efficient operation of the equipment along with grounding specification as required.
- The bidder is responsible to check the Audio visual area / room to determine actual size required based on the room size & design.
- Provide on-site warranty support for 5 years.
- The bidder to provide full documentation including technical details of all components listed in the proposal.
- Bidder has to supply and install all the accessories required for the satisfactory operation of the system with the latest technology solutions.
- Any other components required for the satisfactory operation of the system to be provided by the bidder.
- The bidder should prepare the as built documentation for the overall system.
- The bidder should provide a video wall of 4 x 3 matrix of 47" (Diagonally) length, ultra thin bezel Video wall display.
- The bezel gap should not be more than 4.9 mm.
- Bidder is responsible for fixing and aligning of video wall and also for providing bracket to hide the backend wiring to give an aesthetic look to the video wall.
- A remote sensing device for controlling the video wall must be given.
- Bidder should provide advanced processor for multi input video wall controller for customized video with Ethernet port, and a software must be there to control the 9 cubes of display with customized application
- Bidder need to provide an IP based intelligent controller which can handle heavy traffic, along with customized GUI application for controlling video wall and other application.
- Bidder has to provide HDMI SWITCHER to connect multiple HDMI inputs.
- A video scalar must be there to give unified image resolution which will increase the color depth and reduce the blur image in case of enlargement.
- Bidder should provide a server to control the feed from various police station monitoring data feed, BSNL data feed and Application data feed with appropriate hardware and software.
- A data flipper must be there to switch or flip the video/data automatically.

**Scope of work for installing active components:-**

- Supply, Installations, Testing & Commissioning of Switches as per Technical specification.
- The switches will be installed at locations identified for Network Operating Center.
- The System required to be configured the setup in such a way that it provides a GUI (Graphical User Interface) to control entire Network Operating Center.



## Schematic Diagram



## Minimum Technical Specification

| Item No. 1 - HD Video Wall - 4 x 3 Matrix of 47" or above LED (Diagonally) |                                                                                                                                                                                                                                                                                                                                |      |                         |                      |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| Item Description                                                           |                                                                                                                                                                                                                                                                                                                                | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
| Screen Size                                                                | 47" or above                                                                                                                                                                                                                                                                                                                   | 12   |                         |                      |
| Aspect ratio                                                               | 16:09                                                                                                                                                                                                                                                                                                                          |      |                         |                      |
| Panel Type                                                                 | Direct LED/IPS                                                                                                                                                                                                                                                                                                                 |      |                         |                      |
| Panel Life                                                                 | 50,000<br>hours (Backlight half-life) or Better                                                                                                                                                                                                                                                                                |      |                         |                      |
| Number of Pixels (H x V)                                                   | 1,920 x 1,080 pixels or Better                                                                                                                                                                                                                                                                                                 |      |                         |                      |
| Brightness                                                                 | 500 cd/m2 or better                                                                                                                                                                                                                                                                                                            |      |                         |                      |
| Contrast Ratio                                                             | 1,400:1 or better                                                                                                                                                                                                                                                                                                              |      |                         |                      |
| Dynamic Contrast Ratio                                                     | >= 500,000:1                                                                                                                                                                                                                                                                                                                   |      |                         |                      |
| Viewing Angle                                                              | >= 178°/178° (Horizontal/Vertical)                                                                                                                                                                                                                                                                                             |      |                         |                      |
| Response Time                                                              | 12 ms (G to G) or better                                                                                                                                                                                                                                                                                                       |      |                         |                      |
| Connection Terminal                                                        | VIDEO IN BNC x 1,AUDIO IN (L/R) Pin jack x 1 set (Side) (Shared with Component IN), HDMI IN HDMI TYPE A x 1, Component IN BNC x 1 set, DVI-D IN, PC IN, AUDIO IN (L/R), DVI-D 24pin x 1, Mini D-sub 15pin x 1 (Female), M3 jack x 1 (Shared with DVI-D IN), AUDIO OUT (L/R) Pin jack x 1 set                                   |      |                         |                      |
| Power Requirements                                                         | 220-240 V AC, 50/60 Hz                                                                                                                                                                                                                                                                                                         |      |                         |                      |
| Power Consumption                                                          | 250 W or lower                                                                                                                                                                                                                                                                                                                 |      |                         |                      |
| Speaker Out                                                                | 20 W, 8 Ω [10 W + 10 W ]                                                                                                                                                                                                                                                                                                       |      |                         |                      |
| Bezel gap (Bezel to bezel)                                                 | 4.9 mm or lesser                                                                                                                                                                                                                                                                                                               |      |                         |                      |
| Features                                                                   | Daisy Chain, DVI Min 10 Units, Remote Daisy Chain Min 25 Units, Remote Operation Lock, ID Control with Serial Control, VESA 400 x 400-mm Compatibility, Landscape and Portrait Orientation, 1:1 Pixel Mode, Automatic Picture Position, PC/DVI Power Management, Power-on Screen Delay, Seam Hides Video Off Mode, Heat Status |      |                         |                      |

**Item No. 2 - Wall Mounting Kit for 3 x 3 Video Wall with Standing Metal Wall**

| Item Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| Allowing Displays to be mounted directly onto wall thereby saving entire back room space. Exclusive mount design permits rear sides of all individual monitors being accessible from front for any service, maintenance or cabling etc.<br>Suitable for proposed LED Display & up to 65 Kgs individual monitor weight Metal wall paneling to hold minimum 1000 kgs weight of Video Wall and brackets. Independent brackets have retractable facility. Standing Metal Wall to hold Video Wall | 1    |                         |                      |

**Item No. 3 - Remote Sensing Device for controlling of Video Wall**

| Item Description                                                                               | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
|------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| This device will be used for giving remote commands to all the Video wall cubes simultaneously | 1    |                         |                      |
| There will be Loop in - loop out system for giving user remote signals                         |      |                         |                      |
| This can be used for remote programming & maintenance.                                         |      |                         |                      |
| Appropriate Probes & Sensors to be supplied.                                                   |      |                         |                      |

**Item No. 4 - Video Wall Digital Controller**

| Item Description                                                                                                                                                                                                                                                     | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| SDRAM- 512 MB                                                                                                                                                                                                                                                        | 1    |                         |                      |
| Flash - 4GB                                                                                                                                                                                                                                                          |      |                         |                      |
| Memory Card - supports SD and SDHC cards up to 32 GB                                                                                                                                                                                                                 |      |                         |                      |
| External Storage Support USB mass storage devices up to 1 TB                                                                                                                                                                                                         |      |                         |                      |
| Ethernet:-10/100 Mbps; auto-switching; auto-negotiating; auto-discovery; full/half duplex; industry-standard TCP/IP stack; UDP/IP; CIP; DHCP; SSL; IEEE 802.1X; SNMP; BACnet IPv4 or IPv6; Active Directory authentication; IIS v.6.0 Web Server; SMTP e-mail client |      |                         |                      |
| USB:- Supports USB HID and USB mass storage class devices via rear panel USB 2.0 host ports, supports computer console via front panel USB 2.0 device port                                                                                                           |      |                         |                      |
| RS- 232/ 422/ 485:- For 2-way device control and monitoring, all ports support RS-232 up to 115.2k baud with software handshaking, one port also supports RS-422 or RS-485 and hardware handshaking                                                                  |      |                         |                      |
| IR/ Serial:- Supports 1-way device control via infrared up to 1.2 MHz or serial TTL/RS-232 (0-5 Volts) up to 115.2k                                                                                                                                                  |      |                         |                      |

| <b>Item No. 4 - Video Wall Digital Controller</b>                                                                                                                                         |      |                         |                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| Item Description                                                                                                                                                                          | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
| baud                                                                                                                                                                                      |      |                         |                      |
| Power Pack:- 2.0 Amps @ 24 Volts DC; 100-240 Volts AC, 50/60 Hz power pack                                                                                                                |      |                         |                      |
| IR/ Serial:- Supports 1-way device control via infrared up to 1.2 MHz or serial TTL/RS-232 (0-5 Volts) up to 115.2k baud                                                                  |      |                         |                      |
| USB: (1) USB Type A female; USB 2.0 port for storage devices                                                                                                                              |      |                         |                      |
| COM 1: (1) 5-pin 3.5mm detachable terminal block; Bidirectional RS- 232/422/485 port; Up to 115.2k baud; hardware and software handshaking support                                        |      |                         |                      |
| IR - SERIAL OUTPUT 1 - 8: (2) 8-pin 3.5mm detachable terminal block comprising (8) IR/Serial output ports; IR output up to 1.2 MHz; 1-way serial TTL/RS-232 (0-5 Volts) up to 115.2k baud |      |                         |                      |

| <b>Item No. 5 - Video Wall Engine</b>                                                                                                                   |      |                         |                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| Item Description                                                                                                                                        | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
| Configuration of the complete system via a graphical Interface .                                                                                        | 1    |                         |                      |
| Administrative control of the complete system                                                                                                           |      |                         |                      |
| Live Preview of Input Source.                                                                                                                           |      |                         |                      |
| Specifications of the Video wall controller / Processor                                                                                                 |      |                         |                      |
| Controller with processing board and required nos. Of Input & Output cards                                                                              |      |                         |                      |
| Deliver the screen wall management software as described before including all required licences and install it ready for Operation on the server of the |      |                         |                      |
| Free definition of user rights and the user levels                                                                                                      |      |                         |                      |
| Management of operators to address rights and hierarchy to split the wall in different areas                                                            |      |                         |                      |
| Auto detect of input and output                                                                                                                         |      |                         |                      |
| Dynamic control of windows                                                                                                                              |      |                         |                      |
| Creation of presets (layouts)                                                                                                                           |      |                         |                      |
| Drag & drop function for all sources                                                                                                                    |      |                         |                      |
| Control of the windows on the large screen wall from Control and observation computers.                                                                 |      |                         |                      |
| Chronological controlled showing of presets                                                                                                             |      |                         |                      |
| FPGA Technology based Architecture controller                                                                                                           |      |                         |                      |
| Non windows based video wall controller                                                                                                                 |      |                         |                      |
| The processor should be controlled through RJ45 cable                                                                                                   |      |                         |                      |
| The software should be able to control through Wifi                                                                                                     |      |                         |                      |

|                                                                          |  |  |  |
|--------------------------------------------------------------------------|--|--|--|
| Input: 8 nos. Of HDMI connection.<br>Output: 12 nos. Of HDMI connection. |  |  |  |
| Should be chassis based                                                  |  |  |  |

| <b>Item No. 6 - Application Software- GUI Interface</b>                                                                                               |      |                         |                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| Item Description                                                                                                                                      | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
| The system required to be configured the setup in such a way that it provides a GUI to control video wall and other application                       | 1    |                         |                      |
| GUI should be customized at any given time during support period as per customer requirement like logo, adding event, adding equipment interface etc. |      |                         |                      |
| There will be multiple pages of GUI with 1 home page and there should not be any limitation in making no of pages in GUI                              |      |                         |                      |
| GUI can be accessible from multiple devices and control the video wall and other AV equipment simultaneously                                          |      |                         |                      |
| GUI will be installed in operating component device as well as into the controllers for better synchronization and backup                             |      |                         |                      |
| By operating GUI the software should call all Audio Visual equipment and video wall.                                                                  |      |                         |                      |
| GUI should be live synchronized simultaneously with different device                                                                                  |      |                         |                      |
| There should be a button panel from where the agent can push the video and drag it to video wall                                                      |      |                         |                      |
| There should be a provision to automatically reset the value after predefined time and the video get switch over the flipper unit.                    |      |                         |                      |

| <b>Item No. 7- Speaker</b>                                                                                                                                       |      |                         |                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| Item Description                                                                                                                                                 | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
| 5.2ch platform with 5.1 package included                                                                                                                         | 1    |                         |                      |
| 140W (6 $\Omega$ , 1kHz, 1ch driven, THD 10%)                                                                                                                    |      |                         |                      |
| 4K / 60p full-rate pass-through (two designated HDMI inputs)                                                                                                     |      |                         |                      |
| Type / Full-range, 1 speaker, Frequency range 150 Hz - 20 kHz, Input impedance 6 ohms                                                                            |      |                         |                      |
| Type Built-in amplifier, Frequency range 35 Hz - 150 Hz, Dynamic power 100W, Input impedance 22 kohms, Power supply 230 V, 50 Hz / 60 Hz, Power consumption 65 W |      |                         |                      |

| <b>Item No. 8 - Power Amplifier</b> |      |                         |                      |
|-------------------------------------|------|-------------------------|----------------------|
| Item Description                    | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |

|                                                                                                                                                                                                                          |   |   |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|--|
|                                                                                                                                                                                                                          |   | d |  |
| Power Output:-<br>140 W per channel (6 $\Omega$ , 1 kHz, THD 10%, 1 ch driven)<br>90 W per channel (6 $\Omega$ , 1 kHz, THD 0.7%, 2 ch driven)<br>70 W per channel (8 $\Omega$ , 20 Hz - 20 kHz, THD 0.08%, 2 ch driven) | 1 |   |  |
| Output connectors:- 6 - 16 $\Omega$                                                                                                                                                                                      |   |   |  |
| Input sensitivity/impedance:- 200 mV / 47 k $\Omega$                                                                                                                                                                     |   |   |  |
| Frequency response:- 10 Hz - 100 kHz — +1, - 3 dB (Direct Mode)                                                                                                                                                          |   |   |  |
| S/N Ratio:- 98 dB (IHF-A weighted, DIRECT mode)                                                                                                                                                                          |   |   |  |
| Tuning frequency range:- 87.5 - 108.0 MHz                                                                                                                                                                                |   |   |  |
| Tuning frequency range:- 522 - 1611 kHz                                                                                                                                                                                  |   |   |  |
| Power supply:- AC 230 V, 50 / 60 Hz                                                                                                                                                                                      |   |   |  |
| Power consumption:- 310 W (Standby 0.1W, Bluetooth Stand by 1W) Dimensions (W x H x D):- 434 x 151 x 319 mm                                                                                                              |   |   |  |
| Weight:- 7.5 kg                                                                                                                                                                                                          |   |   |  |
| Built-in Bluetooth                                                                                                                                                                                                       |   |   |  |
| Auto setup with room EQ                                                                                                                                                                                                  |   |   |  |
| Front panel USB input                                                                                                                                                                                                    |   |   |  |
| HDMI Rear 5 in / 1 out                                                                                                                                                                                                   |   |   |  |
| Digital audio inputs : 2 Opt / 1 Coax                                                                                                                                                                                    |   |   |  |
| Audio: 2 in, Video : CVBS 2 in / 1out                                                                                                                                                                                    |   |   |  |
| AM / FM Radio                                                                                                                                                                                                            |   |   |  |

**Item No. 9 - Input / Output Switcher**

| Item Description                                                      | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
|-----------------------------------------------------------------------|------|-------------------------|----------------------|
| This will be an intelligent software to control matrix switching unit | 1    |                         |                      |
| It should support HDMI, DVI and VGA ports.                            |      |                         |                      |
|                                                                       |      |                         |                      |

**Item No. 10 - HDMI Matrix Control Switcher**

| Item Description                                                                                                                                                                                     | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| "HDMI Switcher" lets you connect multiple HDMI inputs to receive more digital content with better picture quality on your TV or LCD's.                                                               |      |                         |                      |
| The unique auto-adaptive equalizers enable the use of longer cables for TV or LCD's connection anywhere in the home. It provides commercial grade output with several control options for switching. |      |                         |                      |
| The unit is controlled through a front panel source selection switches with provision for RS232C & contact closure. It can al                                                                        |      |                         |                      |

|                                                                                                                                                   |  |  |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
| so be controlled through IRremote Control, RF remote control or also through remote IP address.                                                   |  |  |  |
| The unit also senses which input has the signal and switch the TV to that source automatically in auto mode.                                      |  |  |  |
| The resolution that the splitter supports are 720i, 720P, 1080i, & 1080P.<br>Units are compatible with any of the controllers available in market |  |  |  |
|                                                                                                                                                   |  |  |  |

**Item No. 11 - Digital Video Scalar**

| Item Description                                                                                                                | Qty. | Matched/ Not Matched | Deviation, if any |
|---------------------------------------------------------------------------------------------------------------------------------|------|----------------------|-------------------|
| Number/signal type 1 Composite1 RGBHV/YUV (YUVi, YUVp, and YUV-HD) 1 HDMI/DVI                                                   | 1    |                      |                   |
| Connectors 1 female BNC for composite1 female 15-pin HD for RGB/YUV1 female HDMI for HDMI/DVI                                   |      |                      |                   |
| Resolution range 640x480 to 1600x1200 and 1920x1200* NTSC, PAL, SECAM, 480p, 576p, 720p, 1080i, 1080p, and 2k* reduced blanking |      |                      |                   |
| Analog sampling 12 bits per color; 13.5 MHz standard (video) 170 MHz standard (RGB)                                             |      |                      |                   |
| Digital pixel data bit depth 8, 10, or 12 bits per channel; 165 Mhz pixel clock (HDMI)                                          |      |                      |                   |
| Number/signal type 1 HDMI (HDCP)                                                                                                |      |                      |                   |
| Connectors 1 female HDMI                                                                                                        |      |                      |                   |
| Frequency response 20 Hz to 20 kHz, $\pm 0.5$ dB                                                                                |      |                      |                   |
| THD + Noise < 0.1% @ 1 kHz, 20 Hz to 20 kHz bandwidth (at nominal level)                                                        |      |                      |                   |
| S/N >90 dB, at maximum output (unweighted)                                                                                      |      |                      |                   |
| Number/signal type 3 stereo unbalanced                                                                                          |      |                      |                   |
| Connectors (3) 3.5 mm TRS connectors                                                                                            |      |                      |                   |
| Number/signal type (1) 2-channel LCPM audio or digital pass-through                                                             |      |                      |                   |
| Connectors 1 female HDMI (shared with HDMI video)                                                                               |      |                      |                   |
| Serial control port 1 bidirectional RS-232 rear panel 3 pole captive screw connector                                            |      |                      |                   |

**Item No. 12 - Video Data Flipper**

| Item Description                                                              | Qty. | Matched/ Not Matched | Deviation, if any |
|-------------------------------------------------------------------------------|------|----------------------|-------------------|
| The flipper server has the capacity to view minimum 8 video feeds.            |      |                      |                   |
| There should be capacity scale and make proper resolution of each video feeds |      |                      |                   |

|                                                                                                                                                    |  |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
| There will be facility to show minimum 8 feeds in 1 screen in different size and similar size.                                                     |  |  |  |
| User can change 5 of the video feeds by clicking, dragging of input/ video feeds.                                                                  |  |  |  |
| Should have capacity to flip the video/ input to video wall in the timeinterval of 3,5,7,10 seconds or time will be customized as per requirement. |  |  |  |
| There should be minimum 52 layouts in which user can define the different size of input.                                                           |  |  |  |
| Flipper server can harden operating system to avoid any virus and malfunctioning.                                                                  |  |  |  |
| Appropriate hardware to be supplied with HDMI/ DVI and Ethernet port.                                                                              |  |  |  |

| <b>Item No. 13 - Supervisory Suite and Server</b>                                                                          |      |                      |                   |
|----------------------------------------------------------------------------------------------------------------------------|------|----------------------|-------------------|
| Item Description                                                                                                           | Qty. | Matched/ Not Matched | Deviation, if any |
| Should have four core, 1.8 GHz, 10MB processor                                                                             | 1    |                      |                   |
| High End 1300 Watt chasis based server                                                                                     |      |                      |                   |
| Should have boot drive/ boot volume < 2TB                                                                                  |      |                      |                   |
| Must have minimum 16 GB RAM                                                                                                |      |                      |                   |
| Must have minimum 1 TB hard disk.                                                                                          |      |                      |                   |
| It should be integrated with ATA/ SAS controller                                                                           |      |                      |                   |
| Should have minimum 8 Slim line DVD writer drive                                                                           |      |                      |                   |
| It should have chasis intrusion switch                                                                                     |      |                      |                   |
| It should have built in internal speaker                                                                                   |      |                      |                   |
| It should have USB optical mouse, 40 USB keyboard                                                                          |      |                      |                   |
| Must have 5 year support, 4 hr onsite service                                                                              |      |                      |                   |
| It will be used to manage agent work load.                                                                                 |      |                      |                   |
| Supervisory suit will be having summary of load of Audio Visual on Network Command Center                                  |      |                      |                   |
| There should be a drag and drop facility for allocating task to the agent                                                  |      |                      |                   |
| There is a special GUI for supervisor for managing, operating and maintenance of all Audio Visual equipment and video wall |      |                      |                   |
| Supervisor have the overriding function to display on video wall                                                           |      |                      |                   |
|                                                                                                                            |      |                      |                   |



| <b>Item No. 14 - Tran receiver (In Lot)</b>                                                 |      |                         |                      |
|---------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| Item Description                                                                            | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
| Tran receiver with 1080p full HD video and audio transfer at 9.5 Mhz                        | 1    |                         |                      |
| Tran receiver should support CAT 5/6 and above cables                                       |      |                         |                      |
| LED indication feedback for:-                                                               |      |                         |                      |
| 1. Receiving the signal                                                                     |      |                         |                      |
| 2. Non availability of the signal                                                           |      |                         |                      |
| 3. Signal pas through                                                                       |      |                         |                      |
| Tran receiver should give text message on display or video wall for status of video signal. |      |                         |                      |
|                                                                                             |      |                         |                      |

| <b>Item No. 15 - 24 Port Switch</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |      |                         |                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------|----------------------|
| Item Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Qty. | Matched/<br>Not Matched | Deviation,<br>if any |
| Connector Options:- 10/100/1000 Mbps ports: RJ-45<br>1 Gbps SFP ports for uplink/stacking: SX, LX, TX, LHA, LHB, direct-attached copper cable (Twinax) for stacking<br>100 Mbps/1 Gbps SFP ports for uplink: FX, SX, LX, TX, LHA, LHB; 10/100/1000 Mbps RJ-45 ports for uplink<br>1/10 Gbps SFP+ ports for uplink/stacking: USR, SR, LR, ER, LRM, direct- attached copper cable (Twinax) for stacking<br>Out-of-band Ethernet management: 10/100/1000 Mbps RJ-45<br>Console management: RJ-45 serial External power connector: Redundant system power supply and extended PoE power supply | 1    |                         |                      |
| IPV 6 support:- Host functionality management, Hardware support for IPV6, IPV 6 static routing                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |      |                         |                      |
| Maximum jumbo frame size:- 9216 bytes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |      |                         |                      |
| Traffic management:- ACL-based inbound rate limiting and traffic policies, Broadcast, multicast, and unknown unicast rate limiting, Inbound rate limiting per port, Outbound rate limiting per port and per queue.                                                                                                                                                                                                                                                                                                                                                                         |      |                         |                      |
| High Availability:- Redundant external power supply, Layer 3 VRRP protocol redundancy, Real-time state synchronization across the stack, Hitless failover from master to standby stack controller, Protected link groups, Hot insertion and removal of stacked units                                                                                                                                                                                                                                                                                                                       |      |                         |                      |
| Embedded Security:- 802.1X Accounting, MAC authentication, DHCP snooping, Dynamic ARP inspection, Bi-level Access Mode (Standard and EXEC Level), EAP pass-through support, Packet filtering on TCP Flags, IEEE 802.1X username export in sFlow, Protection against Denial of Service (DoS) attacks                                                                                                                                                                                                                                                                                        |      |                         |                      |

| <b>Item No. 16 - Distribution Amplifier</b>                                                                                                                                                                                                                                                             |             |                                      |                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------|------------------------------|
| <b>Item Description</b>                                                                                                                                                                                                                                                                                 | <b>Qty.</b> | <b>Matched/<br/>Not Match<br/>ed</b> | <b>Deviation,<br/>if any</b> |
| It should be able to boost the Signal                                                                                                                                                                                                                                                                   | 1           |                                      |                              |
| It will be used to send your HDMI output of set-top boxes, DVD Players, D- VHS Players, PC's and other HDTV devices to as many as 2/4/8 HDMI inputs of monitor /LCD/Plasma/Projectors with the same strength & quality and an ability to daisy chain or cascade for multiple larger number of displays. |             |                                      |                              |
| The resolutions, the distribution amplifier should support are 720i, 720P, 1080i and 1080P.                                                                                                                                                                                                             |             |                                      |                              |
| It should work on simple plug and play functionality.                                                                                                                                                                                                                                                   |             |                                      |                              |
| It should be able to connect to both HDMI and DVI-D single link Displays.                                                                                                                                                                                                                               |             |                                      |                              |
| It should have minimum 16 ports.                                                                                                                                                                                                                                                                        |             |                                      |                              |

| <b>Item No. 17 - Connectors / Cables and Accessories</b>                                                                    |             |                                      |                              |
|-----------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------|------------------------------|
| <b>Item Description</b>                                                                                                     | <b>Qty.</b> | <b>Matched/<br/>Not Matche<br/>d</b> | <b>Deviation,<br/>if any</b> |
| Bracket and connectors as required (in Lot)                                                                                 | 1           |                                      |                              |
| Cables & other accessories as required (in Lot)<br>-HDMI / DVI Cable or as per the equipments offered and site requirements |             |                                      |                              |

| <b>Item No. 18 - Rack</b>                                                                                                                                                                         |             |                                      |                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------|------------------------------|
| <b>Item Description</b>                                                                                                                                                                           | <b>Qty.</b> | <b>Matched/<br/>Not Matche<br/>d</b> | <b>Deviation,<br/>if any</b> |
| 27" 800 x 800 24 U Rack with front Glass/ Acrylic door, Ventilated Top & Bottom, Fully powder coated Rigid Steel body with Accessories like Cooling Fan, Power Strip-5 Amp with Mounting Hardware |             |                                      |                              |
|                                                                                                                                                                                                   |             |                                      |                              |

| <b>Item No. 19 - HD Graphics peripheral Card</b>                                                                                                                                                   |             |                                      |                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------|------------------------------|
| <b>Item Description</b>                                                                                                                                                                            | <b>Qty.</b> | <b>Matched/<br/>Not Match<br/>ed</b> | <b>Deviation,<br/>if any</b> |
| Minimum 1 GB Graphic device with HDMI / DVI port. It should give minimum 1080 pix resolution. It should have the capacity for dual / duplicate display without 4compromising on native resolution. | 4           |                                      |                              |

**6. Desktop PC with control desk**

- 1) PC of reputed make (as shall be approved by BDA) with minimum requirements as: Intel core i7, 8 GB RAM, 2 TB HDD, **with RAID Compatibility & Redendency Backups for all PC which are related to SCADA & AUTOMATION.** for Windows 7 professional OEM ( or latest Operating System. ) license version, 21” monitor, keyboard, mouse, at least two USB ports and all other accessories as may be necessary for operation of SCADA system.
- 2) A suitable control desk for housing the PC and placing the monitor, keyboard and mouse on top of control desk. Desk shall have sufficient space for the operator to use the system with convenience. BDA approval shall be taken prior to procurement of the control desk.
- 3) Inkjet printer of HP or reputed equivalent as shall be approved by BDA.
- 4) Licence Office software loaded in the PC
  - (a) Microsoft office 2010 or latest of OEM version to facilitate report preparation in word, excel, power point, etc.
  - (b) Basic software packages such as adobe acrobat reader etc
- 5) USB dongle license, as applicable
- 6) In-built web server, as applicable, for configuration/ data logging/viewing
- 7) SCADA software loaded in PC

**7. Vendor scope of commissioning:**

- (a) Vendor shall verify and make all the connections of communication cables that are laid by BDA up to the entry point of string monitoring boxes, weather monitoring equipment, data station panel. All further operations such as unsleeving, splicing, crimping, ferruling, routing, dressing and connecting to the respective terminals within the weather equipment / data station panels shall be in the scope of vendor. All necessary cable lugs, ferrules, hardware etc for this purpose shall be in vendor scope of supply. All necessary tools for carrying out this commissioning shall be in vendor scope.
- (b) Interconnection of PC (SCADA) with its peripherals and accessories on the console (control desk) using appropriate cables, accessories and hardware as provided by vendor.
- (c) Installation and configuration of operating system (Windows), SCADA software, Microsoft office and all other software on PC.
- (d) Installation and configuration of remote monitoring features in SCADA.
- (e) Customization, configuration and demonstration of following:
  - 1) SCADA screens showing plant-specific mimic diagrams, live display of parameter values, breaker On/Off displays, alarm indications, faults, events, etc based on interactive discussions with BDA engineer at site.
  - 2) Daily, weekly, monthly reports on plant performance, based on interactive discussions with BDA engineer at site.
  - 3) Trend graphs for plant monitoring and management reporting, based on interactive discussions with BDA engineers at site.
- (f) (Service engineer shall be present at the site at the time of commissioning of the plant. The engineer shall support in trouble shooting and resolve in case of any problems.

- (g) Training to BDA engineers on operation and maintenance of the Data station panel (data loggers / PLCs) and SCADA software.

#### **2.14.5 DESIGN PARAMETERS**

##### **A. General:**

Proposed automation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All equipment shall be new of proven design, reputed make and shall be suitable for continuous operation. Electronic instruments shall utilize solid-state electronic components, integrated circuits, micro controllers etc., and shall be of proven design. The equipment/instruments such as flow meter, level sensor, underground depth sensors etc. should as per site requirement and in tune with realistic conditions of site such as head, pressure etc.

For transmitting instruments, the output signal shall be 4-20 mA DC linear having two/three or four wire system.

Unless otherwise stated, overall accuracy of all measurement systems shall be  $\pm 0.25\%$  of measured value and repeatability shall be  $\pm 0.5\%$ .

Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

The instruments shall be designed to permit maximum inter-changeability of parts and ease of access during inspection and maintenance & must be compatible so that the system of similar or dissimilar technologies are added on in future, LCS , MCS must be capable to integrate all these addition like Additional Automated meter reading (AMR) or automation of distribution network & billing etc.

The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail. The instruments shall be given enough protection against corrosion.

All field instruments and cabinets/panel mounted instruments shall have tag plates/ name plates permanently attached to them.

The performance of all instruments shall be unaffected for the  $\pm 10\%$  variation in supply voltage and  $\pm 5\%$  variation in frequency simultaneously.

##### **B. Data station panel (Main SCADA panel):**

The data signals as listed above reach the SCADA room. These shall be integrated using a suitable Data station panel. Accordingly, the panel shall have following features:

##### **1. All necessary devices such as**

###### **(a) Data loggers / PLCs :**

Data loggers for logging (at software selectable logging intervals 0.1s to 24 hours) and storage of above data signals. Data loggers shall have minimum 10Hz sampling rate per channel, USB ports for independent data access, adequate flash memory, at least

64MB RAM, RS485, RS232 and Ethernet TCP/IP communication interfaces. (or) Alternatively, suitable PLCs for respective analog signals, digital signals, RS 485 MODBUS signals shall be used and integrated.

- (b) Device servers, wherever required, as applicable, such as serial to Ethernet servers etc. with appropriate number of ports.
  - (c) Ethernet I/O devices such as RTU microcontrollers, wherever required, as applicable, for processing the analog and digital signals, with appropriate number of input / output channels.
  - (d) Network switches such as Ethernet switches, etc., wherever required, as applicable, with appropriate number of ports.
  - (e) Any other devices as may be necessary for the specific SCADA schematic design adopted by the vendor for accomplishing the objective of SCADA integration.
2. In case of mV-based analog signals (ex: pyranometer), amp-box shall be provided to avoid distortion of signals due to long cable distance from roof-top to SCADA room.
3. Power supply units
4. Other accessories such as DIN rails, terminal blocks, MCBs, surge arrestors, fuses, etc., as may be required for the system, based on the specific design.

**5. Enclosure requirements:**

- (a) Frame, doors with CRCA sheet of 2mm thickness
- (b) Gland plates with CRCA sheet of 3mm thickness Gland plates to be fitted with cable glands. Holes shall be punched by the vendor according to this requirement.
- (c) Cable lugs, hardware – nuts, bolts, washers, ferrules, cable ties for making cable interconnections to the panel shall be provided by the vendor.
- (d) Base frame of suitable ISMC channel
- (e) Cable entry from bottom side and through glands in gland plates
- (f) Grouting provisions in base frame for fixing the panel on ground
- (g) Earthing provisions
- (h) Painting colour shade RAL 7032 using seven tank process.
- (i) IP42 (indoor)

**C. Technical Specification for SCADA at MCS**

**Architecture**

The SCADA architecture shall provide the following:

Client / Server architecture based on TCP/IP networking and report-by-exception (RBE) technology Standalone single server operation.

Additional servers for client load sharing and remote locations.

Permanent Standby Server designed to be placed outside corporate firewalls providing a read-only access to the server while ensuring corporate security.

Fully automated data transfer between servers to provide complete server redundancy. This transfer shall include configuration, real-time data, historic data and event lists. Database updates shall be on an incremental basis with tuneable parameters.

A scalable fully distributable architecture providing:

- Unlimited number of server systems.
- Unlimited number of display clients.

Where multiple servers are deployed, the system shall be capable of being configurable from a single client.

All redundancy shall be handled by the database, with the operational state of systems preserved through a server changeover. The system shall not rely on driver redundancy for data transfer when providing redundant server. The system shall present a uniform view of data including communication status after a fail over.

Forced changeover between main and standby allowing seamless changeover without shutting down.

Clients to connect to a synchronizing server as soon as the configuration and current data in the database has synchronized. Incomplete data sets as per clients request on event or trend provide indications that the synchronization is still in progress to ensure that conclusions are not drawn from incomplete data sets.

Configurable compression of data communications between client/server and server/server to allow optimisation of communications performance over WAN networks.

Change reporting on Client/Server and Server/Server links rather than polled communication to permit operation on WAN networks.

Capable of operating Client/Server and Server/Server links over low to medium speed channels depending upon database size.

Application shall be native 32-bit and 64-bit versions and supported on Windows® Server and Workstation operating systems including Windows 2000, Windows XP, Windows 2000 Server, Windows 2003 Server, Windows 7 (32 and 64 bit) and Windows Server 2008 R2 and later.

### **Database**

The SCADA database shall be of true database design and optimized for real-time SCADA operation. The database shall be object oriented and organized in a hierarchical structure.

Templates of standard configuration shall support multiple object types including, but not limited to:

Point / Tag objects

PLC or RTU objects

Mimics or Graphic display objects

Trend objects

Logic programs

Schedules

Link objects

The SCADA database shall allow users to extend the database scheme to store custom data, in either the configuration or data stream. These changes can be performed online without need for server restart.

### **Operator Interface**

SCADA software shall provide the ability to support multiple local and remote display clients.

Display facilities shall be available via LAN, WAN and dial-up connection.

Rich Clients shall support database management and configuration changes.

Rich Clients shall support multiple monitors (multi-head display), allow logon for all heads from a single location. The system should also provide navigation facilities such that displays on each head can be controlled from any head.

Integrated Web Sever capability shall be available, providing all display and operational facilities of the Rich Client without the need for additional software to be installed.

Web Clients shall allow users to view Mimics, Trends, Database Objects, Reports as well as perform control functions using a standard web browser.

Changes made to the SCADA server shall require no additional steps to be performed in order for those changes to be available to Rich Clients and Web Clients.

Rich Client shall be configurable to connect to one, or multiple server systems

Full function display clients shall automatically fail-over & reconnect to a redundant server node when server change-over occurs.

Look and feel shall be provided by the SCADA system operator interfaces, including provision for "favourites lists" .

SCADA software shall provide the ability to support for Citrix Xen App and Windows Terminal Services.

### **Mimics / Graphics**

SCADA system Mimics shall support a wide range of graphical facilities. Scalable Vector Graphics are required in order to permit operation of the SCADA system with different resolution clients operating simultaneously. Fixed resolution bitmap graphics are not acceptable.

Mimics shall be multi-layered, object oriented and permit mimics to be embedded in other mimics. 24-bit Colour shall be supported on mimics as standard.

Import of mimics shall be supported from DXF format, including integration of multi-layered DXF drawings in to native SCADA mimics.

Mimics shall support the ability to specify OPC data source information to display directly on the mimic. This permits data from other systems to be seamlessly integrated in to the SCADA display.

Objects embedded and displayed on any mimic shall be viewable through both the full function client and web client displays.

### **Start-up**

The SCADA system shall start-up unattended, and without compromising system security.

### **Configuration**

The SCADA software shall provide full seamless On-line configuration of all database parameters including but not limited to:

- Communication channels
- PLCs
- Points / Tags
- Sequences
- Schedules
- Alarm redirection



- Mimics / Graphics
- Trends/graphs
- Reports

All aspects of the look and feel of the SCADA system, including default field values, shall be configurable. It is not acceptable for colour regimes, communication parameters and other aspects of the system to be hard-coded.

It shall be possible to add user defined fields to the SCADA database. These fields should be accessible both internally and externally to the SCADA system; being exposed via OPC, ODBC, OLE Automation, XML/SOAP, etc.

The SCADA server shall provide detailed diagnostics concerning its internal operation. The diagnostics shall be available through capture to a log file as well as online locally on a server and remotely via Telnet and Web interface.

Stored configuration records should be maintained in the historic database for a configurable time period, support redundant SCADA server configurations and allow access from standard database interfaces such as queries and simple mechanisms for displaying and filtering the configuration records.

### **Alarm Management**

The alarm system shall provide facilities where actions can be triggered by alarms. These facilities shall be provided as a built-in integrated part of the system and shall include, but not be limited to the following:

- Configuration criteria for alarm actions
- Escalate Alarm priority
- Delivery of alarm to users via SMS
- Delivery of alarm to users via E-mail
- Trigger other actions including sequences

Where a full function Rich Client is connected to multiple SCADA systems, alarms from all systems shall be combined and filtered, based on user privilege and areas of responsibility. Consequential alarms to allow one (or more) alarms to be suppressed as the result of another alarm occurring. Suppressed alarms will be received and processed by the SCADA Server and recorded in the event journal for future auditing, however the operator shall not be forced to take an action on an alarm where the cause is known.

### **Event Journal**

The system shall provide, as a built in feature and without the requirement for custom or external software, facilities for event logging. These facilities shall be separate from the alarm list and include the capability to insert user comments at any place in the event list.

Historical Data



The SCADA system shall provide a built in data historian with the following facilities as standard features. These shall be provided without the addition of external software modules:

- Time-series relational database
- ODBC / SQL interface to historical (trend) data
- Historical data to be stored with time-stamp, point quality, alarm status
- Historic storage is to be based on configurable criteria including time between samples, alarm state change
- Compression capability

### **System Security & Access**

The SCADA system shall provide a high level of inherent security. To this end the SCADA software shall provide security access down to data point level, and support individual Users, User Groups and a matrix of system capability and access to any level of the SCADA database.

Full function Rich & Web client interfaces shall require explicit administrative configuration to valid connection to the SCADA server.

The SCADA system security shall provide the ability to be integrated with Windows domains to authenticate logon attempts against a trusted domain.

Open Connectivity

To provide easy access for customized reports and external data manipulation the SCADA software shall provide inherent OPC and ODBC database connectivity without the need for additional software options or modules. Integration with desktop Microsoft products is essential.

### **Reports**

An integrated reporting package shall be able to generate, print and export reports:

Triggered by SCADA events

On user demand

On timed schedules.

Reports shall be able to be generated in a number of formats including:

HTML for viewing via Web interface

PDF format

CSV format

MS Office® suite format.

Generated reports shall be able to be:

E-mailed to assigned users

### **Standard Drivers**

The SCADA system shall provide native support for fully integrated Wide Area SCADA PLC protocols. This shall include the capability for supporting all protocols in redundant SCADA server configurations and support redundant communication paths.

Apart from PLC and RTU communication drivers, the system shall also support as standard the following drivers:

SMS (with TAP and UCP service) to mobile phones

A full function system is required including calendar based rosters

SNMP - monitoring of network devices such as routers, computers, UPS, etc.

NTP - time server monitoring and alarming

ODBC - query data from other databases

Windows Performance Monitoring

OPC-DA driver

### **Logic**

The SCADA system shall support logic sequences with full access to all SCADA system services at run time. Programming of sequences shall be to the IEC61131-3 international standard and support as a minimum the following languages:

Ladder Diagrams (LD)

Function Blocks (FB)

Structured Text (ST)

Sequential Function Charts (SFC)

Special scripting languages to perform the control strategy will not be accepted.

### **D. Zonal Pumping Station-PLC Specifications**

#### **Processor**

The processors must have an internal non-volatile memory to store application and data. Processor must also have a reserved slot for a removable cartridge so that the application and data backup can also be performed on a mobile device.

It must be possible to connect a PC (programming terminal) or a human-machine interface via a USB port integrated in the processor.

The range must provide processors with at least 3 built-in Ethernet ports featuring a web server, compliant with various operating systems: minimum is Windows, iOS, and android.

Embedded web server must provide CPU diagnostic, including detailed information on Ethernet system networking.

The Embedded web server must be customizable by the user to display application variables and advanced diagnostics features. Each processor should have a savable real-time clock which manages:

The current date and time

The date and time of the last application shut-down. The date and time should be managed even when the processor is switched off for 20 days.

NTP server must be provided within the CPU.

The processors must be equipped with ground connection contacts without additional cabling.

The PLC must be able to load the program with the use of the memory cartridge.

Data Exchange through high speed link of 1Gbps

Possible to add modules or add remote I/O islands in the configuration without interrupting the running process.

The complete environmental footprint of the product must be known and all products must be designed with eco-design requirements (Green Premium)

#### Operating system

The operating system (OS) must be capable of multitasking with up to 4 periodic tasks and more than 60 event or I/O tasks.

Physical input can be program to prohibit any modification or downloading of the program.

Outputs can be set to fallback position when the PLC switches to STOP mode via channel by channel parameter entry.

Able to set breakpoints and watchpoint in application to check all system and data when executing application for debugging. System must also provide Step-by-Step running feature to execute all operations one by one in the application. Engineering tool must provide a trending tool embedded to display variables at a minimum of 1ms sampling rate

#### Memory

Application memory execution can be done on through embedded or removable memory.

No battery supply is needed for non-volatile backup.

The processor must provide up to 64 MB of integrated non-volatile memory as well as removable memory up to 8 GB.

Feature to store the program, comments and symbols in the PLC. The "empty terminal" functionality must be possible whichever IEC language is used. It must be also possible to use the memory extension to back up files (production data, recipes, etc)

#### Communication

The Ethernet connection must support SNMP agent functions for the standard MIB II base (RFC 1213). Synchronized and unsynchronized drops with PLC scan can be managed over standard and open Ethernet communication.

Must provide exchanges of variables:

Explicit exchanges (via function blocks integrated in the application)

Implicit exchanges (Using cyclical variables generated by the single declaration of the device)

Dedicated function blocks should be available.

The PLC must be accessible via Ethernet (from a remote site) using a standard Internet browser or any other platform (android, iOS). These functions must not require any prior configuration or special software. In addition, the use of these functions must have no effect on the PLC scan time.

Variables or animated objects in the Internet browser's web pages must be refreshed automatically from the PLC using a standard Internet protocol, without having to update the entire page.

A device must be reconfigured automatically after replacement

The PLC must have serial links which support various types of communication: Modbus or open protocols.

#### **Standards and certifications**

The PLC must conform to the main national and international standards covering electronic equipment for industrial control systems:

CE marking according EN 61131-2

Be compliant with IEC - 62443 standard

Cyber Security

The system MUST be Achilles level 2 certified

The system must be able to secure communication between PLC and engineering workstation / SCADA providing authentication and integrity of data

The internal firmware of the CPU must be digitally signed and encrypted.

The integrity of the firmware must be checked before any application download and at startup of the system.

The integrity of the engineering software must be checked on demand

The user must be able to disable the following Ethernet services:  
FTP/TFTP/HTTP/EIP/DHCP/BOOTP/SNMP

The system provides an access control list for each protocol and each connected IP address  
Any modification of the operating mode of the system (Run / Stop / Program modifications) must be authenticated real time memory Integrity Control.

#### **E. SCADA FOR TUNNEL PUMPING STATION**

SCADA should be scalable & can be expandable as and when required as per requirement  
It should support web browser on the WAN with the appropriate security settings. The web browser clients shall support view and control capabilities, controlled by both login security and license types

The SCADA software shall be configurable as a single global database regardless of the number of stations in the system.

SCADA System should have true unlimited tag licensing Vendor has to submit customer name with running PQR for more than 70000 Tags running.

Cloud Based SCADA Not Acceptable.

SCADA System Run Time should have flexibility to operate in English or Hindi user Selectable.

The trend page should have indication of alarms & values with moving cursor on the same page.

SCADA System should have inbuilt provision for development. No additional cost shall be charged by vendor to provide development facility.

The minimum tasks requiring include:

I/O Device

Monitoring, alarm generation, distribution and acknowledgement of alarm

Collection, storing and distribution of historical trends

Processing, storing and distribution of reports in a web-friendly format

Storing and distribution of configuration to remote client stations

Network communications between SCADA stations

Field Device communications (where supported by the field device)

All currently available drivers should be included with the software and included in the price. Department will pay no additional license fee.

The software shall be able to group the users into Roles. Roles shall be able to be configured with clearly defined privilege levels and clearly defined plant areas.

The software shall support a large number of users. For each user, it shall be possible to define a password and a role for that user. Passwords shall be hidden both in the configuration and the runtime environment to ensure that other personnel cannot access another account.

Flexibility to define time-based or periodic scheduling for reading and writing of variables to and from field devices.

For remote field devices that are capable of supplying an historical log of alarms and tag value changes, if the communications link fails for whatever reason, on re-establishment of the remote link, all historical alarm, event and trend data archived by the PLC shall be automatically backfilled into the native SCADA alarm and trend history files.

The software shall not limit the number of graphic displays.

Graphic display pages shall be capable of a minimum of 2000 analog tags.

The software must support Historical Trend Graphs as part of a graphic display. The number of trend graphs per page shall not be limited and it can lay trend graphs on top of each other to provide comparisons.

The SCADA software shall include an integrated development package utilizing menu-driven, fill in the form style of configuration to develop the runtime system.

Add, modify and replace alarms, trends and reports online without restarting the server. Feasible to integrate video cameras to allow viewing of live video.

| Capacity Description                                              | Size                                   |
|-------------------------------------------------------------------|----------------------------------------|
| Number of SCADA I/O Device Subsystem servers                      | 255                                    |
| Number of SCADA Cluster servers for Trending, Alarm and Reporting | 255                                    |
| Number of SCADA Client stations                                   | 255                                    |
| Number of field devices                                           | 4095                                   |
| Physical I/O tags being read/written to field controllers         | Unlimited and demonstrable to >1000000 |
| Internal I/O tags within the SCADA networked system               | Unlimited                              |
| Alarm tags                                                        | > 100000                               |
| Analog trend tags                                                 | > 20000                                |
| Average refresh time on a graphic display                         | < 1s                                   |
| Average recall time for historical trend values                   | < 5s per day of data                   |

### **Specifications of PLC/ HMI/**

Online Analytical Monitoring /Control panel

The hardware is a unique blend of rugged industrial I/O, real-time multi-tasking software and powerful communication capabilities. It shall be a locally intelligent unit having local memory and processor installed at a respective control and monitoring location in the water network; this can be a pumping station or a tube well station. The Redundant PLC hardware shall be programmable in SFC, IL, LD, ST & FBD.

The high performance modular Redundant PLC must be designed to log all the pumping station parameters with time stamping in its NON-VOLATILE memory at the defined logging interval.

The PLC shall be battery backed-up so as to maintain the parameters during power failure.

The PLC shall be designed to have communication compatibility for wireless mode viz. for GSM, GPRS, Radio, satellite or wired mode viz. Telephone and serial to transmit data and receive commands remotely.

Following shall be the other minimum design features of the PLC for pumping plant:

16-bit or higher dual core processor based CPU

Data memory of 8 MB and program memory of 64 MB

128 mb flash memory for user program backup.

Having option of Data storage <=32 GB

3 nos. of communication ports

RTC.

Timers and counters sufficient as required.

While the design of the offered PLC Hardware shall be as per the site design on case-to-case basis, the offer PLC shall have full expandability.

Surge withstand 1 kV for transistor output in common mode conforming to EN/IEC 61000-4-5 Environment

Standards CSA C22.2 No 142, UL 1604, UL 508, Resistance to conducted disturbances, induced by radio frequency fields

EN/IEC 61131-2 : 2007

Marine specification (LR, ABS, DNV, GL

1 kV for Ethernet line conforming to EN/IEC 61000-4-4

Digital Inputs with following feature

Input Voltage ranges: 24 VDC, Input current (max): 7 mA @24 VDC/channel • ON/OFF delay times: 1.6 ms

Conforming to IEC 61131-2 type 1

Input impedance 4.7 kohm

Response time 50 usec

Filtering time 1usec

Execution Time for 1 kinst. 0.7 msec and 0.3 for event and periodic

Analog Inputs with

Input Amplification: 1M Ohm for voltage & 50 Ohm for current input

Maximum allowed overload 13V DC & 40 mA.

### **HMI Specification**

- Minimum 7" wide 800X480 Pixel LCD display with back-lit to display.
- Inbuilt Ethernet, USB mini port, USB type A for report generation, data logging, 485 Port embedded.
- 64000 color
- Real Time Clock
- Minimum Internal memory 48 MB
- Touch Screen
- Facility to connect printer directly
- Serial and parallel printing option
- Make:- Proface /Schneider/Allen Bradley/ ABB

### **2.14.6 Uninterruptible Power Supply (UPS)**

The power for Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA/HMI) shall be derived from separate UPS. The central PLC based SCADA system and all the remote I/O systems shall be powered by UPS. This shall also include corresponding managed Ethernet switches, internal and external communication systems, monitors and LCD screens. The UPS provided shall be sized to provide sufficient power to maintain system functioning for a period of minimum 1 hour, in case of power failure.

The above feature should be demonstrated during Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

UPS shall be of stand alone online type not parallel redundant.

## **2.15 CCTV**

The CCTV shall be suitable for day to day operation by semi skilled personnel in the monitoring and operation of the facility.

On completion of installation and commissioning, the facility shall be checked to receive the best clarity footages from both indoor and outdoor cameras.

The facility shall be supported with sufficient backup power facility to maintain system functioning for a period of minimum 1 hour, in case of power failure.

CCTV monitoring station shall be provided at central monitoring Room, which shall be based in the administration building. CCTV Viewer screens shall be fixed both at monitoring station and security centre.



### **Compliance Table**

The bidder shall fill in the following compliance tables fully detailing the level of compliance and how the level of compliance is achieved.

| <b>Description</b>                                                                                                                                                                                                                                                                                                                                                     | <b>Compliance</b> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>1. SCADA Architecture</b>                                                                                                                                                                                                                                                                                                                                           | √                 |
| Client / Server architecture                                                                                                                                                                                                                                                                                                                                           | YES / NO          |
| Standalone single server operation                                                                                                                                                                                                                                                                                                                                     | YES / NO          |
| Additional servers for user load sharing                                                                                                                                                                                                                                                                                                                               | YES / NO          |
| Fully automated data transfer between servers                                                                                                                                                                                                                                                                                                                          | YES / NO          |
| A scalable fully distributable architecture                                                                                                                                                                                                                                                                                                                            | YES / NO          |
| Configurable from a single client                                                                                                                                                                                                                                                                                                                                      | YES / NO          |
| Redundancy shall be handled by the database                                                                                                                                                                                                                                                                                                                            | YES / NO          |
| Configurable compression of data communications                                                                                                                                                                                                                                                                                                                        | YES / NO          |
| Change reporting on Client/Server and Server/Server                                                                                                                                                                                                                                                                                                                    | YES / NO          |
| Capable of operating Client/Server and Server/Server links over low to medium speed channels                                                                                                                                                                                                                                                                           | YES / NO          |
| SCADA should be having a capability to integrate with IP camera/ CCTV and should able to display the remote images within SCADA environment.                                                                                                                                                                                                                           | YES / NO          |
|                                                                                                                                                                                                                                                                                                                                                                        |                   |
| <b>2. Operator Interfaces</b>                                                                                                                                                                                                                                                                                                                                          |                   |
| Multiple local and remote clients                                                                                                                                                                                                                                                                                                                                      | YES / NO          |
| Display facilities shall be available via LAN, WAN and dial-up connection.                                                                                                                                                                                                                                                                                             | YES / NO          |
| Display clients shall be supported as Thin Clients                                                                                                                                                                                                                                                                                                                     | YES / NO          |
| Integrated desktop Web capability                                                                                                                                                                                                                                                                                                                                      | YES / NO          |
| Changes made to the SCADA server shall require no additional steps                                                                                                                                                                                                                                                                                                     | YES / NO          |
| SCADA Software shall provide an Android™ and iOS™ based mobile client and server system                                                                                                                                                                                                                                                                                | YES / NO          |
|                                                                                                                                                                                                                                                                                                                                                                        |                   |
| <b>3. Configuration</b>                                                                                                                                                                                                                                                                                                                                                |                   |
| Seamless On-line configuration of all database parameters including but not limited to: <ul style="list-style-type: none"> <li>– Communication channels</li> <li>– PLC/RTUs</li> <li>– Points</li> <li>– Sequences</li> <li>– Schedules</li> <li>– Alarm redirection</li> <li>– Mimics</li> <li>– Trends (historical and ad-hoc)/graphs</li> <li>– 3D Plots</li> </ul> | YES / NO          |

| Description                                                                                                                                                                                                                                                                                                                                                                                                              | Compliance |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| – Reports                                                                                                                                                                                                                                                                                                                                                                                                                |            |
| Configuration changes shall be capable of being made from local and remote workstations                                                                                                                                                                                                                                                                                                                                  | YES / NO   |
| Changes should be updated automatically in local caches where appropriate                                                                                                                                                                                                                                                                                                                                                | YES / NO   |
| Look and feel of the SCADA system, including default field values, shall be configurable                                                                                                                                                                                                                                                                                                                                 | YES / NO   |
| Possible to calculate the value of internal points without using logic                                                                                                                                                                                                                                                                                                                                                   | YES / NO   |
| 4. Alarm Management                                                                                                                                                                                                                                                                                                                                                                                                      |            |
| Facilities where actions can be triggered by alarms. These facilities shall be provided as a built-in integrated part of the system" <ul style="list-style-type: none"> <li>– Configuration criteria for alarm actions</li> <li>– Escalate Alarm priority</li> <li>– Delivery of alarm to users via SMS</li> <li>– Delivery of alarm to users via E-mail</li> <li>– Trigger other actions including sequences</li> </ul> | YES / NO   |
| Integrated paging facilities                                                                                                                                                                                                                                                                                                                                                                                             | YES / NO   |
| Tracking of alarms                                                                                                                                                                                                                                                                                                                                                                                                       | YES / NO   |
| Alarms from all systems shall be combined and filtered, based on user privilege and areas of responsibility                                                                                                                                                                                                                                                                                                              | YES / NO   |
|                                                                                                                                                                                                                                                                                                                                                                                                                          |            |
| 5. Event Journal                                                                                                                                                                                                                                                                                                                                                                                                         |            |
| Built-in feature                                                                                                                                                                                                                                                                                                                                                                                                         | YES / NO   |
| Separate from Alarm List                                                                                                                                                                                                                                                                                                                                                                                                 | YES / NO   |
| Ability to insert user comments                                                                                                                                                                                                                                                                                                                                                                                          | YES / NO   |
| Event lists shall be obtainable through an SQL-like query                                                                                                                                                                                                                                                                                                                                                                | YES / NO   |
| Event data is to be stored in a time-series relational database                                                                                                                                                                                                                                                                                                                                                          | YES / NO   |
| The event journal shall support the following: <ul style="list-style-type: none"> <li>– ODBC / SQL interface to event data</li> <li>– Filter and browse via full function display client and Web Client</li> </ul>                                                                                                                                                                                                       | YES / NO   |
| 6. Historical Data                                                                                                                                                                                                                                                                                                                                                                                                       |            |
| In-built historian without the addition of external software components                                                                                                                                                                                                                                                                                                                                                  | YES / NO   |
| Time-series relational database                                                                                                                                                                                                                                                                                                                                                                                          | YES / NO   |
| ODBC / SQL interface to historical (trend) data                                                                                                                                                                                                                                                                                                                                                                          | YES / NO   |
| Historical data to be stored with time-stamp, point quality, alarm status                                                                                                                                                                                                                                                                                                                                                | YES / NO   |

| <b>Description</b>                                                                                                            | <b>Compliance</b> |
|-------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Historic storage is to be based on configurable criteria                                                                      | YES / NO          |
| Compression capability                                                                                                        | YES / NO          |
| Capability to backfill this data in to the historian                                                                          | YES / NO          |
| A programmable API                                                                                                            | YES / NO          |
| Fixed and user configurable views of the historic data tables                                                                 | YES / NO          |
| Validate historic data prior to exposing it externally to the SCADA system                                                    | YES / NO          |
| Selectable archiving rates                                                                                                    | YES / NO          |
| Point-by-point storage compression regimes                                                                                    | YES / NO          |
| Annotation on history samples                                                                                                 | YES / NO          |
| Modification of historic data for normalization and correction                                                                | YES / NO          |
| Auditing of modified or annotated history                                                                                     | YES / NO          |
| <b>7. System Security</b>                                                                                                     |                   |
| High level of inherent security                                                                                               | YES / NO          |
| Security access down to data point level                                                                                      | YES / NO          |
| Support individual Users and User Groups                                                                                      | YES / NO          |
| Restricted access to sensitive system information based on user privilege                                                     | YES / NO          |
| Full function client interfaces shall require explicit administrative configuration to valid connection to the SCADA server   | YES / NO          |
| Web interface facilities shall provide the capability to operate the Web interface using SSL and encrypted data               | YES / NO          |
| Web functionality shall be provided in an integrated way with the web server facility tightly coupled with the SCADA database | YES / NO          |
| Support for Windows Authentication                                                                                            | YES / NO          |
| <b>8. Open Connectivity</b>                                                                                                   |                   |
| Inherent OPC and ODBC database connectivity                                                                                   | YES / NO          |
| Integration with desktop Microsoft products                                                                                   | YES / NO          |
| OPC Data Access                                                                                                               | YES / NO          |
| ODBC                                                                                                                          | YES / NO          |
| OPC Historic Data Access / Alarm & Event                                                                                      | YES / NO          |
| OLE Automation interface                                                                                                      | YES / NO          |
| .NET support                                                                                                                  | YES / NO          |
| ODBC / SQL to the SCADA historical database & event database                                                                  | YES / NO          |
| Support for specific database packages (e.g. Oracle)                                                                          | YES / NO          |
| SQL Export for creating csv files                                                                                             | YES / NO          |
| <b>9. Reporting</b>                                                                                                           |                   |
| Integrated reporting package                                                                                                  | YES / NO          |

| <b>Description</b>                                                                                                                                                                                                                                                  | <b>Compliance</b> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Report generation shall use latest technology in database access                                                                                                                                                                                                    | YES / NO          |
| Reports shall be able to be generated in a number of formats including: <ul style="list-style-type: none"> <li>– HTML for viewing via Web</li> <li>– PDF format</li> <li>– CSV format</li> <li>– MS Office® suite format</li> <li>– Crystal Reports 2011</li> </ul> | YES / NO          |
| Generated reports shall be able to be: <ul style="list-style-type: none"> <li>– printed on a local or network printer</li> <li>– stored on disk file, locally or remotely</li> <li>– e-mailed to nominated users</li> </ul>                                         | YES / NO          |
| 10. Standard Drivers                                                                                                                                                                                                                                                |                   |
| Native support for fully integrated Wide Area SCADA PLC/RTU protocols                                                                                                                                                                                               | YES / NO          |
| Redundant SCADA server configurations and support redundant communication paths                                                                                                                                                                                     | YES / NO          |
| Monitor communication statistics, log driver diagnostics, and provide online access to driver and channel diagnostics remotely                                                                                                                                      | YES / NO          |
| Captured diagnostics shall be able to be translated to HTML for analysis in clear human- readable format                                                                                                                                                            | YES / NO          |
| SMS / Paging                                                                                                                                                                                                                                                        | YES / NO          |
| SNMP (supporting version 2 and 3)                                                                                                                                                                                                                                   | YES / NO          |
| NTP                                                                                                                                                                                                                                                                 | YES / NO          |
| ODBC                                                                                                                                                                                                                                                                | YES / NO          |
| Windows Performance Monitoring                                                                                                                                                                                                                                      | YES / NO          |
| OPC-DA driver                                                                                                                                                                                                                                                       | YES / NO          |
| 11. PLC/RTU Protocol Support                                                                                                                                                                                                                                        |                   |
| Local serial port communication                                                                                                                                                                                                                                     | YES / NO          |
| Terminal server serial port communication                                                                                                                                                                                                                           | YES / NO          |
| Citrix XenApp and Terminal Services Support                                                                                                                                                                                                                         | YES / NO          |
| Ethernet LAN communication via TCP and UDP ports                                                                                                                                                                                                                    | YES / NO          |
| Time synchronization                                                                                                                                                                                                                                                | YES / NO          |
| Presetting output configuration points                                                                                                                                                                                                                              | YES / NO          |
| Fully integrated incorporation of events from a PLC/RTU                                                                                                                                                                                                             | YES / NO          |
| Unsolicited exception reporting                                                                                                                                                                                                                                     | YES / NO          |
| update SCADA database point value / alarm state / point quality / timestamp                                                                                                                                                                                         | YES / NO          |
| support the ability the backfill time-stamped data in to Event Logs, Historic Data                                                                                                                                                                                  | YES / NO          |

| Description                                                                                                                                                                                                                                                                     | Compliance |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Driver architecture shall support user accessible interfaces to access major driver functions.<br><ul style="list-style-type: none"> <li>– enable / disable outstation communications</li> <li>– trigger an integrity poll</li> <li>– alter communication parameters</li> </ul> | YES / NO   |
| maintain current state of target device information                                                                                                                                                                                                                             | YES / NO   |
| redundant server architecture shall retain state information and be able to receive solicited and unsolicited information from the outstation immediately following a server transition                                                                                         | YES / NO   |
| DNP3 protocol shall be fully supported natively                                                                                                                                                                                                                                 | YES / NO   |
| DNP3 Master and DNP3 Slave                                                                                                                                                                                                                                                      | YES / NO   |
| Support for SCADA Pack E IEC61131-3 Target 5                                                                                                                                                                                                                                    | YES / NO   |
| Modbus Master / Slave serial                                                                                                                                                                                                                                                    | YES / NO   |
| Open Modbus/TCP Master / Slave                                                                                                                                                                                                                                                  | YES / NO   |
| IEC 60870-5-104 and IEC 60870-5-101 (KEMA certified)                                                                                                                                                                                                                            | YES / NO   |
| Allen Bradley DF1                                                                                                                                                                                                                                                               | YES / NO   |
| RS Linx                                                                                                                                                                                                                                                                         | YES / NO   |
| OPC-DA client                                                                                                                                                                                                                                                                   | YES / NO   |
| 12. Logic                                                                                                                                                                                                                                                                       |            |
| Support logic sequences with full access to all SCADA system services at run time                                                                                                                                                                                               | YES / NO   |
| Programming of sequences shall be to the IEC61131-3 international standard                                                                                                                                                                                                      | YES / NO   |
| functional block librarian                                                                                                                                                                                                                                                      | YES / NO   |
| Sequences shall be able to be modified and started and stopped online                                                                                                                                                                                                           | YES / NO   |
| Sequence changes shall be a native part of the database and replicated to redundant SCADA                                                                                                                                                                                       | YES / NO   |
| servers                                                                                                                                                                                                                                                                         |            |
| Data Grids/Data Tables/Data Sets. (Ability to store custom calculations/data)                                                                                                                                                                                                   | YES / NO   |
| Ability to integrate data storage elements (Data Set Row) into templates/instances                                                                                                                                                                                              | YES / NO   |
| 13. RTU / Tube well PLC                                                                                                                                                                                                                                                         |            |
| RTU Processor, Dual Core Processor with processing speed of 22 ns to execute one Boolean.                                                                                                                                                                                       | YES / NO   |
| Memory - 64 MB expandable upto 128 MB                                                                                                                                                                                                                                           | YES / NO   |
| Communication -<br>1 nos RS 485, 1 nos RS 232/RS 485, 1 Nos 10/100 base Ethernet port, 1 Nos USB Port                                                                                                                                                                           | YES / NO   |
| Web Server Integrated                                                                                                                                                                                                                                                           | YES / NO   |
| 3 gn (vibration frequency: 8.4...150 Hz)                                                                                                                                                                                                                                        | YES / NO   |

| <b>Description</b>                                                                                             | <b>Compliance</b> |
|----------------------------------------------------------------------------------------------------------------|-------------------|
| Operating temperature:- (-10 to 55) deg C.                                                                     | YES / NO          |
| 14. Master PLC (Zonal PLC's)                                                                                   |                   |
| Processor in the range must provide up to 64 MB of integrated non-volatile memory to save application and data | YES / NO          |
| Processors with at least 3 built-in Ethernet ports featuring a web server                                      | YES / NO          |
| System compliant with various operating systems: minimum is Windows, iOS, and android.                         | YES / NO          |
| No battery supply is needed for non-volatile backup                                                            | YES / NO          |
| Processor and IO of same family and having same mounting arrangement                                           | YES / NO          |
| Rack based IO's and Processor                                                                                  | YES / NO          |
| Modular IO structure arrangement                                                                               | YES / NO          |
| Hot-swappable IO's and independent of mounting arrangement                                                     | YES / NO          |
| Control Panel Manufacturing setup                                                                              | YES / NO          |
| CPRI approved Panel Builder                                                                                    | YES / NO          |
| ISO certified                                                                                                  | YES / NO          |

## **7 B 3. SUB-SECTION**

# **GENERAL MECHANICAL REQUIREMENTS SPECIFICATION**

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### **3. GENERAL MECHANICAL REQUIREMENTS**

#### **3.1 Submersible Pumps**

#### **3.2 General**

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the specifications without surging, cavitations or excessive vibration to the limits specified. The pump shall meet maximum allowable shut off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range within the limits of stable pump operation..The total head capacity curve shall be continuously rising towards the shut off as flow decreases throughout the entire curve from run out to shut off head with the highest at shut off.

Its total head capacity curve shall be continuously rising towards shut off with the highest at shut off, and its capacity shall be meet to handling sludge volume.

- (a) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.
- (b) The pumps shall be designed to handle solid sizes of up to 100 mm for the raw sewage application and 50 mm for all other process fluids. Specific gravity of sewage is 1.02 and sludge 1.05.
- (c) Pumps shall run smooth without undue noise and vibration, cavitations, oil or water leaks over the range of operation. To ensure vibration free operation, all rotative components of pump shall be statically and dynamically balanced to BS 6861/.as per zones A& B of ISO 10816 -1 Vibration levels shall not exceed the levels given in BS 4675.
- (d) The pump set shall be suitable for starting with discharge valve open and/or closed.
- (e) The pump set shall be capable of withstanding the accidental rotation in reverse direction.

##### **3.2.1 Pump Requirements**

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the Specification without surging, cavitation, or excessive vibration to the limits specified.

The pump shall meet maximum allowable shut-off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range, within the limits of stable pump operation, as recommended by the manufacturer, to prevent surging, cavitations and vibration.

To ensure vibration-free operation, all rotative components of each pumping unit shall be statically and dynamically balanced to BS 6861 and the following requirements shall be met:

- The mass of the unit and its distribution shall be such that resonance at normal operating speeds is within acceptable limits.
- In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the below limits.
- At any operating speed, the ratio of rotative speed to the critical speed of a unit, or components thereof, shall be less than 0.8 or more than 1.3.

Vibration levels shall not exceed the levels given in BS 4675 for Class machines, quality bands A and B.

The completed units, when assembled and operating, shall be free of cavitations, vibration, noise, and oil or water leaks over the range of operation.

All units shall be so constructed that dismantling and repairing can be accomplished without difficulty. The vendor shall be responsible for proper operation of the pump.

The controls and starting equipment are suitable for use with the pump motor, taking into account all requirements including starting currents and number of starts per hour.

For the performance curve of the selected pump impeller, the head shall continuously rise as flow decreases throughout the entire curve from run out to shutoff head.

### **3.3 Design Conditions**

Pumps shall be designed and constructed to satisfactorily operate and perform within the designated design conditions and the requirements specified herein. They shall be designed for a life of 100,000 hours with service intervals at 20,000 hours.

Castings, fabrications, machined parts and drives shall conform to the industry standards for strength and durability and shall be rated for continuous duty over the entire operating range. Bearings shall be of the anti-friction type designated for an L10 life of at least 50,000 h in accordance with BS 5512.

Pump maximum operating speed shall not exceed 1450 rpm.

Pump set shall be of non-clog design, capable of passing spheres of a minimum 80-mm upto 13.5kw and motor above 13.5kw should not be less diameter 100mm passing spheres particles, suitable for wet installation on Auto coupling.

The Pump, motor and associated electrical equipment shall be rated for a minimum 10 starts per hour and be capable of double this number of starts for short periods of time.

The pump manufacturer should guarantee the following parameters.

- Flow Rate
- Total Head
- Power Input
- Efficiency : shall be 80% and above

The Pump shall be technologically very advanced in design for handling wastewater, process water, unscreened raw sewage and Sludge upto liquid cdry mater contain is over 3% in heavy-duty utilities and industrial applications.

The pumps shall be suitable for submerged Installation, they shall be extremely reliable and very easy to service.

The Pump shall be with Vortex impeller with provide free passage of solids up to 80 mm to reduce the risk of clogging and ensure maximum up time and reduced operating costs.

Material of construction:

|                           |   |                 |
|---------------------------|---|-----------------|
| Pump Casing               | : | EN-GJL -250     |
| Impeller                  | : | EN-GJL- 500-7   |
| Pump Shaft                | : | AISI UNS31803 H |
| Mechanical Seal Primary   | : | SiC / SiC       |
| Mechanical Seal Secondary | : | Carbon/ Ceramic |

\* Material test certificates from Government approved metallurgical laboratory shall be furnished by the Contractor

## **PUMP MOTOR**

The motor shall be watertight according to IEC class IP 68, and incorporate class H , insulation materials to withstand a continuous operating temperature of 180 deg C. The pump and motor shall be able to operate continuously submerged in and capable of handling liquids with a maximum temperature of 40 deg C.

### **Watertight cable connection:**

The cable connection shall be of Polyurethane-filled stainless steel, hermetically sealed to ensure that Liquid couldn't penetrate through the cable into the motor with easy to remove cable entry.

The pump and electric cables shall be capable of continuous submergence, without loss of waterproof integrity to a depth of 20 m. The motor must be designed to take a minimum of 20 starts per hour.

### **Rotor shaft:**

The motor construction shall be compact with short rotor shaft for reduced vibrations, Increased efficiency and lifetime, of shaft seal and ball bearings.

### **Double Mechanical Seal:**

The shaft seals shall be efficient single-unit cartridge system to ensure longer operating time and less down-time, easy to replace in the field without use of special tools.

**The mechanical seals should be able to withstand rotation on either side.**

### **3.4 Stainless steel clamp :**

The entire unit shall be with unique clamp assembling system, which enables quick and easy disassembly of pump from motor unit with no tools required, to provide easy access for service and inspection.

Impeller Super Vortex:

The Vortex generated in the pump housing keeps fibre or grassy Sludge moving ensuring trouble free operation.

Sensors: to protect motor Pumpset should be with Moistures.

Motor Eff should not be less than 86% for full load condition containing IE3 component.

Pumpset to be operated in full range of the curve.

Cast Iron MOC should be suitable for 4to 10pH.

Pumpset weight should not be less than 264kg.

### **3.5 Fabrication**

#### **General:**

Impellers shall be fabricated according to the rated motor size as follows :

- Non-clog type statically and dynamically balanced, keyed to the shaft
- Provided with pump-out vanes to prevent material from getting behind the impeller and into mechanical seal area.
- Pumps must be **equipped with a method of restoring impeller to casing clearance in the axial direction, to restore the pump efficiency, at site, without the need for dismantling of pump and machining for replacement of wear rings.**
- Impeller clearance adjustment shall not be done unless approved by the Engineer
- Impellers shall be of **enclosed type with Single or multi vanes type.**
- The pumps shall be provided with proprietary monitoring and control units for inclusion in the motor controls. Analog inputs shall include the following:
  - Winding temperature
  - Water in oil Sensor
  - Bearing temperature if the motor rating is above 75kw.

Motor shall be fabricated as follows :

- Motors shall be 380 to 415 V, 3 phase, 50 Hz, rated at 10% above the maximum power requirement. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions.

I. Variation of supply voltage from the rated motor voltage                      +/- 10

II. Combined voltage and frequency variations                                      +/- 10%

- Motors shall be squirrel cage, induction, air filled, totally sealed to IP 68, suitable for an immersion depth of 20m.  
The insulation class of motor winding shall conform to class – F and the maximum temperature rise shall not exceed 95°C, when measured by winding resistance method and 85°C, when measured by thermometer method for an ambient temperature of 45°C.
- Motor temperature shall be monitored using a thermal sensor in each phase of winding , set to stop the motor when the monitored absolute temperature reaches 130 deg C.
- The cable shall be brought directly out of the submersible motor without joints, and shall be of sufficient length, minimum 30 m to be terminated to the control box or if the location of the control box is beyond 20m from pump than use an IP 67 junction box to terminate power & control cable of the pump set before the control box.
- Motors shall be capable of start up and operation in the event of a completely flooded wet well. Motors shall be selected to meet the maximum power required for the selected impeller at all operating conditions.
- Motor cooling must be achieved by a cooling jacket, using the pumped media to cool the motor. The pump impeller must be equipped with a system to ensure a pumped flow of liquid through the cooling jacket and also incorporate a device to prevent the liquid channels from blocking with hair and foreign material.

Motor shall be designed to withstand 120% of the rated speed for two minutes without any mechanical damage in either direction of rotation.

The motor shaft shall be of large diameter, lightly stressed to ensure rigidity, with impeller and bearing location shoulders and a keyway for location of the impeller.

The motor windings shall be protected with a waterproof material.

The motor shall incorporate a cut-out device to detect the presence of any liquid in the motor enclosure, in the form of non-resetting moisture switch.

The terminal connections for the power and protective circuits shall be housed in a completely sealed and waterproof junction box, complete with all external corrosion resistant cable glands.

The pump Units shall be provided with power and protection circuit cables of sufficient length to reach from the motor junction box to the local isolator, located at the access level.

Pumps Shafts shall be fabricated as follows:

- Pump Shafts shall be of such diameter that they will not deflect more than 0.05mm measured at the mechanical seal, whilst operating at full driver output
- The Shaft shall be turned, round and polished.
- The Shaft shall be key-sealed for securing the impeller.

Shaft Seals shall be fabricated as follows:

- The Drive motor and pump/ motor bearings shall be sealed along the shaft with tandem mechanical seals operating in oil filled chamber. The seals shall require neither routine maintenance nor adjustment, but shall be capable of being easily inspected and replaced.
- Two back to back mechanical seals shall seal the motor off from the pump.
- The primary shaft seal shall be of silicon carbide/silicon carbide.
- The secondary seal shall be silicon carbide with carbon.
- Seals must be capable of withstanding rotation in either direction.
- A detector shall indicate when moisture (water in oil sensor) is leaking past the first seal.

Bearings shall be fabricated as follows.

- Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the operation of the pump.
- The upper bearing(s) shall be of the grease lubricated sealed for life type, the lower bearing(s) shall be lubricated by the internal oil supply.
- The bottom bearing(s) shall be of the angular contact ball bearing type in combination with roller bearing(s).

Installation:

Pumps to be installed Vertical permanently in a pump room with required accessories

The pump motor is enclosed and water tight and should not be damaged if the installation site is flooded with water.

Characteristic Curves :

- Characteristic and system curves for the pumps shall be supplied to a reasonably large scale which shall show the capacity of the pumps under single and multi pump operation at the duty point.
- When tested through their complete range of workable heads at the maker's works, all the pumps shall give results which conform to the curves submitted with the tender, Curves showing pump efficiency and kW, loading shall also be included.



Submittals for approval:

The manufacturer shall furnish the pump curves, system curves and necessary hydraulic calculations to justify the sizes of any pump selected. The manufacturer shall also provide the following.

1. Pump Data Sheets
2. Performance curves
3. Quality assurance plan
4. O & M manuals.

### **3.6 Spare Parts and Tools**

The following spare parts shall be supplied to the Employer as per Manufacturers recommendations:

- Sets of complete upper and lower bearings
- Sets of 'O' rings
- Set of mechanical seal (primary & secondary).
- Moisture switch kit
- Cable entry kit

Factory Inspection and Testing :

Third party inspection / Client Inspector shall witness factory test of the pumps prior to shipment:

- The pump casing has been tested hydro-statically to 1.5 times the maximum closed valve pressure
- Impeller, motor rating and electrical connections checked for compliance with the Specifications.
- The pump has been run for 30 minutes submerged under a minimum of 2 m water after the operational test (e) above, the insulation tests (b) above has been performed again, and after the performance test (2) below.

Each pump shall tested at the factory for performance according to BS 5316 Part 1, including:

- Flow
- Outlet pressure
- Motor power
- Efficiency

The following certification and submit to the Engineer prior to shipment:

- Certified copies of the pump characteristic curves and reports generated by the tests described above and as required by BS 5316 Pat 1

- Foundry composition certificates for all major castings (pump case, impeller, motor housing) showing exact material composition and tests conducted to ensure compliance with the pump manufacturer's material specifications.

Coatings and Protection shall be provided as follows

- All parts of the pump and motor shall be 100% holiday free fusion bonded epoxy coated to a minimum thickness of 300 microns.

The Contractor guarantees given when tendering in respect both of performance and efficiency shall be binding and considered part of the contract.

The fulfilment of these guarantees shall be verified at the works test in accordance with procedure given in British Standard 5316 and 4999 etc.

### **3.7 Site Inspection and Testing**

The equipment delivered to the Site shall be examined by us to determine that it is in good condition and in conformance with the approved working drawings and certifications. All equipment shall be installed in strict conformance with the Specification and the manufacturer's instructions.

The pump manufacturer's representative shall supervise the installation, commissioning and start-up of the pumping equipment.

All cables shall be 'megger' tested to confirm the integrity of the insulation.

The commissioning tests shall be performance and reliability trails, mainly for the purpose of satisfying the Engineer that the pump sets have been correctly assembled and installed and that the are operating.

The Contractor shall be responsible for any failure of the whole equipment or any part thereof, whether such failure shall be determined by the methods detailed herein or otherwise. If the Contractor interrupts the pump test or trial, or through negligence on the part of the Contractors staff, it shall be completely repeated for the pumpset concerned.

**Life Cycle Cost of Pumps Shall be provided as following components**

| <b>Requirements: General inputs:</b> |                            |                                              |                                                                             |
|--------------------------------------|----------------------------|----------------------------------------------|-----------------------------------------------------------------------------|
| Flow                                 | -----<br>m <sup>3</sup> /h | Energy price<br>(high tariff):<br>-- Rs /kWh | n - Life in years: 15<br>i - Interest rate: xx %<br>p - Inflation rate: xx% |
| Head:                                | ----- m                    |                                              |                                                                             |
|                                      | <b>per year</b>            | <b>total (life)</b>                          |                                                                             |
| Initial investment cost              |                            |                                              |                                                                             |
| Pump system [INR]                    |                            |                                              |                                                                             |

|                                                |  |  |  |
|------------------------------------------------|--|--|--|
| Further investment [INR]                       |  |  |  |
| Installation and commissioning cost [INR]      |  |  |  |
| Energy cost                                    |  |  |  |
| Energy consumption [kWh/Year]                  |  |  |  |
| Specific Energy [kWh/m <sup>3</sup> ]          |  |  |  |
| Change of efficiency per year [%/Year]         |  |  |  |
| Operating cost [INR/Year]                      |  |  |  |
| Routine maintenance cost [Rs/Year]             |  |  |  |
| Repair cost [Rs./Year]                         |  |  |  |
| Other yearly costs [Rs/Year]                   |  |  |  |
| Downtime and loss of production cost [Rs/Year] |  |  |  |
| Environmental cost                             |  |  |  |
| Decommissioning and disposal cost              |  |  |  |

- (a) Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, and single stage type.
- (b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.
- (c) Double Mechanical seals (back to back) shall be provided to protect the motor from ingress of sewage along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. . Seals must be capable of withstanding rotation in either direction. A detector shall indicate when moisture is leaking past the first seal.
- (d) Impeller shall be non-clog enclosed type with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials.
- (e) The critical speed of the rotor shall be at least 30% above the operating speed.
- (f) Pump-sets shall have double bearings. Bearings shall be of the anti-friction type. Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the operation of the pump. The bearing life shall be minimum 40,000 hrs of operation.

- (g) Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. The joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails / rope from access level. It shall be provided with all necessary fixings for guiding the pumps during lifting/lowering. Each pump shall be provided with a SS 316 lifting chain conforming to BS 1663 and BS 4942.
- (h) Each pump shall be provided with an automatic coupling device for attaching to the duck foot bend base at low level by using lifting chain SS 316 and guide rail SS 316, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple from the duck foot bend base and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.
- (i) Each pump shall be tested at the manufacturers premises for the full operating range of the pump to BS 5316 Part 1 .Pump performance shall be within the tolerance limits specified in the above said BS.

### **3.8 Induction Motor**

#### **3.8.1 Motor for Dry Pit Sewage / Sludge Pumps**

##### **3.10.1.1 Design Requirements**

The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply.

The motors shall generally conform to IS: 325 or relevant equivalent internationally approved standards. Additionally the specific requirements mentioned in the following clauses shall also be met. All motors shall be EFF-1 energy efficient type.

##### **3.10.1.2 Performance and Characteristics**

- (a) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
  - (i) Variation in supply voltage  $\pm 10\%$
  - (ii) Variation in supply frequency  $\pm 5\%$
  - (iii) Combined voltage and frequency variation  $\pm 10\%$
- (b) Motors shall be suitable for full voltage direct-on-line starting or star delta starting. Minimum permissible starting voltage shall be 85% of the rated voltage.
- (c) The Power rating of the motor shall be the larger of the following :
  - (i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 49.0 Hz.
  - (ii) Maximum power input while operating single pump corresponding to the speed of 50 Hz.

##### **3.10.1.3 Insulations**

Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation. The degree of enclosure protection of motors shall be of minimum IP 55.

Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in suitable insulating compound or varnish followed by proper baking. At least three such submersions and backings shall be applied to the assembly.

#### **3.10.1.4 Constructional Features**

The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

- (a) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
- (b) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

#### **3.10.1.5 Terminal Box**

Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

The terminals shall be of the stud type with necessary plain washers, spring washers and checknuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

Separate terminal boxes shall be provided for the following: (i ) Starter leads; and

- (ii) Space heater

#### **3.10.1.6 Accessories**

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

#### **3.10.1.7 Heating during Idle Period**

For motors rated below 30kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

Motors rated 30kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

#### **3.10.1.8 Earthing Pad**

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

#### **3.10.1.9 Rating Plate**

The following details, in addition to those specified in applicable standards shall be included on the rating plate.

Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.

Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

#### **3.10.1.10 Tests**

Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard in the presence of the Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer's approval. The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

### **3.8.2 Low Voltage Motors**

Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard).

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

Motors rated 30 kW and above shall be provided with space heaters with adequate capacity to maintain motor temperature to prevent moisture condensation on the insulation during idle condition. The space heaters shall be suitable for 240V single phase 50 Hz supply. The degree of enclosure protection of motors shall be of minimum IP 55.

### **3.8.3 HV Motor (For Process Air Blowers)**

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage.

- (a) Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.
- (b) The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motors which is inclusive of 20% tolerance.
- (c) Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from cold condition and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.
- (d) The three phases shall be segregated by metal barriers within both line and neutral terminal box.
- (e) The earthing pads shall be of non-corrodible metal, welded/brazed at two locations on opposite sides. The pad size shall be 75 x 65 x 25 mm with two holes drilled at 40mm centres, tapped & provided with suitable bolts and washers for connecting the earthing strip.
- (f) At least six resistance type temperature detectors for the stator winding each having D.C. resistance of 100 ohms at 0 degrees Celsius, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the RTD's shall be platinum.
- (g) At least one vibration detector for the stator winding, embedded in the stator winding at location where vibration may be expected, shall be provided. Compression-type piezoelectric type accelerometers, velocity transducers or proximity transducers shall be applied to the vibration detection system.
- (h) Motors shall have space heaters suitable for 240V single phase 50Hz AC supply. These shall be placed in easily accessible position in the lower part of motor frame. Provision shall be made to measure temperature of bearing by inserting hand held temperature measuring device.
- (i) Motors shall have drain plugs so located that they will drain water, resulting from condensation or other causes from all pockets in the motor casing.

Data:

| Sr.No | Description                                                                          | Unit             | Particulars                                   |         |
|-------|--------------------------------------------------------------------------------------|------------------|-----------------------------------------------|---------|
| (a)   | Type of motors (Main Motor)                                                          |                  | Squirrel Cage                                 |         |
| (b)   | Supply System fault level 0.433 KV                                                   | KVA              |                                               |         |
| (c)   | Rated Voltage                                                                        | KV               |                                               |         |
| (d)   | No. of Phases and frequency                                                          |                  | 3 Phase, 50Hz                                 |         |
| (e)   | Type of duty/designation                                                             |                  | Continuous/S1                                 |         |
| (f)   | Method of Starting                                                                   |                  |                                               |         |
| (g)   | Class of insulation                                                                  |                  | F                                             |         |
| (h)   | Ambient reference temperature                                                        | deg. C           | 40                                            |         |
| (i)   | Temperature rise shall be limited to<br>Class B<br>Thermometer<br>Winding resistance | deg. C<br>deg. C | 70<br>80                                      |         |
| (j)   | Location                                                                             |                  | Indoor                                        | Outdoor |
| (k)   | Type of Cooling (IS:6362)                                                            |                  | TEFC                                          | TEFC    |
| (l)   | Degree of Protection                                                                 |                  | IP55                                          | IP65    |
| (m)   | Terminations                                                                         |                  |                                               |         |
|       | (i) Short time current withstand for terminal box                                    | kA(rms)          | 25                                            |         |
|       | (ii) Duration                                                                        | Sec              | 1                                             |         |
|       | (iii) Dynamic current withstand for terminal box                                     | kA(peak)         | 31                                            |         |
|       | (iv) External cable details<br>Type                                                  |                  | 0.433KV, UE, Al. Cond. XLPE                   |         |
|       | (v) Earthing Conductors<br>MaterialSize                                              | mmxmm/SWG        | GI<br>Main motor - 50 x 10                    |         |
| (n)   | Colour shade of paint                                                                |                  | Light grey, Semiglossy<br>Shade: 631 of IS: 5 |         |

Note: a) Bidder to assess fault level MVA at substation tapping point and supply voltage rating for motors shall be as per CPHEEO and other standards.

b) Vibration sensors Nine (9) nos. shall be provided per pump set (pump & motor) and blower motor.

c) Voltage rating for HT motors:

A) Motors rated upto 355 kW - LT Supply

B) Process Air Blower Motors up to 355 kW - HT or LT supply.

C) Motors > 355 kW - HT supply.



### **3.8.4 Induction Motor (Submersible Pump & Mixers)**

#### **3.10.4.1 Performance and Characteristics**

- a) The submersible motor shall conform to IS: 9283:1979 and the submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979. The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply. Pump motor shall be of the squirrel cage submersible type; protected to IP 68. Motor for submersible pump shall be capable of start up and operation in the event of a completely flooded wet well. Motor cooling for submersible pump must be achieved by a cooling jacket, using the pumped media to cool the motor. The pump impeller must be equipped with a system to ensure a pumped flow of liquid through the cooling jacket and also incorporate a device to prevent the liquid channels from blocking with hair and foreign material. This motor shall be capable of starting 10 times per hour. The insulation class of motor winding shall conform to class F / H as specified in the pump or mixer specification. Additionally the specific requirements mentioned in the following clauses shall also be met. The motor shall be of Eff-2 energy efficient type.
- b) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions :
  - (i) Variation of supply voltage from rated motor voltage  $\pm 10\%$
  - (ii) Variation of supply frequency from rated frequency  $\pm 5\%$
  - (iii) Combined voltage and frequency variation  $\pm 10\%$

The starting current of motor shall not exceed 300% of rated full load current for soft starter starting and 600% of rated full load current for DOL starting, under any circumstances. Motors shall be suitable for full voltage direct-on-line starting or soft starter starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard) unless otherwise specified.

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibrations shall be within the limits specified in applicable standard unless otherwise specified for the driven equipment.

Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.

Motor insulation shall conform to Class F / H as specified in the pump or mixer specification and the maximum temperature rise shall be limited to class B. The motor windings shall be protected with a waterproof material and shall incorporate a thermal sensor in each phase to safe guard against high winding temperatures. The thermal sensor shall be connected into the control circuit of the starter and signals taken for continuous monitoring of winding temperatures. The motor shall incorporate a cut out device to detect the presence of any liquid in the motor enclosure, in the form of non resetting moisture switch. The terminal connections for the power and protective circuits shall be housed in a completely sealed and water proof junction box, complete with all external corrosion resistant cable glands. The pump units shall be provided with power and protection circuit cables of sufficient length to reach from the motor junction box to the local isolator located at the panel floor level.

Protection against increase in stator winding temperature bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if leakage of sewage into the oil housing is above 30 % concentration.

Bimetallic thermal switch to trip the motor against increase in temperature shall be provided. The power rating of the motor shall be larger of the following:

- (i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 49 Hz.
- (ii) Maximum Power input while operating single pump corresponding to the speed of 50 Hz.

Motor shall be offered for routine and type tests in accordance with IS: 4029 and IS: 325 at the manufacturer's works.

#### **3.10.4.2 Submersible Cable**

- (a) The submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979. The power cable shall be PVC insulated and PVC sheathed, flexible, 3.5 core flat type. The size of the conductor shall be adequate for continuous use under water and air. The half core shall be used for earthing.
- (b) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.
- (c) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.
- (d) The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

#### **3.10.4.3 Earthing**

Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043:1966. For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

#### **3.10.4.4 Insulation**

- (a) Any joints in the motor insulation such as at coil connections or between slot and end winding sections, shall have strength equivalent to that of the slot sections of the coil.
- (b) The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.
- (c) The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783:1978 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII):1970 for dry type motors.

#### **3.10.4.5 Temperature Rise**

The temperature-rise test of the motor shall be carried out with the motor coupled to the suitable pump as per relevant standard.

#### **3.10.4.6 Constructional Features**

The motor shall be suitable for continuous use in fully or partially submerged condition. A built in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not, by providing either external or internal cooling arrangement.

#### **3.10.4.7 Terminal Box**

Terminal box shall be of weather proof construction to eliminate entry of water and dust.

The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

### **3.9 Sluice Gate & Weir Gates**

#### **3.9.1 Cast Iron Gate:**

##### **(a) Design Requirements and Construction Features**

The construction of sluice gates shall be in accordance with the specification and generally as per IS: 13349. All sluice gates shall be of the rising spindle type.

(b) Frame

The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

(c) Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

(d) Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position.

(e) Lifting Mechanism

- (i) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kg.m.
- (ii) Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.
- (iii) Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

(f) Wall Thimbles

The cross section of the thimble shall have the shape of the letter 'F'.

(g) Lifting Lugs

Lifting lugs shall be provided for all gates.

(h) Flush Bottom Seal

- (i) When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.
- (ii) A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

- (i) All the sluice/Weir gates in Hydropower Screw turbine area, STP Headworks (Screen channel & grit mechanism area), Primary and Secondary Clarifier distribution & inlet and outlet control area, All Bypass/Weir gate arrangement, Filter area and others shall be provided with permanently fixed electric actuator under this contract.
- (j) Two Nos. of Portable type of electric actuator and one nos. of battery operated actuator for emergency operation shall be provided for opening and closing of sluice gates, so that the closing and opening operation time shall be maximum of 10 minutes only for Chlorine Contact Tank and Aeration Tank area.
- (k) The material of construction of sluice Gate shall be as follows:

| S. No. | Component                                                   | Material                                                |
|--------|-------------------------------------------------------------|---------------------------------------------------------|
| (i)    | Wall Thimble                                                | Cast Iron : IS 210 Gr. FG 200                           |
| (ii)   | Frame and Slide                                             | Cast Iron : IS 210 Gr. FG 200                           |
| (iii)  | Seating faces                                               | Stainless Steel : ASTM Countersunk fixing A276 type 316 |
| (iv)   | Wedge                                                       | Stainless Steel : ASTM A743 CF8M or SS316               |
| (v)    | Stem                                                        | Stainless Steel: ASTM extension A276 type 316           |
| (vi)   | Stem nut                                                    | Stainless Steel : ASTM A743 CF8M                        |
| (vii)  | Stem Coupling                                               | Stainless Steel : ASTM A276 type 316                    |
| (viii) | Fasteners, anchor                                           | Stainless Steel : ASTM bolts and nuts A276 type 316     |
| (ix)   | Lifting mechanism, Pedestal gear house cover and stem guide | Cast Iron : IS 210 Grade FG 200                         |
| (x)    | Lift nut                                                    | Bronze : ASTM B 148 (CA952, CA954 or CA958)             |

### **3.9.2 Modulating Sluice Gate**

It shall be as per IS: 13349-1992.

Wall thimble mounted Sluice gates shall be used for isolation of flow from a chamber to a closed conduit. It shall be suitable for modulation application.

#### **Salient Features**

- It shall be of flange back frame gate suitable for mounting on the face of a Cast iron Wall thimble using studs and with a gasket between gate frame and wall thimble flange. Wall thimble shall have cross section “F” and depth of 300 mm. Gates having square / rectangular opening to be provided with thimble having square/ rectangular opening aperture with square / rectangular flange for gate frame mounting.
- It shall have Square/Rectangular shaped natural rubber Gasket with predrilled holes for positioning in between machined face of wall thimble flange and frame flange.
- It shall have open top frame provided with short length extension guides to support ½ vertical height of the slide when the slide is in full open position.
- Frame will be provided with liners for modulating duty application.

- Frame specially designed to permit front access for tightening of thimble mounting nuts so as to enable mounting of gates side by side or near corners.
- Rigid shutter designed to withstand the applicable water head. Shutter to be provided with cast integral pocket to house the stem-connecting block, which connects the spindle to the shutter for up and down operation.
- Seat facing fitted on machined plain surface of frame and shutter-using counter sunk screws for better fitments.
- The type of bottom closing offered is Flush bottom closing (FBC). In flush bottom closure gates, sealing to be metal to rubber for bottom side and metal-to-metal on balance three sides.
- Adjustable type individual side wedging arrangement for gates meant for seating water head application and adjustable type individual side as well as top & bottom wedging arrangement for gates meant for unseating water head application.
- Adjustable Channel type stem guide brackets in requisite quantity to prevent buckling of spindle in event of over-closing of gate.
- Rising stem / spindle to suit the distance between centerline of gate opening and top of operating platform as stated below in price schedule. The spindle shall be provided with square / trapezoidal threading with the threaded length being approximately 400mm more than the height of waterway opening.
- Spindle couplings to connect multiple stem / spindles in case the maximum length of one-piece stem / spindle exceeds 4.5 to 5 meters resulting into provision of more than one stem / spindle.
- Rising spindles are provided with Stem cover of Polycarbonate tube to protect spindle threads from effect of dust, dirt and weather.
- Rising spindles are provided with gate opening indicating arrangement to indicate the position of shutter.
- Provision of safety stop nut on spindle to prevent the chances of over-closing of gate, which may otherwise damage either the spindle or the lifting platform.
- Lift mechanism mounted on separate platform above gate frame so that gate operating thrust comes on to the platform.

Operation of gate by means of electric lift mechanism comprise of pillar mounted Electric Actuator with manual override unit. These actuators should have an inbuilt with local control push buttons and suitable for modulating application.

| SI.No. | Part Description                     | Materials of Construction          |
|--------|--------------------------------------|------------------------------------|
| a      | Frame & Shutter                      | CI IS: 210 Gr. FG 200              |
| b      | Wall Thimble                         | CI IS: 210 Gr. FG 200              |
| c      | Seating Faces & Counter Sunk Fixing  | Stainless Steel ASTM A240 type 316 |
| d      | Wedging Device (with SS 304 Linings) | CI IS: 210 Gr. FG 200              |
| e      | Stem, Stem Extension & Coupling      | Stainless Steel ASTM A276 type 316 |
| f      | Stem Block                           | Stainless Steel ASTM A743 CF8M     |

| Sl.No. | Part Description                       | Materials of Construction          |
|--------|----------------------------------------|------------------------------------|
| g      | Fasteners, Anchor Bolt, Studs & Nuts   | Stainless Steel ASTM A276 type 316 |
| h      | Lifting Mechanism, Pillar, Head Stock  | CI IS: 210 Gr. FG 200              |
| i      | Stem Guide                             | CI IS: 210 Gr. FG 200              |
| j      | Stem Guide Bracket                     | Structural steel                   |
| k      | Stem cover with Indicating Arrangement | Polycarbonate Tube                 |
| l      | Lift Nut                               | Bronze IS: 318 Type LTB-2          |

### **8.6.3 Mechanically Operated Stoplogs**

The construction and general design of Aluminum Stoplogs shall be in accordance with the specifications mentioned here under. They shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

The stoplogs shall be capable of performing the isolation duties in waste water treatment plant and pumping stations for those applications where the side water depth is at least 300 mm less than the height of stoplogs.

The stoplogs as well as stoplog frame shall be made of extruded sections and not fabricated so as to keep welding to minimum.

The Stoplogs shall be designed for seating water pressure equal to the height of the topmost log.

The Stoplogs shall have an on-seating leakage rate of not more than 1.25 liters / minutes / meter length of sealing perimeter.

The Stoplogs shall be supplied alongwith all accessories such as Stoplogs, lifting system, storage rack etc and miscellaneous items like fasteners, gaskets, anchor bolts etc required to erect and install these items.

Each Stoplog shall be manufactured as detailed hereunder and shall be supplied duly tested as per requirement. The Stoplog assembly shall be supplied as a factory assembled unit and shipped to site as a ready to install unit.

This assembly shall be uncrated at site and installed as complete assembled unit without stripping down into components. This is to ensure that the performance integrity of the stoplogs remains as factory tested and supplied condition, thus minimizing the influence of the installation process to achieve optimum performance at site after installation.

#### **(a) Constructional Features**

The constructional features and details of components of the required stoplogs are to be as under:

The stoplogs shall be made of extruded section of Aluminum material of grade 6061 T-6 and having minimum thickness of 5 mm. The sections used shall have adequate strength to prevent distortion during normal handling, installation and while in service.



The extruded stoplogs section shall be sufficiently rigid to withstand the designated water head. Maximum bending stress shall not exceed 7600 PSI at the maximum operating head.

The extruded stoplog section shall be designed for adequate and prompt drainage while removal.

The stoplogs shall be provided with lifting pins to enable lifting of stoplogs using mechanically operated lifting beam.

The total height of stacked stoplogs shall be approximately 300 mm above the maximum height of water.

The stoplog sectional height shall not be less than 250 mm and not more than 1250 mm so as to ensure that minimum sectional pieces are provided to achieve the required total height.

Stoplogs suitable for lifting manually using lifting rods should not weigh more than 50 kgs to enable 2 persons to lift them and transfer to storage rack. Stoplogs suitable for lifting using mechanically operated lifting beam, which can engage / disengage automatically with lifting pins provided on logs, shall be so designed that the total lifting load does not exceed 1000 kgs including the water pressure acting on the stoplogs.

The aluminum stoplogs shall be provided with minimum 120 micron thick coat of suitable epoxy paint to prevent oxidation of aluminum material.

#### (b) Stoplog Frames

The stoplogs frames shall be made of extruded section of Aluminum material of grade 6061 T-6 and having minimum thickness of 5 mm. The sections used shall have adequate strength to prevent distortion during normal handling, installation and while in service.

The stoplogs frames shall comprise of bottom invert section and two vertical side guide section for housing the stoplogs. The frames shall be suitable for embedment in two parallel walls on sides and in floor invert at bottom.

The vertical sides of the frame shall extend up to the top of the operating platform to facilitate in removal and insertion of stoplogs. For lengths above 3 meters the vertical side guides can be provided in sectional construction.

The aluminum frame shall be provided with minimum 120 micron thick coat of suitable epoxy paint to prevent oxidation of aluminum material.

#### (c) Seals

The stoplogs sealing arrangement shall comprise of continuous resilient seal along the bottom and both sides to restrict leakage in accordance with the requirement listed in this specification. The resilient seals shall be of EPDM or Neoprene rubber as per ASTM



D2000. The side seals shall be mechanically retained and all the seals shall be easily replaceable. Seals fixed by gluing will not be accepted. The fasteners used shall be of stainless steel material as specified.

**(d) Lifting Beam**

Lifting beam shall be provided to insert and pull out the stoplogs using an electric hoist arrangement.

If the hoisting weight of stoplog is over 50 kgs then suitable provision for handling the stoplogs with the lifting beam should be provided by the contractor. The lifting beam shall be designed to automatically engage with an installed stoplog and lift the same out of frame. The lifting beam also shall have arrangement to disengage the stoplogs by an operator standing on the platform. One lifting beam shall be provided for stoplog having same / equal width in the plant. The lifting beam shall be constructed of Carbon steel material with epoxy painted and shall be designed to lift a load of minimum 1500 kgs.

**(e) Storage Rack**

A movable storage rack shall be provided to house the stoplogs and lifting beam when they are not in use. The storage rack shall be constructed of Stainless Steel material. The storage rack shall be so designed that the resilient seals of the log shall not remain under compression during storage.

The material of construction for various components shall be as under:

| <b>Component</b>                  | <b>Material</b>                     |
|-----------------------------------|-------------------------------------|
| Stoplogs & Frame                  | Aluminum alloy 6061 T-6             |
| Resilient Seals                   | EPDM ASTM D2000                     |
| Rubber seal retainer bar          | Stainless Steel ASTM A 240 type 316 |
| Assembly bolts, nuts and fastener | Stainless Steel ASTM A 276 type 316 |

### **3.9.3 WEIR GATES**

The downward opening weir gates shall be manufactured from Cast Iron and shall be Flange back type suitable for wall mounting and generally manufactured in line with provisions of AWWA C-560 / IS 13349 with improvements as desired and specified hereunder for weir application.

The weir gates shall be capable of performing continuous weir duty in plant and shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

The weir gates shall be designed for water tightness at any level of opening for off-seating pressure equal to depth of shutter. The weir gates shall have off-seating leakage rate of not more than that permitted under AWWA-C560 / IS 13349.

All the weir gates shall be shop tested to verify the leakage performance at operating head, torque tested at operating head to verify the suitability of actuating mechanism and PMI tested to verify the correctness of the material used. This testing will be done in presence of client / client representative or approved third party inspection agency.

The weir gates shall be rising spindle type and the operation shall be by means of Manual / Electric operating mechanism.

The weir gate shall be supplied along with all accessories such as gates assembly, gasket between wall and gate assembly, studs and nuts for mounting on wall, stem connecting block, spindle, spindle couplings, spindle guides, pedestal, operating mechanism as required, gate opening indicating arrangement and required anchor bolts and fasteners for stem guides and pedestal.

The main gate assembly comprising of frame, guides and shutter will be supplied as a factory assembled unit and shipped to site as a ready to install unit on the wall. This gate assembly will be uncrated at site and installed as complete assembled unit without stripping down into components. This is to ensure that the performance integrity of the weir gates remains as factory tested and supplied condition, thus minimizing the influence of the installation process to achieve optimum performance at site after installation.

(a) Constructional Details :

The weir gates shall be manufactured generally as per provision of AWWA C-560 / IS-13349 with suitable changes for weir application. The constructional features and details of components of the required gates shall be as under:

(b) Gate Frame

The gate frame will be made from cast iron and shall be sufficiently rigid to withstand the designated water head. The gate frame shall be flange back type to suit the designed head and site condition. Back flange of the gate aperture frame to be precisely machined flat and drilled to engage with the face wall. A rubber gasket will be provided between the wall and the gate for ease in future dismounting of the gate for repairs / replacement and seal any leakage between the flange of frame and the wall. The gate frame of these sluice gates shall either be self contained type or non self contained type depending upon site requirement. In case of non self contained gates the frames shall be without yoke at their top. In case of self contained gates the frames shall have extension guides of requisite length and shall be provided with a yoke at their top. The length of guides shall be sufficient to engage at least half the overall vertical height of door when the gate is fully lowered to open and shall be in accordance with the relevant provisions of AWWA C-560 / IS-13349.

(c) Gate Slide / Shutter/Door

The gate slide / shutter will be made from cast iron and shall be sufficiently ribbed to withstand the designated water head. The gate slide / shutter will be provided with integral pocket to house the thrust nut used to connect the stem with the slide.

**(d) Seating/Sealing Faces:**

Seating face shall be of Stainless steel. The seating / sealing faces on door shall be secured in place using taper screws which cannot be mechanically removed after fitting on facings. The taper screws adopted for facings shall be of same material as that of the seat facings.

To enable continuous sealing at any level of opening of the downward opening weir gate so as to achieve precise level control, the full face of the shutter will be fitted with specified seating / sealing faces and the sealing faces on shutter will always be in full face contact with corresponding metal / resilient sealing arrangement mounted on frame perimeter.

The mating seating/sealing faces on the gate frame and door shall be precisely finished for proper contact. They should be so finished that the clearance or gap, if any, between the mating sealing faces does not exceed 0.1mm at any level of weir gate opening.

**(e) Manual Gate Operating Headstock/Lift Mechanism**

The operating headstocks shall be designed in such a manner as to permit the gate operation by a single Person under the specified maximum operating head with an effort of less than 18 Kgs. on the crank /handwheel.

The headstock may be ungeared or geared type and the geared headstock may be either of single speed or of double speed, as might be necessary to make it convenient for one person to open or close the gate as fast as practicable. Two speed headstocks shall be supplied with gates requiring higher hoisting capacities. In this type of headstock the low speed is meant for crack opening the gate when the effort required to open the gate is maximum and the high speed is meant for further faster opening after the gate is crack opened.

Geared headstock shall be supplied with easily removable crank handle or handwheel with a radius not exceeding 375mm.

All the gears of geared headstock shall be kept completely encased in cast iron housing to protect them from damage, dirt, dust, water etc. and other atmospheric effects and thus ensure their smooth operation. Grease Nipples shall be provided at proper places for lubricating with grease.

Headstock meant for mounting on operating platform shall be supplied with a pedestal/floor stand to provide a convenient operating height of approximately 900 mm. The pedestal of the headstock shall be provided with a covered window opening to enable cleaning and greasing of stem threads.

**(f) Lifting Spindle/Stem**

The sluice gates shall be supplied with Rising type lifting spindles/stems. The stem shall be provided with acme / square threading, length of threaded portion being about 400mm more than the height of waterway opening. This much extra length is required to allow for a minor variation of approximately 100mm on either side of the specified height of operating platform.

The design of stem will be done as per the provision in AWWA C-560 / IS-13349.

(g) Stem Block/ Thrust Nut

The rising type stem shall be connected to the door through a stem block/thrust nut housed in a ribbed pocket cast integral with the door. The bottom end of stem shall thread into the stem block and is locked in place by a set screw to prevent the stem from unscrewing. The Stem block shall be cast bronze or Gunmetal.

(h) Safety Stop Nut

The stem shall be provided with a safety stop nut to prevent the chances of over opening of gate which may otherwise result into spindle unscrewing from the operating nut and falling of shutter. The stop nut shall be furnished with a set screw for setting it in a fixed position after the gate is installed. Upon installation the safety stop nut should be set in such a way that its bottom remains about 1 to 2 mm away from the top of headstock, in gate open position. In case of stainless steel stem, the stop nut shall also be of stainless steel material of the same grade.

An adjustable stopper arrangement will be provided on the frame and this stopper will engage with corresponding arrangement on shutter so as to prevent over closure of the shutter.

(i) Stem Coupling

For ease in transportation and handling, maximum length of one piece stem shall be restricted within 5 meter length. Where the stem are required to be furnished in more than one piece, threaded stem couplings shall be furnished to interconnect different sections of the stem. The couplings shall have provision for pinning after inserting in the threaded end of the stem. In case of stainless steel stem, the couplings shall also be of stainless steel material of the same grade.

(j) Stem Guide Bracket

Longer stems shall be provided with sufficient number of stem guides to prevent buckling of stem. The stem guide bracket to be provided shall be Adjustable Centre Type - wherein a separate stem guide is bolted on to the wall bracket. The stem guide shall be adjustable in the slots on wall bracket in a direction perpendicular to the face of wall. Wall bracket should also offers minor adjustment in the direction parallel to the wall. The stem guides shall have machine bored split journals to facilitate erection. The journal shall be lined with brass/gunmetal bush.

(k) Pipe Hood For Stem

A Pipe hood shall be provided on the top of headstock in case of rising spindle/stem gates to cover the spindle threads for protection against damage, dirt, dust, water etc. It shall be made of transparent fracture resistant polycarbonate material. The pipe hood shall have vent holes to prevent condensation.

(l) Gate Opening Indicating arrangement

Gate opening indicating arrangement shall be provided to indicate the position of the shutter. This shall comprise of scale mounted on the pipe hood and an indicator nut mounted on the rising spindle to show the extent of the opening and closing. The minimum scale graduation shall be 25 mm.

**MATERIAL OF CONSTRUCTION:**

The material of construction for various components shall be as under:

| <b>Component</b>                           | <b>Material</b>                     |
|--------------------------------------------|-------------------------------------|
| Gate frame, Shutter                        | Cast Iron to IS:210 Gr FG 200       |
| Headstock, Stem Guides, Stem Guide Bracket | Cast Iron to IS:210 Gr FG 200       |
| Seating faces,                             | Stainless Steel ASTM A 240 type 316 |
| Rubber Seals                               | EPDM Rubber to ASTM D 2000          |
| Rubber seal retainer bar                   | Stainless Steel ASTM A 240 type 316 |
| Assembly bolts, nuts and fastener          | Stainless Steel ASTM A 276 type 316 |
| Stem & Coupling                            | Stainless Steel ASTM A 276 type 316 |
| Yoke                                       | Steel Epoxy painted                 |
| Thrust nut and Lift nut                    | Gunmetal / Phosphor Bronze          |

**3.9.4 Hand Operated Hoists and Trolleys**

- (a) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety code in the locality where equipment will be installed.
- (b) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S.1663/B.S.3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress-relieved welded steel construction.
- (c) Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall conform to BS-436, BS-545 and BS-721.  
Spur and helical gears must comply with B.S. 436 and worm with BS 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S., 2525-32:1954.

- (d) Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action
- (e) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

### **3.9.5 Rotary Air Blowers High Speed Turbo Blower**

Turbo blowers are single-stage, high speed gearless air cooled radial turbo blowers designed to meet varying flow and pressure requirements in various processes. Blower is a modern frequency controlled, gearless driven machine along with lubricant-free aerodynamic bearings, guarantees an economical, reliable and maintenance-free operation.

Turbo Blowers employ the high precision machined cast impellers, hydrodynamic air foil bearings (air-lubricated), highly efficient Permanent Magnet motors and sensor-less Inverter drives, which eliminate the complicated gear trains or pulley & belt to provide considerable energy savings without much scheduled maintenance and with very low level of noise. Acoustically enclosed unit with noise not exceeding 80dB at distance of 1 meter from periphery of the Blower unit.

#### **A. Permanent Magnet (PM) Motor**

The Blower shall be driven with Permanent Magnet motor. The rotor of the motor has built-in permanent magnet, the power is required only to rotate the shaft. With the rotor being specifically designed to rotate at high speed, the size of the rotor is small. Rotor shall be of titanium & inconel alloy is lighter in weight. Because of these two factors the twisting torque is comparatively very small. The high electric grade material & high rotating speed produce less heat & hence cooling energy required is comparatively lower. PM Motor shall be synchronous motor, which has no slip & hence power factor shall be high. The efficiency is consistently maintained more than 95% from full load to partial load conditions. The PM motor is entirely air cooled and capable of a wide range of operating speed. Integrated variable speed drive ensuring starting current of the PMS motor to be less than 10% of the full load current. Current (Ampere) based active control should be used to enable high rise-to-surge.

#### **B. Frequency Inverter**

The frequency inverter, DC choke and RFI filter are standard and integrated in the Turbo Blower package. Other types of harmonic filters shall be supplied as per site conditions.

#### **C. Air Foil Bearings**

Air bearings shall not come in any physical contacts when shaft is in motion, which doesn't require any lubricant. The Air Foil bearings are of aerodynamic bearings. At standstill (idle

mode) the shaft sits on a foil tightened by springs. During operation, due to shaft rotation a cushion of air is generated between the foil and shaft which maintains the shaft in suspension without any need for an external source of compressed air. This increases energy efficiency. The bearings are not lubricated and the system is absolutely oil-free.

#### **D. Impeller & Casing**

The impeller is directly mounted on the shaft of the motor. The impeller is made up of machined cast stainless steel Gr. SUS630 having high structural strength /Aluminum alloy material. The profile is backward leaning to provide larger flow capacity, wide operating flow range & high efficiency.

The impeller alone is first dynamically balanced & again dynamically balanced together after mounting on the shaft. The spiral casing and the blower bellmouth are made of cast aluminum, while the discharge connection is made from Stainless steel.

#### **E. HMI Display**

HMI display indicates the Discharge Pressure, Inlet Temperature, Discharge Temperature, Flow Rate, Power consumed, Speed and the across the inlet filters. It shall also displays the performance curve with the actual operating point in it. HMI Touch Screen Graphical Display with on-line performance curve showing Pressure v/s Flow, Operating Point.

HMI should provide on-line display of instantaneous values & trending of following parameters: Pressure Drop across Suction Filters, Suction Air Temperature, Discharge Air Temperature, Discharge Air Pressure, Input Power & Dissolved Oxygen; RPM, Run Hours with facility for MODBUS connectivity to SCADA to display these parameters. Facility for remote control of pressure, flow, power, D.O. parameters shall also be provided. Integrated Mass Flow Meter for instantaneous on-line flow measurement with +/- 1% accuracy.

The following operation mode can be selected from HMI.

- a. Constant Current
- b. Constant Pressure
- c. Constant Volumetric Flow
- d. Constant Oxygen (Dissolved Oxygen Control)

#### **3.9.6 Acoustical Enclosure**

- (a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel. Provide clear, transparent Lexan or plastic windows to visually observe gauges.



- (b) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40°C.
- (c) The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 80 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

All the accessories shall be complied as per specification mentioned in Centrifugal single stage blower.

### **3.10 Blower**

- a) The blower shall be of single-stage centrifugal, and shall be designed integral type. The flow rate should be adjustable by controlling the rotation speed with frequency converter or inlet vane or discharge guide vane according to the inlet temperature and differential pressure to ensure the optimal power consumption. Regulation should be possible in the range of 100-50% of the specified design flows at all project design temperatures and at design pressures.
- b) The regulation should be fully automated and contain a program for continuous optimization of blower efficiency with respect to changes in inlet temperature, differential pressure and required flow.
- c) The pressure grade of the blower casing shall be minimum PN10. The casing shall be cast and bolted together and allow the impeller to be removed with the casing in situ.
- d) The impeller shall be open radial flow type (with backward leaning) and made of aluminium alloy, all surface of the vanes should be finish machining.
- e) High frequency, variable rotation speed and air-cooling motor should be adopted. The impeller and cooling fan should be directly connected with the motor shaft.
- f) The motor shall be equipped with magnetic bearings (If required), which should have the characteristic of magnetic suspension and continuous variable rotation speed. The motor should be installed at a frame with flexible fastening devices.
- g) Two radial magnetic bearings and one axial magnetic bearing shall be orientated accurately via the active-bearing controller controlling the rotor. The active bearing controller shall be powered by one DC and one 3 phase AC input. The service life of all bearings should be more than 100000 hours.
- h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers.
- i) The local control cabinet should be equipped with display screen and keypad unit. The running state of the blower should be able to monitor at real time. The displayed data at least include the following:
  - Actual flow (%)
  - Running time (hour)
  - Running time (day)
  - MWh counter



- Differential pressure
  - Reference flow (%)
  - Model of the blower
  - Power frequency of the motor (Hz)
  - Current (A)
  - Transition temperature
  - Motor temperature
- j) When operating, if the control system finds fault, the blower will give an alarm automatically or stop and the fault code will be displayed at the control cabinet. All signals can be transferred to the control centre of the plant.
- k) The blower should have the following protection functions (but not limited to):
- Over voltage of the main power supply
  - Under voltage of the main power supply
  - I-phase fault
  - Over voltage/Under voltage of the auxiliary power supply
  - Inlet and outlet air pipe blocking
  - Air temperature is higher than the specified limited temperature
  - Cooling air temperature is high than the specified limited temperature

### **Accessories**

a) Inlet filter and silencer :

Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise from pipes. Filter/silencer housing shall consist of stainless steel plate and acoustical sound-deadening material on the inside.

Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2m/sec at peak air flow.

b) Discharge Flex Connector :

Each blower shall be provided with discharge expansion Bellows joint of SS316. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.

c) Discharge Cone Diffuser Silencer :

Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 20 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of stainless steel plate and acoustical sound-deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.

d) Blow-off (Bypass) Valve :

Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve operator shall be motorized, equipped with open/closed limit switches, and shall be suitable for air service at 200°C operating temperature. Controls for the valve shall be mounted in each local blower control cabinet with indicating light.

e) Blow-off silencer :

Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of stainless steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.

f) Discharge check valve (Back-flow Barrier) :

Each blower shall be provided with one discharge check valve flange ends located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/BS: 4504. The pressure losses of the fully open valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.

g) Noise Protection Cover:

The blower and motor should be covered with one Acoustic cover, which should be equipped with electric cooling ventilator.

h) Base plate and anchor bolts:

Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork-lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

**Material of Construction**

|   | Description                                  | Material of Construction                      |
|---|----------------------------------------------|-----------------------------------------------|
| a | Blower Housing & Gear Box                    | CI IS 210 Gr. FG 250                          |
| b | Impeller                                     | Aluminium alloy                               |
| c | Shaft                                        | Carbon Steel (High Tensile) EN 19             |
| d | Base plate                                   | Profiled steel                                |
| e | Inlet filter, silencer casing                | Galvanised Steel                              |
| f | Acoustic enclosure                           | Al-Zn coated steel, insulated with glass wool |
| g | Blow-off silencer and motor cooling silencer | Galavanised steel                             |
| i | Inlet cone extension                         | Galavanised steel                             |
| j | Coupling                                     | Alloy Steel                                   |
| k | All connecting accessories and anchor bolts  | AISI 316                                      |

## **Control**

The control system of the blower should be well connected with the control system of the whole plant. All the real time monitor and protection function shall connect with the control software; the remote control shall be carried out with 4-20 mA or network.

Local control panel and control cabinet shall be combined, that include display screen and keypad, main switch and lock stop push button. The blower operation shall be controlled by the main running switch and keypad.

## **Performance Guarantee:**

The Performance of the compressor shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%.

Compressor or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

### **3.11 Motors for application area**

Motors shall be squirrel cage type conforming to IS 325. The power rating shall be at least 125% of maximum power requirement. The other features of motors shall be as follows :

- Type of duty : Continuous (SI)
- Method of starting : Star-Delta
- Class of insulation : F (Temperature rise limited to class B)
- Type of enclosure : TEFC and Flame proof

#### **3.11.1 Electric Actuator**

- (a) All local controls shall be protected by a lockable cover.
- (b) Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be oil or grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.
- (c) The valve actuator shall be capable of producing not less than 1½ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.
- (d) The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.
- (e) The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.
- (f) Each starter shall be equipped as follows :
  - (1) 2 No. Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.

- (2) 1 No. Three phase thermal cut-out device.  
1 No. Control circuit transformer fully protected by fuses on primary and secondary circuits.
- (3) 1 No. Set of "Open", "Close" and "Stop" buttons.
- (4) 1 No. Local- Off-Remote switches with padlocking facilities.
- (5) 1 No. Set of torque and limit switches for "Open" and "Close" positions.
- (6) 3 No. Sets of auxiliary limit switches in each direction.
- (7) Valve position Analog Transmitter (i.e Actuator accept To Read Analog signal from
- (8) Actuator to PLC and also To Write Analog Signal from PLC to Actuator) & mechanical indicator and hand wheel for manual operation.
- (9) Reduction gear unit
- (10) Trip signals of Thermo switch, Torque Switch and Thermal Overload Relay shall b provided for Indication and also integrated to PLC.

### **3.11.2 Butterfly Valve**

Butterfly valves shall be of double eccentric and resilient seated type generally as per BS EN 593 and IS 13095.

Butterfly valves shall be suitable for bi-directional pressure testing. The valves shall be of double flanged long type.

The valves shall be electrically/pneumatically/manual operated to suit the process requirement mentioned elsewhere in this tender document. The valve shall be free from induced vibrations. Valve shall be suitable for mounting in any position.

The valve seat shall be of metal to metal seated design for Process Air and Backwash Air application. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

The shaft shall be stainless steel with Bronze or equivalent seal with self-lubricating bearings.

Disc pins shall be stainless steel. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.

All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 450 mm and above shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be of worm and worm wheel design type, totally enclosed, grease filled and weather proof. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Material of construction of valves shall comply with following requirement:

| Item                                   | PN 10Valves                                                                                                  |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Body                                   | Process and Backwash Air: Ductile (SG)<br>Iron IS 1865 Gr.500/7 Biogas<br>application: SS ASTM A 743 Gr.CF8M |
| Disc                                   | Process and Backwash Air: Ductile (SG)<br>Iron IS 1865 Gr.500/7 Biogas<br>application: SS ASTM A 743 Gr.CF8M |
| Shaft                                  | Stainless Steel BS 970 Grade 431 S 29                                                                        |
| Body Seat                              | Stainless Steel ASTM A 276 Gr.316/CF8M                                                                       |
| Disc seat                              | Stainless Steel ASTM A 276 Gr. Gr.316/<br>CF8M                                                               |
| Shaft Bearing                          | Bronze backed with PTFE                                                                                      |
| Internal Fasteners                     | Stainless steel AISI 316                                                                                     |
| Nuts, bolts & washers for pipe flanges | High tensile steel hot dip galvanized                                                                        |

The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.

Valves shall be capable of closing against the maximum flow that can occur in system. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall be secured to the discs by tapered stainless steel cotter pins.

Valves shall be provided with position indicator to show the position of the disc, mounted on the driven shaft end.

Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully open or closed position (i.e. set points).

### **3.11.3 Sluice Valves**

- (a) Sluice valve shall generally confirm to IS 14846.
- (b) Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage.
- (c) Valves of 400mm and above shall be provided with thrust bearing arrangement for ease of operation.
- (d) Valves of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.
- (e) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

- (f) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.
- (g) The material of construction of valve shall be as follows :

| S. No. | Component          | Material                                                         |
|--------|--------------------|------------------------------------------------------------------|
| (i)    | Body               | Ductile (SG) Iron IS 1865 Gr.500/7                               |
| (ii)   | Doors              | Ductile (SG) Iron IS 1865 Gr.500/7 with EPDM rubber encapsulated |
| (iii)  | Spindle            | Stainless Steel: BS:970 Gr 431                                   |
| (iv)   | Bush               | Bronze : IS:318 Gr LTB2                                          |
| (v)    | Internal Fasteners | SS 316                                                           |

#### **3.11.4 Knife Gate Valves**

Design & Construction Details:

The Knife gate valves shall be manufactured generally as per the latest AWWA C520-10 standards.

Other constructional features and details of components of the required valves are to be as under:

The valve body should be of ductile iron construction as specified. The valve should be provided with gate made of stainless steel of grade as specified and the gate should have beveled knife edge at the bottom to cut through and easily enter in the solids settled in the bottom and ensure positive shut-off / closure in sewage environment.

The Valve should be designed for sealing in uni-directional flow application.

The valve should be provided with replaceable type flexible sealing arrangement to offer drop tight shut off. The seals should be made of EPDM rubber and should be held in place by an easily removable type seal retainer ring. The seals should be mechanically retained in place in a machined groove on the face of seal retainer ring. The sealing system should be field replaceable at site.

The valve housing should have integral as cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure with a view to avoid seal wear and achieve drop tight shut off. The surface of the gate coming in contact with the seal should be polished & buffed.

The bonneted valves shall have glandless design to avoid repeated tightening / replacement of gland packing. The stuffing "O" ring seal should be pressurized by thrust washer from both the sides and should be pressurized / tighten by thrust retainer nut.

The packings should be of graphited synthetic yarn to reduce the friction and offer higher life.

Provision shall be made to enable tighten the gland packing by means of a pusher arrangement to minimize the leakage through the back of the valve. Replacement of gland packings should be possible in installed condition of the valve without there being line pressure.

The spindle should be double start / single threaded and non-rising type for compact & safe operation. Gate opening indicating arrangement should be provided to find out the extent of gate opening /closing. The operation of the valves shall be manual / motorized as specified elsewhere in the tender specification.

In case the valve is to be operated from a far then it shall be provided with joining couplings, extension spindle, spindle guides and mounting pedestal with suitable anchor bolts / anchor fasteners on the platform.

**Materials of construction:**

| Component                                         | Material                                                                       |
|---------------------------------------------------|--------------------------------------------------------------------------------|
| Body                                              | : Ductile iron to BS 2789 Grade 420/12                                         |
| Seal Retainer ring                                | : Stainless steel to ASTM A-351 Grade CF8M                                     |
| Inlet Seal / Rubber Seals / O rings<br>Knife gate | : EPDM Rubber                                                                  |
| Spindle                                           | : Stainless Steel ASTM A 240 type 316                                          |
| Assembly bolts, nuts and fastener                 | : Stainless Steel ASTM A 276 type 316                                          |
| Spindle nut                                       | : Stainless Steel ASTM A 276 type 316                                          |
| Bracket / Adapter plate                           | : Gunmetal / Phosphor Bronze / Brass                                           |
| Packing                                           | : Mild Steel to IS : 2062 grade A, Epoxy<br>Painted : Graphited synthetic yarn |

**3.11.5 Slide Gate Valve**

- (a) Valve shall be of wafer type with elastomer body sealing arrangement for bi-directional shut-off.  
  
The valves shall be designed to allow gland repacking without relieving line pressure.
- (b) Body shall be two-piece cast construction bolted together with a mid-flange.
- (c) The elastomer body seal shall be held in body such that it is kept away from direct impingement of any particles in the flow medium.
- (d) The gate shall be provided with a beveled edge to facilitate positive closure of valve even with contaminated area.
- (e) The body internals shall be countered such that settlement of particles in the media.
- (f) Purge connection shall be provided optionally for these valves for cleaning the seating area.



(g) The material of construction of valve shall be as follows

| S. No. | Component  | Material                           |
|--------|------------|------------------------------------|
| (i)    | Body       | Ductile (SG) Iron IS 1865 Gr.500/7 |
| (ii)   | Gate       | Stainless Steel: BS:970 Gr 316     |
| (iii)  | Stem       | Stainless Steel: BS:970 Gr 316     |
| (iv)   | Body seal  | Stainless Steel : BS:970 Gr 316    |
| (v)    | Hand wheel | Cast Iron : IS:210 FGGr 260        |

### **3.11.6 Non Return Valve**

(a) Type of Valve:

- For Raw Sewage, Clear water & Sludge Application: Only Swing type non return valve complying to IS 5312 is accepted for the individual delivery line & Common header of the pump. Swing door valves of size 600mm and above shall be of Multidoor type.
- For Process Air Application: Only Flap type non return valve is accepted for the individual delivery line & Common header of the Air Blower.

(b) The valves shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body. Hydraulic passages and doors shall be designed to avoid cavitation.

(c) Valves shall possess high speed closing characteristics and to be designed for minimum slam condition when closing.

(d) Valve of diameter greater than 450 mm shall be provided, in addition to others, supporting feet and jacking screws. Hinge pins / shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixing.

(e) Maximum pressure drop across the valve shall be 0.4 mwc. Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

The material of construction of valve shall be as follows:

| S. No | Component          | Material                                 |
|-------|--------------------|------------------------------------------|
| 1     | Body and Door      | Ductile (SG) Iron:IS 1865 Gr.500/7       |
| 2     | Body and Door Ring | Stainless Steel : ASTM A743, CF8M        |
| 3     | Hinge Pin          | Stainless Steel : BS970 431 S29          |
| 4     | Bearings Bush      | Stainless Steel backed Teflon            |
| 5     | Internal Fasteners | SS 316                                   |
| 6     | External Fasteners | High Tensile steel hot dipped galvanised |



### **3.11.7 Telescopic Valves**

The telescopic valve shall be a proprietary item of proven design manufactured in cast iron and adjustable to cater for variation in level.

The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.

The bell mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.

The bell mouth shall be connected by swept tees to a cast iron sludge outlet pipe of suitable diameter

| Component  | Material                      |
|------------|-------------------------------|
| Bell Mouth | Cast Iron : IS:210 Gr. FG 260 |
| Piping     | Cast Iron : IS:210 Gr. FG 260 |
| Spindle    | Stainless Steel Gr. 304       |
| Hand wheel | Cast Iron : IS:210 Gr. FG 260 |

### **3.11.8 Diaphragm Valves**

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS EN 1092-1.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional 'O' ring seal of nitrite rubber or other approved material.

Diaphragms shall be composed of moulded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

### **3.11.9 Isolating Cocks**

For isolation of small bore pipe work tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

### **3.11.10 Pressure / Vacuum relief valves**

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions. Minimum of 3 nos of these valves of 150mm diameter shall be installed in the plant at digester and downstream piping.

Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS EN 1092-1.

### **3.11.11 Adjustable Weir Plates**

The adjustable weir plates shall be manufactured from 3mm thick SS 304 Plates and to the approval of the Employers Representative.

Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm through SS304 clamping plates. Fixings shall be designed for ease of accurately leveling the plates, securing the plates, and shall enable the plates to be adjusted during the life of the Works to accommodate differential settlement of the structure

### **3.11.12 Eccentric Structure Valve**

- (a) Valve shall be eccentric structure or horseshoe type disc and body. The valve shall be used for sludge line and flow control.
- (b) The valves shall be for a smooth flux of fluid and suitable for fluid contained sludge and impurities at the treatment plant.
- (c) The material of construction of valve shall be as follows:

| S. No. | Component  | Material                                             |
|--------|------------|------------------------------------------------------|
| (i)    | Body       | Ductile (SG) Iron:IS 1865 Gr.500/7                   |
| (ii)   | Disc       | Ductile (SG) Iron:IS 1865 Gr.500/7with rubber lining |
| (iii)  | Stem       | Stainless Steel: BS:970 Gr 304                       |
| (iv)   | Hand wheel | Cast Iron : IS:210 Gr FG 260                         |

### **3.11.13 Air Valves**

- (a) The air valve must be of the type that incorporates a kinetic and an automatic air release valve in one unit. It should be able to release air (gases) and to admit air into the sewage line, when the line is emptied.

- (b) The air valve must guarantee complete separation of liquid sewage from the sealing system of the air valve under all working conditions.
- (c) The air valve must have arrangement for draining and flushing by external water.
- (d) All sealing mechanism system parts of the air valve should be made of stainless steel-316.
- (e) The body of the valve should be such as to minimise the accumulation of sewage deposit at the bottom of the coating or of cast iron. The valve mechanism must be such as to prevent opening of the air valve upon every slight pressure change in line. Air Valve shall be Epoxy powder coating shall be provided inside and outside.
- (f) Each air valve must be supplied with a resilient seated sluice valve for isolation for maintenance purpose.

| S. No. | Component        | Material                           |
|--------|------------------|------------------------------------|
| (i)    | Body & Top Cover | Ductile (SG) Iron:IS 1865 Gr.500/7 |
| (ii)   | Float/Balls      | SS 316                             |
| (iii)  | Cover Bolts      | Austenitic alloy steel             |
| (iv)   | Gaskets & Seals  | EPDM                               |

### **3.12 Domestic Water Pump sets**

The Pump shall be of Centrifugal type, self priming and monoblock type. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non-return valves on the discharge side shall be forged steel. Piping shall be as per IS: 1239 heavy class.

### **3.13 Approved Vendor/Manufacturer/Make List-Mechanical Equipment**

| S.No. | Item Description         | Approved Vendor/ Manufacturer/ Make                                                      |
|-------|--------------------------|------------------------------------------------------------------------------------------|
| 1     | Air Compressor           | M/s Ingersoll Rand                                                                       |
|       |                          | M/s Kaeser                                                                               |
|       |                          | M/s Kirloskar Pneumatic                                                                  |
|       |                          | M/s Atlas Copco                                                                          |
|       |                          | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 2     | Air Blowers (Roots Type) | M/s Swam                                                                                 |
|       |                          | M/s Everest                                                                              |
|       |                          | M/s Usha compressors                                                                     |
|       |                          | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |

| S.No. | Item Description                 | Approved Vendor/ Manufacturer/ Make                                                      |
|-------|----------------------------------|------------------------------------------------------------------------------------------|
| 3     | Chlorination System              | M/s Industrial Device                                                                    |
|       |                                  | M/s Pennwalt                                                                             |
|       |                                  | M/s Capital Controls M/s Siemens                                                         |
|       |                                  | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 4     | Cranes (EOT, Hoists ,Jib cranes) | M/s W.H. Brady                                                                           |
|       |                                  | M/s Transpade Engineers                                                                  |
|       |                                  | M/s Eddy Cranes                                                                          |
|       |                                  | M/s Safex Electromech                                                                    |
|       |                                  | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 5     | Centrifuge Decanter              | M/s Pennwalt                                                                             |
|       |                                  | M/s Humboldt Wedag                                                                       |
|       |                                  | M/s GEA Westfalia                                                                        |
|       |                                  | M/s Andritz                                                                              |
|       |                                  | M/s Alpha Laval                                                                          |
|       |                                  | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 6     | Exhaust Fans                     | M/s Alstom                                                                               |
|       |                                  | M/s Howden                                                                               |
|       |                                  | M/s Bajaj                                                                                |
|       |                                  | M/s Crompton                                                                             |
|       |                                  | M/s Almonard                                                                             |
|       |                                  | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 7     | Flash Mixer/ Agitator            | M/s Fibre & Fibre                                                                        |
|       |                                  | M/s Ceecons                                                                              |
|       |                                  | M/s Remi                                                                                 |
|       |                                  | M/s Milton Roy                                                                           |
|       |                                  | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 8     | Horizontal Centrifugal Pumps     | M/s KBL                                                                                  |
|       |                                  | M/s Grundfos                                                                             |
|       |                                  | M/s Wilo/Mather & Platt M/s KSB                                                          |
|       |                                  | M/s Pentair                                                                              |
|       |                                  | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 9     | Submersible Pumps                | M/s KSB                                                                                  |
|       |                                  | M/s Xylem                                                                                |
|       |                                  | M/s Wilo                                                                                 |
|       |                                  | M/s ABS Sulzer                                                                           |
|       |                                  | M/s Grundfos                                                                             |
|       | Submersible Pumps-Tube           | M/s ABS Sulzer                                                                           |

| S.No. | Item Description                   | Approved Vendor/ Manufacturer/ Make                                                      |
|-------|------------------------------------|------------------------------------------------------------------------------------------|
|       | installed                          |                                                                                          |
|       |                                    | M/s Xylem                                                                                |
|       |                                    | M/s Wilo                                                                                 |
|       |                                    | M/s Grundfos                                                                             |
|       |                                    | M/s KSB                                                                                  |
|       | Progressive Cavity Screw Pumps     | M/s Rotomac Pumps                                                                        |
|       |                                    | M/s Netzch technology                                                                    |
|       |                                    | M/s PD Pumps                                                                             |
|       |                                    | M/s Tushaco Pumps                                                                        |
|       |                                    | M/s Roto Pumps                                                                           |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 10    | Chemical Dosing Pumps              | M/s Milton Roy                                                                           |
|       |                                    | M/s Prominent                                                                            |
|       |                                    | M/s Heidelberg                                                                           |
|       |                                    | M/s Positive Metering Pumps                                                              |
|       |                                    | M/s Swelore                                                                              |
|       |                                    | M/s SR Metering Pumps                                                                    |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 11    | Submersible Mixer                  | M/s ABS- Suzler                                                                          |
|       |                                    | M/s Grundfos                                                                             |
|       |                                    | M/s KSB                                                                                  |
|       |                                    | M/s ITT FLYGT-Xylem                                                                      |
|       |                                    | M/s. Eurotek                                                                             |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 12    | Clarifiers and Thickener Mechanism | M/s Voltas                                                                               |
|       |                                    | M/s Triveni                                                                              |
|       |                                    | M/s Shivpad                                                                              |
|       |                                    | M/s Emco KCP                                                                             |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 13    | Vortex type Grit Removal Mechanism | M/s Triveni                                                                              |
|       |                                    | M/s Bilfinger                                                                            |
|       |                                    | M/s Huber                                                                                |
|       |                                    | M/s Estragua                                                                             |
|       |                                    | M/s Smith & Loveless Inc.                                                                |
|       |                                    | M/s. Ekoton                                                                              |

| S.No. | Item Description        | Approved Vendor/ Manufacturer/ Make                                                      |
|-------|-------------------------|------------------------------------------------------------------------------------------|
|       |                         | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 14    | Butterfly Valve         | M/s Pentair                                                                              |
|       |                         | M/s Fouress                                                                              |
|       |                         | M/s VAG Valves                                                                           |
|       |                         | M/s AVK Valves                                                                           |
|       |                         | M/s KBL                                                                                  |
|       |                         | M/s. DVPL -Durga M/s. Jupiter                                                            |
|       |                         | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 15    | Sluice Gate Valve       | M/s VAG                                                                                  |
|       |                         | M/s KBL                                                                                  |
|       |                         | M/s AVK                                                                                  |
|       |                         | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 16    | PP Valve                | M/s Shenco                                                                               |
|       |                         | M/s. DVPL -Durga                                                                         |
|       |                         | M/s. Jupiter                                                                             |
|       |                         | M/s U N Polyvalves                                                                       |
|       |                         | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 17    | Penstock Gates          | M/s Jash                                                                                 |
|       |                         | M/s Yashwant                                                                             |
|       |                         | M/s. DVPL-Durga                                                                          |
|       |                         | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 18    | M.S- Cement Lined Pipes | M/s Jindal                                                                               |
|       |                         | M/s PSL                                                                                  |
|       |                         | M/s Welspun                                                                              |
|       |                         | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 19    | SS Pipes                | M/s SAIL *                                                                               |
|       |                         | M/s Jindal *                                                                             |
|       |                         | M/s. Remi Pipes                                                                          |
|       |                         | M/s Rupam Steel                                                                          |
|       |                         | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 20    | DI/GI pipes             | M/s Electrosteel                                                                         |
|       |                         | M/s Lanco steel                                                                          |
|       |                         | M/s Jindal                                                                               |
|       |                         | M/s Kejriwal Castings                                                                    |
|       |                         | M/s Surya Pipes                                                                          |

| S.No. | Item Description                   | Approved Vendor/ Manufacturer/ Make                                                      |
|-------|------------------------------------|------------------------------------------------------------------------------------------|
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 21    | DI Pipe Fittings                   | M/s Kiswok                                                                               |
|       |                                    | M/s Kejriwal Castings                                                                    |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 22    | Motorised Weir Gates               | M/s Jash                                                                                 |
|       |                                    | M/s. DVPL-Durga                                                                          |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 23    | Chlorine Tonners                   | M/s ISGEC                                                                                |
|       |                                    | M/s Meenakshi Associates                                                                 |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 24    | Fine Bubble Diffusers              | M/s Environmental Dynamics                                                               |
|       |                                    | M/s OTT GMBH                                                                             |
|       |                                    | M/s Rehau                                                                                |
|       |                                    | M/s Southern scogen M/s. Eutotek                                                         |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 25    | Centrifugal Air Blowers            | M/s Howden                                                                               |
|       |                                    | M/s Siemens                                                                              |
|       |                                    | M/s Neuros                                                                               |
|       |                                    | M/s Godrej Aerzen                                                                        |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 26    | Mechanical Screens (Bar/Drum Type) | M/s Jash Engineering                                                                     |
|       |                                    | M/s Bilfinger screens                                                                    |
|       |                                    | M/s Headworks                                                                            |
|       |                                    | M/s Huber                                                                                |
|       |                                    | M/s Eva Screens Ltd.                                                                     |
|       |                                    | M/s. United Technologies                                                                 |
|       |                                    | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 27    | Hot water Boiler                   | M/s Thermax Limited                                                                      |
|       |                                    | M/s Rakhoh                                                                               |
|       |                                    | M/s Thermal Engitech                                                                     |
|       |                                    | M/s Cethar Limited                                                                       |
|       |                                    | M/s Cheema Boilers Ltd.                                                                  |
|       |                                    | Equivalent makes can be proposed which meets                                             |

| S.No. | Item Description    | Approved Vendor/ Manufacturer/ Make                                                      |
|-------|---------------------|------------------------------------------------------------------------------------------|
|       |                     | the qualification criteria mentioned below.                                              |
| 28    | Electric Actuators  | M/s Auma                                                                                 |
|       |                     | M/s Limitork                                                                             |
|       |                     | M/s Rotork                                                                               |
|       |                     | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 29    | Pneumatic Actuators | M/s Rotex                                                                                |
|       |                     | M/s D Torque                                                                             |
|       |                     | M/s Elomatic                                                                             |
|       |                     | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 30    | UPVC & HDPE Pipes   | M/s Jain Irrigation                                                                      |
|       |                     | M/s Finloex                                                                              |
|       |                     | M/s Duraline                                                                             |
|       |                     | M/s Manikya Plasticschem                                                                 |
|       |                     | M/s Pennwalt Agro                                                                        |
|       |                     | M/s. Prince Pipes & Fittings Pvt. Ltd.                                                   |
|       |                     | M/s Supreme                                                                              |
|       |                     | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 31    | Motors              | M/s Crompton Greaves Ltd                                                                 |
|       |                     | M/s Marathon Electric (Alstom)                                                           |
|       |                     | M/s Kirloskar Electric company                                                           |
|       |                     | M/s Bharat Bijlee Ltd                                                                    |
|       |                     | M/s ABB                                                                                  |
|       |                     | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 32    | Ball Valves         | M/s BDK Engineers                                                                        |
|       |                     | M/s Flowchem                                                                             |
|       |                     | M/s Virgo                                                                                |
|       |                     | M/s KBL                                                                                  |
|       |                     | M/s Microfinish                                                                          |
|       |                     | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 33    | Knife Gate valves   | M/s Jash Engineering (Scheute)                                                           |
|       |                     | M/s Bray                                                                                 |
|       |                     | M/s Fouress                                                                              |
|       |                     | M/s VAG                                                                                  |
|       |                     | M/s AVK                                                                                  |
|       |                     | M/s. DVPL -Durga M/s. Jupiter                                                            |
|       |                     | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |



| S.No. | Item Description                                       | Approved Vendor/ Manufacturer/ Make                                                      |
|-------|--------------------------------------------------------|------------------------------------------------------------------------------------------|
| 34    | Diaphragm valves                                       | Crane Process                                                                            |
|       |                                                        | Microfinish                                                                              |
|       |                                                        | BDK Engineers                                                                            |
|       |                                                        | Leader                                                                                   |
|       |                                                        | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 35    | Eccentric Plug valves                                  | M/s Dezurik                                                                              |
|       |                                                        | M/s VAAS                                                                                 |
|       |                                                        | M/s. Arflu                                                                               |
|       |                                                        | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 36    | Alum Rapid Induction Mixer                             | M/s Rite water solution                                                                  |
| 37    | Biogas Scrubber                                        | M/s Innovative Environmental                                                             |
|       |                                                        | M/s Combustion research associates                                                       |
|       |                                                        | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 38    | Gas Flare                                              | M/s Combustion research associates                                                       |
|       |                                                        | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 39    | Heat Exchanger                                         | M/s Alpha Laval                                                                          |
|       |                                                        | M/s Positron Engineering Corporation M/s Ammus                                           |
|       |                                                        | M/s Rakhoh                                                                               |
|       |                                                        | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 40    | Air conditioner                                        | M/s Bluestar                                                                             |
|       |                                                        | M/s Voltas                                                                               |
|       |                                                        | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 41    | Screw Impeller Submersible Pumps                       | M/s Hydrostal                                                                            |
|       |                                                        | M/s Kubota Pumps                                                                         |
|       |                                                        | Equivalent makes can be proposed which meets the qualification criteria mentioned below. |
| 42    | Screw Turbine Hydro Power Generation System            | M/s JASH Engineering                                                                     |
|       |                                                        | M/s REHART                                                                               |
|       |                                                        | M/s KAUS-Gmbh                                                                            |
|       |                                                        | M/s SPAANS                                                                               |
|       |                                                        | Equivalent makes can be proposed which meets the qualification criteria mentioned below  |
| 43    | Direct Drive TurboBiogas Mixing (Sliding Vane) Blowers | M/s. Godrej Swam                                                                         |

| S.No. | Item Description                                                 | Approved Vendor/ Manufacturer/ Make                                                     |
|-------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
|       | Geared Centrifugal Blower                                        | M/s. Godrej                                                                             |
|       |                                                                  | Equivalent makes can be proposed which meets the qualification criteria mentioned below |
| 44    | Disc Filter                                                      | M/s. Aqua Aerobic System Inc.                                                           |
|       |                                                                  | M/s. Jash Nordic                                                                        |
|       |                                                                  | M/s. Huber                                                                              |
|       |                                                                  | M/s. Jonhson                                                                            |
|       |                                                                  | M/s. Yucheon                                                                            |
|       |                                                                  | M/s. Siemens                                                                            |
| 45    | HydroBiogas Engine & Auxiliary Power Generator Generation System | M/s. Rehart Power GE Jenbacher                                                          |
|       |                                                                  | M/s Waukesha Engines                                                                    |
|       |                                                                  | M/s MWM / Catterpillar                                                                  |
|       |                                                                  | Equivalent makes can be proposed which meets the qualification criteria mentioned below |

**Note: Bidder shall select the equipments from makes listed above or approved equivalent. Before placing the purchase order, approval shall be obtained from the BDA/Competent Authority, For the Makes which are not listed above.**

All the equipment, to be supplied under this contract has to be from experienced manufacturer. The equipment of only those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one

(1) manufacturer.

In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following:

1. Demonstrate that the proposed makes are "Superior / Equivalent" to the approved makes.
2. Manufacturer involved in manufacture of specified equipment for at least 10 years before bid date
3. At least 5 successful installations (both in India / abroad) commissioned in last 5 years before bid date and satisfactorily operating for at least one year before bid date. End user certificate shall be provided for the same.

Manufacturer to provide full contact information for each reference as part of technical bid And the above qualities and requirements shall be demonstrated and evidenced by inspection of manufacturing units and successfully installed plants (at the End users plant/premises) for the equipment"s desired and successful operation and certification by the Employer/Engineer (BWSSB)/Representative.

The Employer shall reserve the right to accept or reject the Bidder proposed makes of Equipment. 8.50Warranty

- A. Comply with the requirements of each type of Equipment and specification mentioned elsewhere in this document.
- B. Warrant all components to be free of defects in materials or workmanship for 12 months from date of satisfactory completion of performance test.
- C. Individual warranties by component manufacturer in lieu of single source responsibility by the main Equipment manufacturer shall not be acceptable.
- D. Items which fail during the warranty period, excluding expendable items, shall be replaced without cost to the Owner.
- E. Provide manufacturer"s guarantee and warranty certificates prior to equipment start-up.

### **3.14 Pipelines, Pipe work and Fittings**

#### **3.14.1 Applicable codes**

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Engineer.

#### **3.14.2 Materials**

- IS : 210 Specification for grey iron casting
- IS : 290 Specification for coal tar black paint
- IS : 456 Code of practice for plain and reinforced concrete
- IS : 458 Specification for pre cast concrete pipes (with and without reinforcement)
- IS : 516 Method of test for strength of concrete
- IS : 638 Specification for sheet rubber jointing and rubber insertion jointing
- IS : 783 Code of practice for laying of concrete pipes
- IS : 816 Code of practice for use of metal arc welding for general construction in mild steel
- IS : 1367 Technical supply conditions for threaded steel fasteners
- IS : 1387 General requirements for the supply of metallurgical materials
- IS : 1500 Method for Brinell hardness test for metallic materials
- IS : 1536 Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
- IS : 1537 Specification for vertically cast iron pressure pipes for water, gas and sewage

- IS : 1538 Specification for cast iron fittings for pressure pipes for water, gas and sewage
- IS : 1916 Specification for steel cylinder pipes with concrete lining and coating
- IS : 2078 Method for tensile testing of grey cast iron
- IS : 3597 Method of tests for concrete pipes
- IS : 3658 Code of practice for liquid penetrant flow detection
- IS : 5382 Specification for rubber sealing rings for gas mains, water mains and sewers
- IS : 5504 Specification for spiral welded pipes
- IS : 6587 Specification for spun hemp yarn
- IS : 7322 Specification for specials for steel cylinder reinforced concrete pipes

### **3.14.3 Code of Practice**

- IS : 783 Code of practice for laying of concrete pipes
- IS : 3114 Code of practice for laying of cast iron pipes
- IS : 3764 Excavation work - Code of Safety
- IS : 4127 Code of practice for laying of glazed stoneware pipes
- IS : 5822 Code of practice for laying of electrically welded steel pipes for water supply.
- IS : 6530 Code of practice for laying of asbestos cement pressure pipes.

### **3.14.4 Steel Cylinder Pipes and Specials**

#### **3.57.6.1 Design**

In general the design of steel cylinder pipes with concrete lining and coating shall conform to clause 8 of IS 1916. In addition to above, in case of buried pipe line, the pipe shall also be designed for the Earth load, and traffic load.

### **3.14.5 Manufacturing**

#### **3.57.7.1 General**

Steel cylinder pipes and specials with concrete lining and coating shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained. The pipes and specials shall be inspected by Engineer at site and factory, and defects noticed, if any, such as protrusions, grooves, dents, notches, etc. shall be rectified, if agreed to by the Engineer. Care shall be taken that the resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum specified, as per Table 1 of IS: 1916, the damaged portion should be cut out as cylinder and replaced by an undamaged piece of pipe at no extra cost to the Engineer.

The Engineer shall at all reasonable times have free access to the place where the pipes and specials are manufactured for the purpose of examining, inspection and testing the pipes and specials and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirement or in the relevant Indian Standards shall be performed by Supplier/Contractor at his own cost and in presence of the Engineer, if desired. For this sufficient notice before testing of the pipes and specials shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and specials of that lot. The decision of the Engineer in this matter shall be final and binding on the Contractor.

#### **3.57.7.2 Materials**

All material shall conform to Clause 7 of IS 1916.

#### **3.57.7.3 Manufacturing Process**

Steel cylinder pipes with concrete lining and coating shall be manufactured as per Clause No.9 of IS: 1916 and specials shall be manufactured as per Clause 7 of IS:7322. In case of spiral welded pipes, they shall be manufactured as per Clause 3 of IS: 5504. Internal lining shall be upto the full length of the pipes and specials. However, external coating shall be done leaving about 100 mm length of the pipes and specials from their ends. The internal lining and external coating to pipes and specials shall be done at factory. Before lining/coating by concrete/mortar the surface of pipes and specials shall be thoroughly cleaned. In the event that loose mill scale, tuberculation, or an accumulation of dirt, debris, oil or grease is present, it shall be removed from the surface by hand, by machine or both and given a coating of neat cement slurry.

#### **3.57.7.4Dimensions**

The clear cover to the reinforcement whether steel cylinder or cage shall be not less than 9 mm for lining of pipe/special and 12 mm for coating of the pipe/special.

The permissible tolerance for diameter and length of pipe shall be as per Clause 4 of IS: 1916, whereas for diameter, arm length and angular deviation of specials the tolerance limit shall be as per Clause 6 of IS: 7322.

#### **3.57.7.5Workmanship and Finish**

Workmanship and finish of pipe shall conform to Clause 4 of IS: 1916.

#### **3.57.7.6 Testing**

Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where

feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS: 3658 or other approved means.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the inspection shall be borne by the Contractor

### **3.57.7.7 Penetration Test**

A suitable liquid penetrant (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrate time, the excess penetrant which remains on the surface, is removed. Then a light colored powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

### **3.57.7.8 Marking**

The following information shall be clearly marked on each pipe and special:

- i) Internal diameter, external diameter and thickness
- ii) Class of pipe and special with its serial number
- iii) Date of manufacture and
- iv) Name of manufacturer or his registered trade mark or both

### **3.14.6 Jointing**

#### **3.57.8.1 General**

Jointing of steel cylinder pipes and specials with concrete lining and coating be done as per the relevant IS. After jointing, extraneous material if any, shall be removed from the inside of the pipe and special. The welding of joints for pipes and specials at work sites shall comply with 816. Electrodes used for welding shall comply with IS: 814.

#### **3.57.8.2 Butt Welded Joint**

After pipes and specials are laid in the trench, the faces of pipes/specials shall first be tack-welded alternately at one or more diametrically opposite pairs of points. After completing tack welding, full welding shall be carried out in suitable runs following a sequence of welding portions of segments diametrically opposite. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2)

for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

#### **3.57.8.3 Lap Welded Joint with Slip-in-ends**

In the case of pipes with plain or slip-in-ends, swaged end of the steel cylinder may be formed by heating one of its ends and expanding it or rolling it out to the required shape. The minimum depth and maximum clearance between the swaged end and the plain end of pipes for field welding shall be provided as directed by the Engineer. Lap welding shall be done from the external face at the junction of pipe and socket. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

#### **3.57.8.4 Flanged Joints**

The flanges for steel cylinder pipes and specials shall be as per BS EN 1092-1/BS4504. Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might be necessary for contractor to follow the instructions and specifications given by the valve manufacturer. All bolts, nuts and packing material required for flanged joints shall be provided by the Contractor. Bolts and nuts shall conform to IS: 1367 whereas rubber gasket of required thickness shall conform to IS: 638.

The bolts shall be evenly tightened in comply with relevant BS standard. Random inspection shall be carried out by jointly the Engineer and the contractor.

#### **3.57.8.5 Cleaning of pipes and specials**

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

#### **3.57.8.6 Testing at work site**

After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.



Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rewelded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

Proper arrangement of thrust blocks shall be provided during pressure testing or pipe laying works.

### **3.14.7 Steel Pipe work**

Pipe/fitting material and dimensional standard shall conform to following:

| <b>Size mm (NB)</b>              | <b>Material Specification (Steel)</b> | <b>Dimensional Standard</b>                                                               |
|----------------------------------|---------------------------------------|-------------------------------------------------------------------------------------------|
| Pipes upto 150 mm                | 1239 PT, ERW, Black PT-1 HVY          | 1239 ERW                                                                                  |
| 200 to 2400                      | 2062                                  | 3589 - ERW 3589 for dimensions and minimum thickness. Pipe thickness shall be as per 2825 |
| Elbows upto 25                   | ASTM-A 105                            | ANSI B 16.11 3000 # S.W.                                                                  |
| 40 to 150                        | ASTM-A 234 GR WPB                     | ANSI B 16.9                                                                               |
| 200 & above (meters)             | 2062                                  | LR. BE. Sch 40 ANSI B 31.1                                                                |
| Coupling upto 25                 | ASTM-A 105                            | ANSI B 16.11 3000 # S.W.                                                                  |
| Tees 40 to 200                   | ASTM - A 234 GR WPB                   | ANSI B 16.9 BE, Sch 40                                                                    |
| Above 200                        | IS 2062                               | IS 2825 (min. Pipe thickness)                                                             |
| Reducers upto 25                 | ASTM-A 105                            | ANSI B 16.11 3000 S.W.                                                                    |
| 40 to 200                        | ASTM-A 234 GR WPB                     | ANSI B 16.9 BE, Sch 40                                                                    |
| Above 200                        | 2062                                  | IS 2825 (min. Thickness for larger pipes)                                                 |
| Flanges                          | 2062                                  | BS EN 1092-1                                                                              |
| Bolts, Anchor Bolts and all nuts | SS316                                 | 1364                                                                                      |
| Gaskets All                      | 638 (rubber) reinforced               | 3 mm thickness                                                                            |

Facilities shall be provided for draining the pipe system and releasing air.



The pipe work layout within pump stations shall have the approval of the pump manufacturer. Fluid velocities in suction pipe work leading to pumps shall not exceed 1.5 m/s. Fluid velocities in delivery pipe work leading from pumps shall not exceed 2.0 m/s.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe support shall be included in the Contract. The Contractor shall be responsible for ensuring that the internal surface of all pipe work is thoroughly cleaned before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding. Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer.

Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.

Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm may be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fiber glass wraps set in coal tar enamel coats conforming to American Water Works Association specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.

The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipe work supplied by him. Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer.

Buried pipes shall in addition be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level for design purposes. Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipe lines.

All pipe joints shall be of the butt welded type. End preparations and fabrication requirements shall generally conform to I.S. 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved.

Laying of welded steel pipes shall meet the requirements of I.S. 5822.

### **3.14.8 Welded Joints for Steel Pipes**

Welding of joints in steel pipes shall be carried out manually by the metal arc welding process complying with AWWA Standard C206.

Before starting the welding of pipe joints in the Works the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength and arrangements for air testing of individual joints.

Welding shall only be carried out by welders approved by the Engineer and each welder shall identify his work by means of a stenciled mark.

Welded joints other than for closing lengths shall be of the spherical spigot and socket type. For pipes of 675 mm diameter and smaller the pipe joint shall be welded externally. For pipes larger than 675 mm the pipe shall be welded internally and a sealing weld made externally. All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15° apart around the joint circumference.

For pipes larger than 900 mm diameter a triple run convex fillet weld shall be used. For pipes of 900 mm diameter or less a double run convex fillet weld shall be used. The minimum leg length of the fillet as deposited is to be equal to the full thickness of the pipe wall. The actual throat depth shall not be greater than 9/10th and not less than 7/10th of the minimum leg lengths as deposited. The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the weld shall have an even contour with regular finish and shall indicate proper fusion with the parent metal. All slag shall be thoroughly removed after depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap on to the parent metal without proper fusion or containing any other defects whatsoever shall be cut out and rewelded to the satisfaction of the Engineer at the Contractor's expense.

At closing lengths where two plain ended pipes are to be joined by a welded joint the gap between the two ends shall not exceed 75 mm. An external steel sleeve collar, of a thickness not less than that of the pipe itself and approximately 300 mm in length shall be placed centrally over the two ends to be jointed and the end of each pipe shall then be fillet welded to the sleeve collar in accordance with the above procedure.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Engineer.

### **3.14.9 Welder Performance Test**

The Contractor shall submit for the Engineer's approval the names of persons whom he proposes to employ as welders with evidence that, as a minimum preliminary qualification, they have passed the qualifying tests prescribed in Clause 11 of BS 2633 and possessed certificates from an independent testing authority. The Engineer may further require any such person to perform satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Engineer and if ordered by the Engineer he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure tests on individual welded joints, is below a reasonable standard of quality of consistency in the Engineer's opinion.

### **3.14.10 Testing of Welded Joints**

Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and re-welded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

### **3.15 Hydraulic Losses**

Hazen-Williams Roughness Coefficient "C" for Head Loss calculation for Different Types of sludges.

The frictional losses due to liquid flow in sewage shall be as per the table furnished Hazen-William formula using C values as below:

| Solids in Sludge | Roughness Coefficient C |                 |
|------------------|-------------------------|-----------------|
|                  | Raw Sludge              | Digested Sludge |
| 0                | 100                     | 100             |
| 1                | 83                      | 100             |
| 2                | 71                      | 91              |
| 3                | 60                      | 83              |
| 4                | 53                      | 78              |
| 5                | 47                      | 73              |
| 6                | 42                      | 69              |

| Solids in Sludge | Roughness Coefficient C |                 |
|------------------|-------------------------|-----------------|
|                  | Raw Sludge              | Digested Sludge |
| 7                | 37                      | 65              |
| 8                | 33                      | 60              |
| 9                | 29                      | 55              |
| 10               | 25                      | 48              |

Manning's coefficient of roughness n for

(a) RCC channels shall be 0.018

(b) Cast Iron, Ductile Iron and Mild Steel with cement mortar lining shall be 0.011

a) K values for fittings

The losses in mwc shall be calculated as per empirical formulas. K values for fittings shall be as given in below table

| Sr.No. | Type of Fittings                 | Factor |
|--------|----------------------------------|--------|
| 1      | Sudden Contraction               | 0.5    |
| 2      | Entrance shape well rounded      | 0.5    |
| 3      | Elbow 90 degrees                 | 1.0    |
| 4      | Elbow 45 degrees                 | 0.75   |
| 5      | Elbow 22 degrees                 | 0.5    |
| 6      | Tee 90 degrees                   | 1.5    |
| 7      | Tee in straight pipe             | 0.3    |
| 8      | Gate valve open                  | 0.4    |
| 9      | Valve with reducer and increaser | 0.5    |
| 10     | Globe valve                      | 10.0   |
| 11     | Angle                            | 5.0    |
| 12     | Swing check                      | 2.5    |
| 13     | Venturi meter                    | 0.3    |
| 14     | Orifice                          | 1.0    |

### 3.16 Pipe work Protection

All underground steel piping shall have their external surfaces protected by application of one coat of tar enamel, wrapping of fiberglass, one more coat of enamel and a final wrap of enamel impregnated fiberglass. Pipe surface shall be thoroughly cleaned by shot or sand blasting. Primer paint recommended by the enamel manufacturer for the grade of enamel used shall be applied over this cleaned surface within four hours of cleaning. The primer paint shall be thoroughly mixed and applied as recommended by the manufacturer and the coating shall be free of bubbles, globules, drips and runs. The primer shall be thoroughly dry before enamel is applied and the latter shall not be applied later than 3 days after application of primer. First flood coat of enamel shall be overlaid by a single spiral wrap of fiberglass overlapping at least 20 mm on pipe up to 250 mm diameter and 25 mm on larger diameter pipes. Enamel shall be heated slowly in clean kettles, equipped with indicating or recording thermometers (100°C to 350°C range), to the recommended temperature. The enamel shall be stirred continuously. It shall be seen that

fiberglass impregnates in the flood coat. Second coat of enamel and second wrap of bitumen impregnated fiberglass shall be applied in the same way. The total thickness of the coating shall not be less than 2.5 mm. Each end of the pipe left bare for a distance of 150 mm for welding shall be hand coated and wrapped after field welding is completed and hydro tested. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness gauges, and bond test and holiday detectors.

### **3.17 External protection**

All underground pipework having a cover less than 1.5 m and more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All underground pipelines having a cover more than 1.5 m shall be externally protected by guiniting of minimum 40 mm thick as per specification.

All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns.

### **3.18 Flexibility in Pipe work**

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided (as per Engineer's directive) with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints (SS316 Bellows and Dismantling joints) shall also be provided for case of erection and future dismantling of all valves and Equipment. Particular care shall be taken to ensure that pipe work thrusts are not transmitted to machinery or associated apparatus.

The Contractor shall indicate on his detailed drawings what thrust blocks are required.

### **3.19 Puddle Flanges**

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer prior approval.

### **3.20 Small Bore Pipes and Hoses**

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joint or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipe work to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipe work through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Racks or trays shall be fixed to the duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes and racks of trays proposed, shall be submitted at the time of tendering.

### **3.21 Support of Pipe work and Accessories**

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

### **3.22 Cast Iron Pipes**

#### **3.22.1 Manufacturing**

##### **3.65.1.1 General**

C.I. pipes and fittings shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained.

Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian Standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and fittings of that lot. The decision of the Engineer in this matter shall be final and binding of the Contractor and not subject to any arbitration or appeal.

### **3.65.1.2 Materials**

The general requirements relating to the supply of material shall be as per IS: 1387.

The material for pipes and fittings shall be of good quality cast iron conforming to IS: 210 (Grade –FG150).

### **3.65.1.3 Dimensions**

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS: 1536/1537/1538 for different class of pipes and fittings.

The tolerances for pipes and fittings regarding dimensions and deviations from straight line in case of pipes shall be as per relevant IS codes.

The standard weight of uncoated pipes and fittings and the permissible tolerance shall be as per relevant IS codes.

### **3.65.1.4 Workmanship and Finish**

The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects, other than any unavoidable surface imperfections which result from the method of manufacture and which do not affect the use of the pipes in the opinion of Engineer.

The pipes and fittings shall be such that they could be cut, drilled or machined and may be accepted

provided the hardness of the external unmachined surface does not exceed 230 HBS. In the case of spigot and socket pipes and fittings for lead joints, the socket shall be without the centering ring.

In the case of flanged pipes the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the centre line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

### **3.65.1.5 Testing**

#### **a. Mechanical Tests**

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.



**b. Brinell Hardness Test**

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

**c. Retests**

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

**d. Hydrostatic test**

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

**3.65.1.6 Coating**

Coating shall not be applied to any pipe and fitting unless its surface is clean, dry and free from rust. All pipes and fittings shall be coated externally and internally with the same material, by dipping in a tar or suitable base bath. The pipe and fitting may be either preheated before dipping or the bath may be uniformly heated. The coating material shall set rapidly with good adherence and shall not scale off. In all instances where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 65° C, but not so brittle at a temperature of 0°C as to chip off when scribed lightly with a penknife. In case of pipes and fittings which are imperfectly coated or where the coating does not set or conform to the required quality, the coating shall be removed and the pipes and fittings recoated.

In case the pipes are to be used for conveying potable water, the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or odour whatsoever to the potable water after disinfection and suitable washing of the mains.

**3.65.1.7 Marking**

Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks:

- i) The nominal diameter.
- ii) Flow direction and line marks for installation
- iii) Class reference
- iv) Mass of pipe
- v) Date of manufacture and
- vi) Manufacturer's name, initials or identification mark.

Marking shall be done as per relevant IS code.



### **3.23 Jointing**

#### **3.23.1 General**

Jointing of CI pipes and fittings shall be done as per the requirements of following Employer's Requirements and as per the relevant IS. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382.

#### **3.23.2 Tyton joints**

In jointing cast iron spigot and socket pipes and fittings with tyton flexible joints the contractor shall take into account the manufacture's recommendations as to the methods and equipment to be used in assembling the joints. In particular the contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per IS: 5382, is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by Engineer.

#### **3.23.3 Flanged Pipes**

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS: 638, of thickness between 1.5 to 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

#### **3.23.4 Cleaning of Pipes and Fittings**

The Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

#### **3.23.5 Testing at work site**

After the pipes and fittings are laid, jointed and the trench partially backfilled except at the

joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until atleast two days have elapsed.

Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe as directed by the Engineer.

The duration of test shall not be less than 5 minutes. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm<sup>3</sup>/h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{3.3}$$

Where,

- $q_L$  = The allowable leakage in cm<sup>3</sup>/hr
- $N$  = Number of joints in the length of the pipeline
- $D$  = Diameter in mm, and
- $P$  = The average test pressure during the leakage test in Kg/cm<sup>2</sup>

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints

shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer's Requirements specified elsewhere.

### **3.24 Un plasticised PVC Pipes and Fittings**

Unplasticised polyvinyl chloride pipes, fittings and specials shall be to BS 3505 for potable water and BS 4346: Part 1 for fittings.

The pipes shall be of the spigot and socket type with approved gasket type flexible joint. The rubber gaskets shall be to BS 2494, Class C.

Where PVC pipes, fittings and specials are to be connected to cast iron, stainless steel or steel pipes, all metallic pipes, „Viking Johnson" type flange adaptors or stepped couplings shall be used.

#### **3.24.1 Polyethylene Pipes**

Polyethylene pipes shall comply with BS 6437. The welding method shall be adapted to international standard and contractor shall obtain the approval of the Engineer before proceeding with such works. HDPE Pipelines: Indian Standard Materials IS4984 PE100.

#### **3.24.2 Rubber Hosing**

Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling chlorine and sulphur dioxide solutions at a working pressure of 12 bar.

#### **3.24.3 Copper Tubes and Fittings**

Copper tubing and fittings for work above ground level shall comply with BS 2871 and BS 864: Part 2 respectively and be jointed with capillary joints. For underground location the copper pipe shall be to BS 2871: Part 1.

#### **3.24.4 Flanged Joints**

All flanges shall comply with BS EN 1092-1/BS 4504. The nominal pressure rating for particular flanges shall be at least equal to the highest pressure rating of the pipes or fittings to which they are attached, but with a minimum nominal pressure of PN 10. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets. In general, valves shall have flanged body ends.

All flanged joints which are buried or in chambers shall be protected with Densomastic and Densotape wrapping, applied in accordance with the manufacturer's instructions.

Flanges shall be installed on the pipes in the factory and field welding of flanges shall only be allowed with the approval of the Engineer.

Where pipework outside pumping stations and surge vessel chambers is cathodically protected, an insulated flange shall be incorporated at the first flange inside the structure. These flanges shall be tested to ensure that electrical insulation is achieved.

### **3.24.5 Gaskets and Joint Rings**

Joint rings shall be manufactured to conform with BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80°C.

Gaskets may be inside the bolt circle type and shall comply with BS 4865: Part 1. Alternatively the gasket shall be to the full diameter of the flange, drilled to suit the appropriate bolt provisions.

Chloroprene rubber with a hardness of 71 to 80 IRHD shall be used.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any soluble constituent, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint shall be made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

### **3.24.6 Flexible Couplings and Flange Adaptors**

Flexible couplings and flange adaptors shall be of the Viking Johnson or similar approved pattern and be assembled in accordance with the manufacturer's instructions and protected, if buried or in chambers with Densomastic and Densotape wrapping applied in accordance with the manufacturers' instructions. Flexible joints shall be harnessed or tied where necessary

### **3.25 Storage & Shipment**

#### **3.25.1 Protection of Pipes and Fittings for Shipment**

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

#### **3.25.2 Storage of Pipeline Materials**

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

### **3.25.3 Transportation of Pipes and Fittings**

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

### **3.25.4 Inspection of Pipes and Fittings**

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundness. Damaged pipes which in the opinion of the Engineer cannot be satisfactorily repaired shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the Engineer.

### **3.25.5 Built-in Pipe work and other Plant**

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe work and other Plant is in accordance with the requirements of the programme. Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS EN 1092-1/BS 4504 but shall be undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

## **3.26 Pipe laying**

### **3.26.1 Carting & Handling**

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

### **3.26.2 Storage**

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

## **7 B 4. SUB-SECTION**

### **CCTV AND VIDEO SURVEILLANCE SPECIFICATION**



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#### **4. TECHNICAL SPECIFICATIONS FOR CCTV AND VIDEO SURVEILLANCE**

##### **4.1 Fixed Outdoor Camera**

| <b>Feature</b>       | <b>Specifications</b>                                                                                                                                                                                                                             |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. General           | IP True Day/Night Outdoor Fixed Box Camera; POE Enabled. ONVIF Compliant, low light visibility, clear visibility under rainy/cloudy/lightning conditions. The camera shall have IR enhancement technology. Immunity against EMI, RFI & lightning. |
| 2. Lens              | 3-22 mm lens                                                                                                                                                                                                                                      |
| 3. Light Sensitivity | Color: 0.5 lx at 50 IRE, F1.2, AGC high or better & Black & White : 0.2 lx at 50 IRE, F1.2, AGC high or better (without IR)                                                                                                                       |
| 4. Compression       | MPEG4/H.264/MJPEG or equivalent                                                                                                                                                                                                                   |
| 5. Signal System     | PAL                                                                                                                                                                                                                                               |
| 6. Resolution        | 2MP or better                                                                                                                                                                                                                                     |
| 7. Onboard Memory    | Shall support SD / Micro SD cards storage of minimum 64 GB.                                                                                                                                                                                       |
| 8. Video streaming   | Multi-streaming (Minimum 5 No. User-defined & configurable - different frame rate, bit rate, resolution, quality, and compression format) support. The camera shall support 128 bit AES encryption.                                               |
| 9. Image Features    | Electronic Image Stabilization, auto-focus & WDR                                                                                                                                                                                                  |
| 10. Casing           | IP 66 or better & vandal-proof Mounting accessories, brackets, poles, nuts, bolts, washers shall be of Stainless Steel / Aluminium.                                                                                                               |
| 11. Miscellaneous    | Camera Housing: Stainless Steel / Aluminium material.                                                                                                                                                                                             |

##### **4.2 Fixed Outdoor Camera – Panoramic**

| <b>Feature</b>       | <b>Specifications</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. General           | IP True Day/Night Outdoor Fixed 4-lens Dome Camera for general surveillance for a radial distance of approx. 40 meters; capturing clear, identifiable/readable images of objects at a radial distance of approx. 8 meters; at a radial distance of approx. 8 meters; POE Enabled, ONVIF Compliant, low light visibility, clear visibility under rainy/cloudy/lightning conditions also, IR enhancement technology. Immunity against EMI, RFI & lightning. The camera shall have a canopy firmly attached to protect the dome from rains, droplets from all directions. |
| 2. Field of View     | 180 degree (Horizontal), adjustable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 3. Light Sensitivity | Color: 0.5 lx at 50 IRE, F1.2, AGC high or better & Black & White : 0.2 lx at 50 IRE, F1.2, AGC high or better                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 4. Compression       | MPEG4/H.264/MJPEG or equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 5. Signal System     | PAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 6. Resolution        | 2MP x 4 or better (per lens)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 7. Onboard Memory    | Shall support SD / Micro SD cards storage of minimum 64 GB.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 8. Video streaming   | Multi-streaming (Minimum 5 No. user-defined & configurable - different frame rate, bit rate, resolution, quality, and compression format) support. The camera shall support 128 bit AES                                                                                                                                                                                                                                                                                                                                                                                |

|                   |                                                                                                                                                                   |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                   | encryption.                                                                                                                                                       |
| 9. Image Features | Electronic Image Stabilization & WDR                                                                                                                              |
| 10. Casing        | IP 66 or better & vandal-proof IP 66 or better & vandal-proof Mounting accessories, brackets, poles, nuts, bolts, washers shall be of Stainless Steel / Aluminium |
| 11. Miscellaneous | Operating environment Temperature: 0 to 55 deg. C<br>Camera Housing: IP66, vandal-proof & of Stainless Steel / Aluminium material.                                |

#### **4.3 PTZ Camera (18x)**

| Feature              | Specification                                                                                                                                                                                                                  |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. General           | IP True Day/Night Outdoor PTZ Dome Camera PoE enabled, ONVIF Compliant, low light visibility, clear visibility under rainy/cloudy/lightning conditions also, IR enhancement technology. Immunity against EMI, RFI & lightning. |
| 2. Zoom              | 18x Optical Zoom & 12x Digital Zoom (or better), Left & Right 360 degree, speed>450 per sec; Tilt up & down 5 degree above horizontal to 90 degree down, Speed>150 per sec (adjustable, per camera)                            |
| 3. Light Sensitivity | Color: 0.5 lx at 50 IRE, F1.2, AGC high or better & Black & White : 0.2 lx at 50 IRE, F1.2, AGC high or better                                                                                                                 |
| 4. Compression       | MPEG4/H.264/MJPEG or equivalent                                                                                                                                                                                                |
| 5. Signal System     | PAL                                                                                                                                                                                                                            |
| 6. Resolution        | Full HD or better                                                                                                                                                                                                              |
| 7. Onboard Memory    | Shall support SD / Micro SD cards storage of minimum 64 GB.                                                                                                                                                                    |
| 8. Video streaming   | Multi-streaming (Minimum 5 No. user-defined & configurable - different frame rate, bit rate, resolution, quality, and compression format) support . The camera shall support 128 bit AES encryption.                           |
| 9. Image Features    | Electronic Image Stabilisation, AutoPan & Patrol Mode, Masking & WDR, Pan speed, Tilt speed, zoom speed, focus speed, iris speed & increment step size shall be tunable per individual camera from VMS application.            |
| 10. Casing           | IP 66 or better & vandal-proof, Housing, Mounting accessories, brackets, poles, nuts, bolts, washers shall be of Stainless Steel / Aluminium                                                                                   |
| 11. Miscellaneous    | Camera Housing: IP66, vandal-proof & of Stainless Steel / Aluminium material.                                                                                                                                                  |

#### **4.4 Automatic Number Plate Recognition Camera with Edge processor (ANPR)**

| Feature    | Specification                                                                                                                                                                                         |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. General | IP True Day/Night Outdoor Fixed Box Camera, PoE enabled, ONVIF Compliant, low light visibility, clear visibility under rainy/cloudy/lightning conditions also. Immunity against EMI, RFI & lightning. |
| 2. Lens    | 5-50 mm lens                                                                                                                                                                                          |

|                      |                                                                                                                                                                                                      |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3. Light Sensitivity | Color: 0.5 lx at 50 IRE, F1.2, AGC high or better & Black & White : 0.2 lx at 50 IRE, F1.2, AGC high or better (without IR)                                                                          |
| 4. Compression       | MPEG4/H.264/MJPEG or equivalent                                                                                                                                                                      |
| 5. Signal System     | PAL                                                                                                                                                                                                  |
| 6. Resolution        | 2 MP or better                                                                                                                                                                                       |
| 7. Onboard Memory    | Shall support SD / Micro SD cards storage of minimum 64 GB.                                                                                                                                          |
| 8. Video streaming   | Multi-streaming (Minimum 5 No. User-defined & configurable - different frame rate, bit rate, resolution, quality, and compression format) support.. The camera shall support 128 bit AES encryption. |
| 9. IR                | Shall have IR illumination (built-in or external) with a coverage distance of minimum 40 meters                                                                                                      |
| 10. Image Features   | Electronic Image Stabilization, auto-focus, Head Light Compensation (HLC) & WDR of 100dB or better. Ability to capture & process image/s of multiple vehicles entering/exiting in parallel also.     |
| 11. Casing           | IP 66 or better & vandal-proof, with heat resistant & KG3 or better coated glass window. Housing, Mounting accessories, brackets, poles, nuts, bolts, washers shall be of SS                         |
| 12. Edge Processing  | The camera shall come with the associated edge processing equipment / server / workstation.                                                                                                          |
| 13. Miscellaneous    | Camera Housing: IP66, vandal-proof & of Stainless Steel / Aluminium material.                                                                                                                        |

#### **4.5 VMS, Incident Management / Disaster Management Software**

| <b>Features</b>        | <b>Specifications</b>                                                                                                                                                                                                                                                                 |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Functional Requirement | VMS based on the open architecture which facilitates integration with other IT systems with the help of APIs (distributed free of charge)                                                                                                                                             |
| Platform               | Windows / Unix / Linux                                                                                                                                                                                                                                                                |
| Functions              | Event handling, motion detection,                                                                                                                                                                                                                                                     |
| Compatibility          | The VMS should be built on the open standards and shall be compatible with products from industry leading manufacturers                                                                                                                                                               |
| Recording              | <ul style="list-style-type: none"><li>Should record audio / video</li><li>Continuous recording, by trigger (motion or alarm), by schedule</li></ul>                                                                                                                                   |
| Storage                | <ul style="list-style-type: none"><li>Distributed, fault tolerant database architecture</li><li>Multi-level storage: should support multi level storage (live recording on primary disk, archiving on secondary, and so on) should delete video after configurable duration</li></ul> |
| Video Search           | <ul style="list-style-type: none"><li>Should be able to search video based on date / time, camera. Should have advanced / smart / quick search function</li></ul>                                                                                                                     |

| Features                          | Specifications                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                   | <ul style="list-style-type: none"> <li>Should be able to export searched video to standard video codec (or with video player in case of proprietary format)</li> </ul>                                                                                                                                                                                                                                                          |
| Viewing                           | <ul style="list-style-type: none"> <li>Simultaneous viewing and recording from various cameras by multiple users</li> <li>Multi Monitor viewing</li> <li>Camera sequence mode</li> <li>Control PTZ function of PTZ camera</li> <li>The VMS should have viewing client (not applicable incase of web based VMS) to enable the feed display on the workstation / remote location</li> <li>Drag and drop camera viewing</li> </ul> |
| Event Management                  | <ul style="list-style-type: none"> <li>Register event, associated video, and alert operator on screen with audio</li> <li>Motion detection, sound detection, camera tampering events should be alerted to the operator, Integration of ANPR cameras</li> </ul>                                                                                                                                                                  |
| Camera Management                 | <ul style="list-style-type: none"> <li>Show connection status of cameras, alert operator in case of connection failure to any camera</li> <li>Manage firmware upgrades, setting IP addresses</li> </ul>                                                                                                                                                                                                                         |
| Security                          | User management, password management, user access level management                                                                                                                                                                                                                                                                                                                                                              |
| General Features & Specifications | Multi-map Presentation Options and User-Friendly PTZ Controls                                                                                                                                                                                                                                                                                                                                                                   |
|                                   | Graphic Video Footprints with Real-Time PTZ Controls                                                                                                                                                                                                                                                                                                                                                                            |
|                                   | Sensor Management Tools, Alarm Management Options, and data Editing                                                                                                                                                                                                                                                                                                                                                             |
|                                   | Enhanced Displays for Video Forensics and Access to Video Archive Systems                                                                                                                                                                                                                                                                                                                                                       |
|                                   | supports jpeg or bmp or gif data input.                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | Capable of Managing an assigned area of interest                                                                                                                                                                                                                                                                                                                                                                                |
|                                   | Capable of Ingesting video and sensor inputs into an open architecture format, onto one screen                                                                                                                                                                                                                                                                                                                                  |
|                                   | Provides a monitoring capability of the video/ sensor subsystem, to be relayed to the key operations center                                                                                                                                                                                                                                                                                                                     |
|                                   | Multi-site video surveillance, and command and control                                                                                                                                                                                                                                                                                                                                                                          |
|                                   | Provides a multiple-perspective geographic display of site locations with site-specific surveillance information including Sensor locations and alarm conditions.                                                                                                                                                                                                                                                               |
|                                   | Provides a remote ability to set and/or modify operational characteristics of surveillance devices and storage                                                                                                                                                                                                                                                                                                                  |
|                                   | Online control of Pan/Tilt/Zoom (PTZ) cameras, sensors,                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | Ability to Record and Retrieve stored video.                                                                                                                                                                                                                                                                                                                                                                                    |
|                                   | Integrated-alarm visualization rule and device control displays in either a single or double monitor format                                                                                                                                                                                                                                                                                                                     |
|                                   | Ability to slue PTZ cameras to alarm-generated areas.                                                                                                                                                                                                                                                                                                                                                                           |

| Features | Specifications                                                                                                                                                                                                                                                                                          |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | Automatic tracking and classification of objects such as cars and people and push content to security personnel over local LAN as required.                                                                                                                                                             |
|          | Capability of Real-time analysis of connected cameras to detect abnormal activity and Security threats.                                                                                                                                                                                                 |
|          | Capability to filter large amounts of video and support display of time Line, Customizable Site Map, Live Video, Video Playback, Integrated Site Map , Remote live view, Multi-site capability, Event based Recording all over local LAN                                                                |
|          | Capability of video analytics based on defined policies pre feeded at the time of installations with features like Motion & Blackout masking, Perspective settings , environment selection, map configurations, disk usage limits, footage expirations, software health monitoring                      |
|          | Definable and available triggers should be for : Vehicles Moving , Vehicles Parking, Vehicles Starting to Move, People Moving, Anything Moving, Camera Obstructed, Cord Cut, Hardware alarm Input, Unknown Starting, unknown Moving, Unknown Parking, Item left Behind, Item Removed, People Loitering. |
|          | Motion Tracking, Object Classification, Mosaic, Object Persistence, Alarm Policy Settings, Alarm on object type, Alarm on object direction, Alarm on camera manipulation, Automatic Alarm Response, Automatic PTZ control, Audible Siren, Alarm I/O (relay), NAS or SAN support, Event based search     |
|          | Left-Object/Removed-Object Detection component that automatically detects objects in the field of view of a camera that have been left-behind, or that have been removed                                                                                                                                |
|          | Perimeter Breach Detection component that automatically detects objects in the field of view of a camera that move from and to configurable regions                                                                                                                                                     |
|          | Motion Detection component that automatically detects moving objects in the field of view of a camera, and is capable of filtering out movement in configurable directions and movement due to camera motion (e.g. from wind)                                                                           |
|          | A People Loitering Detection component that automatically detects objects that have moved continuously within the camera field of view for a configurable period of time.                                                                                                                               |
|          | Ability to deploy the Alarm Components on PC computer servers or on remote, ruggedized, externally-mountable, stand-alone platforms                                                                                                                                                                     |
|          | Vehicles Moving – should activate alarm if it detects Vehicles moving in the scene and passing through the Alarm Mask. Object Direction may be used to further filter alarms, as well as Object Speed, Object Size.                                                                                     |

| Features | Specifications                                                                                                                                                                                                                                              |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | Vehicles Parking – should activate alarm if vehicles are parking in Alarm Mask. The Length of Time field in seconds or minutes may be used to specify how long vehicles are able to park before the alarm.                                                  |
|          | Vehicles Starting to Move should activate alarm if it detects a vehicle starting to move from a stopped position. if a parked car begins to move, an alarm will sound. Object Direction, Object Speed and Object Size may be used to further filter alarms. |
|          | People Moving - Similar to the Vehicles Moving trigger, but should apply to People.                                                                                                                                                                         |
|          | Anything Moving - Similar to the Vehicles Moving trigger, but should apply to any objects which are moving (People, Vehicles, Unknown).                                                                                                                     |
|          | Camera Obstructed - should activate alarm if the field of view is obstructed.                                                                                                                                                                               |
|          | Cord Cut - Will alarm if the video signal is lost                                                                                                                                                                                                           |
|          | Hardware alarm Input - Should be able receive signals from external devices through alarm I/O and act accordingly                                                                                                                                           |
|          | Software should be an Open IP-Surveillance product, enabling simultaneous digital video recording from network, mega-pixel and analog devices, intelligent video analysis and remote access to live and recorded images from any networked computer.        |
|          | Software should allows to add, edit, delete or disable and enable Policies for video management                                                                                                                                                             |
|          | Option of remote viewing and control over Blackberry®, ip phone or any android handheld to keep updated while in the field                                                                                                                                  |
|          | Software should be jointly and simultaneously able to manage video analytics and video management as one product                                                                                                                                            |
|          | Software should be able to store video to local hard disk, a RAID configuration or even a storage-area network (SAN).                                                                                                                                       |
|          | Software should support display of time Line, Customizable Site Map, Live Video, Video Playback, Integrated Site Map , Remote live view, Multi-site capability, Encryption, Event based Recording                                                           |
|          | Option of On-screen digital Video tracking & digital zoom on tracked area                                                                                                                                                                                   |
|          | Option of On-screen object follow thru within tracked area                                                                                                                                                                                                  |
|          | Management of Recorded video with On-screen time graph and multiple color coded event indicators for selective and simultaneous view of alarm and non alarm situations for quick viewing                                                                    |
|          | User friendly and time graph based selection for playback and instant archival of video events on external media                                                                                                                                            |



| Features | Specifications                                                                                                                                                                                                                                                                                                                                                                             |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | On selection of specific area on video with specific date and time period , instant retrievals of all past events/ activities at this selected area should be retrieved and viewed instantly as a single video / movie clip                                                                                                                                                                |
|          | Software should be intelligent and capable of automatically discriminating between objects like people, animals, vehicles                                                                                                                                                                                                                                                                  |
|          | Intelligent Object tracking in adverse weather condition and poor visibility                                                                                                                                                                                                                                                                                                               |
|          | Should be able to filter large amounts of video and focus human intelligence                                                                                                                                                                                                                                                                                                               |
|          | Multi-map Presentation Options and User-Friendly PTZ Controls                                                                                                                                                                                                                                                                                                                              |
|          | Graphic Video Footprints with Real-Time PTZ Controls                                                                                                                                                                                                                                                                                                                                       |
|          | Sensor Display and Management Tools, Alarm Management Options                                                                                                                                                                                                                                                                                                                              |
|          | Enhanced Displays for Video Forensics and Access to Video Archive Systems                                                                                                                                                                                                                                                                                                                  |
|          | Supports jpeg or bmp data input                                                                                                                                                                                                                                                                                                                                                            |
|          | Capable of Managing an assigned area of interest                                                                                                                                                                                                                                                                                                                                           |
|          | Capable of geo-referencing and supporting cross-cueing of sensors                                                                                                                                                                                                                                                                                                                          |
|          | Provides a monitoring capability of the video/ sensor subsystem, to be relayed to the key operations center                                                                                                                                                                                                                                                                                |
|          | Multi-site video surveillance, and command and control.                                                                                                                                                                                                                                                                                                                                    |
|          | Provides site-specific surveillance information including sensor locations, coverage and alarm conditions                                                                                                                                                                                                                                                                                  |
|          | Insertion and Deletion of Cameras & Sensors                                                                                                                                                                                                                                                                                                                                                |
|          | Provides a remote ability to set and/or modify operational characteristics of surveillance devices and storage.                                                                                                                                                                                                                                                                            |
|          | Online control of Pan/Tilt/Zoom (PTZ) cameras                                                                                                                                                                                                                                                                                                                                              |
|          | Capable of selecting and displaying simultaneous, multiple camera views for a single geographical location.                                                                                                                                                                                                                                                                                |
|          | Ability to Record and Retrieve stored video.                                                                                                                                                                                                                                                                                                                                               |
|          | Software should simultaneously perform and view following: record live video, playback recorded video, provide alert messages, viewing of live video form selected camera, Connected and live video analytics servers in the network, Time selection with motion and alert graph for recorded video data with different color indication for motion and alert indication along with video. |
|          | Software shall offer a Maps application for importing maps, creating maps, linking maps, editing maps which enables a user to integrate interactive maps in the system. A map is a visual representation of where                                                                                                                                                                          |



| Features | Specifications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | cameras are located at a site. When you view them in you can see where cameras are placed, and then you can click a camera to view live video and view following information.                                                                                                                                                                                                                                                                                                                                                                                           |
|          | Software shall provide a Forensics software application that detects past and real-time security events using stored forensics data collected from surveillance video feeds.                                                                                                                                                                                                                                                                                                                                                                                            |
|          | Software Forensics Analyzer shall allow the user to quickly search for and detect security events that occurred in the past. Examples include :<br>a. Scan days and weeks of pre-recorded video within minutes<br>b. Locate and extract information about potential security breaches<br>c. Allow users to run regular queries to detect patterns.<br>d. Allow users to apply any rule to any amount of collected or stored video data.                                                                                                                                 |
|          | Software shall provide the ability to set up security rules for surveillance cameras.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|          | Software shall detect, identify, classify, and track objects in real time. The software should then immediately generate alerts or alarms if user-defined security rules are violated                                                                                                                                                                                                                                                                                                                                                                                   |
|          | Software shall support object-based algorithms and must be able to provide the following functionality :<br>a. Learn the scene, Detect and track objects, Adapt to a changing outdoor environment, Ignore environmental changes including rain, hail, wind, swaying trees, and gradual light changes.<br>b. Classify objects, Detect “enters”, “exits”, “appears”, “disappears”, “inside of”, “loitering”, “leave behind”, “taken away” events.<br>c. Detect scene change events.<br>d. Create object size and size change filters.<br>e. Create salience/tide filters. |
|          | Software shall classify objects groups as the following :<br>Person, Vehicle, Unknown, Anything.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|          | Software shall be able to combine object tracking with object classification to allow the detection of specific objects in a region of interest, while ignoring other object types. The user shall be able to configure the following scene change event parameters for each camera:<br>a. Scene change<br>b. Partial view<br>c. Full view                                                                                                                                                                                                                              |
|          | Software shall have a sophisticated rule-based engine with powerful analytics capabilities that provides automatic event notification,                                                                                                                                                                                                                                                                                                                                                                                                                                  |

| Features       | Specifications                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | Video distribution and process activation in response to events and behaviors.                                                                                                                                                                                                                                                                                                                                                                   |
|                | Software shall be able to create rules and responses based on digital or contact closure input events from external devices, such as Critical infrastructure-related events, Network connection failures, Fatal errors, Hard disk failures, Software service down, Video encoder failures, Security-related events, Digital input pin change, Video lost, Onscreen alarms. Maintenance-related events, User event notification using SMTP (Mail) |
|                | Software shall be to perform the following tasks simultaneously:                                                                                                                                                                                                                                                                                                                                                                                 |
|                | a. Digitizing and compressing video.                                                                                                                                                                                                                                                                                                                                                                                                             |
|                | b. Writing video to files on local hard disks and maintaining an accurate index of the stored video files.                                                                                                                                                                                                                                                                                                                                       |
|                | c. Deleting older video files as needed, to free up space to record newer video files.                                                                                                                                                                                                                                                                                                                                                           |
|                | d. Selectively transferring recorded video to long-term storage media.                                                                                                                                                                                                                                                                                                                                                                           |
|                | Software shall be capable of managing online storage that is, online video shall be available for immediate playback. Storage shall be intelligently managed so that the video that is most likely to be requested by users will be retained online.                                                                                                                                                                                             |
|                | Generating and managing system logs and audit reports, Defining the reporting level for system events generated by various services, Filtering log files and events                                                                                                                                                                                                                                                                              |
| Approved Makes | Nice, Milestone, Verint, 2020 Imaging, I2V, Videonetics                                                                                                                                                                                                                                                                                                                                                                                          |

#### 4.6 Features of the Incident & Disaster Management Software (IDMS)

| Disaster Management System |                                                                                                                                                                                                                                                                                                        |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Features                   | Specifications                                                                                                                                                                                                                                                                                         |
| Disaster Management System | I. Organization Registry – Creates database of organizations to help facilitate coordination; allows organizations to record their Offices, Warehouse and Field Sites including their locations so they can be mapped as well as links to other modules such as Human Resources, Assets and Inventory. |
|                            | II. Project Tracking - By telling you <i>Who's Doing What, Where, and When</i> , the system shall provide a valuable tool to help organizations responding to disasters know where the greatest needs are and coordinate with others who are engaged in similar work.                                  |
|                            | III. Human Resources – Manages the people                                                                                                                                                                                                                                                              |

|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Disaster Management System</b> |                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Features</b>                   | <b>Specifications</b>                                                                                                                                                                                                                                                                                                                                                                                                |
|                                   | involved. It tracks where they are, what skills they have and help ensure that everyone is effectively engaged with the work that needs to be done; includes both staff and volunteer management capabilities.                                                                                                                                                                                                       |
|                                   | IV. Inventory – Record and automates transactions for sending and receiving shipments; supports multiple Catalogs of Items as well as providing alternative items to ensure more effective use of supplies. Allows organizations to manage requests, donations and warehouses.                                                                                                                                       |
|                                   | V. Assets – Manages assets such as vehicles, communications equipment and generators; tracks where they are, who they have been assigned to, and what condition they are in. This ensures that assets are used effectively and efficiently.                                                                                                                                                                          |
|                                   | VI. Assessments – Collects and analyzes information from assessments to help organizations more effectively plan their disaster management activities. Data can either be entered into an interactive web form or imported via an Excel template.                                                                                                                                                                    |
|                                   | VII. Shelter Management – Manages information about the location and status of temporary shelters, including resources required, staff and volunteers assigned to the shelter, and provides a check-in/check-out system for shelterers and their families allowing persons to be tracked and shelter populations to be monitored.                                                                                    |
|                                   | VIII. Scenarios & Events – Plan for different scenarios, including recording what human resources, assets, facilities and tasks will be needed to effectively respond.                                                                                                                                                                                                                                               |
|                                   | IX. Mapping – shall have fully integrated mapping functionality which allows any location-based data to be visualized on a map. Maps provide situational awareness which is essential when either planning to prepare for or respond to a disaster.                                                                                                                                                                  |
|                                   | Messaging – Provides support for messages to be sent by Email, SMS, Twitter and Google Talk. Distribution Groups can be set up to allow messages to be easily sent to many people at once. Interactive messages allow people to send short message queries to the system and receive automatic responses.                                                                                                            |
| Incident Management System        | The IMS (Incident management system) shall be a full 2 Dimensional geo-spatial GIS based system for managing and controlling routing operations and incidents within the city of Kolhapur where Security systems are getting deployed in phases. The IMS system shall maintain operational continuity and facility management, whilst addressing several key critical issues regarding security, safety and facility |

| Disaster Management System |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Features                   | Specifications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                            | <p>management, such as:</p> <ul style="list-style-type: none"> <li>• Fusion of information from different sensors, systems, data sources like CCTV, Fire Alarm Systems.</li> <li>• Interface to various sensors and systems as a future upgrade.</li> <li>• Real time management during both routine operation and emergency situations.</li> <li>• Ability to analyze potential threat scenarios and incidents.</li> <li>• Advanced camera management.</li> <li>• Pro-active decision support tool</li> <li>• Comprehensive site planning capability, in terms of security and safety</li> <li>• Utilizing advanced simulations and predictions.</li> <li>• Use of advanced virtual scenario generator to train management and staff.</li> </ul> |
|                            | <p>The IMS shall provide both 2D and 3D interactive geo-spatial GIS display of Kolhapur that provides situational awareness and real-time location of all sensors, personnel and alarms.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                            | <p>The IMS shall be an open architecture system allowing simple integration to external modules, sensors and systems and to allow for future scalability.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                            | <p>The IMS shall seamlessly integrate with existing cameras, DVR's, access control and all other allocated devices and systems, in order to provide an on-line display of 2D / 3D geospatial situational awareness, live video streams and operational/decision support data, all in one unified IMS system located in the main Control Room, as well as in remote IMS system stations.</p>                                                                                                                                                                                                                                                                                                                                                       |
|                            | <p>The IMS shall facilitate viewing of live and recorded images and controlling of all cameras based on authorization and user privileges.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                            | <p>The IMS shall facilitate popup of video on video wall of Control Room and operator workstation upon alarm and rule based event handling.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                            | <p>The IMS shall have the ability to automatically designate and display camera(s) based on any point selected on the 3D GIS Map.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                            | <p>The IMS shall present the position of the Security personnel who are equipped with GPS/Rfid locators, on a 3D GIS interactive map.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                            | <p>The IMS shall manage all security, safety and any other incident that may occur combining the following:</p> <ul style="list-style-type: none"> <li>• 2D and 3D maps providing a visualization of the site – both indoor and outdoor</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

| <b>Disaster Management System</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Features</b>                   | <b>Specifications</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | <ul style="list-style-type: none"> <li>• Ability to create and evaluate various simulation scenarios utilizing comprehensive methodologies including :blast effects, flood effects, gas propagation and crowd behaviour.</li> <li>• Support real-time analysis techniques</li> </ul>                                                                                                                                                                                                          |
|                                   | <p>The IMS shall be vendor agnostic and have the ability to interface with any type of security, safety or other systems including</p> <ul style="list-style-type: none"> <li>• CCTV Surveillance Systems</li> <li>• Access Control Systems</li> <li>• Perimeter and Intruder Detection System</li> <li>• Fire, Smoke, Water, Chemical and Gunshot Detection Systems</li> <li>• Mobile Device</li> <li>• Building Automation Systems including: Elevators, Lights and HVAC Systems</li> </ul> |
|                                   | <p>The IMS shall provide support for four distinct displays as follows:</p> <ul style="list-style-type: none"> <li>• Multi-site General Status Display</li> <li>• Operational / Electronic log Display</li> <li>• 2D/3D geospatial situational awareness Display</li> <li>• Devices (CCTV cameras, analytics and other visual devices) Display</li> </ul>                                                                                                                                     |
|                                   | <p>The IMS shall support five modes of operation as follows:</p> <ul style="list-style-type: none"> <li>• Planning Mode</li> <li>• Training Mod</li> <li>• Real-Time Mod</li> <li>• Debriefing Mode</li> <li>• Maintenance Mode</li> </ul>                                                                                                                                                                                                                                                    |
|                                   | <p>The IMS shall encompass the following components</p> <ul style="list-style-type: none"> <li>• IMS Server</li> <li>• IMS Devices Server</li> <li>• IMS Database Server</li> <li>• Mouse, Keyboard and Control Stick</li> </ul>                                                                                                                                                                                                                                                              |
|                                   | <b>System Requirements</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                   | Control rooms                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                   | <p>The Control Rooms should include the following functional elements:</p> <ul style="list-style-type: none"> <li>• Video Surveillance that provides the ability to control and monitor the video streams and events generated.</li> <li>• 2 dimensional/ 3 Dimensional geo-spatial GIS System that provides situational awareness of all the sensors in the complex, the geographical location of the alarms and the location of security personnel in the complex.</li> </ul>               |

| <b>Disaster Management System</b> |                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Features</b>                   | <b>Specifications</b>                                                                                                                                                                                                                                                                                                                                                                                    |
|                                   | <ul style="list-style-type: none"> <li>Advanced Event Management that provides the operator/s with a decision support tool to manage all events.</li> <li>Enterprise Level situational awareness by gaining a high level of status on the remote sites.</li> </ul>                                                                                                                                       |
|                                   | The IMS shall support Multi operated workstations per Command &Control Center.                                                                                                                                                                                                                                                                                                                           |
|                                   | The IMS shall support different profiles per workstations and users.                                                                                                                                                                                                                                                                                                                                     |
|                                   | The IMS shall support a multi-site monitor and control configuration.                                                                                                                                                                                                                                                                                                                                    |
|                                   | All IMS workstations shall provide the ability to monitor and control all site's CCTV cameras, devices and legacy systems, retrieve recorded video and images from the NVR/DVR seamlessly, using a unified database.                                                                                                                                                                                     |
|                                   | The IMS shall integrate with access control system, receive alarms from the access control system and pop up video from the appropriate cameras related to the access control alarm.                                                                                                                                                                                                                     |
|                                   | The IMS shall integrate with perimeter intrusion system, receive alarms from the perimeter intrusion system and pop up video from the appropriate cameras related to the perimeter intrusion alarm.                                                                                                                                                                                                      |
|                                   | Each control room may have one or More Operators simultaneously using CCTV cameras. Operator control on cameras shall be dependent on the policies decided by The IMS Administrator. The IMS shall provide different privileges and priorities configurations for monitoring and controlling certain cameras, devices or systems. The administrator should be able to configure the system, accordingly. |
|                                   | The IMS system shall allow overtaking control of local or remote site system, from the central command and control station.                                                                                                                                                                                                                                                                              |
|                                   | The IMS system shall fuse all the information gathered from the wide deployment of sensors and devices thus enabling the operator to be aware at all times of the events and incidents occurring under his/her responsibility.                                                                                                                                                                           |
|                                   | <b>IMS System compatibly</b>                                                                                                                                                                                                                                                                                                                                                                             |
|                                   | <p>The IMS shall be vendor agnostic and have the ability to connect to any type of security, safety, facility management or other systems including:</p> <ul style="list-style-type: none"> <li>CCTV Surveillance Systems</li> <li>DVR / NVR</li> </ul>                                                                                                                                                  |

| <b>Disaster Management System</b> |                                                                                                                                                                                                                                                                                             |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Features</b>                   | <b>Specifications</b>                                                                                                                                                                                                                                                                       |
|                                   | <ul style="list-style-type: none"> <li>• Video analytics</li> <li>• Mobile Devices such as GPS, RFID, PDA</li> <li>• BAS (Building Automation Systems) including: Elevators, Lights and HVAC Systems.</li> <li>• Legacy systems.</li> <li>• Future implemented devices/ systems.</li> </ul> |
|                                   | 2D / 3D interactive GIS data support                                                                                                                                                                                                                                                        |
|                                   | The IMS shall be able to support both 2D and 3D GIS data display. The IMS can originally start as a 2D system with a seamless upgrade path to 3D GIS data display. Such upgrade would not require any SW development other than adding the respective 3D models of the various locations.   |
|                                   | The IMS shall be seamlessly integrated with GIS information.                                                                                                                                                                                                                                |
|                                   | The IMS shall support a "Drill down" display from global information view down to the sensor level view.                                                                                                                                                                                    |
|                                   | The IMS shall support on-demand GIS layered information (ESRI standard compatible) display.                                                                                                                                                                                                 |
|                                   | The IMS shall support vector data.                                                                                                                                                                                                                                                          |
|                                   | The IMS shall support a display of multiple GIS information.                                                                                                                                                                                                                                |
|                                   | The IMS shall support uploading new GIS layers to and from the system.                                                                                                                                                                                                                      |
|                                   | The IMS shall allow the user to show or hide selected layers on the 3D display.                                                                                                                                                                                                             |
|                                   | The IMS shall provide an orientation option by pointing a 3D location, and receiving all location GIS attributes (attributes should take in consideration all GIS layers currently uploaded in the system).                                                                                 |
|                                   | The IMS shall provide the ability to define a 3D geographical ZOI (Zone Of Interest) and receive all ZOI GIS attributes (attributes should take in consideration all GIS layers currently uploaded in the system).                                                                          |
|                                   | The IMS shall allow the user to "jump" to any required location (address, facility, favorite locations etc).                                                                                                                                                                                |
|                                   | Layered Map — Ability to use several layers to view special situations. The ISM shall facilitate addition of maps.                                                                                                                                                                          |
|                                   | Smart CCTV management                                                                                                                                                                                                                                                                       |
|                                   | The IMS shall provide full integration with all CCTV cameras models and brands (vendor agnostic).                                                                                                                                                                                           |
|                                   | The IMS shall provide full integration with all DVR /NVR systems models and brands (vendor agnostic).                                                                                                                                                                                       |
|                                   | The IMS shall provide full integration with all video analytics models and brands (vendor agnostic).                                                                                                                                                                                        |
|                                   | The IMS shall display each physical camera (and other                                                                                                                                                                                                                                       |



| <b>Disaster Management System</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Features</b>                   | <b>Specifications</b>                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                   | physical devices) at the exact geographical location on the 3D GIS display.                                                                                                                                                                                                                                                                                                                                                                    |
|                                   | The IMS shall calculate the cameras Line Of Sight (LOS) coverage pointing out any gaps and overlaps.                                                                                                                                                                                                                                                                                                                                           |
|                                   | The IMS shall provide the ability to view live and recorded video based on authorization and privileges for pre-defined users as defined by the system administrator in the system.                                                                                                                                                                                                                                                            |
|                                   | The IMS shall provide manual camera selection.                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                   | The IMS shall support Rule based automatic camera(s) selection and PTZ designation upon alert.                                                                                                                                                                                                                                                                                                                                                 |
|                                   | The IMS shall allow a user to select an area on the 3D image and the system will automatically designate all relevant fixed and PTZ camera(s) covering that exact GIS point on the map based on geographical calculations and references.                                                                                                                                                                                                      |
|                                   | The IMS shall have manual PTZ camera control based on user priorities.                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | The IMS shall enable the operator to run video playback instantaneously while viewing real time video of the same channel on a split screen.                                                                                                                                                                                                                                                                                                   |
|                                   | The IMS shall have the ability to freeze a video frame (snapshot) from any online live camera and export to a standard graphic file format.                                                                                                                                                                                                                                                                                                    |
|                                   | The IMS shall have the ability to record video from any online camera and export to a standard video file format. The IMS shall display current sensors status (where supported by the sensors), and shall alert on any faulty sensors.                                                                                                                                                                                                        |
|                                   | Remote devices operations - PDA                                                                                                                                                                                                                                                                                                                                                                                                                |
|                                   | The IMS shall provide support for remote devices, including PDAs, smart phones, laptops and support the following features: <ul style="list-style-type: none"> <li>• Receive exported Camera(s) snapshot from the IMS</li> <li>• Receive exported short video-clips from the IMS.</li> <li>• Receive exported 3D snapshot from the IMS</li> <li>• Receive text messages from the IMS.</li> <li>• Receive Action items from the IMS.</li> </ul> |
|                                   | Rules engine                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                                   | The rules-engine shall provide the operator with the ability to define rules for initiating automatic, semi-automatic (manually approved by the user), and manual predefined responses, to various routine and emergency situations.                                                                                                                                                                                                           |
|                                   | The IMS Rules engine shall be 3D geographically based.                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | The IMS Rules engine shall allow setup of any Boolean configuration of any sensor and input                                                                                                                                                                                                                                                                                                                                                    |



|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Disaster Management System</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Features</b>                   | <b>Specifications</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                   | to the system to create appropriate system response to alert and routine situations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                   | The IMS Rules engine shall support ascription of single/multiple alerts, occurrences and incidents.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                   | The IMS Rules engine shall provide incidents escalation mechanism.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                   | Simulations and predictions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                   | The IMS shall support simulations and predictions based on smart algorithms display.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                   | The IMS use of 3D simulations would enhance the training and planning procedures, by allowing an accurate evaluation of implications and consequences of future events on the 3D fully GIS model of the site. The IMS shall support the design and runtime stage of all simulations as a user friendly scenario generator tool.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                   | The IMS scenario generator shall be capable of interfacing with common simulation software's and vendors.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                                   | The IMS shall support the use of 3D simulative predictions, based on smart algorithms in the planning, training and real time modes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                   | The environment parameters which support the predictions accuracy would be fed in real-time to the IMS either manually or automatically (where environment sensors are available for integration).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                   | The IMS shall have the ability to effectively predict, simulate and display human behavior in order to evaluate site evacuation, point to bottle-neck locations and estimate evacuation times.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                   | <b>Operational Modes</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                                   | Planning mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                                   | <p>The IMS shall provide a Planning operating mode that provides the following features:</p> <ul style="list-style-type: none"> <li>• The IMS shall have the ability to create and maintain emergency plans for all types of alarms, threats and locations.</li> <li>• The IMS shall have the ability to plan for the deployment of devices, including cameras and sensors, to ensure total and optimal coverage of the site. This shall allow the user to plan device placement before the facility has been constructed or renovated.</li> <li>• The IMS shall have the ability to create comprehensive simulations including: blast effects, gas propagation and crowd behavior.</li> <li>• The IMS shall have the ability to analyze and evaluate security gaps and the quality of security.</li> </ul> |

|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Disaster Management System</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Features</b>                   | <b>Specifications</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                   | <ul style="list-style-type: none"> <li>• The IMS shall have the ability to effectively evaluate and optimize routes for building evacuation by determining bottle-neck locations and evacuation times.</li> <li>• The IMS shall have the ability to create and maintain staff rosters, personnel call trees and action checklists.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                   | <b>Training mode</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                                   | <p>The IMS shall provide a Training operating mode that provides the following features:</p> <ul style="list-style-type: none"> <li>• The IMS shall have the ability to create advanced training scenarios for various types of groups.</li> <li>• The IMS shall have the ability to conduct mission rehearsals during training drills</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                                   | <b>Real-time mode</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                   | <p>The IMS shall provide a Real-Time Operating mode that provides the following features:</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                   | <b>Event management</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                   | <p>The IMS shall have the ability to manage an unlimited number of alarms.</p> <ul style="list-style-type: none"> <li>• Events received by the system will cause the following: <ol style="list-style-type: none"> <li>1. An automatic designation of best/all camera(s) coverage for that event geographical location, on the video display.</li> <li>2. The sensors that detected the alarm will be shown and highlighted on the 3-D GIS virtual display.</li> </ol> </li> <li>• The user should be able to receive alarms and manage multiple alarms at the same time.</li> <li>• The IMS will enable prioritizing events handling according to: severity, geographic location or event classification. The priority can be changed manually.</li> <li>• The IMS should provide the ability to group several events to one incident.</li> <li>• The IMS shall provide the ability to ascribe and group several alerts to one incident.</li> <li>• The IMS should be able to handle more than one event/incident concurrently with easy switch between the events / incidents.</li> <li>• The IMS will provide the operator all the relevant information in regard to: event location in the 3-D GIS environment in order to help in reaching the best decision for the event management.</li> <li>• The IMS shall provide security and safety management personnel the ability to deploy security and safety teams and resources to the threat location and track them at all times utilizing GPS or RFID.</li> <li>• Once operator accepts the event, the appropriate checklist with the rule based action items to</li> </ul> |

|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Disaster Management System</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Features</b>                   | <b>Specifications</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                                   | execute, would automatically pop up.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                   | <b>Routine management</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                   | <ul style="list-style-type: none"> <li>• Scheduling application (i.e. MS Outlook) – The user would be able to schedule tasks, activities and meetings giving each entity a 3D GIS location, time and attribute.</li> <li>• Site status – The IMS shall support all infrastructure and business related status in user define graphical display (e.g. gages, graphs, other).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                                   | <b>Tracking/Retracing</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                   | <ul style="list-style-type: none"> <li>• The IMS shall provide 3D object tracking - The ability to locate a moving object (human or vehicle), track its movement in a crowded environment and Display the suspect's movement and trail on the 3D GIS map at Real- Time</li> <li>• The IMS shall have the ability to locate and track suspects using recorded video from the CCTV DVR/NVR and display the suspect's movement and trail on the 3D GISmap.</li> <li>• The IMS shall provide the ability to track suspects using DVR/NVR from a certain point forward or backward in various speeds.</li> <li>• The IMS will support real time or recorded tracking by selecting and setting the cameras on screen based on the advancing path of the tracked object.</li> <li>• The IMS shall support a display of the suspect's presumed advancing ways and direction in case of a lost suspect event.</li> </ul> |

#### 4.7 Enterprise Management System

|                |                                                                                                                                                                                                                                 |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>General</b> | Enterprise Management System shall monitor all the operations of the components attached to the network. The EMS GUI shall be able to provide fault, configuration, inventory & performance management of all network elements. |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

#### 4.8 Servers & Storage System

|           |                                                                                                                                                                                                                                                                                                                                 |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| General   | The following specifications are indicative minimum specifications for the server system. Bidders are advised to work with the software OEMs, to propose a suitable server configuration and quantity. The software OEMs should provide a written assurance for the workability/technical feasibility of the proposed solution. |
| Processor | Two socket x86-64 architecture, E5-2600 Series Processor 2.4GHz with 1 populated CPU                                                                                                                                                                                                                                            |

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RAM                | Minimum 16 GB DDR 4 (in 8GB Modules) expandable to 128GB                                                                                                                                                                                                                                                                                                                                                                                           |
| HDD                | 10K HDD (1.8TB x 3 numbers with RAID)                                                                                                                                                                                                                                                                                                                                                                                                              |
| Network Interface  | Minimum 4 x 1 Gbps NIC                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Raid Support       | RAID controller should support all HDD slots on the chassis; RAID controller should support RAID 1, 5, 6 HOT Pluggable                                                                                                                                                                                                                                                                                                                             |
| External Interface | 5 USB Ports, 2 VGA, Serial Port ,ODD, USB Keyboard, Mouse, Monitor                                                                                                                                                                                                                                                                                                                                                                                 |
| Form Factor        | 2U rack Mounted                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Others             | Dual redundant hot pluggable SMPS each capable of powering fully populated chassis, Redundant Fans, Sound Card & speakers, Internet+Antivirus Security packages, other Softwares as defined in this Tender & also those required to achieve the functional requirements & overall system integration. Mirrored on-board cache, Support for SATA drives. MIL-STD-1275 Surge & spike protection. To be free from EMI, RFI, VHF, Mobile disturbances. |

#### 4.9 Storage System

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. External Storage | NAS/DAS with required storage to record all the cameras (at 18FPS frame rate, full resolution and for 30 days in H.264 compression) & management software. The storage shall have the usable storage capacity calculated by the bidder for all new Cameras (at all locations) + 20% spare space, whichever is higher using RAID 5. Calculations shall be submitted as part of detail engineering. To be ONVIF Compliant. |
| 2. Expansion        | Shall support connection of storage expansion enclosures                                                                                                                                                                                                                                                                                                                                                                 |
| 3. RAID             | Shall support all industry standard RAID configurations.                                                                                                                                                                                                                                                                                                                                                                 |
| 4. Disk Support     | SAS - 15K RPM SAS - 10K RPM<br>NL-SAS 7200 RPM, SSD drives& SATA<br>The Storage should support Disk Expansion trays/enclosures to accommodate 3.5" and 2.5" disks.                                                                                                                                                                                                                                                       |
| 5. OS Support       | SAN shall support operating systems such as MS Windows 2008/2012, RHEL, SUSE, Microsoft Hyper-V, VMWare in standalone and clustering environment.                                                                                                                                                                                                                                                                        |

#### 4.10 Video Monitors

|                  |                                                                                        |
|------------------|----------------------------------------------------------------------------------------|
| General          | CCTV Monitor suitable for continuous (24x7x365) use with MTBF of more than 80,000 Hrs; |
| Screen           | 42" LED                                                                                |
| Resolution       | 1920x1080 or better                                                                    |
| Monitor Mounting | Wall Mount (Brackets to be provided)                                                   |

#### 4.11 Workstations

| Features      | Specifications                              |
|---------------|---------------------------------------------|
| 1. Processor  | Intel Core I-7 Processor, latest generation |
| 2. Memory     | Min. 8GB, DDR-3 or better                   |
| 3. Video Card | Minimum 2 GB onboard video memory           |

|             |                                                                              |
|-------------|------------------------------------------------------------------------------|
| 4. HDD      | 500 GB or better; SATA @ Min. 7500 RPM – 8MB Cache                           |
| 5. Ethernet | 10/100/1000, Auto Negotiating Ethernet controller                            |
| 6. OS       | Windows 8 Professional (64 bit) / Latest Windows OS / Linux                  |
| 7. Monitor  | 21" LED, Ultra HD Display                                                    |
| 8. Speakers | Shall have built-in / external speakers                                      |
| 9. Others:  | Antivirus & Internet Security software, suitable for 24 x 7 x 365 operation. |

#### **4.12 Video Decoders**

| <b>Features</b>           | <b>Specifications</b>                                                                                                                                                         |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Functional Specifications | Shall be able to connect 4 monitors per decoder.<br>Shall support HD resolution per monitor<br>Shall be compliant with the supplied VMS software<br>Shall be ONVIF compliant. |

#### **4.13 Network Switch - 24 port Giga as a Layer-3 Core Switch**

| <b>Features</b>          | <b>Specifications</b>                                                                                                                                                                             |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Switch                | Layer-3 Managed with 24 Port 10/100/1000 Mbps, auto negotiating, auto crossover, auto polarity, FE Switch, with 2/4 10 Gig fiber ports, IPV6 Compliant<br>Rack Mounted. To be IEEE802.3 compliant |
| 2. Switching Capacity    | > 100 GBPS, >80 MPPS packet forwarding rate with 64 byte packets                                                                                                                                  |
| 3. Power Supply          | Dual redundant power supply (with MIL-STD-1275 Surge & spike protection)                                                                                                                          |
| 4. Operating Temperature | 0° C to 45° C                                                                                                                                                                                     |

#### **4.14 Network Switch - 24 port switch Layer 2**

|                                   |                                                                                                                                                     |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Features                       | Specifications                                                                                                                                      |
| 2. Switch                         | Layer-2 Managed with 24 Port 10/100/1000 Mbps FE Switch with 2 1000 Base-Fx ports (IPv6 Compliant). 1U / 2U Rack Mounted. To be IEEE802.3 compliant |
| 3. Switching Capacity             | >50 Gbps                                                                                                                                            |
| 4. 64-Byte Packet Forwarding Rate | >50 Mpps                                                                                                                                            |
| 5. Operating Temperature          | 0° C to 45° C                                                                                                                                       |

#### **4.15 Network Switch - 8 port PoE switch Layer 2**

| <b>Features</b>    | <b>Specifications</b>                                                                             |
|--------------------|---------------------------------------------------------------------------------------------------|
| Switch             | Layer-2 Managed with 8 Port 10/100/1000 Mbps FE Switch with 2 1000 Base-Fx ports (IPv6 Compliant) |
| Switching Capacity | >10 Gbps                                                                                          |

| Features                       | Specifications                         |
|--------------------------------|----------------------------------------|
| 64-Byte Packet Forwarding Rate | >8 Mpps                                |
| PoE                            | Shall support PoE and PoE + standards. |
| Operating Temperature          | 0° C to 75° C                          |

#### 4.16 UPS& Diesel Generator

| Features                     | Specifications                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Output Parameters</b>     |                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1. Output Power Capacity     | UPS Sizing shall be done by bidder for the Control Room for all electronics included in the Control Room with 25% spare capacity & distributions. Incomers (3 Nos) shall be 415VAC $\pm 10\%$ , 50Hz $\pm 3\text{Hz}$ , 3-Phase, Wall mounted ACDB with double pole isolations (for incomers & outgoings) properly selected. Sizing calculations shall be furnished component-wise for which the UPS system would be catering. |
| 2. Battery Type              | Maintenance-free sealed Ni-Cd battery leak-proof. Complete with Battery Racks for the Control Rooms. Sizing shall be done by bidder for all electronics included in the Control Room with 25% spare capacity & distributions. All charging/discharging/other tests shall be in bidder's scope.                                                                                                                                 |
| 3. Typical recharge time     | 3 hour(s)                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 4. Mechanical Parameters     |                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 5. Back-up                   | 30 minutes with Ni-Cd batteries                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Diesel Generator (DG)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                |
|                              | The DG Set Sizing shall be done by bidder for the Control Room for all electronics included in the Control Room with 50% spare capacity & distributions.                                                                                                                                                                                                                                                                       |
|                              | The DG Set shall be low noise                                                                                                                                                                                                                                                                                                                                                                                                  |

#### 4.17 Server/Network Rack Floor-Mount (42U)

| Features  | Specifications                                                                           |
|-----------|------------------------------------------------------------------------------------------|
| Rack size | 42U                                                                                      |
|           | Adjustable 19" rail in the front and rear for fixing the server and networking equipment |
|           | Top and bottom cable entry facility                                                      |
|           | Front section with glass door and lock and back cover                                    |
|           | Cable mangers of 1U                                                                      |
|           | Floor mount with caster wheels                                                           |
|           | Inbuilt power distribution unit with at least 8 Nos of 220 VAC, 5A outlets.              |

| Features | Specifications                                                                                 |
|----------|------------------------------------------------------------------------------------------------|
|          | Minimum 4 nos of cooling fans for proper cooling should be provided.                           |
|          | Mounting hardware should be provided for fixing switches, patch panels and network components. |

#### 4.18 PTZ keyboard/joystick

| Features                                          | Specifications                                                                                                                                                                                                           |
|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. General                                        | Fully functional dynamic keyboard controllers with joystick                                                                                                                                                              |
|                                                   | Controls all pan / tilt and zoom functions                                                                                                                                                                               |
|                                                   | Control up to 255 units from a single keyboard                                                                                                                                                                           |
|                                                   | Many preset options and advanced tour programming                                                                                                                                                                        |
|                                                   | Compatible with DN-PTZ camera                                                                                                                                                                                            |
| 2. Key Application                                | Wired keyboard control operation of <a href="#">PTZ</a> & other functions for weatherproof dome cameras.                                                                                                                 |
| 3. Pan / Tilt / Zoom Protocol Languages Supported | Selectable                                                                                                                                                                                                               |
| 4. PTZ Data Transfer Baud Rates Supported         | Selectable 1200 bps / 2400 bps / 4800 bps / 9600 bps / higher                                                                                                                                                            |
| 5. Additional Features                            | Dynamic joystick for smooth camera movements, preset location option for quick access to frequently monitored Areas. All joystick movements shall also be possible using external mouse attached to the decoder Station. |

#### 4.19 Field UPS

|              |                                                                                                                                |
|--------------|--------------------------------------------------------------------------------------------------------------------------------|
| General      | Online UPS of 1 KVA rating to provide uninterrupted & conditioned power supply to field cameras & active networking components |
| Battery Type | Maintenance-free sealed Lead-Acid battery with suspended electrolyte: leak-proof                                               |
| Back-up      | 60 minutes with SMF batteries at half-load                                                                                     |

#### 4.20 Passive & Field Networking Components

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Outdoor Junction Box | <ul style="list-style-type: none"> <li>• IP55 junction box suitable for outdoor application.</li> <li>• The box shall have customized locking mechanism.</li> <li>• The box shall have wire management (including OFC, power, Ethernet Loop).</li> <li>• The box shall fit all the field equipment (Amplifier, Media Converter/Switch, UPS, Batteries, Power Supply, LIU, PoE injector, Patch Panels etc. with proper mounting arrangements.</li> </ul> |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



|                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                              | <ul style="list-style-type: none"> <li>• The door shall be surface mounted with 130° opening. It shall have concealed removable hinges with captive pin. Hinges can be mounted to allow left or right hand opening.</li> <li>• Sealing shall be ensured by an injected one-piece polyurethane gasket or better.</li> <li>• Bidders will have to estimate the size of the junction box which shall accommodate all the equipment installed on the field for any location.</li> <li>• The junction box shall be of SS construction complete with SS mounting arrangements, accessories, bolts, nuts, washers, screws, etc.</li> <li>• Battery &amp; UPS compartment shall be separate from the other accessory compartment.</li> <li>• JB shall have power isolation provisions using Double pole MCB for incomers &amp; outgoings in addition to RCCB's.</li> <li>• JB shall have terminals for power wiring &amp; for connection of communication wires (part of OFC cable), properly segregated.</li> <li>• JB shall have an outside indication of voltage, current &amp; LED indication of incoming power availability.</li> <li>• All individual components in the Junction Box shall be provided with clear &amp; legible printed acrylic labels indicating the component type.</li> <li>• The junction box shall also have a drawing pocket complete with all as-built drawings for the relevant Junction Box.</li> <li>• All cable entries shall be through double compression SS cable glands (only from the bottom of Junction Box).</li> <li>• Unused cable entries shall be provided with SS plugs.</li> <li>• Junction box shall be provided with an additional FRP canopy to completely cover the Junction Box from rainfall (in any direction). The Canopy shall have suitable coverage.</li> <li>• Approved Make: Rittal or equivalent</li> </ul> |
| 2. Camera Mounting Poles with Lighting Arrestor and Earthing | <p>Height - as required based on site topography &amp; coverage requirements, including any overlapping coverages with adjacent cameras; Successful bidder to provide the detailed drawings of Poles and specifications of the pole.</p> <p>Poles shall be of SS &amp; shall be suitable for structural purposes as per IS-1161. These shall be grouted with RCC. Pole construction shall not result-in / allow for water collection/stagnation inside the same.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 3. Joint Closures                                            | <p>24 Port Joint Closure Cylinder Min. 3 –way air/water sealable with splice tray. To be suitable for burial in marshy/water logged areas (w/o ingress of water).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 4. 24C OFC                                                   | <p>Shall be loose tube multi-tube Single Mode cable with 4 jelly filled tubes populated with 6 fibres cores. All interstitial spaces shall be jelly filled. The tubes shall have separate colors with individual color coded fibres. The attenuation loss per km shall be 0.4 dB or lesser (for both 1310 &amp; 1550nm).</p> <p>Cable shall be Flame resistant as per IEC 60331-25. With Round GI wire or corrugated steel tape armour. Shall be rodent resistant (e.g., using wire braided outer armour). Shall prevent moisture ingress even due to outer sheath damage / poorly sealed joints.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |



|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | <p>Cable shall be suitable for direct burial also. Double armoured. Cable shall have it's running meter stamped/marked every 1 mtr (to be resistant to damages caused by cable pulling activities). UV resistant outer insulation (colour to be decided as part of detail engineering) &amp; additional moisture resistant inner insulation. Cable drum lengths shall be adequately considered to minimize joints.</p> <p>Multimode cables shall have min 8 spare fibers which shall be spliced &amp; connected at both ends also.</p> <p>All cores of the OFC cables shall be terminated in the Control Room.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 5. CAT-6 Cable        | <p>Cat.6, U/UTP, AWG23 cable. 100 Ohm impedance. Data transmission frequencies of up to 450 MHz; metal-free ; flame-retardant; ISO/IEC 11801 ed. 2.2; IEC 61156-5 2nd ed.; EN 50173-1; EN 50288-6-1; TIA 568-C.2; Fire rating: IEC 60332-1 Compliant</p> <p>Supply of UTP CAT 6 Cable shall include cabling from Switch to individual outlets in Casing Capping/PVC Cable Duct/ Flame resistant mechanically protective Conduit as per requirement, supply &amp; installation of Information Outlet at the equipment end, factory crimped patch cords of required length at both the patch panel end as well as equipment end, including material, fittings &amp; fixtures, screws etc. Cable lengths &amp; CAT-6 cabling with connections/PoE/extendors to ensure that collision detection mechanisms shall work as expected &amp; timeout errors are eliminated.</p>                                                                                                                                                                                                                            |
| 6. Power Cable (LV)   | <p>3-Core, 2.5 sq mm, with annealed electrolytic multistranded copper conductor with resistance &gt; less than 8.2 7.41 Ohm/Km; Fire retardant, low smoke, low toxic, PVC black outer sheath meeting BS-5308, insulated (min 0.3 mm inner+1.8 mm outer sheath) Rated for 1.1KV, For Outdoor: GI round wire Armoured with galvanized steel wire with 90%+ coverage; IS 694:1990 reaffirmed 1995 or latest compliant.</p> <p>Cable drum lengths shall be adequately considered to minimise joints.</p> <p>Higher Cable sizes (if required) to meet the distance/higher current consumption requirements (from sources upto 500 mtrs away) shall be considered by the bidder instead of the 2.5 sq.mm cables indicated, at no extra cost to the Corporation.</p> <p>Shall prevent moisture ingress even due to outer sheath damage / poorly sealed joints. Cable shall be suitable for direct burial also.</p> <p>Cable shall have it's running meter stamped/marked every 1 mtr (to be resistant to damages caused by cable pulling activities). UV resistant outer insulation of Black colour.</p> |
| 7. PoE Injectors      | <p>PoE Injector shall be mounted in the outdoor junction box. It shall come with 4 ports and shall be able to operate the 4 cameras (consider the type of camera that has the highest power consumption) However 1 shall be left as spare/unused.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 8. Ethernet Extenders | <p>Should support Transmission Distance &gt;900m; Should transmit individual Ethernet data channels with Passthrough PoE over standard UTP cable; Shall meet IEEE 802.3af standard for Power over Ethernet; Operating Temperature upto &amp; even &gt;55 DegC. Any power provisioning required for the same shall be in bidder's</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

|                                           |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                           |  | scope.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 9. LIU                                    |  | LIU should be provided for terminating the optic fiber cables. It shall provide minimum bending radius and the splice trays shall function as a splice cover for pigtail splicing. It shall be made of aluminum with powder coating in compliance with latest industry standard. Cable glands shall be provided for secured anchoring of incoming cables. Rubber grommets shall be provided at the cable entry point for tight sealing. The splice tray shall be made of ABS materials. 12/6 Port |
| 10. Pigtails                              |  | SC Type; 1 M; Insertion Loss < 0.5 0.2 db; Return Loss > 40db better than -60dB; Bend Radius>30mm, APC type, Corning/equivalent                                                                                                                                                                                                                                                                                                                                                                   |
| 11. Optic Fiber Connectors                |  | Optic fiber connectors should be single mode SC/ST type, APC type, with push-pull mechanism and fully in compliance with latest industry standard. Optic fiber connectors should be of standard make, Corning/equivalent. with very low losses & return losses.                                                                                                                                                                                                                                   |
| 12. Optic Fiber Adaptors                  |  | Optic fiber adaptors should be suitable for single mode SC/ST APC type fiber cable connectors and shall be fully in compliance with latest industry standard. It shall be with snap/latch mechanism. Optic fiber adapters should be of standard make, Corning/equivalent. with very low losses & return losses.                                                                                                                                                                                   |
| 13. Optic Fiber Patch Cords (Single Mode) |  | Optic fiber patch cords should be suitable for single mode SC/ST APC type fiber cable connectors with plastic moulded plug type connectors in compliance with latest industry standard. Optic fiber patch cords should be of standard make, Corning/equivalent. Min. Return Loss>50db better than -60dB.                                                                                                                                                                                          |
| 14. OF Testing                            |  | The manufacturer of the cabling system shall provide optical fibre testing procedures that clearly describe the tools and settings to be used to ensure correct measurements of the system. All the OF links have to be tested and must pass the acceptance criteria.                                                                                                                                                                                                                             |
| 15.                                       |  | Acceptability criteria shall be: The measured attenuation shall be lower than the acceptable link attenuation calculated (Formula: Allowable cable loss per km x Km of fiber in link + 0.4dB x No. of connectors = Maximum allowable loss)                                                                                                                                                                                                                                                        |
| 16.                                       |  | Testing shall consist of a bi-directional end to end by using either OTDR or Fiber Cable Tester for the complete system. The system loss measurements shall be provided at 1310 and 1550 nanometers for single mode fibers & shall be recorded & witnessed for all cores.                                                                                                                                                                                                                         |
| 17. CAT 6 I/O                             |  | The RJ45 connector shall be screened to ensure protection against EMI and for Alien cross-talk compliance. It offers the 500 MHz performance required to be used to form a 100 meters Class EA channel as specified in ISO/IEC 11801:2002/A1:2008 and EIA/TIA 568 B2-10. All outlets fitted with shutters.                                                                                                                                                                                        |
| 18. CAT-6 Patch Cord                      |  | Factory-crimped Patch Cords (1m/2m/as required) CAT 6; 4 pair UTP Cable 23 AWG Solid Bare Copper polyethylene insulation                                                                                                                                                                                                                                                                                                                                                                          |
| 19. Patch Panel                           |  | 12/24 Port Cat-6 Patch Panel; All Ports ISO/IES 1801:2000 &TIA/EIA 568-B.2-1 & FCC Compliant; Rear wire Manager                                                                                                                                                                                                                                                                                                                                                                                   |

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 20. Rack 6U       | Wall Mount;<br>Height - 6 U, Width - Depth: 600mm*600mm minimum<br>Powder coated steel Body with front door of glass.<br>Completely covered & have security locks<br>Uninhibited access to all mounting points inside the racks<br>Proper ventilated with One Two fans<br>Power cable management<br>One Power strips having 7 Nos - 5A/15A sockets each incl 1 no additional as spare (Power strip/distribution shall meet MIL-STD-1275 surge & spike protection). All incoming & outgoing shall be through Double Pole isolation MCBs in addition to RCCB's.                                                                                                                                                                                                                                                                                                 |
| 21. Rack 42U      | 42U; Adjustable 19" rail in the front and rear for fixing the server and networking equipment; The rack shall be floor mounted. Top and bottom cable entry facility with cable glands; Front section with glass door and lock and back cover; Cable mangers of 1U<br>Floor mount with caster wheels- Inbuilt power distribution unit with at least 8 4 Nos of 220 VAC, 5A outlets as spare for future usage (this is in addition to the actual requirement per such Rack); Minimum 4 nos of cooling fans for proper cooling should be provided; Mounting hardware should be provided for fixing switches, patch panels and network components. Redundant Power supply & distribution. (Power strip/distribution shall meet MIL-STD-1275 surge & spike protection). All incoming & outgoing shall be through Double Pole isolation MCBs in addition to RCCB's. |
| 22. OF Patch Cord | SC to SC OM3 Patch Cords ( 3 Mtrs); Optic fiber patch cords should be suitable for multimode SC/ST type fiber cable connectors with plastic moulded plug type connectors in compliance with latest industry standard. Optic fiber patch cords should be of standard make, Corning/equivalent. Min.. Return Loss>50db better than -60dB.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 23. HDPE Conduit  | 2" Flame resistant mechanically protective Conduit Pipe with required accessories (couplers etc) for underground/wall mount cable laying. The conduit shall be laid along the length of cable & shall be glanded at both ends. Supply of necessary Glands, couplers, etc shall be part of bidder's scope. Colour shall be orange.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 24. GI Pipe       | 2" C-Class GI Pipe with required accessories for road/gate/other required crossings.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

#### **4.21 Control Room Infrastructural Set-up**

**The control room size shall be 300 Sq. Ft. approximately.**

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. False Flooring   | <p>False Flooring: The Data Room should have False Flooring confirming to the following specifications:</p> <p>□ Access flooring, shall provide a maximum finished floor height of 450mm from the existing floor level, The system shall provide suitable pedestal and understructure design to withstand various static loads and rolling loads subjected to it in an office/server/ UPS/DCS/ panel/rack areas, The entire access floor system shall provide for adequate fire resistance, acoustic barrier and air leakage resistance, The system shall be able to accept provided with an independent floor covering i.e, Anti static. The system shall be able to with stand a UDL of 1500 Kgs/SQ, MT and a point load of 450 kgs, The understructure should be able to accept a pedestral Axial load of 2200 Kgs, □ Panels shall be made from steel, the bottom of the panel shall be embossed in hemisphere shape to give strength and flexible rigidity, The top sheet shall be plain and resistance welded at various location after the top and bottom sheets have been digressed and phosphate. The above hollow panel shall have an infill of light weight cementation material, The entire panel shall be coated with epoxy coated on the exposed surface, The top surface shall have Anti-static vinyl flooring on all the sides for edge protection ,Panels shall remain flat through and stable unaffected by humidity or fluctuation in temperature throughout its normal working life, Panels shall provide for impact resistance top surfaces with minimal deflection Corrosion resistance properties and shall not be insulated against heat and noise transfer ,Panels shall be freestanding onto the understanding with stringers. □ Pedestals installed to support the panel shall be suitable to achieve a minimum finished floor height of 100mm to a maximum of 600 mm from the existing floor level, Pedestral design shall confirm speedy assembly and removal for relocation. STRINGERS: Stringers system is all steel construction .hot dipped galvanized. rectangle channels with pre punchers counter sunk holes at both ends for securing the stringers onto the pedestral head ensuring maximum lateral stability in all direction. Quantity: Max Approx. 10 to 15 Sqm per Control Room.<br/>Approved Make: Unitile / Uniflair / Equivalent</p> |
| 2. Flooring         | <p>Floor finishing with Anti-static, fire resistant laminated solid resilient unbreakable and homogeneous flexible quartz reinforced PVC Vinyl tiles composed of 100% vinyl from face to back with alkaline resisting colour pigments and other plastic compounds in different shades and designs and in different sizes and thickness and shall conform to IS : 3462 or its Equivalent British Standard.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 3. Wall Painting    | <p>The existing walls &amp; roof shall be painted in plastic/velvet. All partitions shall be 2hr fire rated.<br/>Make: Asian Paints / Nerolac / Berger /Equivalent</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 4. Doors            | <p>All the entry &amp; exit doors should be metal door with fire rating of 2 hours &amp; a toughened glass window.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 5. Air-conditioners | <p>2 Nos of 2 TR Micro processor based precision Air-conditioning unit for each data center &amp; 2 T comfort AC for the monitoring rooms; 1.5T comfort AC for conference room, 1T comfort AC for Control Room In-charge Cabin – For Monitoring Room &amp; conference Room</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6. Data Electrical Cabling & | Internal electrification & cabling jobs like point wiring, internal Lighting, Distribution boards etc;<br>All electrical lighting shall be of the LED type.<br>Electrical Cabling –Finolex, Equivalent<br>LED Lightings – Philips, Havells, Crompton Greaves, Equivalent.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 7. Conference Table          | 1 nos. Suitable for 8 Pax sitting. Modular/branded. With provisions to mount/install wireless base stations, PA Systems & Telephones. Shall have LAN & Power points for atleast 50% of seating capacity. All wiring shall be done by the bidder. Only for Primary Control Room<br>Make: Godrej Interio, Equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 8. Conference Chairs         | 16 Nos. Comfort office chairs in net with hand rest, relaxible push-back revolving, height-adjustable.: – for all locations<br>Make: Godrej Interio, Equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 9. Operator Work Desks       | 4 nos. Modular branded desks suitable for IT use. (for all Stations, Decoders, etc) With provisions to mount/install wireless base stations, PA Systems & Telephones. All wiring shall be done by the bidder. Suitable Cable ducting shall be provisioned. Additional 3 Nos power points (Non UPS) per Operator Desk shall be provided for customer use (over and above the vendor's requirements & PA SystemPower requirements). – for all locations<br>Make: Godrej Interio, Equivalent                                                                                                                                                                                                                                                                                                                                |
| 10. Operator Chairs          | 4 nos. Comfort office chairs in net with hand rest, relaxible push-back revolving, height-adjustable (for all Stations, Decoders, etc). – for all locations. Additional 3 Nos shall be considered per Control Room<br>Make: Godrej Interio, Equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 11. Office Cabinet           | Modular, fire-rated / branded office cabinets. Quantity: Max. Cum. With lock & key<br>Make: Godrej Interio, Equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 12. Miscellaneous            | 4 nos. Large LED/LCD display clock – wall mount - with day & date for both Control Rooms                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 13. Safety                   | 2 nos. Very Early Smoke Detection System for the Data Room.<br>Make: System Sensor/ Xtralis / Equivalent<br>2 nos. Rodent Repellent system Make: MAESAR / Equivalent<br>All cable entries shall be properly sealed & cables shall be rigidly supported & glanded.<br>Suitable Fire Extinguishers for each section of both control rooms.<br>2 nos. Fire Alarm: Intelligent microprocessor based fire detection and alarm system. The Fire Alarm Panel should be A Single Loop Analogue Addressable Type with capability to handle at least 99 Detectors & 99 Device.<br>· Have Backlit Graphical Display of at least 4 x 40 Characters<br>· Supporting a Event Log of at least 750 events.<br>· Possible to give 10 Passwords in 3 Levels<br>· Compliant with EN 54 Standards.<br>Make: Honeywell / Siemens / Equivalent |
| 14. Security                 | 7 No. IP Dome Cameras of suitable lens.<br>Fixed type Indoor Cameras as per Section 8.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 15. A3 Color Laser Printers  | 1 number A3 size color laser printers shall be provisioned in Primary & Secondary Control Rooms each.<br>Make: HP, Samsung, Epson, Canon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

#### **4.22 List of Approved Makes**

|                                |                                      |
|--------------------------------|--------------------------------------|
| Cameras                        | Axis, Bosch, Pelco, Sony, DVTel      |
| VMS & SMS                      | Verint, Qognify (Nice), 2020 Imaging |
| Active Networking              | Cisco, Moxa, Allied Telesys          |
| Servers, Workstations, Storage | HP, Lenovo, Dell                     |
| Video Monitors                 | Samsung, Sony, LG                    |

## **7 B 5. SUB-SECTION**

### **BOOSTER PUMP SPECIFICATION**

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## **5. Hydro Pneumatic Variable Speed System**

### **5.1 Hydro Pneumatic system for Pressure Booster Application**

Application : Potable Water

Pump Type : Vertical multi stage pumps.

No of Pumps : \_\_\_\_ nos (\_1\_W + \_1\_ S)

Total system flow : \_\_\_\_ Cum/hr.

Each pump flow : \_\_\_\_ Cum/hr.

Total Head : \_\_\_\_ Mtr.

Allowed liquid temp : 5 °C to 70 °C

System pressure max : 16 bar

Mains power supply : 400 V, 50 Hz, PE

Nominal power : \_\_\_\_kW

Suction port : \_\_\_\_mm

Discharge port : \_\_\_\_mm

Suction condition : Positive or Negative lift

#### **Applications:**

Hydro Pneumatic systems are designed for water supply and maintained the required pressure in the water utility points for various areas like as:

- Township projects.
- Apartments.
- IT Park.
- Hotels.
- Hospital.
- Multiplex.
- Metro stations.
- Airport.
- Stadium.
- Schools and colleges.
- Golf course.

***Hydro Pneumatic pressure booster systems should be factory assembled, tested and certified by the manufacturer. Site assembled systems shall not be accepted.***

Hydro Booster system consists of two to six pumps connected in parallel with common suction, delivery manifolds. It is mounted on a base frame provided with a control cabinet and all the necessary fittings.

## **5.2 Pumps**

Pumps should be of vertical multi-stage design from Grundfos or approved equivalent subject to compliance with the stated specifications.

- Pumps should be of vertical, multistage, in-line centrifugal pump suitable for installation in pipe systems
- Impellers and intermediate chambers should be made of stainless steel DIN W. Nr 1.4301
- For optimum efficiency, the impeller is of all welded, laser-welded type to avoid inter-stage leakage. Spot welding of impellers will not be acceptable.
- Pump head and base should be made of Cast iron. All cast iron parts should be coated with Cathodic Electrolysis Deposition (CED) of thickness 18 +/- 4 µm
- The base has suction and discharge ports on the same level. (in-line)
- Pumps should be equipped with maintenance free mechanical shaft seal of cartridge type.
- Provision for replacing the mechanical seal without dismantling the pump and motor.
- Power transmission should be via cast iron split coupling.
- Pipe work connection should be via DIN flanges.
- Pumps should be tested and certified as per ISO 9906 guidelines.

## **5.3 Motors**

Motors should be of flange mounting – top pull out design, from Grundfos or approved equivalent subject to compliance with the stated specifications

- Motors should be of TEFC design, IE2/IE3 efficiency class, 2-pole with operating speed of 2900 rpm.
- Motors should be with double-lock drive end bearings to withstand high thrust.
- Maximum noise level should be 72dB at 1-meter level.
- Motor insulation class should be “F”.
- Motors enclosure class should comply with IEC 60034.
- Motors should be protected against external mechanical impacts according to IK-code (International Mechanical Protection) in DS/EN 50102.
- Motors should be cooled according to IEC 60034-6.
- Rated bearing life of motors should be of L10 grade.
- Temperature rise of motors should confirm to class B
- Motors above 3kw ratings should have a positive temperature co-efficient (PTC) of Thermik make for thermal protection
- Vibration level of motors should be according to ISO 10816. Motors having RMS vibration speed more than 2.8 mm/sec will not be acceptable.
- Maximum no of start and stop of motors – up to 3.0KW: 200nos & 4-30Kw: 100nos.

#### **5.4 Manifolds, Valves, Base frame & Accessories**

- Suction and Delivery manifolds in Hot Dip Galvanized steel. (80-110micron)
- DIN standard flange connections.
- One non-return valve and isolating valves for each pump is provided in delivery side and one isolating valve is provided in suction side.
- Manifolds and valves are suitable for 16bar pressure rating.
- Pumps should be mounted on the common base frame.
- Base frame and panel side support is in Galvanized steel.
- Suitable range of pressure gauges and pressure transmitter should be connected at the discharge manifolds.
- Common expansion joints on the suction and delivery port to prevent the vibration in the pipe line. (Optional)
- Vibration dampening pad for minimize the noise and vibration in the system.(Optional)
- Concrete foundation as per manufacturer recommendation. (1.5 times X the weight of the booster system)

#### **5.5 Control Panel**

Control cabinet with an IP 41 enclosure of suitable rating (or specified optional cabinet) with the keypad and display screen mounted through the outer door. In addition to the electronic pump controller, the control cabinet shall include VFDs (each pump have dedicated VFD), circuit breakers for each pump and the control circuit, control relays for alarm functions and fuses.

Control cabinet shall include the following, but not be limited to:

- Motor protection
- Dry run protection – Float switch / Inlet pressure monitoring device for suction lift condition
- Controller with On-board Ethernet port
- 320 X 240 pixels color display unit.
- Pump Fault Lights – A Red light for fault indications
- Visual Alarm
- Manual Operation

#### **5.6 Pump Logic controller:**

Approved Manufacturers: *subject to compliance with the stated specifications*

- Multi Pump Controller shall be listed by and bear the label of Underwriter's Laboratory Inc (UL). The controller shall be specifically designed for variable speed pumping applications
- Pump logic controller in built in Variable frequency drives are not accepted. Logic controller should be external to the Variable Frequency Drives (VFD) used in the system

- Multi Pump Controller shall have programs to safeguard the system against the following conditions
  - Pump flow surges
  - System Hunting
  - End of curve protection
- Multi Pump Controller shall be capable of controlling up to six pumps in parallel.
- Multi Pump Controller shall have a color graphical display unit with key function. Current status of settings and measured values are to be displayed in the default screen.
- Constant pressure control function should ensure that, the system should deliver constant pressure in variable demand condition.
- Automatic case cade function should ensure that, pumps should automatically adapt to variable demand condition by switching the pumps ON or OFF. Pumps should runs at energy efficiently with limited no of pumps.
- Multi Pump Controller shall be capable of accepting an additional analog input signal from a flow sensor. This input shall be used for the end of curve protection
- Multi Pump Controller shall be capable of accepting 7 different set points activated through either clock program or individual digital inputs
- Multi Pump Controller shall be capable of accepting additional analog input as external set point influential signal to vary the primary analog input signal. This external set point influential signal shall be user selectable from various types of signals like ambient temperature signal or like
- Multi Pump Controller shall have program function to accept the pump curve data for optimizing the system performance in terms of energy consumption for the pump being controlled
- Multi Pump Controller should have self learning functions for optimizing the number of pumps based on energy consumption
- The hydraulic stabilization program shall utilize a proportional-integral control function. The proportional-integral values shall be user adjustable in the Multi Pump Controller over a finite range.
- Multi Pump Controller shall be self-prompting and all alarm messages shall be displayed in plain English. The operator panel shall have the following features:

- Multi fault memory and recall of last 24 faults with time stamping.
- Red fault light with related alarm message on default screen with graphical representation of the fault
- Soft touch membrane keypad switches
- Multi Pump Controller shall have an installation wizard to enable the user to configure the system with minimum assistance
- Multi Pump Controller shall have minimum 2 level password protection to safeguard the settings against unwanted / unauthorized changes
- Display should have menu driven function for the operation easiness
- Low suction pressure cut out to protect the pumps against operating with insufficient suction pressure
- High system pressure cutout to protect the piping system against high-pressure conditions
- Soft pressure built up function for smooth start of the system for filling the instance empty pipes.
- Number of starts per hour function should be provided to reduce the noise emission and improves the comfort of system.
- The pilot pump selection should be provided for reducing main pumps operating hours when low flow condition.
- Forced pump changeover should be provided for ensures all the pumps run for the same number of operating hours.
- Stop function should be available for stop the last pump in operation if there is no or very small consumption.
- Clock program should be available to set the different 10 set points with specific date and time to operate the system for different requirement.
- Backup battery need to be connected controller to ensure the uninterrupted power supply (Optional).
- Multi Pump controller should have provision for fixing different communication interface modules to suitable seamless interface with Building Management System communication protocols like Modbus/ PROFIBUS/ BACnet/ GSM.

- The pump logic controller shall be Grundfos - Multi Pump Controller or approved equal housed in a NEMA 1 enclosure
- Multi Pump controller should have on-board Ethernet port

#### **5.7 System operational logic (For System with Multiple VFD & Multi Pumps)**

Multi Pump Controller should have provision to operate under modes such as

- Constant pressure with pressure transmitter input
- Proportional Pressure with additional flow transmitter input
- *Under constant pressure mode*, Multi pump controller should initiate timed sequence to start a pump which is having lowest number of running hours under VFD operation.
- Multi Pump Controller shall use the back ground pump curve data to decide on the pump switching based on best efficiency point. Assist pump when started with VFD, shall vary its speed in relation with duty pump equally to maintain the set pressure value.
- Multi Pump Controller shall have program function to equalize running hours of pumps through timed changeover in daily or weekly basis
- Multi Pump Controller shall switch over to assist pumps configured in the system, in case the duty pump develops any fault
- *Under proportional pressure mode*, Multi Pump Controller with an additional flow sensor input, shall be able to adjust the system pressure proportional to the system flow, to ensure additional energy savings

#### **5.8 Pressure Tank**

Pressure tank optimizes water supply and prolongs the life of a pump by acting as a buffer between pump and outlet in the system. By reducing the number of starts/stops, the tank will extend the life of the pump and considerable amount of water can be used without any pump action.

- Pressure tanks for cold water applications are ideally suited for approved for use with drinking water.
- MS Tank body.
- Butyl, Double diaphragm bladder.
- Max liquid temperature - 70deg C.
- Pre-charge pressure - 1.5Bar.



## **7 B 6. SUB-SECTION**

### **EMERGENCY TELEPHONE SYSTEMS SPECIFICATION**



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## **6. EMERGENCY TELEPHONE SYSTEM**

### **6.1 Purpose**

Tunnels standard ESC 340 requires emergency telephones to be installed in new tunnels using electric passenger rolling stock. This document establishes the standard requirements for these emergency telephones and the network environment in which they operate.

### **6.2 Scope and application**

The scope of this document covers the wider telecommunications network in which tunnel emergency telephones operate as Tunnel Emergency Telephone Systems. For the remainder of this document the term System, Systems or The System shall refer to Tunnel Emergency Telephone Systems.

This standard is applicable to Systems in tunnels as required by *ESC 340* and also applicable to provision of new and replacement Systems in tunnels which may pre-date *ESC 340* and so may not meet that standard, particularly with respect to the dimension of refuges.

This standard also has scope to include telephones at locations outside but near tunnel portals where they may be useful in co-ordinating a response to an emergency incident in tunnels.

The type of emergency the System is intended to deal with is non specific, even though parts of this standard may seem to be specifically dealing with the need to a fire emergency.

This standard is not applicable to any general emergency telephone systems outside of tunnels or EWIS that may be required on underground stations and which may interface with tunnels.

### **6.3 References documents**

#### **6.3.1 Australian and International Standards**

*AS/ACIF S008 Requirements for customer cabling products*

*AS/ACIF S009 Installation requirements for customer cabling (Wiring rules)*

*AS 3013 Electrical installations - Classification of fire and mechanical performance of wiring system elements*

*BSC 6387 Specification for performance requirements for cables required to maintain circuit integrity under fire conditions*

#### **6.3.2 Documents Shall be provided by the contractor**

*Communications Outdoor Cabling Standard*

*Signalling Bungalow Telecommunications Cabling ESM 107 Telecommunications Equipment Rooms & Tunnels*

*Telecommunications Design Process for Design Projects*

*Analogue Two Wire Weatherproof Field Telephones*

*Emergency Telephone Location Lights for Underground Railway*

### **6.3.3 Drawings Shall be provided by the contractor**

*Emergency Telephone Sign for Tunnel Installation*

*ESR Emergency Phones Telecommunications Cable Schematic*

*Firephone Termination Cabinet ESR Underground*

*Firephone Termination Cabinet (Remote Telephone)*

*Heavy Duty Slope Top Weatherproof MDF Enclosure for 2 x 27 Way Frames Standard Configuration*

### **6.4 Terms and definitions**

EWIS Emergency Warning and Intercommunication System PABX Private Automatic Branch Exchange

WAN Wide Area Network

IDF Intermediate Distribution Frame

MDF Main Distribution Frame

VDC Volts Direct Current

RMC Rail Management Centre

DRC Disaster Recovery Centre (for the RMC)

C&CS Communications and Control Systems Division of IP65 Ingress protection rating 65

System Tunnel Emergency Telephone System

### **6.5 General requirements**

The System shall provide a highly reliable and high availability telephone communications as a means of reporting and aiding a response to emergency situations that may arise in tunnels.

The System shall be simple in operation to allow use of telephones by untrained staff, emergency services staff and anyone from the general public that may be caught up in an emergency situation in a tunnel.

To keep the System simple, static and clear on ownership and accountabilities, it shall be dedicated to its purpose and independent of:

- a) the public telephone network
- b) administrative telephone networks
- c) administrative data networks

The System shall maintain full service for two hours in the event of a fire and then at least limited services in any particular tunnel segment after the event.

Alternate telephones shall be fed via cabling and equipment from opposite ends of the tunnel segment they are in.

Subsequent to a fire in any tunnel segment, or any other failure of the System at a common point, the System shall maintain operation of at least each alternate telephone along the length of all tunnel segments. The intent of this requirement is to meet two primary purposes:

a) so that where a user encounters a failed telephone, then the next telephone along in the tunnel segment will not be affected by the same failure

b) so that failure of any one network element will allow limited emergency telephone services and avoid the need for suspension of train services through the tunnel

The System shall include remote monitoring and supervision arrangements designed for ease of maintenance and to minimise the requirement for maintenance personnel to enter the tunnels.

The System shall be integrally comprised of the following basic elements:

- a) telephones
- b) Answering point
- c) emergency telephone location lights
- d) signage
- e) cabling and termination frames
- f) PABX(s)
- g) telephone testing sub-system
- h) backbone telecommunications network

The System design and construction shall be co-ordinated with that of other Tunnel infrastructure, with particular attention to emergency tunnel lighting and cable route.

## **6.6 Telephones**

### **6.6.1 Emergency telephones**

Emergency telephones shall be in accordance with *SPM 0082*, which provides for basic requirements summarised as follows:

- a) weather resistant

- b) vandal resistant
- c) line powered
- d) enabled for automated testing
- e) red in colour
- f) simple in operation involving no dialling

Emergency telephones shall be of common make and model throughout the System with appropriate spares kept in Signal Maintenance Depots and Signal Store for maintenance purposes.

#### **6.6.2 Control Room telephones**

Control Room telephones are to be installed in the Control Room on Station Platforms that adjoin a tunnel portal. Other locations on the Stations should also be considered on a site by site basis for additional telephone(s) where appropriate to aid in response to a tunnel emergency situation.

The function of these telephones is to allow communications between the Rail Management Centre and the Station to aid the response to a tunnel emergency.

These telephones shall be PABX System integrated to provide identification of connected parties and one key operation to access other parties co-operating in the System.

The emergency telephone functionality may be incorporated into telephones intended for operational communications with the Rail Management Centre where combining the functionality is beneficial to meeting total telephony requirements and ensure the telephone is regularly tested. In these cases the telephone's access key/button should clearly be labelled as "Emergency - RMC".

#### **6.7 Answering point**

The answering point for calls from each emergency telephone shall generally be the Train Controller at the Rail Management Centre in control of the section of track where the Emergency Telephone is situated.

Emergency calls shall be directed to a target on the Train Controllers' integrated voice communications facility and be automatically identified as an emergency call from the particular location of the telephone.

The Train Controllers' facility shall be configured to allow calling of each particular telephone or by group call to all telephones within particular tunnel segments. Group calling for long segments of tunnel may be split into logical sub-segments to fall within the technical limits of the group calling facility of the answering point which is sometimes limited to a maximum of 20.

The System shall allow for calls to be automatically diverted to an alternate answering point at a Disaster Recovery Centre when triggered by failure or by manual blocking of the RMC PABX.

## **6.8 Emergency telephone location lights (blue lights)**

Emergency telephone location lights, also referred to as 'blue lights', shall be in accordance with *SPM 1572*, which provides for basic requirements summarised as follows:

- a) indicate the location of an emergency telephone in the tunnel
- b) flash to indicate that the associated telephone is ringing
- c) weather resistant
- d) vandal resistant
- e) blue in colour
- f) visible from 90m in tunnel situations

Blue lights shall generally be powered and monitored from the same low voltage circuits and Systems that power and monitor the tunnel emergency lighting.

Blue lights shall be of common make and model throughout the System.

Appropriate spare units shall be provided and kept in Maintenance Depots and/or Store for maintenance purposes.

## **6.9 Cabling**

### **6.9.1 General**

Cabling and cabling products shall generally be in accordance with *AS/ACIF S008*, *AS/ACIF S009* and *ESM 102*, with the additions requirements included in this standard.

Fire safe cable shall be specifically designed to address issues of fire management and safety and include properties of low smoke generation, flame retardant, not support combustion, not contain jelly, not contain halogen or other materials that would produce poisonous or corrosive gas in a fire.

Fire rated cables shall be fire safe and be rated either at 2 hours to *AS3013 (WS 5X)* or 3 hours to *BSC6387 CWZ*.

### **6.9.2 PABX cabling**

Cabling from the PABX equipment to PABX termination points shall be fire safe or made fire safe by containment in a fire safe covering, with the exception of the following situations where standard cabling used for the PABX may be used:

- a) where cabling is contained within the same equipment rack as the PABX
- b) where cabling is contained within a room that is not part of an underground station or other underground facility
- c) where cabling is contained within a room that is protected by a fire suppression system

### **6.9.3 Telephone cabling**

Telephone cabling shall be fire rated with the exception of the following situations:

- a) where not at all used for emergency telephones
- b) where contained in a cable route outside (but leading into) the tunnel or underground facility

Telephone cable between the telephone and its closest termination point shall be 2 pair. Telephone cabling distribution should be arranged to:

- a) feed alternate telephones along each tunnel segment from PABX equipment at opposite ends of the segment<sup>6</sup>.
- b) minimise the number of termination points and keep terminations to a maximum of 10 between the PABX and telephones<sup>7</sup>.
- c) use full unjointed cable lengths between termination points.
- d) use multiple paired cable rather than multiple 2 pair cables where appropriate to improve cable manageability

### **6.9.4 Joints**

The System shall not use any joints in cabling.

Full lengths of cable between termination points shall be used for maintenance and repair work on the system and appropriate lengths of cable shall be kept in store for this purpose.

Where emergency repairs cannot be undertaken without jointing of cable, replacement of any jointed section shall be scheduled as high priority remedial works under routine maintenance.

### **6.9.5 Signals IDFs**

Signals IDF shall be located between the PABX terminations in the Telecommunications Equipment Room and the first termination point within any tunnel segment to provide demarcation in responsibility between Telecommunications and Signalling disciplines. This IDF shall preferably be installed within a Signalling Equipment Room, and where this is not reasonably possible or appropriate, it should be installed in a location that is agreed between Telecommunications maintenance and Signals maintenance stakeholders.

The Signals IDF may also be used for termination of other Signals related telecommunications cabling that appears within the same room (such as cabling for Signal Post Telephones and Signals data lines).

### **6.9.6 Tunnel IDFs**

Tunnel IDF shall be installed at the location of emergency telephones where required in the tunnel to provide an intermediate point for cable distribution.

The purpose of the Tunnel IDF is to provide a termination and test point for local cable distribution and the connecting cables to the telephone and Blue Light at that location.

The Tunnel IDF basic requirements are:

- a) weatherproof to IP66
- b) vandal resistant
- c) constructed of materials that are fire safe and resistant to corrosive ground waters and with the main enclosure constructed from 316 grade stainless steel.
- d) secured by Falcon 17 lock
- e) suitable for surface mounting underneath an emergency telephone

Where appropriate the Tunnel IDF may provide a shared resource with cabling for trackside Signal telephone cabling in the same tunnel segment.

#### **6.9.7 Tunnel test box**

Tunnel test boxes shall be provided at the location of emergency telephones where there is not a Tunnel IDF located.

The purpose of the Tunnel Test Box is to provide a test point for the telephone and a connection point for the blue light and avoid the need for opening of the telephone casing for testing or cable connection.

The Tunnel test box has similar basic requirements to the Tunnel IDF but will be smaller and will be dedicated to the Emergency Telephone at that location.

#### **6.9.8 Outdoor IDFs**

Outdoor IDFs shall be installed at locations where required outside the tunnel to provide an intermediate point for cable distribution.

The purpose of the Outdoor IDF is to provide a termination and test point for local cable distribution and a transition point between the different types and specification of cable required within the tunnel and outside a tunnel.

The Outdoor IDF basic requirements are:

- a) weatherproof to IP66
- b) vandal resistant
- c) constructed of materials that are fire safe and resistant to corrosive ground waters and with the main enclosure constructed from 316 grade stainless steel.
- d) secured by Falcon 17 lock
- e) suitable for surface mounting underneath an emergency telephone



f) dimensioned to cater for multiple tunnels and other required services such as Signal Post Telephone cable.

Where appropriate the Outdoor IDF may provide a shared resource with other cabling required for Signals related communications.

#### **6.9.9 Cable route**

Design, location and construction of cable route for the System shall be co-ordinated with that of routes required by other services within the tunnel.

The main cable route for telephone cabling in tunnel segments shall consist of a heavy duty tray that is constructed of materials that are fire safe and resistant to corrosive ground waters

A dedicated tray or dedicated and segregated space within a general communications tray shall be provided for the System. This dedicated tray or segregated space shall be clearly labelled at approximately 3m intervals as emergency telephone.

The emergency telephone cable tray or space shall not be used for other purposes with the exception of:

- a) cable associated with Signal Telephones in the same tunnel segment
- b) optical fibre used by C&CS to provide backbone networks that support the System

Conduits used for minor routes or crossings shall be:

- a) vandal resistant
- b) constructed of materials that are fire safe and resistant to corrosive ground waters

#### **6.10 PABX(s)**

PABXs shall be incorporated into the wider Operations Control Telephone network and configured to allow calls to be routed to the answering point at RMC and alternate answering point at the DRC.

PABXs shall be dedicated to the purpose of the System with the exception where small numbers<sup>9</sup> of telephones in particular tunnel segments may be provided from an Operations Control PABX where appropriate.

PABXs shall be installed in a Telecommunications Equipment Room<sup>10</sup> and powered from the room's 48VDC power supply, which shall have a minimum nominal battery backup time of 12 hours.

PABX network design shall be referred to C&CS designers at concept design stage for direction and/or advice on networking aspects including:

- a) where the PABXs are to fit into the wider network
- b) suitability of the model of PABX proposed
- c) availability and suitability of use of existing rooms

PABX installation and configuration design shall be referred to C&CS designers at detail design stage for direction and/or advice on site aspects including:

- a) rack location within the room and any cable tray work required
- b) MDF allocation for cable termination or any MDF extension required
- c) DC Circuit Breaker allocation or any DC Power Supply extension required
- d) number allocation
- e) routing plans
- f) trunk signalling protocols
- g) synchronisation plans

#### **6.11 Telephone testing subsystem**

The System shall utilise an automated remote telephone testing sub-system designed to co-operate with that remote testing feature within the telephones.

The purpose and functions of this subsystem are:

- a) to provide early detection and reporting of any out of order telephones by way of a scheduled automated testing routine
- b) to enable remote diagnosis of the nature of reported telephone faults
- c) reduce the frequency of routine inspections within the tunnel<sup>11</sup>

The telephone testing sub-system shall be comprised of:

- a) a carrier grade server installed in a Telecommunications Equipment Room and maintained by C&CS
- b) test lines connected between the server and the PABX associated with the answering point
- c) dedicated terminals installed in appropriate Signal maintenance depots connected to the Server by a C&CS WAN
- d) remote access by C&CS maintenance staff by way of both dial up and WAN

To avoid the need of providing and maintaining multiple testing sub-systems, the telephone testing sub-system shall preferably provide a shared resource between multiple Emergency Tunnel Telephone Systems and other trackside Signals related telephones that are enabled with a compatible remote testing facility.

## **6.12 Emergency telephone location**

Telephones shall be located as required by *ESC 340* in line with the following principles.

The principles for selection of location of emergency are summarised below:

- a) only in nominated safe locations such as refuges or walkways with appropriate clearance from the track.
- b) no more than 90m from the next telephone along in the tunnel
- c) at track crossovers or other complex tunnel configuration
- d) near tunnel portals, inside the tunnel
- e) appropriate outdoor locations near tunnel portals where they may be useful in co-ordinating a response to an emergency incident in the tunnel

In legacy tunnels, which pre-date *ESC 340*, it may be necessary to locate emergency telephones in refuges that do not meet the requirements of the standard. In this situation, attention shall be given to selecting the most appropriate refuges. Examples of inappropriate refuges are:

- a) refuges which are under size and have other equipment mounted on the walls
- b) refuges overly affected by ground water seepage

Each location where an emergency telephone is installed shall also be fitted out with:

- a) the emergency telephone
- b) emergency lighting
- c) an emergency telephone location light visible from the location of the next telephones along in the tunnel segment
- d) A sign, generally in accordance with drawing *SK 0142*, adjacent to the location to depict the purpose of the telephone

## **6.13 Asset ownership and accountability**

C&CS Division shall have asset ownership and operational accountability for:

- a) PABXs and supporting telecommunications network
- b) The telephone testing subsystem
- c) cabling between the Telecommunications Equipment Room and the Signals IDF
- d) The Signals IDF with the exception of any terminations of cable running towards emergency telephones
- e) Control Room telephones

The applicable regional Asset Manager<sup>13</sup> shall have asset ownership and operational accountability for:

- a) Cabling between the Signals IDF and emergency telephones including terminations of this cabling in the Signals IDF
- b) Emergency telephones and Emergency telephone location lights including all associated items of their fit out within the tunnels

Responsibility for Configuration Control and provisioning of services shall reside with C&CS.

Responsibility for nomination of the answering point shall reside with the manager responsible for the RMC.

## **7 B 7. SUB-SECTION**

# **TECHNICAL SPECIFICATIONS FOR FIRE FIGHTING SYSTEM**

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## **7 TECHNICAL SPECIFICATION OF FIRE FIGHTING SYSTEM**

### **7.1 FIRE HYDRANT SYSTEM**

#### **7.1.1 Scope of work**

The scope of work shall cover supply, installation, testing and commissioning of the fire hydrant system as follows:

The Fire Fighting System shall comprise the Sprinkler System (Wet type), and Hand held Appliances.

Water from the underground Fire Water Storage Tanks as per capacity given in drawings shall be supplied for the uses listed below:

- a. Sprinkler System (pressurised) inside tunnel.
- b. Sprinkler System, under normal conditions, shall be lowest pressurized by means of the electric motor driven Jockey Pump.
- c. The sprinkler pumps shall be provided as specified in the NO OBJECTION CERTIFICATE by the approving authorities.
- d. The piping and valve connections shall be done so that the water from the discharge of the pump sets is able to supply water, automatically to the sprinkler system in case of malfunctioning of the sprinkler pumps.
- e. The electric motor driven hydrant pump starts automatically at a pre-set pressure by means of a pressure switch. If for any reason the electric motor driven Hydrant Pump does not start at the pre-set pressure or is unable to maintain the pressure, the standby pump starts at the pre-set pressure.
- f. The hydrant pump shall be stopped only manually.
- g. The Stand by Pump shall be started automatically at a pre-set pressure but shall be stopped only manually.
- h. Contractor shall ensure hydro testing for 2 times for checking that water is held at the desired pressure for minimum 24 hours.

#### **7.1.2 Standards**

The fire hydrant installation shall conform to and meet with the requirements set out by the following:

| <b>Code Number</b> | <b>Description</b>                                                                     |
|--------------------|----------------------------------------------------------------------------------------|
| IS: 13039 – 1991   | Code of practice for External Hydrant System Provision & Maintenance.                  |
| IS: 3844 – 1989    | Code of practice for installation of internal fire Hydrants and hose reel on Premises. |
| IS: 4927           | Unlined flax canvas hose for Fire Fighting                                             |
| IS: 5290           | Landing Valves                                                                         |
| IS: 5612 part 1&2  | Specification of hose clamps and hose bandages.                                        |
| IS: 903            | Fire hose delivery coupling, branch pipe, nozzle and nozzle spanner.                   |
| IS: 904            | Specification for 2-WAY & 3 way suction collecting headers for Firefighting purpose.   |



|          |                                                                   |
|----------|-------------------------------------------------------------------|
| IS: 906  | Specification for revolving branch pipes.                         |
| IS: 908  | Specification or fire Hydrants Stand post type.                   |
| IS: 2871 | Specification for branch pipe, universal for firefighting purpose |
| NFPA 14  | Standard for the Installation of Standpipe and Hose Systems       |
| TAC      | Tariff Advisory Committee rules & guidelines                      |

### **7.1.3 Hydrant System Equipment**

#### **Fire Department Connection**

Freestanding: Two (2) ways, and four (4) ways as specified and indicated on the Drawings, chrome plated, freestanding, clapper type breeching inlets with caps and chains as mention in drawing. Fire department connection shall be confirming to IS: 904. Each unit shall be clearly labeled for the system that it serves. The label format shall be approved by local fire authority and submitted to the Architect/ Engineer for review and approval. The breeching inlets shall be complete with concrete anchors; removable caps with attached chain, polished chrome trim, non return valve, etc. Breeching inlets shall be suitable for the required working pressures.

The label format shall be approved by fire authority and submitted to the Architect/ Engineer for review and approval. Each breeching inlet shall be complete with removable caps with attached chain, polished chrome trim, non return valve, etc. Breeching inlets shall be suitable for the working pressures.

All fire department connections shall conform to BSI and I.S. Standards and shall be suitable for the required working pressures and with require support like concrete anchors and non return valve.

#### **External (Yard) Fire Hydrants**

Contractor shall provide external hydrants and shall be complying with IS: 13039. The hydrants shall be controlled by a cast iron butterfly valve installed in underground lockable chambers. Hydrants shall have instantaneous type 65 mm dia outlets. The hydrants shall be single or double outlet as indicated on the Drawings and conforming to BSI, I.S.908-1975 with C.I bend and flanged riser of required height to bring the hydrant to correct level above ground.

Contractor shall provide for each external fire hydrant two 65 mm dia.15 M long rubberized permanent line hose pipe with gunmetal male and female instantaneous type coupling machine wound with G.I. wire (hose to I.S.636 type 2 and coupling to I.S. 903 with certification), branch pipe with nozzle to I.S. 903. All shall be acceptable to the local fire authority.

Orifice plate shall be installed before hydrant, as specified and required for hydrants exceeding 4.00 to 5.00 kg/cm<sup>2</sup> pressures to regulate the pressure such that the nozzle pressure shall not exceed the outlet pressure required by the local fire authority under full flow conditions. Hydrants shall be installed in such a way that they should not affect the parking or other activity.

#### **Internal Fire Hydrant**

Contractor shall provide on each landing and other locations as shown on the drawings double headed gunmetal / Stainless Steel landing valve with 100 mm dia inlet as per IS: 5290, with shut off valves having cast iron wheels as shown on the drawings. Landing valve shall have flanged inlet and instantaneous type outlets as shown on the drawings.

Instantaneous outlets for fire hydrants shall be standard pattern and suitable for fire hoses.

Contractor shall provide for each internal fire hydrant station two numbers of 63 mm dia. 15 m long rubberized fabric lined hose pipes with gunmetal or stainless steel male and female instantaneous type coupling machine would with GI wire (hose shall comply to IS: 636 type 2 and couplings shall comply to IS: 903), fire hose reel, gunmetal or stainless steel branch pipe with nozzle shall comply to IS: 903. This shall be measured and paid for separately.

Each internal hydrant hose cabinet shall be provided with a drain in the bottom plate. All drain point shall be connected to UG flushing tank located at basement

Each internal hydrant hose cabinet containing items as above shall also be provided with a nozzle spanner and a Fireman's Axe. The cabinet shall be recessed in the wall as directed. This shall be measured and paid for separately.

Each hose cabinet shall be conspicuously painted with the letters "FIRE HOSE".

#### **Hose Reel**

Contractor shall provide standard fire hose reels of 20mm dia high pressure Dunlop (or equivalent) rubber hose 30 m long with gunmetal or stainless steel nozzle, all mounted on a circular hose reel of heavy duty mild steel construction having cast iron brackets. Hose reel shall be connected directly to the wet riser with an isolating valve. Hose reel shall conform to IS: 884 and shall be mounted vertically. This shall be measured and paid for separately.

#### **Fire Hose**

All hose pipes shall be of 63 mm diameter RRL/CP as required, conforming to IS : 636 or IS : 8423. The hose shall be provided with copper alloy delivery coupling. The hose shall be capable of withstanding a bursting pressure of 35.7 Kg/Sq.cm without undue leakage or sweating. Hose shall be provided with instantaneous spring-lock, type couplings.

#### **Branch Pipe, Nozzle**

Branch pipes shall be of gun metal with loaded tin bronze ring at the discharge and to receive the nozzle and provided with a leaded tin bronze ring to fit into the instantaneous coupling at the other end. Nozzle shall be of spray type of diameter of not less than 16 mm and not more than 25 mm. Nozzle shall be of loaded tin bronze branch pipe and nozzle shall be of instantaneous pattern conforming to IS: 903.

#### **Hose Cabinet**

Hose cabinet shall be provided for all internal and external fire hydrants. Hose cabinets shall be fabricated from 16 gauge MS powder coated sheet of fully welded construction with hinged double front door partially glazed with 3 mm thick glass panel with locking arrangement. Stove enamelled fire red paint (confirming to shade No. 536 of IS: 5) shall be used to prominently write "FIRE HOSE CABINATE" (size of letters shall be as given in the schedule of quantities). Cabinet surfaces in contact with the walls shall not be powder coated but instead given two coats of anti-corrosive bitumastic paint.

#### **Internal Hose**

The internal Hose located at each fire duct at each mid landing The fire Hose box shall be of MS frame with glass door & lock, shall confirm IS-884. The frame of door shall be made of 16 gauge thick MS sheet and spray painted to shade No. 536 of IS: 5. It shall be mounted on raised Brick platform complete as required.

The Fire box shall be of size not less than 0.75 m X 0.60 m X 1.20 m suitable to accommodate the following:

- a. Landing Valves (Single/double headed)
- b. Hose pipe
- c. Hose reel (36.5 m)
- d. Branch pipes, nozzles (2 sets)
- e. Fire man's axe and hand appliances

#### **External Hose Cabinet (FRP / GRP)**

The hose cabinet shall be of size not less than 750mmx600mmx250mm to accommodate the following:

- a. Single/Double headed yard hydrant valve
- b. Hose pipe (2 length of 15 m)
- c. Branch pipes, nozzles (2 sets)
- d. Fire man's axe

#### **Pressure Gauge**

Pressure gauge shall be confirming to the IS: 3624 and installed on the wet risers near all branch connections to hydrant system and sprinkler system and where required by the local authorities. Pressure gauge shall be installed with isolation valve with inbuilt SS strainer. Pressure gauge shall be minimum 100mmdia dial, gunmetal burden type gauge with gunmetal isolation cock, tapping and connecting pipe and nipple. The gauge shall be installed at appropriate level and height for easy readability.

#### **Hydrant/Valve Chambers**

Suitable brick masonry chambers shall be constructed for valves and hydrants where required. The construction shall be of brick work in cement mortar 1:5 (1 cement: 5 coarse sand) on cement concrete foundations 150 mm thick 1:5:10 mix (1 cement: 5 coarse sand: 10 graded stone aggregate 40 mm nominal size) 12 mm thick cement plaster inside and outside finished with a floating coat of neat cement inside with cast iron surface box approved by the fire brigade including excavation, back filling complete.

Valve chambers shall be 1200 mm X 1200 mm for depths up to 1000 mm. Unless and otherwise specified chamber shall be closed with the heavy duty cast iron cover with the frame with clear opening of 450 mm X 900 mm confirming to IS: 1726.

#### **Air Vessel/Air Cushion Tank**

Air Cushion tank shall be confirming to IS: 3844 and of adequate size and capacity indicated on the drawings. It shall be provided at the top most point of the fire system piping. The tank shall be complete with 20 mm dia. Brass Air Valve (Ball Type), Stop Valve (20 mm dia), Drain Valve (20 mm dia) and pressure gauge including 20 mm dia. Steel galvanized pipes and fittings, unions, etc. as required to complete the work as per project conditions.

Air cushion tank shall be the size indicated on the Drawings measured by numbers and shall include Air Valve, Pressure Gauge, and Globe Valves for testing and draining. Clamps, Pipes, Fittings, Tees Elbows Union and all other items required to complete the installation.

### **Orifice Plates**

Provides orifice plate fabricated from 6 mm thick stainless steel plate to reduce pressure on individual hydrants to restrict the operating pressure to a maximum of 4.00 to 5.00 kg/cm<sup>2</sup>. It shall include all the require flanges.

### **Drain Valve**

Provide 25 mm dia black steel pipe in accordance with IS: 1239 (heavy class) with 25 mm Ball valve confirming to IS: 9890 for draining any water in the system in low pockets.

### **Inspection & Testing Assembly**

Inspection and testing of the fire hydrant system shall be done by and in accordance with local authorities.

### **Painting**

All external steel surface shall be thoroughly cleaned to remove rust, scale etc before applying the primer.

- a. All underground piping shall be provided protective wrappings as per TAC norms.
- b. All over ground piping/hose boxes/landing valves/hose reel, M S frames etc shall be painted with twocoats of RED LEAD primer or equivalent followed by two coats of Post Office Red coloured Synthetic enamel finish paint.
- c. All other equipment shall be given a red oxide/zinc chromate primer and two (2) coats of synthetic enamel.

## **7.2 SPRINKLER SYSTEM**

### **7.2.1 Scope of Work**

The scope of work shall cover supply, installation, testing and commissioning of the sprinkler system, sprinkler piping, sprinkler pumps and panel, sprinkler system connection to fire alarm.

The scope of work shall include supply, installation, testing and commissioning of the system as a whole. The sprinkler heads are to be fixed into heavy quality black steel pipes, conforming to IS: 1239 or any other approved specification. The size of pipe will vary from 25 mm to 150 mm to suit the hydraulics of the system. The System shall conform to CFO Rules for the installation of sprinkler systems in general for 'Ordinary Hazard' category-in respect of design, density and spacing of sprinkler heads.

Reduction in pipe sizes shall not be made by use of bushings. All piping shall be done by means of welding, screwed & flanged jointing as per codes.

Due care shall be taken that sprinklers are not applied with paint at the time of applying paint to piping and fittings.

All control, drain, test and alarm valves shall be provided with signs to identify their purposes, functions, direction of flow the satisfaction of the Consultants.

### 7.2.2 Standards

| IS Code   | Description                                                                             |
|-----------|-----------------------------------------------------------------------------------------|
| IS: 9972  | Specification for Automatic Sprinkler Heads for Fire Protection Service.                |
| IS: 15105 | Design and Installation of Fixed Automatic Sprinkler Fire Extinguishing Systems.        |
| IS: 15325 | Design and Installation of Fixed Automatic High and Medium Velocity Water Spray System. |
| IS: 1239  | Mild steel tube, tubular and other wrought steel fittings.                              |
| IS: 2643  | Dimensions for pipe threads for fastening purpose.                                      |
| NFPA 13   | Standard for sprinkler installation                                                     |
| TAC       | Tariff Advisory Committee rules & guidelines                                            |
| FM Global | Sprinkler Standards                                                                     |

### 7.2.3 Sprinklers System Components

#### Quartzoid Bulb Automatic Sprinkler

Sprinkler heads shall be made of brass/quartzoid bulb sufficiently strong, in compression to withstand any pressure, surge or hammer likely to occur in the system. The yoke & body shall be made of high quality gun metal brass with arms streamlined to ensure minimum interference with the spread of water. The deflector of suitable design shall be fitted to give even distribution of water over the area commanded by the sprinkler.

The bulb shall contain a liquid having a freezing point below any natural climatic figure and a high coefficient of expansion. The temperature rating of the sprinkler shall be stamped on the deflector & the colour of the liquid filled in the bulb shall be according to the temperature rating as per NFPA standard.

The sprinkler heads shall be of type & quality approved by the local fire brigade authority. The inlet shall be screwed.

The sprinklers shall have 15mm nominal size of the orifice for ordinary hazard. The orifice size shall be marked on the body or the deflector of the sprinkler. The sprinkler heads shall be protected with metal guards to prevent accidental or mechanical damages, as desired by the Project Manager. Contractor shall submit detailed submittal and discharge spray pattern for the Sprinkler for the approval of consultant.

Sprinklers shall be confirming to IS: 9972 and shall be installed as per guidelines mention in IS: 15105, NFPA and FM global whichever is more stringent. Sprinkler shall be thermo-sensitive glass-bulb actuated type and shall be standard products from an established company of repute and standing and approved by appropriate local fire authority and UL listed.

All Sprinklers shall be brass castings polished chrome or white (polyester) as approved and tested as per test given in IS: 9972 like leakage resistance test, function test, 30-Day leakage test and all other testes mention in standard. Sprinklers shall be pendant, upright or side wall type as specified and shown on drawings. Wherever shown and specified sprinklers shall be concealed type. All sprinklers drops shall be provided with UL listed & local CFO approved flexible drop pipe with all necessary joints & accessories.

Temperature classifications of sprinklers in each space shall be as shown on the drawings or as required. Sprinklers shall be selected for the coverage shown on the drawings. Wherever the specified sprinklers are not adequate, the contractor may offer appropriate size required and shall get the same approved from the consultant.

### Temperature classifications

Sprinklers in each space shall be as shown on the drawings or as required. Sprinklers shall be selected for the coverage shown on the drawings and ordinarily is 12/12 mm with K factor of 115 (meteoric). Wherever the specified sprinkler is not adequate, the contractor may offer appropriate size required.

Following table shall be used for selection of temperature rating of sprinklers for different areas:

| Maximum Ceiling | Temperature           | Temperature     | Color (with Code)  | Glass Bulb Color                |
|-----------------|-----------------------|-----------------|--------------------|---------------------------------|
| Temperature     | Rating                | Classification  | Fusible Link)      |                                 |
| 100°F / 38°C    | 135-170°F / 57-77°C   | Ordinary        | Uncolored or Black | Orange (135°F) or Red (155°F)   |
| 150°F / 66°C    | 175-225°F / 79-107°C  | Intermediate    | White              | Yellow (175°F) or Green (200°F) |
| 225°F / 107°C   | 250-300°F / 121-149°C | High            | Blue               | Blue                            |
| 300°F / 149°C   | 325-375°F / 163-191°C | Extra High      | Red                | Purple                          |
| 375°F / 191°C   | 400-475°F / 204-246°C | Very Extra High | Green              | Black                           |
| 475°F / 246°C   | 500-575°F / 260-302°C | Ultra High      | Orange             | Black                           |
| 625°F / 329°C   | 650°F / 343°C         | Ultra High      | Orange             | Black                           |

### Sprinkler Installation

Sprinkler heads shall be located in positions shown on the drawings. While slight relocation may result from building construction features or interference from other services, the maximum spacing between sprinkler heads and coverage area shall not exceed those stipulated in the TAC regulations and the NFPA 13-1994 Rules.

Allowance shall be made for such relocations within a radius of 1500 mm of the indicated positions without additional cost. The Fire Protection Services Trade shall co-ordinate with the ceiling Trade to set out the sprinkler locations to suit the site location of the unit grid. In general, all sprinklers shall be located at the centre of the ceiling unit and a provision of about 10% more sprinklers and pipe work than required in TAC and NFPA Rules shall be included in this sub-contract. Chrome plated wire mesh guards shall be used to protect the sprinkler heads which are liable to accidental or mechanical (at no extra cost) damage.

### **Alarm Valve**

Each zone shall be controlled by fire alarm valve or zone control valve. Alarm valve shall be installed as per TAC guide line. They are designed to sound a continuous alarm while a sprinkler system operates. Alarm valve shall be mechanical operated with all require accessories requirement of NFPA-13 and IS: 15105 section 14.7. Alarm valve shall be installed where there is no danger of freezing. Alarm valve shall be provided with test connation and installed in such location where alarm can be audible.

Each installation shall be provided with a set of installation control valves comprising of the following:

- a. An Alarm Valve.
- b. A Water Motor Alarm & Gong.

Installation valves shall be installed on the sprinkler circuits as shown on the drawings. Contractor shall submit detailed shop drawings showing the exact location, details of installation of the valves/alarm in all respects.

Installation valve shall comprise of a cast iron body with gunmetal/stainless steel trim, and double seated clapper check valves, pressure gauges, test valve and orifice assembly and drain valve with pressure gauges, turbine water gong including all accessories necessary and required and as supplied by original equipment manufacturer and required for full and satisfactory performance of the system. A cast iron isolation valve with lock and chain at the inlet of the installation valve shall be provided.

### **Inspection and Test Valve Assembly**

Inspection and testing of the automatic starting of the sprinkler system shall be done by providing an assembly consisting of gunmetal/stainless steel valves, gunmetal/stainless steel sight glass, bye-pass valve and orifice assembly as per approved drawing.

### **Flow Switch**

Flow switch shall have a paddle made of flexible and sturdy material of the width to fit within the pipe bore. The terminal box shall be mounted over the paddle/ pipe through a connecting socket. The Switch shall be potential free in either N O or N C position as required. The switch shall be able to trip and make/break contact on the operation of a single sprinkler head. The terminal box shall have connections for wiring to the Annunciation Panel. The flow switch shall have connections for wiring the seat shall be of S.S to the Annunciation Panel. The flow switch shall have IP: 55 protections.

The flows switch shall work at a triggering threshold flow rate of 10 to 40 lpm. Further, it shall have a 'Retard' to compensate for line leakage or intermitted flows.

### **The Main Stop Valve**

These shall be of cast iron body of requisite size. When closed, these will shut off supply of water to the installation. A location plate must be fixed on the outside or an external wall, as near to the main stop valve as possible, bearing the words **SPRINKLER STOP VALVE INSIDE** on raised letters or other approved type letter. The word '**SPRINKLER STOP VALVE**' shall have letter height of at least 35mm and the word '**INSIDE**' shall be at least 25 mm in height. The words shall be painted white on black back ground.

All stop valves shall be right handed i.e. they shall be so constructed that in order to shut the valve the spindle shall turn from left to right. There shall be an indicator which will show whether the valve is open or shut.



## **Deluge Valve System**

Deluge system basically used for fire zone compartment/separation in basement. A Deluge System is a fixed fire protection system in which the pipe system is empty until the deluge valve operates to distribute pressurized water from open nozzles. Deluge systems are more complex than wet pipe and dry systems because they contain more components and equipment. The deluge valve is activated by operation of a fire detection system installed in the basement.

The deluge system can be activated by electrically through the use of a solenoid valve installed off the release line. But, in all cases, the deluge valve itself is activated hydraulically. When the detection device is activated, the deluge valve is tripped and water flows into the piping system, discharging through all spray nozzles.

Deluge valves shall be installed on the nozzles circuits as shown on the drawings. Contractor shall submit detailed shop drawings showing the exact location, details of deluge the valves/alarm in all respects. Contractor has to consider microprocessor based multi-hazard releasing control panel for use on deluge systems. The deluge valve & panel approved by Underwriters Laboratory listed, FM Global and complies with UL Standard 86. Control panel collation near deluge valve in a steel cabinet with removable door and key lock.

## **Pipes for Drainage:**

Sprinkler pipes shall be so installed that the system can be thoroughly drained. As far as possible all pipes shall be arranged to drain to the installation drain valve as shown in the drawing for ordinary hazard system.

In the case of basement & other areas where sprinkler pipe-work is below the installation drain valve & in other trapped points in the system, auxiliary valves of the following sizes shall be provided.

- a. 20 mm valves for pipes upto 50mm dia.
- b. 25 mm valves for 80mm dia pipe.
- c. 50 mm valves for pipes larger than 80mm dia.

## **7.2.4 Testing**

Entire sprinkler piping shall be confirming and tested in accordance with IS: 15105. Piping shall be tested with the sprinklers in position to a hydrostatic test pressure of 1.5 times the casing pressure of the pump and maintained for a period of 48 hours at the end of which there shall be no loss in pressure.

Test valves in each sprinkler installation shall be opened (with temporary drain connection) and the following observations recorded:

- a. Start up of jockey pump.
- b. Start up of sprinkler pump.
- c. Operation of water motor gong.
- d. Operation of flow switches in the appropriate branch.
- e. Operation of tamper switches for shut off valves.

All branches shall be tested and witnessed and attested by the Engineer in Charge. All the operating tests shall be carried out in the presence of any local authority, Fire Brigade or Insurance company.



### 7.2.5 Mode of Measurement

Sprinkler pumps and jockey pump with mounting frame, vibration mounts excluding concrete foundation shall be measured per unit.

Flow switches and tamper switches shall be measured per unit and excludes wiring to the Fire Alarm Panel, which shall form part of Fire Alarm Wiring.

Sprinklers shall be identified as pendant, sidewall, or concealed and paid for per unit.

For Piping refer section on Piping for Fire fighting.

Installation valve complete with test valve, orifice plate etc. shall be regarded as one unit.

Control Cabling from Pressure gauge panel to respective started shall be measured in running meter length and paid at unit rates.

Starter with isolator housed in M. S. box for each pump shall be measured as a unit and paid.

### 7.2.6 Approvals

The system shall have proper listing and/or approval from the following nationally recognized agencies:

|   |      |   |                                      |
|---|------|---|--------------------------------------|
| 1 | UL   | : | Underwriters Laboratories Inc        |
| 2 | FM   | : | Factory Mutual                       |
| 3 | NFPA | : | National Fire Protection Association |
| 4 | TAC  | : | Tariffs Advisory Committee           |
| 5 | CFO  | : | Chief Fire Brigade Officer           |

## 7.3 FIRE PUMPS

### 7.3.1 Scope of Work

Work under this section shall consist of furnishing all labour, materials, equipment and appliances necessary and required to completely install electrically operated and diesel engine driven pumps and as required by drawings and specified hereinafter or given in the schedule of rates.

The scope of work shall cover supply, installation, testing and commissioning of the fire fighting pumping system covering the following:

- a. Electrically operated hydrant and sprinkler pumps with motors.
- b. Diesel engine driven pumps with diesel engine, common base plates, coupling, coupling guard and accessories.
- c. Booster pump
- d. Jockey pump
- e. Pump motor
- f. Automatic starting system with all accessories, wiring and connections and pressure switches.
- g. Motor control centre.

- h. Annunciation system with all accessories wiring and connections.
- i. Pressure gauges with isolation valves and piping, bleed and block valves.
- j. Suction strainers and accessories.
- k. Vibration eliminator pads and foundation bolts.
- l. Leak-off drain shall be led to the nearest floor drain.

### 7.3.2 Standards

| IS Code   | Description                                                                   |
|-----------|-------------------------------------------------------------------------------|
| IS: 12469 | Specification for Pumps for Fire Fighting System                              |
| IS: 4691  | Degrees Of Protection Provided By Enclosure For Rotating Electrical Machinery |
| IS: 325   | Three-phase induction motors                                                  |
| IS: 10004 | Performance requirement of spark ignition engines                             |
| IS: 12615 | Energy Efficient Three-Phase Squirrel Cage Induction Motors                   |
| NFPA 20   | Standards for Installation of Stationary Pumps For Fire Protection            |
| IS: 4029  | Guide for Testing Three Phase Induction Motor.                                |
| IS: 15301 | Installation and maintenance of fire fighting pumps                           |
| IS: 5199  | Technical specification for centrifugal pumps                                 |
| FM Global | Pumps Standards                                                               |

### 7.3.3 General Requirements

Pumps shall be installed true to levels on suitable concrete foundations. Base plate shall be firmly fixed by properly grouted foundation bolts.

Pumps and motors shall be truly aligned by suitably instruments. Record of such alignment shall be furnished to the Project Manager.

All pump connections shall be standard flanged type with number of bolts as per relevant standard requirement for the working pressure. Companion flanges shall be provided with the pumps.

Manufacturers' instructions regarding installation, connections and commissioning shall be strictly followed.

Contractor shall provide necessary test certificates, type test certificates, performance curves and NPSH curves of the pumps from the manufacturer when called for. The contractor shall provide facilities to the Project Manager & Consultant for inspection of equipment during manufacturing and also to witness various tests at the manufacturer's works without any cost to the Project Manager or Consultant.

Seismic isolation and clamping for each pump and flexible connection on the suction as well as the discharge side shall be provided.

The contractor shall submit with this tender a list of recommended spare parts for three years of normal operation and quote the prices for the same as a separate submittal / annexure.

The motor shall have a minimum of 15% margin of power rating over the rated pump input power.

An automatic air release valve shall be provided to vent air from the pump. This valve shall be located at the highest point in the discharge line between the pump and the discharge check valve.

### **Pressure Switch**

The pressure switch shall be industrial type single pole double throw electric pressure Switch designed for starting or stopping of equipment when the pressure in the system drops or exceeds the pre- set limits . It shall comprise of a single pole change – over switch, below element assembly and differential spindle.

### **Pump sets**

Centrifugal, End suction, horizontal pump should be selected as per IS. Pump should have following specifications.

### **Materials of Construction**

Casing: Cast Iron

Impeller: Bronz IS: 318,Gr .LTBJ / JTB 2

Casing wearing: Cast iron

Shaft:Stainless steel

Shaft Sleeve:SS-410

Thrust Bearing Antifriction of Titling pad type

Shut up head should not exceed 120% of rated head. Pump shall not develop less than 65% of rated head at 150% of rated capacity. Pumps shall be provided with pressure gauge with isolation cock on the delivery side. In case of motor driven pump the motor rating should be adequate to drive the pump at 150% of rated discharge. The pump and its prime mover (Electric motor or Diesel Engine) shall comply with all the requirements of the Rules of Tariff Advisory Committee.

## **7.3.4 Main Fire Pumps**

### **General**

The electric fire pump shall be suitable for automatic operation complete with necessary electric motor and automatic starting gear, suitable for operation on 415 volts, 3 phase, 50 Hz. A.C. system. Both themotor and the pump shall be assembled on a common base plate, fabricated M.S. channel type or cast iron type.

### **Electric Driven**

Electrically driven pumps shall be provided with totally enclosed fan cooled induction Motors suitable for fire pumps with IP55 enclosure. Motors shall be at least equivalent to the horse power required to drive the pump at 150% of its rates discharge. The motors shall be wound for class F-insulation and windings shall be vaccum impregnated with heat and moisture resisting varnish, glass fiber insulated.

### **Drive**

The pump shall be direct driven by means of a flexible coupling. Coupling guard shall also be provided.

## **Fire Pump**

The fire pump shall be horizontally mounted multi-stage and multi-discharge, centrifugal type. It shall have a capacity to deliver 3200 lpm as specified and developing adequate heads so as to ensure a minimum pressure of 3.2 kg/sq.cm at the highest and the farthest outlet.

The pump shall be capable of giving a discharge of not less than 150 per cent of the rated discharge, at a head of not less than 65 per cent of the rated head. The shut off head shall be within 120 per cent of the rated head.

The pump casing shall be of cast iron to grade FG 200 to IS: 210 and parts like impeller, shaft sleeve, wearing ring etc. shall be of non-corrosive metal like bronze/brass/gun metal. The shaft shall be of stainless steel. Provision of mechanical seal shall also be made.

Bearings of the pump shall be effectively sealed to prevent loss of lubricant or entry of dust or water. The pump shall be provided with a plate indicating the suction lift, delivery head, discharge, speed and number of stages. The pump casing shall be designed to withstand 1.5 times the working pressure.

## **Motor**

The motor shall be squirrel cage A.C. induction type suitable for operation on 415 volts 3 phase 50 Hz. system. The motor shall be totally enclosed fan cooled type conforming to protection clause IP 55. The class of insulation shall be F. The synchronous speed shall be 1500 RPM as specified. The motor shall be rated for continuous duty and shall have a horse power rating necessary to drive the pump at 150 per cent of its rated discharge with at least 65 per cent rated head. The motor shall conform to I.S.325-1978.

## **Motor Starter**

The motor starter shall be as per detail in MCC. The unit shall include suitable current transformer and ammeter of suitable range on one line to indicate the current. The starter shall not incorporate under voltage, overload voltage trip overload or SPP.

The starter assembly shall be suitably integrated in the power and control panel for the wet riser system & sprinkler system.

### **7.3.5 Jockey Pump**

Jockey pump shall be installed in addition to the main pump set. The pressure setting for the pump(s) shall be such that it cuts in approximately at 0.35 Kg/cm<sup>2</sup> below the normal system pressure and cut out at normal system pressure. The main fire pump(s) shall be arranged to cut in approximately at 1.00 Kg/cm<sup>2</sup> below the normal system pressure and shall be capable only of manual shut down at churn pressure. The pumping arrangement shall also incorporate Jockey Pumps to take care of system losses. The capacity of the Jockey Pumps shall neither be more than 5 % of the installed pumping capacity nor less than 3 % thereof (with a minimum of 10.8 m<sup>3</sup>/hr.) unless the aggregate installed pumping capacity is in excess of 820 m<sup>3</sup>/hr, in which case the capacity of the Jockey Pump (s) shall be not less than 25 m<sup>3</sup>/hr plus 1 % of the installed pumping capacity in excess of 820 m<sup>3</sup>/hr. Installation of Jockey Pumps also helps to prevent hydraulic surges.

### **7.3.6 Engine for Engine Driven Pumps**

#### **General**

The diesel pump set shall be suitable for automatic operation complete with necessary automatic starting gear, for starting on wet battery system and shall be complete with all accessories. Both engine and pump shall be assembled on a common base plate.

## **Drive**

The pump shall be only direct driven by means of a flexible coupling. Coupling guard shall also be provided. The speed shall be 1500 RPM as specified.

## **Fire Pump**

The fire pump shall be horizontally mounted centrifugal multi stage. It shall have a capacity to deliver as specified and developing adequate head so as to ensure a minimum pressure of  $3.2 \text{ Kg/cm}^2$  at the highest and the farthest outlet. The pump shall be multi stage as specified. The pump shall be capable of giving a discharge of not less than 150% of the rated discharge at a head of not less than 65% of the rated head. The shut off head shall be within 120% of the rated head.

The pump casing shall be of cast iron to grade FG 200 to IS 210 and parts like impeller, shaft sleeves, wearing-ring etc. shall be of non-corrosive metal like bronze/brass/gun metal. The shaft shall be stainless steel. Provision of mechanical seal shall also be made.

The pump casing shall be designed to withstand 1.5 times the working pressure.

Bearing of pump shall be effectively sealed to prevent loss of lubricant or entry of dust or water.

## **Diesel Engine**

Engine Rating - The engine shall be cold starting type without the necessity of preliminary heating of the engine cylinders or combustion chamber (for example, by wicks, cartridge, heater, plugs etc.). The engine shall be multi cylinder/vertical 4 stroke cycle, air-cooled, diesel engine, developing suitable HP at the operating speed specified to drive the fire pump. Continuous capacity available for the load shall be exclusive of the power requirement of auxiliaries of the diesel engine, and the after correction for altitude, ambient temperature and humidity for the specified environmental conditions. This shall be at least 20% greater than the maximum HP required to drive the pump at its duty point. It shall also be capable of driving the pump as per CFO NOC. The engine shall be capable of continuous non-stop operation for 8 hours and major overhaul shall not be required before 3000 hours of operation. The engine shall have 10% overload capacity for one hour in any period of 12 hours continuous run. The engine shall accept full load within 15 seconds from the receipt of signal to start. The diesel engine shall conform to BS 649/IS 1601/IS 10002, all amended up to date.

## **Engine Accessories**

The engine shall be complete with the following accessories:

- a. Fly wheel dynamically balanced.
- b. Direct coupling for pump and coupling guard.
- c. Corrosion Resistor.
- d. Air cleaner.
- e. Fuel service tank support and fuel oil filter with necessary pipe work.
- f. Electrical starting battery (2 X 24 v).
- g. Exhaust silencer with necessary pipe work.
- h. Governor.
- i. Instrument panel housing all the gauges, including Tachometer, hour meter and starting switch with key (for manual starting).
- j. Necessary safety controls.

## **Fuel System**

The fuel shall be gravity fed from the engine fuel tank to the engine driven fuel pump. The engine fuel tank shall be mounted either over or adjacent to the engine itself or suitably wall mounted on bracket. The fuel filter shall be suitably located to permit easy servicing.

All fuel tubing to the engine shall be with copper, with flexible hose connections where required. Plastic tubing shall not be permitted.

The fuel tank shall be of welded steel construction (3 mm. thick) and of capacity sufficient to allow the engine to run on full load for at least 8 hours. The tank shall be complete with necessary wall mounted supports, level indicator (protected against mechanical injury) inlet, outlet, overflow connections and drain plug and piping to the engine fuel tank. The outlet shall be so located as to avoid entry of any sediment into the fuel line to the engine.

As semi rotary hand pump for filling the daily service tank together with hose pipe 5.00 m long with a foot valve etc. shall also form part of the scope of supply.

### **Lubricating Oil System**

Forced feed Lubricating Oil system shall be employed for positive lubrication. Necessary Lubricating oil filters shall be provided, located suitably for convenient servicing.

### **Starting System**

The starting system shall comprise necessary batteries (2x24v), 24 volts starter motor of adequate capacity and axle type gear to match with the toothed ring on the fly wheel. Bi metallic relay protection to protect starting motor from excessively long cranking runs suitably integrated with engine protection system shall be included within the scope of the work.

The capacity of the battery shall be suitable for meeting the needs of the starting system. The battery capacity shall be adequate for 10 consecutive starts without recharging with cold engine under full compression.

The scope shall cover all cabling, terminals, initial charging etc.

### **Exhaust System**

The exhaust system shall be complete with silencer suitable for outdoor installation, and silencer piping including bends and accessories needed for a run of 15.00 m from the engine manifold.(Adjustment rates for extra lengths shall also be given).The total back pressure shall not exceed the engine manufacture's recommendation. The exhaust piping shall be suitably supported.

### **Engine shut down mechanism**

This shall be auto/ manually operated and shall return automatically to the starting position after use.

### **Governing System**

The engine shall be provided with an adjustable governor to control the engine speed within 5% of its rated speed under all conditions of load up to full load. The governor shall be set to maintain rated pump speed at maximum pump load.

### **Engine Instrumentation**

Engine instrumentation shall include the following:-

- a. Lubricant oil pressure gauge.
- b. Lubricant oil temperature gauge.
- c. Water pressure gauge.
- d. Water temperature gauge.
- e. Tachometer.
- f. Hour meter.

The instrumentation panel shall be suitably resident mounted on the engine.

Engine Protection Devices- Following engine protection and automatic shut down facilities shall be provided:

- a. Low lubricant oil pressure.
- b. High cooling water temp.
- c. High lubricant oil temperature.
- d. Over speed shut down.

### **Pipe Work**

All pipe lines with fittings and accessories required shall be provided for fuel oil, lubricant oil and exhaust systems, copper piping of adequate sizes, shall be used for Lub.oil and fuel oil. M.S. piping will be permitted for exhaust.

### **Anti Vibration Mounting**

Suitable vibration mounting duly approved by Project Manager shall be employed for mounting the unit so as to minimize transmission of vibration to the structure. The isolation efficiency achievable shall be clearly indicated.

### **Battery Charger**

Necessary float and boost charger shall be incorporated in the control section of the power and control panel, to keep the battery in trim condition. Voltmeter to indicate the state of charge of the batteries shall be provided.

### **7.3.7 Fire pumps Accessories:**

The accessories for fire pump shall include but are not limited to the following:

- a. Controller
- b. Vertical-shaft turbine-type pump
- c. Column Pipe and line shaft
- d. Driver and accessories
- e. Surface of underground discharge head
- f. Flow meter or hose header and hose valves
- g. Suction strainer
- h. Automatic air-release valve and fittings
- i. Quality discharge pressure gauge
- j. Pressure-relief valve and waste cone when required
- k. Water-level indicator when required
- l. Pressure recorder
- m. Flexible connections for engine cooling water and fuel lines.
- n. Spare parts.

- o. Instruction and maintenance manual in local language.
- p. Discharge valve
- q. Hose-connection valve
- r. Discharge check valve
- s. All piping connections and fittings
- t. Suction screen to suit requirements
- u. Wiring and power connection for electric motor
- v. Pipe connections to steam turbine
- w. Cooling-water overflow connection for internal-combustion engines
- x. Flexible connections.
- y. Foot valve (for negative suction)
- z. Reducers on pump suction and discharge.

#### **7.3.8 Cooling System:**

The following systems are acceptable:

- a. Cooling by water from the discharge of fire pump (taken off prior to the pump discharge valve) direct into the engine cylinder jackets via a pressure reducing device to limit the applied pressure to a safe value as pacified by the engine manufacturer. The outlet connection from this system shall terminate at least 150 mm above the engine water outlet pipe and be directed into an open dish so that the discharge water is visible.
- b. A heat exchanger, the raw water being supplied from the fire pump discharge (taken off prior to the pump discharge valve) via a pressure-reducing device, if necessary, to limit the applied pressure to a safe value as specified by the engine manufacturer. The raw water outlet connection shall be so designed that the discharged water can be readily observed. The water in the closed circuit shall be circulated by means of an auxiliary pump driven from the engine and the capacity of the closed circuit shall not be less than that recommended by the engine manufacturer. If the auxiliary pump is belt driven there shall be a multiple belt so that should half the belts break, the remaining belts shall becapable of driving the pump.
- c. A frame or engine mounted air cooled radiator with a multiple fan belt driven from the engine. When half the belts are broken the remaining belts shall be capable of driving the fan. The water in the closed circuit shall be circulated by means of an auxiliary pump driven by the engine and the capacity of the closed circuit shall be not less than that recommended by the engine manufacturer.
- d. Direct air cooling of the engine by means of multiple belt driven fans. When half the belts are broken the remaining belts shall be capable of driving the fan.

In case of systems described (b) (c) & (d) above a failure actuated audio-visual alarm shall be incorporated.

#### **Air Filtration:**

The air intake shall be fitted with a filter of adequate size to prevent foreign matter entering the engine.

#### **7.3.9 Mounting, Coupling, and Alignment**

Mount the pump and driver securely to a solid foundation on a common base plate. Provide a foundation sufficiently substantial to form permanent and rigid support for the pump and driver base plate. Connect the pump and driver with a rigid coupling, flexible coupling, or flexible connecting shaft. Do not use all elastomeric (plastic) couplings. An all elastomeric coupling is one that relies solely on an elastomeric material for power



transmission. Examples of recommended couplings are: pin and bushing, jaw, disc, drive shaft, or steel-grid-type couplings where the drive components are metallic. Direct connection or “close-coupling” of the pump and driver is acceptable for electrically driven, in-line, vertically mounted, horizontal split case, and end-suction pumps. Align pumps and drivers on separately coupled-type pumps in accordance with the coupling and pump manufacturers’ specifications for locations in earthquake-prone areas.

#### **Exhaust System:**

The exhaust shall be fitted with a suitable silencer and the total backpressure shall not exceed the engine maker's recommendation. When the exhaust system rises above the engine, means shall be provided to prevent any condensate flowing into the engine.

#### **Engine Shut down Mechanism**

This shall be manually operated and return automatically to the starting position after use. **Fuel**

The engine fuel oil shall be of quality and grade specified by engine makers. There shall be kept on hand at all times sufficient fuel to run the engine on full load for six hours, in addition to that in the engine fuel tank.

#### **Fuel Tank**

The fuel tank shall be of welded steel constructed to relevant Indian or Foreign Standard for Mild Steel Drums. The tank shall be mounted above the engine fuel pump to give gravity feed unless otherwise recommended by the manufacturer. The tank shall be fitted with an indicator showing the level of the fuel in the tank. The capacity of the tank shall be sufficient to allow the engine to run on full load, which is as follows:

| <b>Class of Hazard</b> | <b>Capacity</b> |
|------------------------|-----------------|
| Light Hazard           | 2 Hours         |
| Ordinary Hazard        | 4 Hours         |
| High Hazard (A)        | 6 Hours         |
| High Hazard (B)        | 8 Hours         |

#### **7.3.10 Electric Motor**

The electric drive motor shall be squirrel cage induction conforming to IS 325 - 1996 and rated for continuous duty (S1). Motor shall have not less than class B insulation and minimum enclosure of IP22. The starter shall be air-cooled fully automatic star delta or autotransformer type. Starters shall conform to IS 8544 - 1977 and rated for AC-3 duty. Starter panel shall include an Ammeter with selector.

#### **7.3.11 Pump operation**

For all pump installations (including jockey pumps), each controller will have its own individual pressure sensing line. Connect the controller pressure-sensing line for each pump (including jockey pumps) between the pump’s discharge check valve and the discharge control valve. Ensure the line is made of a corrosion-resistant material (brass, copper or series-300 stainless steel pipe or tube and fittings) and has a minimum internal diameter of 1/2 in. (12.7 mm) nominal size. Do not install a shutoff valve in the pressure-sensing line. Valves that release water in the pressure sensing line to facilitate pump testing are acceptable.

For pressure switches with a high and low actuation settings, adjust the switch so the low adjustment setting initiates pump starting. Set the start pressure of the fire pump as close as possible to the expected no flow (churn) pressure developed by the fire pump to avoid water hammer.

### **7.3.12 Fire Pump Settings**

The fire pump system, when started by pressure drop, should be arranged as follows:

- a. The jockey pump stop point should equal the pump churn pressure plus the minimum static supply pressure.
- b. The jockey pump start point should be at least 0.68 bar (10 psi) less than the jockey pump stop point.
- c. The fire pump start point should be 0.34 bar (5 psi) less than the jockey pump start point. Use 0.68 bar (10 psi) increments for each additional pump.
- d. Where minimum run times are provided, the pump will continue to operate after attaining these pressures. The final pressures should not exceed the pressure rating of the system.
- e. Where the operating differential of pressure switches does not permit these settings, the settings should be as close as equipment will permit. The settings should be established by pressures observed on test gauges.

### **7.3.13 Mode of measurement**

All the pumps shall be measure in actual. All accessories require to fix the pump and make it to operate to satisfy the set require and project manager requirements. This shall include all the basic accessories like MS channel for fixing, anchor fasteners, earthing, supports for pipes and other accessories. It shall be include basic starters and cabling from isolator or panel to pumps.

## **7.4 FIRE EXTINGUISHERS**

### **7.4.1 Scope of Work**

Work under this section shall consist of furnishing all labour, materials, appliances and equipment necessary and required to install fire extinguishing hand appliances as per relevant specification of various authorities.

The scope of work shall cover supply, installation, testing and commissioning of the fire extinguishers system covering but not limited to the following:

- a. CO2 Fire Extinguishers
- b. Dry Chemical Extinguishers
- c. Mechanical Foam
- d. Water Based Fire Extinguishers
- e. Clean Agents

### **7.4.2 STANDRDS**

| IS Code  | Description                                                       |
|----------|-------------------------------------------------------------------|
| IS: 2097 | Specification for Foam Making Branch Pipe                         |
| IS: 4308 | Dry Chemical Powder for Fighting B and C Class Fires              |
| IS: 4861 | Specification for Dry Powder for Fighting Fires in Burning Metals |
| IS: 4947 | Specification for Gas Carriages for use in Fires Extinguishers    |

|              |                                                                                       |
|--------------|---------------------------------------------------------------------------------------|
| IS: 6234     | Portable Water Extinguishers Water Type                                               |
| IS: 6328     | Code of Practice for Design and installation of Fix Carbon Dioxide Fire Extinguishers |
| IS: 4861     | Specification for Dry Powder for Fighting Fires in Burning Metals                     |
| IS: 10204    | Specification for Portable Mechanical Foam Type                                       |
| NFPA 17 &17A | Dry & Wet chemical Extinguishing system                                               |
| NFPA 10      | Standards for portable fire extinguishers                                             |
| NFPA 11      | Low, medium and High expansion foam.                                                  |
| NFPA 12      | Carbon dioxide extinguishers                                                          |
| NFPA 2001    | Clean agent fire extinguishing system.                                                |

#### 7.4.3 General

In general Portable extinguishers shall be of deep drawn from cold rolled steel (Chromium Molybdenum alloy steel), center welded and pressure tested to twice the extinguishers' working pressure. Cylinders shall be externally coated with epoxy primer for maximum corrosion resistance. The water based extinguishers shall be internally coated with "performance polymer alloy" to prevent corrosion.

Hand appliances shall be installed in easily accessible locations with the brackets fixed to the wall by suitable anchor fasteners.

Each appliance shall be provided with an inspection card indicating the date of inspection, testing, change of charge and other relevant data.

All appliances shall be fixed in a true workmanlike manner truly vertical and at correct locations.

Distribution / installation of fire extinguisher to be in accordance to IS: 2190.

All the fire extinguishers shall have ISI certification marked and the selection of hand appliances shall be as follows:

| Class | Combustibles                                                                                    | Hand Appliances                                                                    |
|-------|-------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| A     | Fires in Ordinary combustibles (Wood, Vegetable fibres, rubber, plastics, Paper and the likes). | Gas expelled Water and Antifreeze type extinguishers and Water Buckets.            |
| B     | Fires in flammable liquids, paints, grease, solvents and the likes.                             | Chemical Extinguishers of Carbon dioxide type and Dry Powder type and Sand Buckets |
| C     | Fires in Gaseous substances under pressure and liquefied gases.                                 | Chemical Extinguishers of Carbon di oxide and Dry Powder type                      |
| D     | Fires in reactive chemicals, Active metals and the likes.                                       | Special type of Dry Powder, Extinguishers and sand buckets.                        |

## **Measurement**

Fire extinguishers shall be counted in numbers and include installation of all necessary items required as given in the specifications.

### **7.4.4 Types of Extinguishers**

#### **ABC Type Dry Powder Extinguisher**

The Extinguisher shall be filled with ABC grade 40, Mono Ammonium Phosphate 40% of IS 2171 from any approved manufacturer.

The capacity of the extinguisher when filled with Dry Chemical Powder (First filling) as per IS 4308, Part II, shall be 6 Kg +/-2% or 10 Kg +/- 3%.

The distribution of fire extinguishers to be as per IS 2190 – 1992.

It shall be operated upright, with a squeeze grip valve to control discharge. The plunger neck shall have a safety clip, fitted with a pin, to prevent accidental discharge. It shall be pressurized with Dry Nitrogen, as expellant. The Nitrogen to be charged at a pressure of 15 Kg/cm<sup>2</sup>

Body shall be of mild steel conforming to relevant IS Standards. The neck ring shall be also mild steel and welded to the body. The discharge valve body, shall be forged brass or leaded bronze, while the spindle, spring and siphon tube shall be of brass. The nozzle shall be of brass, while the hose shall be braided nylon. The body shall be cylindrical in shape, with the dish and dome welded to it. Sufficient space for Nitrogen gas shall be provided inside the body, above the powder filling.

The Neck Ring shall be externally threaded - the threading portion being 1.6 cm. The filler opening in the neck ring shall not less than 50 mm. Discharge nozzle shall be screwed to the hose. The design of the nozzle shall meet the performance requirement, so as to discharge at least 85% of contents upto a throw of 4 meters, continuously, at least for 15 seconds. The hose, forming part of discharge nozzle, shall be 500

- a. mm long, with 10 mm dia internally for 6 Kg capacity and 12 mm for 10 Kg capacity. It shall have a pressure gauge fitted to the valve assembly or the cylinder to indicate pressure available inside. The extinguisher shall be treated with anti-corrosive paint, and it shall be labelled with words ABC 2.5 cm long, within a triangle of 5 cm on each face. The extinguisher body and valve assembly shall withstand internal pressure of 30 Kg/cm<sup>2</sup> for a minimum period of 2 minutes. The pressure gauge shall be imported and suited for the purpose.

The Portable fire Extinguisher Dry Powder shall confirm IS:2171 9 (Third revision)

The Portable fire Extinguisher Carbon Dioxide type shall confirm IS:2878 (Third revision)

#### **Carbon Dioxide Extinguisher**

The Carbon Dioxide Extinguisher shall be as per IS: 15683

The body shall be constructed of seamless tube conforming to IS: 7285 and having a convex dome and flat base. Its dia shall be maximum 140 mm, and the overall height shall not exceed 720 mm.

The discharge mechanism shall be through a control valve conforming to IS: 3224. The internal siphon tube shall be of copper aluminium conforming to relevant specifications.

Hose Pipe shall be high pressure braided Rubber hose with a minimum burst pressure of 140 Kg/cm<sup>2</sup> and shall be approximately 1.0 meter in length having internal dia of 10 mm. The discharge horn shall be of high quality unbreakable plastic with gradually expanding shape, to convert liquid carbon dioxide into gas form. The hand grip of Discharge horn shall be insulated with Rubber of appropriate thickness.

The gas shall be conforming to IS:307 and shall be stored at about 85 Kg/cm<sup>2</sup>. The expansion ratio between stored liquid carbon dioxide to expanded gas shall be 1:9 times and the total discharge time (effective) shall be minimum 10 seconds and maximum 25 seconds.

The extinguisher shall fulfill the following test pressures:

- a. Cylinder: 236 Kg/cm<sup>2</sup>
- b. Control Valve: 125 Kg/cm<sup>2</sup>
- c. Burst Pressure of Hose: 140 Kg/cm<sup>2</sup> minimum

It shall be an Upright type. The cylinder, including the control valve and high pressure Discharge Hose must comply with relevant Statutory Regulations, and be approved by Chief Controller of Explosives, Nagpur and also bear IS marking.

The Extinguisher including components shall be IS marked.

#### **7.4.5 Inspection**

##### **Frequency**

Fire extinguishers shall be inspected when initially placed in service and thereafter at approximately 30-day intervals. Fire extinguishers shall be inspected, manually or by electronic monitoring, at more frequent intervals when circumstances require.

##### **Procedures**

Periodic inspection of fire extinguishers shall include a check of at least the following items:

- a. Location in designated place
- b. No obstruction to access or visibility
- c. Operating instructions on nameplate legible and facing outward
- d. Safety seals and tamper indicators not broken or missing
- e. Fullness determined by weighing or "hefting"
- f. Examination for obvious physical damage, corrosion, leakage, or clogged nozzle
- g. Pressure gauge reading or indicator in the operable range or position
- h. Condition of tires, wheels, carriage, hose, and nozzle checked (for wheeled units)

#### **7.4.6 Approvals**

The system shall have proper listing and/or approval from the following internationally recognized agencies:

|      |                                      |
|------|--------------------------------------|
| UL   | Underwriters Laboratories Inc        |
| FM   | Factory Mutual                       |
| NFPA | National Fire Protection Association |
| TAC  | Tariffs Advisory Committee           |
| CFO  | Chief Fire Brigade Officer           |

#### **7.4.7 Testing & commissioning**

This standard requires hydrostatic testing of pressure vessels used as fire extinguishers and specified components of fire extinguishers. Hydrostatic testing shall be performed by persons trained in pressure testing procedures and safeguards who have suitable testing equipment, facilities, and appropriate servicing manual(s) available. A hydrostatic test shall always include both an internal and external visual examination of the cylinder.

Hydrostatic testing shall be conducted using water or some other non-compressible fluid as the test medium. Air or other gases shall not be used as the sole medium for pressure testing. All air shall be vented prior to hydrostatic testing to prevent violent and dangerous failure of the cylinder.

#### **7.4.8 Mode of measurement**

All the extinguishers shall be measured as per actual numbers kept on floor. Supports and clamps extra shall be measured as per actual per extinguishers.

### **7.5 PIPING**

#### **7.5.1 Scope**

The scope of work covers, supply, laying, testing and commissioning of the entire piping system for the fire fighting installations which includes but is not limited to the following:

- a. Piping within pump room.
- b. Piping from pump room to hydrants and sprinklers in parking areas in basements/podium levels, if any, as per drawings.
- c. Piping from pump room to hydrants and sprinklers in upper floors as per drawings.
- d. Drain piping for sprinkler system.
- e. Any additional incidental piping which is not shown in drawings.

#### **7.5.2 Standards**

The following standards shall be applicable:

| <b>IS Code</b> | <b>Description</b>                        |
|----------------|-------------------------------------------|
| IS: 1239       | Mild Steel Tubes & Tubular and fittings   |
| IS: 1879       | Malleable iron fittings                   |
| IS: 778        | Gun Metal gate, globe and check valves    |
| IS: 1537       | Vertically cast iron double flanged pipes |
| IS: 7181       | Horizontally cast double flanged pipes    |
| NFPA 13        | Standard for sprinkler installation       |

#### **7.5.3 General Requirements**

All materials shall be of the best quality conforming to the specifications and subject to the approval of the Consultants.

Pipes shall be fixed in a manner as to provide easy accessibility for repair and maintenance and shall not cause obstruction in shafts, passages etc.

Pipes shall be securely fixed to walls and ceilings by suitable clamps and supports (galvanized after fabrication) at intervals specified. Only approved type of anchor fasteners shall be used for RCC slabs and walls / floors etc.

Valves and other appurtenances shall be so located that they are easily accessible for operations, repairs and maintenance.

Pipes and fittings shall be fixed truly vertical, horizontal or in slopes as required in a neat workman like manner.

Pipe accessories such as gauges, meters, control devices, etc. shall have the same working pressure rating as the associated pipe work. All pipe work shall be free from burrs, rust and scale and shall be cleaned before installation. All personnel engaged on welding operations must possess a certificate of competence issued by an acceptable / recognized authority.

#### **7.5.4 Types of Pipes**

GI heavy grade C class pipes as per IS: 1239 heavy grade (for pipes of sizes 150 mm N.B. and below) suitably lagged on the outside to prevent soil corrosion. GI pipes buried below ground shall also be suitably being lagged with 4 layers of 400 micron polythene sheet over 2 coats of Pykote/Coatek.

Pipelines up to 150 mm dia MS pipes as per IS: 1239, Part-II (heavy grade) while pipelines above 150 mm dia as per I.S.:3589.

All pipe clamps and supports shall be fabricated from MS steel sections and shall be factory galvanized before use at site. Welding of galvanized clamps and supports shall not be permitted.

Pipes shall be hung by means of expandable anchor fastener of approved make and design. The hangers and clamps shall be fastened by means of galvanized nuts and bolts. The size/diameter of the anchor fastener and the clamps shall be suitable to carry the weight of water filled pipe and dead load normally encountered.

Hangers and supports shall be thoroughly galvanized after fabrication. The selection and design of the hanger & support shall be capable of carrying the sum of all concurrently acting loads. They shall be designed to provide the required supporting effects and allow pipeline movements as necessary. All guides, anchor braces, dampener, expansion joint and structural steel to be attached to the building/structure trenches etc. shall be provided. Hangers and components for all piping shall be approved by the Consultants.

The piping system shall be tested for leakages at 2 times the operating pressure or 1.5 time shut-off pressure, whichever is highest including testing for water hammer effects.

Flanged joints shall be used for connections for vessels, equipment, flanged valves and also on two straight lengths of pipelines of strategic points to facilitate erection and subsequent maintenance work.

For pipes underground installation the pipes shall be buried at least one meter below ground level and shall have 230 mm x 230 mm masonry or concrete supports at least 300 mm high at 3m intervals. Masonry work to have plain cement concrete foundation (1 cement: 4 coarse sand : 8 stone aggregate) of size 380x380x75 thick resting on firm soil.

Mains below ground level shall be supported at regular intervals not exceeding 3.0 meters and shall be laid at least 2.0 meter away from the building.

#### **7.5.5 Piping Installation & Support**

Tender drawings indicate schematically the size and location of pipes. The Contractor, on the award of the work, shall prepare detailed shop drawings, showing the cross-sections, longitudinal sections, details of



fittings, locations of isolating and control valves, drain and air valves, and all pipe supports. He must keep in view the specific openings in buildings and other structure through which pipes are designed to pass.

Piping shall be properly supported on, or suspended from, on stands, clamps, hangers as specified and as required. The Contractor shall adequately design all the brackets, saddles, anchor, clamps and hangers, and be responsible for their structural stability.

Pipe work and fittings shall be supported by hangers or brackets so as to permit free expansion and contraction. Risers shall be supported at each floor with Galvanized steel clamps. To permit free movement of common piping support shall be from a common hanger bar fabricated from Galvanized steel sections.

The end of the steel rods shall be threaded and not welded to the threaded bolt.

All pipe work shall be carried out in a proper workman like manner, causing minimum disturbance to the existing services, buildings, roads and structure. The entire piping work shall be organised in consultation and coordination with other agencies work, so that area can be carried out in one stretch.

Cut-outs in the structural members for installing the various pipes area are indicated in the drawings. Contractor shall carefully examine the cut-outs provided and clearly point out wherever the cut-outs shown in the drawings, do not meet with the requirements, propose new cutouts as per requirement and get the same approved from the site in charge/consultant.

Pipe sleeves of diameter larger than the pipe passing through the same, shall be provided wherever pipes pass through walls and slab or any other structural member. The annular space between the pipe and the sleeve shall be filled with fiberglass and finished with retainer rings.

The contractor shall make sure that the clamps, brackets, saddles and hangers provided for pipe supports are adequate or as specified/approved by Consultants. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.

All pipes shall be accurately cut to the required sizes in accordance with relevant BIS codes and burrs removed before lying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reduces shall be used for the piping to drain freely. In other locations, concentric reduces may be used.

Automatic air valves shall be provided at all high points in the piping system for venting. All valves shall be of 15mm pipe size and shall be associated with an equal size gate valves.

Discharge from the air valves shall be piped through a pipe to the nearest drain or sump. All pipes shall be pitched towards drain points.

Pressure gauges shall be provided as shown on the approved drawings. Care shall be taken to protect pressure gauges during pressure testing.

#### **7.5.6 Pipe Fittings**

Pipe fittings mean tees, elbows, couplings, unions, flanges, reducers etc and all such connecting devices that are needed to complete the piping work in its totality.

Forged steel fittings OR D.I. Fittings of approved type with "V" groove for welded joints shall be used for pipes of all sizes.

Fabricated fittings shall not be permitted for pipes diameters 50mm and below.



When fabricated fittings are used, they shall be fabricated, welded in workshops. They shall be inspected by Project Manager before dispatch from the workshop. The welding procedures of the workshop should have been approved by the rules for sprinkler system and applicable to hydrant and sprinkler system. For

“T” connection, pipes shall be drilled and reamed. Cutting by gas or electrical welding shall not be permitted.

#### **7.5.7 Procedure for Pypkote/Coatek Application**

The pipe surface shall be cleaned by a wire brush before applying Pypkote.

Pypkote / Coatek primer shall be applied on pipes immediately after cleaning. This is to prevent any further accumulation of rust on the pipe. This is a cold applied primer and is applied by brush.

After the primer is applied on the pipe, it is allowed to dry for about 30 minutes till it becomes touch dry. Before adhering the tape to the pipe, it is advisable to gently heat the primer coated pipe by a run of LPG torch. Remove the bottom polyethylene from the tape & then heat bottom surface of the tape by LPG torch or any heat source & start wrapping the tape to the pipe by heating the primer coated pipe & by removing the bottom polyethylene from the tape before wrapping better adhesion between the tape & pipe is obtained. Overlaps are maintained with a minimum of 12.5 mm.

The tape is applied over the welded joints after the necessary welding & testing methods of the joints is completed. The procedure for application of tape shall be the same as bare pipe procedure. Overlaps on each side of the weld joints shall be 50 mm.

A final coat of White wash with water based cement paint is done immediately over the entire coated pipe.

#### **Wrapping Coating for underground pipes**

All underground piping shall be protected by coating and wrapping as per the following Procedure. The materials and workmanship shall in general confirm to IS:10221 or as directed by the Owner. **Cleaning** –The pipes shall be thoroughly cleaned by dust, rust, scales, oil, grease etc. By stiff wirebrush and scrappers. The surface shall be coated with the primer immediately after cleaning.

**Priming** –The primer shall be PYPKOTE / RUSTFIRE / CORPORATE under coat. The Manufacturers recommended procedure would be followed for applying the primer.

**Paste Application** –PYPKOTE–AW Paste / CORPORATE paste shall be applied to fill up uneven surfaces in order to ensure smoothness for subsequent wrapping with multi – layer tape.

**Tape wrapping** –the tape is to be wrapped while the second coat of primer is still tacky. Winding is to be done with 50% overlap so that the total thickness of 2.0 mm tape would become 4.0 mm. It should be ensured while wrapping that air bubbles are trapped. The ends of tape shall be secured with nylon binding to ensure that the tape doesn't get loosened while handling.

The total thickness including 2 coats of primer, 50% overlap of tape etc. Should not be less than 4.5 mm or as per manufacturer recommendations. The 'Holiday Test' is to be conducted for detecting any entrapped air or any other defect. The contractor is to arrange for the Holiday Test and to rectify the defects if found any.

#### **7.5.8 Jointing**

##### **Welded Joints**

Joints between MS pipes and fittings shall be made with the pipes and fittings having “V” groove and welded with electrical resistance welding in an approved manner. But welding without “V” groove shall not be permitted.

All joints in the pipe line with screwed fittings shall be seal welded after testing and the weld plus the adjoining portion shall be given two coats of zinc rich primer.

The welding procedure, types of electrodes etc. shall be in accordance with the following IS Specifications. Welding Procedures IS : 823, Welding Electrodes IS : 814, but of approved makes only Testing of Welders IS : 817.

#### **Flanged joints for Pipe Diameter above 65 mm**

Flanged joints with flanges conforming to IS: 6392 shall be provided on straight runs at intervals not exceeding 25m to 30 m on pipe having diameter of 65 mm dia and above, as directed by the Project Manager.

For jointing all types of valves, appurtenances, pumps, connections with other type of pipes, to water tanks and other places necessary and as required for good engineering practice and as shown/noted on the drawings.

Flanges shall be with GI bolts and nuts and 3mm insertion gasket of natural rubber conforming to IS: 11149.

#### **Union Joints for Pipe Diameter up to 50**

Approved type of dismountable unions shall be provided on pipe lines up to 50 mm, in locations similar to those specified for flanges.

### **7.5.9 Hydrant and Sprinkler Mains**

#### **External Hydrant Mains**

G.I. Class C pipes and fittings or as per CFO NOC shall be used for hydrant pipes to be laid in trenches. The widths & depths of the trenches for different diameters of the pipes shall be as follows:

| Pipe Diameter    | Trench Width | Trench Depth |
|------------------|--------------|--------------|
| 15 mm TO 50 mm   | 300 mm       | 600 mm       |
| 65 mm TO 100 mm  | 450 mm       | 750 mm       |
| 150 mm TO 300 mm | 600 mm       | 1000 mm      |

At joints the trench width shall be widened wherever necessary. The work of excavation & refilling shall be done true to line & gradient.

The pipes shall be coated of 4 mm thick anti-corrosive bituminous material of approved quality. The pipe shall be laid on a 75 mm thick layer of sand & filled with sand up to 15 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be disposed off as directed.

In case of bigger diameter (65 mm & above) pipes where the pressure is very high, thrust blocks of cement concrete 1:2:4: (1 cement: 2 coarse sand: 4 grade stone aggregate of 20 mm nominal size) shall be constructed on all bends to transmit the hydraulic thrust without impairing the ground & spreading it over a sufficient area.

CI double flanged pipes of Class B pipes shall be used where pipe diameter exceeding 300 mm and system pressure exceeding 7 kg/cm<sup>2</sup>. Cast iron pipes shall use only cast iron fittings conforming to IS 1538. All flange

joints shall be designed for a pressure rating of 20 kg/cm<sup>2</sup> and joints shall use high tensile bolts with 3mm fiber reinforced Teflon gasket. Pipes shall be given one coat of hot bitumen before being laid in position.

Ductile iron or mild steel pipes, when laid underground, shall be protected against corrosion by two coats of hot bitumen and two wraps of fiberglass tissue over the entire length including fittings & valves. Fittings shall be weld able wrought iron fittings suitable for butt welding and 10% of the welded joints shall be radio graphically tested and found in order. The welded joints shall be randomly selected for testing in consultation with the Engineer. All flanges shall be slip-on welded flanges to IS 6392 with a 3mm fiber-reinforced Teflon gasket and rated for 20 kg/cm<sup>2</sup>.

Underground mains shall be laid not less than 1000 mm below the ground level and shall be at least 2m away from the building face and supported on concrete pedestals at every 3.5 m and held on with galvanized iron clamps. Concrete thrust anchors shall be provided at all bends and tees as shown on drawing and as directed. All excavation for pipe laying shall be carried out with sufficient width for making proper joints. Backfilling shall be done only after the piping is hydro-statically pressure tested. Piping shall be constantly kept clean till tested.

Piping laid above ground shall be supported on cement concrete (1:3:6) pedestals raising the bottom of the pipe at least 150 mm over the ground level and held to the pedestals with galvanized clamps. Pedestals shall be made at 3.0 m centre to centre and as shown on drawings. Cement concrete 1:3:6 thrust anchors shall be provided at all tee-off points and change of direction as shown on drawings and as required. Pipes fixed on walls and ceiling shall have galvanized steel brackets.

#### **Internal Hydrant and Sprinkler Mains**

All internal pipes shall be, unless otherwise specified, heavy quality galvanized mild steel tubes to IS 1239 using wrought G.I steel heavy duty screwed fittings. Flanges shall be provided to mate with valves and other equipment and shall conform to IS 6392. Flanges shall be screwed type. Flanges shall be able to withstand a minimum pressure of 20 kg/cm<sup>2</sup>.

All fittings for hydrant and sprinkler piping shall be extra heavy duty galvanized M.S. screwed type suitable for the pressure encountered in hydrant and sprinkler piping. All tap-offs from vertical riser to floor piping shall have flanged connections for pipe diameter above 65 mm and union connections for pipes up to 50 mm diameter. Contractors to consider the required pressure rating for the pipes & valves as mentioned in drawings and DBR. All flow switches shall have flanges or unions on both sides.

All pipes shall be of approved make and best quality without rust marks. Pipes and fittings shall be fixed in a manner as to provide easy accessibility for repair and maintenance and shall not cause obstruction in shafts, passages etc. Pipes and fittings shall be fixed truly vertical horizontal or in slopes as required in a neat workmanship manner. Pipes shall be securely fixed to walls and ceilings by suitable supports at intervals specified. Only approved type of anchor fasteners shall be used for RCC ceiling and walls.

All pipes shall be adequately supported from ceiling or walls through structural supports fabricated from mild steel structural's e.g. rods, channels, angles and flats generally as shown on drawings. Fasteners shall be shear type anchor fasteners in concrete walls and ceilings and wrought steel spikes of at least 75mm long in brick walls. All pipes supports shall be painted with 1 coats of red oxide primer and two coats of black enamel paint.

All low point loops in the piping shall be provided with 25mm gun metal full-way valves with rising spindle for drain in the system. All valves shall have screwed brass caps. Likewise 25mm gun metal air vents shall be provided at all high point loops to prevent air-locking.

All piping shall have flanged joints at about 25m intervals to facilitate easy maintenance.

### **Exhaust Piping for Engine Driven Pump**

A flexible connection with a section of stainless steel, seamless or welded corrugated (not interlocked), not less than 305 mm (12 in.) in length shall be made between the engine exhaust outlet and exhaust pipe. The exhaust pipe shall not be smaller in diameter than the engine exhaust outlet and shall be as short as possible. The exhaust pipe shall be covered with high-temperature insulation or otherwise guarded to protect personnel from injury. The exhaust pipe and muffler, if used, shall be suitable for the use intended, and the exhaust back pressure shall not exceed the engine manufacturer's recommendations. Exhaust pipes shall be installed with clearances of at least 229 mm (9 in.) to combustible materials.

Exhaust pipes passing directly through combustible roofs shall be guarded at the point of passage by ventilated metal thimbles that extend not less than 229 mm (9 in.) above and 229 mm (9 in.) below roof construction and are at least 152 mm (6 in.) larger in diameter than the exhaust pipe. Pipes passing directly through combustible walls or partitions shall be guarded at the point of passage by one of the following methods:

- a. Metal ventilated thimbles not less than 305 mm (12 in.) larger in diameter than the exhaust pipe
- b. Metal or burned clay thimbles built in brickwork or other approved materials providing not less than 203 mm (8 in.) of insulation between the thimble and construction material.

Exhaust systems shall terminate outside the structure at a point where hot gases, sparks, or products of combustion will discharge to a safe location.

### **7.5.10 Pipe Support**

All pipe supports shall be as per NFPA 13 section 9.0. Hangers shall be designed to support five times the weight of the water-filled pipe plus 250 lb (114 kg) at each point of piping support. The spacing between hangers shall not exceed the value given for the type of pipe as indicated in below Tables. Hanger components shall be ferrous. Detailed calculations shall be submitted, when required by the reviewing authority, showing stresses developed in hangers, piping, and fittings and safety factors allowed. Maximum distance between supports

#### **Pipe support spacing schedule :-**

| Sr.No | Pipe Dia (mm) | Maximum support spacing (Mtr.) | Maximum size of hanger rod (mm) |
|-------|---------------|--------------------------------|---------------------------------|
| i)    | 15 mm         | 2.0                            | 10.0                            |
| ii)   | 20 mm         | 2.0                            | 10.0                            |
| iii)  | 25 mm         | 2.0                            | 10.0                            |
| iv)   | 32 mm         | 2.0                            | 10.0                            |
| v)    | 40 mm         | 2.0                            | 10.0                            |
| vi)   | 50 mm         | 3.0                            | 10.0                            |

| Sr.No | Pipe Dia (mm) | Maximum support spacing (Mtr.) | Maximum size of hanger rod (mm) |
|-------|---------------|--------------------------------|---------------------------------|
| vii)  | 65 mm         | 3.0                            | 13.0                            |
| viii) | 80 mm         | 3.0                            | 13.0                            |
| ix)   | 100 mm        | 4.5                            | 16.0                            |
| x)    | 125 mm        | 4.5                            | 16.0                            |
| xi)   | 150 mm        | 5.5                            | 22.0                            |
| xii)  | 200 mm        | 5.5                            | 22.0                            |

#### **7.5.11 Painting**

All exposed piping for firefighting shall be distinctly painted 'Fire Red' shade 536 to IS:5-1978. Pipes shall first receive two coats of red oxide primer uniformly applied and two coats of oil paint applied thereafter. All pipes supports shall be painted black as specified for support & clamps. Painting shall be done only after completion of fabrication work and testing.

The instructions of paint manufacture shall be followed as far as possible otherwise the work is to be done as directed by the client.

All cleaning materials, brushes, tools and tackles, painting, material etc. Shall be arranged By the contractor at site in sufficient quantity.

All rust, dust shall scales, welding slag or any other foreign materials shall be removed fully So that a clean and dry surface is obtained prior to painting. Any other oily containment shall be removed by use of a solvent prior to surface cleaning.

First coat of primer paint must be applied by brush on dry clean surface immediately or in any Case within 3 hours of such cleaning.

Primer paint – one coat (minimum thickness 100 microns) self – priming epoxy mastic.

Production areas – 2 coats ( thickness minimum 50 microns each ) of epoxy paint ,fire Red shade as per IS : 5

#### **7.5.12 Testing & commissioning**

All piping after installation shall be tested for a hydrostatic test pressure of 20 Kg/cm<sup>2</sup> maintained for 24 hours. All joints and valves shall be checked for leaks and rectified and retested. During testing all valves except drain & air valves shall be kept fully open.

#### **7.5.13 Mode of measurement**

All external piping shall be measured along the centre line of the pipe and paid per unit length and shall include:

- a. All pipes & fittings
- b. Bituminous coating

All internal piping shall be measured similarly but shall include for the pipe supports and clamps instead of excavation.

All valves, air valves, drain valves together with flanges or tail pieces shall be measured per unit.

All excavation and concrete supports and thrust blocks shall be measured as per drawing and paid for per cum.

## **7.6 MEDIUM VOLTAGE CABLING**

### **7.6.1 Scope**

The scope of work shall cover supply, laying, connecting, testing and commissioning of low and medium voltage power and control cabling. Contractor to fulfill all the requirement mentioned in the electrical technical specification of latest revision.

### **7.6.2 Standards**

The following standards and rules shall be applicable:

IS: 1554 Parts I & II

### **7.6.3 Cables**

All cables shall be 1100 Volt grade PVC insulated, sheathed with or without steel armouring as specified and with an outer PVC protective sheath. All cables shall have Flame Retardant, Low Smoke Sheath (FRLS) and meet, ASTM norms for the smoke density and Oxygen Index norms. Cables shall have high conductivity stranded aluminum or copper conductors and cores color coded to the Indian Standards.

All cables shall be new without any kinks or visible damage. The manufacturers name, insulating material, conductor size and voltage class shall be marked on the surface of the cable at every 600mm centers.

### **7.6.4 Installation**

Cables shall be laid in the routes marked in the drawings. Where the route is not marked, the contractor shall mark it out on the drawings and also on the site and obtain the approval of the Architect/Consultant before laying the cable. Procurement of cables shall be on the basis of actual site measurements and the quantities shown in the schedule of work shall be regarded as a guide only.

Cables, running indoors shall be laid on walls, ceiling, inside shafts or trenches. Single cables laid shall be fixed directly to walls or ceiling and supported at not more than 500 mm. Where number of cables is run, necessary perforated cable trays shall be provided wherever shown. Perforated cable trays shall be mild steel or Aluminum as specified in the schedule of work. Perforated trays shall not be directly suspended but supported on mild steel frame work. Cables laid in built-up trenches shall be on steel supports. Plastic identification tags shall be provided at every 30m.

Cables shall be bent to a radius not less than 12 (twelve) times the overall diameter of the cable or in accordance with the manufacturer's recommendations whichever is higher.

In the case of cables buried directly in ground, the cable route shall be parallel or perpendicular to roadways, walls etc. Cables shall be laid on an excavated, graded trench, over a sand or soft earth cushion to provide protection against abrasion. Cables shall be protected with brick or cement tiles. Width of excavated trenches shall be as per drawings. Backfill over buried cables shall be with a minimum earth cover of 600 mm. The cables shall be provided with cable markers at every 35 meters and at all loop points.

All cables shall be full runs from panel to panel without any joints or splices. Cables shall be identified at end terminations indicating the feeder number and the Panel/Distribution board from where it is being laid. All cable terminations for conductors up to 4 sq.mm may be insertion type and all higher sizes shall have tinned copper compression lugs. Cable terminations shall have necessary brass glands and all joints shall be double compression type whether so specified or not. The end terminations shall be insulated with a minimum of six half-lapped layers of PVC tape. Cable armouring shall be earthed at both ends.

#### **7.6.5 Testing**

MV cables shall be tested upon installation with a 500V Meggar and the following readings established:

- a. Continuity on all phases
- b. Insulation Resistance between conductors all conductors and ground

All test readings shall be recorded and shall form part of the completion documentation.

#### **7.6.6 Mode of measurement**

Cable will be measured on the basis of a common rate per unit length indoor or outdoor and shall include the following:

For cables laid indoors:

- a. Cables and clamps  
Installation, commissioning and testing
- b. Cable marking

For cable buried underground:

- a. Cables and protective bricks & tiles
- b. Installation, commissioning & testing
- c. Cable markers

Cable trays/racks will be measured on the basis of unit length for individual sizes and shall include

- a. Aluminum perforated tray M.S framing supporting the Aluminum tray.
- b. Installation and painting in 2 coats of black bituminous paint on one coat of red oxide primer.

Each cable termination will be measured as one unit for payment. Certain cable sizes are grouped together and rates shall be furnished against each group. The item shall include the following:

- a. Lugs, glands, bolts, nuts
- b. All jointing materials
- c. Installations, testing and commissioning
- d. Earthing the glands

For cables buried under ground excavation shall be paid for additionally for the following per unit volume:

- a. Excavation and back filling
- b. 6" Soft Earth Cushioning below and above cable

The cost of laying protective tiles shall be part of cable cost as stated above.

## **7.7 M V SWITCHGEARS & POWER PANELS**

### **7.7.1 Scope**

These specifications cover design, manufacture, test and supply Power Control Centres (PCC), Motor Control Centres (MCC), Power Distribution Boards (PDB), Lighting Distribution Boards (LDB) and similar fabricated switch boards and panels.

### **7.7.2 Standards**

All materials, equipment's, wires and accessories etc. shall generally conform to relevant Indian Standards. Manufacturer shall bring to the notice of Purchasers in case any of the equipment's not conforming to Indian Standards are being used by him.

Some of the standards are listed below for ready reference:

| <b>IS Code</b> | <b>Description</b>                          |
|----------------|---------------------------------------------|
| IS: 2147       | Degree of Protection of enclosures.         |
| IS: 3202       | Code of Practice for Climate proofing.      |
| IS: 375        | Marking arrangement of bus bars and wiring. |
| IS: 4047       | Heavy Duty air-break switches.              |
| IS: 2208       | HRC fuses                                   |
| IS: 2959       | AC Contactors                               |
| IS: 1822       | AC motor starters                           |
| IS: 2075       | Current Transformers                        |
| IS: 3156       | Voltage Transformers                        |
| IS: 1248       | Indicated meters                            |
| IS: 722        | AC Electricity Metes.                       |
| IS: 694        | PVC insulated wires.                        |

### **7.7.3 Climate Conditions**

Switchboards shall generally withstand ambient temperature of 45 deg. C with peak of 50 deg. C for two hours. Humidity will be max. 91%. Boards will be installed in a closed room of 4 meters high and one meter bigger all round the board.



If atmosphere is conducive to corrosion, special care at gasket ting, hardware and paint shall be taken.

#### **7.7.4 Electrical Supply System**

Supply system is derived from 440 volts, 3 phase, 4 wire secondary of a power transformer, with neutral solidly grounded.

Single phase supply shall be derived from one of the three phases and neutral, at 240 volts.

#### **7.7.5 Fabrication**

Boards shall be fabricated out of 2 mm thick (14 SWG) CRCA sheet steel. Larger sections may be used where required. Unsupported span of sheet steel of main framework and door shall not exceed 1 meter in any direction. If unavoidable it shall be braced by folded channels for rigidity and strength.

After fabrication, boards shall be treated for rust removal, welding scales removed, degreased, treated in seven tank process OR by three in one solution, subject to prior approval from Client. Free standing boards shall have min. 75 mm high Channel frame. This frame shall be used for grouting/ bolting of boards on floor. Bolt holes on the bottom of the Channel frame shall be accessible by removing gland plate at corresponding locations. Holes shall be 14 diameters for M12 hardware. Main board can be welded/ bolted to this Channel frame.

For wall mounting boards, external fixing lugs with 14 holes for M12 bolts shall be provided. Those shall not project out when seen from front.

Cable alleys shall have removable gland-plates. Slip holes shall be drilled according to the cable sizes and gland sizes. Extra entries and entries of spare feeders shall be suitably plugged.

#### **7.7.6 Painting**

All steel surfaces shall be thoroughly cleaned, welding scales removed, degreased, treated in seven tank process or with three-in-one solution. Painting shall be powder coating type with color shade as specified in specific requirements. For control panels/ desks, inside surface shall be painted off white. For fire protection panels, fire red paint of shade as 538 as per IS: 5 shall be used.

#### **7.7.7 Construction**

All the Panels shall be suitable of Form-3b type. Boards shall be of compartmental design, modular construction, unless specified otherwise, every components shall be fully covered from all sides. Equipment mounting plate shall be easily removable along with components and wiring. When removed, live bus-bars shall not be accessible.

Modules shall be fixed, semi draw-out or fully draw-out as mentioned in specific requirements. In all alternatives isolator shall be interlocked with the door opening, when ELMCB is implied replacing isolator, a flexible shaft operated by stay put type push button on door shall be used to press 'trip/test' knob on ELMCB. Isolator incoming terminals shall be fully shrouded to avoid accidental contact after door is opened.

Requirements of semi-draw-out and fully draw-out feeders are described elsewhere.

Doors shall be adequately hinged on one side. dust-tight and vermin-proof, door closing knobs sufficiently and ensure dust tightness.

Non deteriorating gaskets shall be provided to make it shall be key operated cam-type, to compress the gasket

Gaskets shall also be provided between shipping sections and all joints. Bus-bar compartments shall be fully shrouded.

Cable compartments shall have clear opening more than 250 mm, excluding bends of sheets, gaskets etc. knobs of the covers shall have captive washers and guide spool for easy alignment with the fixed nut.

Boards shall be flush fronted, single front or double front, with specific requirements of back access/ dead against wall feature.

Lifting hooks shall be provided for each shipping section, giving due consideration to centre of gravity of the Cubical. Hooks, if removable, shall leave no opening retaining property of dust tight.

#### **7.7.8 Bus-Bars**

Bus-bars shall be of electrolytic copper as specified. Current density shall not exceed 1.2 Amps/ sq.mm. For copper. (or as specified in specific requirements ) Vendor can use higher current density, if thinner sections of bus-bars are used with proper spacing and configuration.

Temperature rise in bus-bars shall not exceed 45 deg above ambient of 45 deg C.

Bus-bars sleeve is optional. Black mat finish of bus-bars is preferred for better heat dissipation.

Bus-bars shall withstand short-circuit capacity as mentioned. Number and spacing of supports shall be designed accordingly.

Tapping of bus-bars shall have contact surface at least four times the cross-section of tapping. Cross section of the risers/ tapping shall be rated for 150% of summated capacity of the switches on that section.

Bimetallic joints shall be avoided as far as possible. If provided, copper surfaces shall be tinned or coated with thin film of corrosion inhibiting compound or provided with bimetal plate.

#### **7.7.9 Components**

##### **Air Circuit Breaker**

ACB shall be air break, draw-out/ non-draw-out type and modular in construction. The ACB shall be suitable for operational voltage of 440V, 50Hz supply system.

The air break circuit breaker shall be three/four pole, manual/motorized operation, draw out type of circuit breaker as specified with a stored energy closing mechanism, integral spring charging handle, status indicators (closed, open and tripped), close and trip push buttons and provision for pad-locking in open position.

The ACB shall have trip free mechanism which prevents the operating mechanism from interfering with the tripping or opening action.

It shall have CT operated microprocessor based release providing overload, short time delay short circuit, instantaneous short circuit, earth fault protection with following settings.

$L' : 0.4 - 1x I_n$  (settable)

$'S' : 1.25 - 12x I_n$ , & Time delay  $'ts'$ : up to 400ms (both settable)

$'I' : >15 x I_n$

$'G' : 20 - 60\% x I_n$  & Time delay  $'tg'$  100ms-500ms (both settable)

Separate fault indications shall be provided on release for LSIG trips. On line self test facility, without need of secondary injection, shall be available on the release for release health check-up.

- a. The ACB shall be fully rated for 50oC ambient temperature.
- b. Castell key lock if asked for shall be provided on the ACB itself. It should be possible to remove castell key only when breakers is in OFF condition.
- c. All the vital accessories like Shunt, Motor, under voltage shall be accessible from the front and should not need removing of the breaker from its panel for the addition at site.
- d. Physical contact wear indicator shall be provided to indicate the erosion of the contacts.
- e. It shall have shunt trip coil for remote tripping as per operating voltage specified. Closing and trip coil shall operate satisfactorily under the following conditions of supply voltage variation:
- f. Closing coils - 85% to 110% of rated voltage.
- g. Trip coils - 70% to 110% of rated voltage.
- h. The draw out design of the circuit breaker shall have three positions – 'SERVICE', 'TEST' and 'ISOLATE'. Position indicator shall be provided on the panel to indicate the position of the circuit breaker trolley viz. 'ISOLATE', 'TEST' and 'SERVICE'.
- i. Two set of auxiliary NO and NC contact blocks shall be available wired up to terminal blocks.
- j. Adequate number of contacts shall be provided to have remote annunciation of the breaker feeders:

Breaker 'ON'

Breaker 'OFF'

Breaker 'TRIP'

Breaker 'Service'

Breaker 'Test'

### **Operating Mechanism of ACB**

Circuit breakers shall be provided with power operated mechanism of the motor wound spring charging stored energy type with provision for emergency manual charging facility.

For electrically operated ACBs closing of circuit breaker shall automatically initiate recharging of springs and the motor shall be automatically decoupled when the emergency manual charging handle is coupled. The mechanism shall make one complete closing operation once the switch is operated, even though the control switch is released before the closing operation is complete, provided that there is no counter trips impulse.

Circuit breakers shall be provided with all necessary interlocks including the following:

- a. It shall not be possible to plug-in a closed circuit breaker (in ON condition), or to draw out a circuit breaker in the closed position.
- b. It shall not be possible to operate a circuit breaker unless it is in the fully plugged-in, test, or fully isolated position.

### **Moulded Case Circuit Breaker**

The MCCB shall be 3 pole / 4 pole as the need be. In case of 4 pole MCCB, the 4th pole shall be 100% rated. The MCCB shall be available in fixed version. It shall be possible to convert the MCCB from fixed to plug in/draw-out version. The MCCB shall be manually operated. It shall be possible to convert the MCCB from manually operated to motorized MCCB and vice-versa. Moulded case circuit breakers (MCCB) shall have Thermal magnetic/Microprocessor-based release with overload, short circuit & earth fault protection, as

specified. The release shall have communication in future if specified. The MCCB shall be suitable for adapting accessories, such as auxiliary contact block, extended terminal cover & phase barrier etc. MCCBs shall indicate its suitability for isolation and this should appear clearly with the symbol as specified in standard IS 13947/IEC 60947.

The input and output terminals of the MCCB unit shall be extended and separated so that aluminum cables of given sizes can be easily terminated in the panel.

The MCCB shall be provided with front drive mechanism with door interlock with interlock defeating facility.

The MCCB shall be provided with variable range operating time on short circuit (LSI).

The MCCB shall be provided with auxiliary contact block.

The MCCB shall be fully rated for 50°C ambient temperature.

### **Switch Fuse Unit**

The SDFs should conform to the requirements of IEC 60947-1 and IEC 60947-3 and also to IS 13947-1 and IS 13947-3. The life of SDF should be very high i.e. 25000 operations up to 160A, 20000 operation for current ratings up to 400A and 15000 operation for all ratings above 400A.

The SDFs should be available from 20A to 800A and SD from 63A to 1600A. The SDFs should be available in DP, TPN and FP (with Switched Neutral) for optimization in selection. The SDFs should be compatible for all types of Fuses such as DIN, BS and Cylindrical. The SDFs should have isolable neutral which should be rated for 100% i.e. same as main poles of SDF. The SDFs should be "Suitable for isolation" and should clearly display with the necessary symbol in accordance with standards IS 13947. SDFs up to 160A should have provision of Padlocking in the basic switch. The SDF shall have a rotary handle suitable for door mounting. This handle shall be provided with door interlock and defeat, padlock and defeat facility. Operating handle should have distinctly marked position for ON and OFF.

The shaft connecting rotary hand should be of telescopic type i.e. it should allow user to readily using it for varying panel depth.

The SDF should have been tested for Type II coordination along with fuse and contactor /Overload relay combination. There should be a published chart of type-II selection by the manufacturer.

The terminal of SDF should be suitable for termination of Aluminum bus bars and lugs. The terminal size for SDFs rated up to 63A should be 15mm, up to 125A it should be 20mm, up to 315A it should be 30mm and for 400A SDF terminal size should be 40mm. For ratings more than 400A terminal size should be 55mm.

The SDF should have Positive OFF indicator. This indicator should be directly coupled to the position of the moving contacts.

The SDF should come in IP20 execution i.e. Fuse cover, Terminal Cover and Neutral Cover should come with SDF as standard.

There should be a provision of interlocking the fuse cover on the SDF such that user should not be able to remove fuse cover when SDF is in ON position. This interlocking facility should be supplied with SDF as standard.

The SDFs should be supplied with 5 nos. phase barriers up to current rating 160A and 4 Phase barriers up to current rating 800A as standard. This is to ensure that phase barriers not only prevent phase to phase short circuit but also prevent access to live parts from two sides of the SDF.

The SDF should have self cleaning moving roller contacts to ensure high switching life.

The SDF should be suitable for mounting at 900 in the vertical plane.

There should be provision in the SDF for installing fuse monitoring system. This should be a standard feature of the product.

### **Motor Protection Circuit Breaker**

Motor starter shall be of Direct ON LINE (DOL), Automatic Star Delta type or variable frequency drive type as 'specified'. Star delta starters shall be provided including and above 12.5 HP.

The contactor – MPCB combination shall be type tested for type-2 co-ordination at 50 kA. The MPCB shall sense the overload faults; however the tripping shall be by the contactor only. MPCB shall trip only on short circuit faults.

Apart from MPCB above DOL starter shall have one number and star delta starter shall have three numbers TP contactor suitable for AC-3 duty and electronic timer in star delta starter.

Apart from MPCB above DOL starter shall have one number and star delta starter shall have three numbers TP contactor suitable for AC-3 duty and electronic timer in star delta starter.

The MPCB shall be fully rated for 50oC ambient temperature.

Each starter shall have auto/manual switch for selection & vendor shall provide potential free contact to give status of following: -

Auto or Manual selection

On-Off - Trip

In case required auxiliary contact may be provided & this potential free contact shall be wired up to terminal.

### **Contactors**

Contactors shall be suitable for uninterrupted duty as defined in latest edition of IS: 13947-4. Contactors shall be of full voltage, direct online, air break, single throw, electromagnetic type. Operating coils of all contactors shall be suitable for operation on specified control voltage.

### **Miniature Circuit Breaker**

Miniature circuit breaker shall comply with IS-8828-1996/IEC 60898-1995.

Miniature circuit breakers shall be quick make and break type for 230/415 VAC, 50Hz application with magnetic thermal release for over current and short circuit protection.

The breaking capacity shall minimum be 10 KA at 415 VAC. MCBs shall be DIN mounted. The MCB shall be Current Limiting be type (Class – 3).

MCBs shall be classified (B, C, D ref IS standard) as per their Tripping Characteristic curves defined by the manufacturer.

The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP and TPN miniature circuit breakers shall have a common trip bar independent to the external operating handle.

### **Residual Current Circuit Breaker**

RCCB shall comply with IS-12640-1996/IEC 61008.

These shall work on the principle of core balance transformer.

In a fault-free system, the magnetizing effects of the conductors through which current is flowing cancel each other out for the summation current transformer as, in accordance with Kirchhoff's current law, the sum of all currents is zero. There is no residual magnetic field left that could induce a voltage in the secondary winding. The unbalanced current shall generate a voltage in the secondary winding, which then uses the release and the breaker mechanism to switch off the electrical circuit.

RCCB shall be current operated independent of the line voltage; current sensitivity shall be of 30 mA at 240/415 volts.

The moving contacts of the phases shall be mounted on a common bridge actuated by a rugged toggle mechanism. Hence the closing / opening of all the three phases shall occur simultaneously.

The neutral moving contact shall be so mounted on the common bridge that at time of closing the neutral shall make contact first before the phases and at the time of opening the neutral shall break last after allowing the phases to open first.

Test button shall be provided to test the residual current protective device. Pressing the test button generates an artificial residual current - the residual current protective device must trip.

Due to the use of electronic components in household appliances and industrial plants, insulation faults can also cause residual currents that are not AC residual currents to flow through residual current protective devices, even in the case of devices with ground terminals. Hence, Residual current protective devices that trips for both sinusoidal AC residual currents and pulsating DC residual currents (type A) shall be provided.

Note: All components like MCB, RCCB, RCBO etc. shall be offered with an ISI marking. The manufacturer (through the bidder) has to submit the valid BIS license certificate at the time of offer submission.

Bimetal relays shall be a combination of overload and single phasing preventer. Those shall be hand reset type. For current ratings 100A & above, CT operated relays shall be used. Long starting or saturating CT type BMR shall be used when called for.

Indicating lamps shall be rated for low watts, having ballast resistor to drop 30% voltage, and suitable colored lenses spreading glow in all directions. Timers shall be channel mounted electronic /pneumatic with range as specified.

#### **7.7.10 Metering & Accessories**

Current transformers shall be provided with ratio, VA burden and accuracy class as per single line diagram or specific requirements.

Those shall be epoxy/ resign cast with secondary terminals mounted on the body. Loose hanging secondary leads are not acceptable. If provided, those shall be terminated on a terminal block nearby and wiring neatly dressed.

Potential transformers shall be double wound with ratio, VA burden & accuracy class as per SLD or specific requirements. Primary and secondary fuses shall be provided as per rating.

Control transformers and motor winding heater transformers shall also be double wound having regulation less than 2%. Only primary side fuses are considered adequate.

Ammeters shall be MISC type, suppressed scale for motor feeders, movement located in one corner for maximum scale length, other details as per specifications. Alternatively, digital type instruments shall be provided, if specifically called for.

Voltmeters shall be MISC type square pattern, with movement located in one corner. Usual Voltage range shall be broadly expanded. E.g. For 0-500 V voltmeter 350-450 volts range shall be wide spread.

Wattmeter and power-factor meters shall be three phase, four wire, three element, calibrated for CT ratio and PT ratio as shown in SLD.

Frequency meter shall be vibrating rid type or digital type. Pointer type meter shall be provided, when called for. Any additional metering covering KWH meters, DC meters, etc. shall be as shown in SLD.

### **Wiring Ferrules and Terminals**

Wires shall be PVC insulated 660 volts grade with coding as per IS 375.

### **Power Wires**

Color coded R,Y,B, Black; or grey with colored sleeves at both ends, size to suit current rating with current density not more than 2 Amp per sq.mm. Size & type of lugs shall suit equipment termination & shall be of crimping type; tinned copper.

### **Control Wires**

Color coding

- = Grey or black AC 1.5 sq.mm multi-strand.
- = Red wires for DC circuits.
- = Different colors for voltages other than above.
- = Different colors for voltage when used for.

Two incomers and one bus-coupler, inter-panel wiring shall be red for incomer 1, Yellow for bus coupler, and blue for incomer 2 or prefixed with the breaker designation.

For current transformers secondary, minimum 2.5 mm<sup>2</sup> flexible copper wires shall be used. All wires on doors shall be multi-strand flexible. Wiring shall be terminated with tinned copper; PVC sleeved crimping lugs, type to suit the terminals of equipments at each end. Ferrules shall be yellow, Mel grip type, correctly fitting on outer diameter of wires.

Ferrules shall read towards end termination. Ferrules '6' and '9' should not be single used. However, may be used single when prefixed by letter e.g. K6, J9.

Method of ferruling, described in IS 375, shall be followed. Equi-potential ferruling method shall be followed.

Terminals shall be Elmex make, shrouded type, size to suit the wiring. Miniature version of terminals is not acceptable. When more than one wire is to be terminated two terminals with fixed type shorting link shall be provided. This is applicable for outgoing cable connections as well. Such linked terminals shall bear same number.

All outgoing cable terminals shall be Elmex shrouding type CST up to 10 sq.mm. Bolted type connections with crimping lugs shall be provided for 16 mm<sup>2</sup> and above. In case data regarding outgoing cables is not



furnished, vendor shall assume cable size as 1 amp per mm<sup>2</sup> terminated with crimping type lug of that size. e.g. 250 Amps switch-fuse unit outgoing connection shall be done by 1 No. 240 mm<sup>2</sup> or 2 nos. 120 mm<sup>2</sup> cables in parallel.

No un-shrouded live terminals shall be installed in Cable alley.

Minimum spacing of 150 mm shall be provided between gland-plate and terminal strip up to 50 terminals in control panel. For terminals more than 50, space shall be increased to 200 mm to accommodate incoming cables. Clearance between two rows of terminals shall not be less than 100mm. This shall be especially applicable to Control desks/common control panels. Barrier Plate shall be provided after every 10 (Ten) terminals to avoid parallax.

All C.T. Secondary terminals shall have 2 Nos. 4 mm<sup>2</sup> terminals, shorted with link, per C.T. to function as C.T. shorting/ test terminals.

Control terminals, receiving potential from other sources shall be red or painted red. Corresponding wiring shall also be red for fixed type of feeders.

#### **7.7.11 Miscellaneous**

Nameplates on all feeders feeder shall be rear engraved Perspex with white letters on black background. Two name plates on each feeder shall be provided, one reading feeder number and other reading equipment reference and description for which the feeder is designated. e.g. Feeder Name Plates 4 F3 and equipment reference nameplate

'P 103-- COOLING WATER PUMP', shall be independent.

All similar name plates shall have some fixing screw dimension for interchangeability.

Isolator ON-OFF nameplates shall be provided.

Caution Live terminals stickers in red to be provided at incomers/ other source of supply. Also bus-bar chamber covers shall be affixed with such name plates.

Any special caution boards inviting attention of operator shall be white letters on red background. (E.g. Fire pump feeders, maintenance supply feeders tapped before breaker, auto changeover feeders etc)

440 volts caution stickers with skull and bones, shall be affixed on incomers, bus-couplers and side faces of panels.

All hardware shall be passivity M.S. complete with plain and spring washers. Head shall be hexagonal with screwdriver slot. End of bolt shall be conical to serve as automatic guide and alignment. Captive washers shall also be supplied. Bolts up to M12 shall have screw driver slot also.

Accessories to be supplied with board:

- a. Grouting bolts.
- b. Fuse pullers – 2 nos.
- c. Circuit breaker operating handle (S)
- d. Touch-up paint (100 cc)
- e. Blocking plugs for gland entries/ slip-holes.
- f. 10% door fixing knobs & gland plate fixing hardware.
- g. Lamp grip – 2 Nos.
- h. Blanking plates for short supplied meters/ relays.
- i. Panel to panel coupling gasket & bolts. Corresponding bus-bar coupling hardware.



#### **7.7.12 Ingress Protection (IP):**

Degree of protection for indoor location shall be minimum IP 52.

All doors and openings should be provided with neoprene gaskets to prevent dust entry. All cables alley should be provided with space heaters with thermostat to prevent moisture entry and condensation inside the panel.

#### **7.7.13 Earthing**

Continuous earth-bus shall be provided all along the panel. Joints at coupling faces shall be lap type with minimum two bolts.

Size and material shall be designed to withstand ground fault for 1 second for given fault level.

All hinged doors shall be provided with fully welded boss and connected to earth bus by flexible. Color coding for earth wires & bus bars shall be green or green with yellow tracing. All metal parts shall be ensured for earth continuity.

### **7.8 FIRE DETECTION & ALARM SYSTEM**

#### **7.8.1 General Description**

The fire alarm system will be of the analogue addressable type and networked with a personal computer terminal to display a graphical representation of the fire alarm system installed at IBMS Room. The graphical display terminal (s) will be located within the IBMS (BMS, FAS & SAS) Control Room.

The fire alarm system shall include furnishing, installation, and connection of the Analog/Addressable Microprocessor based LCD/LED Fire Alarm Control Panel consisting of system cabinet(s), main chassis with power supply, stand-by batteries, optional city tie/reverse polarity module, optional relay modules, detection and signaling devices, and any auxiliary modules, remote annunciator assemblies, and miscellaneous peripheral devices to form a complete coordinated system ready for operation.

The fire alarm system will be configured to allow sequenced (phased) evacuation of the centre following initial investigation by the centre staff.

The main networked fire alarm panel will be located in IBMS ROOM with the repeater panels located at areas as required by IT FACILITY HEAD.

Initiating loops and signaling circuits in each loop shall not exceed 80 percent of capacity. Layout of initiating loops shall follow the logical layout of the building by floor or section.

The minimum coverage of detection devices shall include public corridors, storage rooms, electrical and telecommunications rooms. All field devices shall be labeled with loop or circuit and device number.

The system and all associated equipment shall be fully approved and listed by the following agency and regulatory controls:

- a. Must comply with applicable National, State, and/or local Building code recognized at time of installation.
- b. Must comply with NFPA 101 70, 72 fire alarm installation standard recognized at time of installation.
- c. Installation must comply with requirements of Local Authority Having Jurisdiction.

Auxiliary power supply systems shall meet all NFPA 72 standards, including requirements for supervision, location, and accessibility. Battery system shall be sized to provide 24 hours of supervision and then provide 10 minutes operation of all signaling devices. System shall have common keyed locks with fire alarm system control panel.

The fire alarm system shall interface with the AHU, Lift, sprinkler, smoke ventilation (fire strategy), Stairwell pressurization, VESDA system, and Burglar alarm system, access control system, parking management system, gate automation and public address zones.

RS-232 shall be used for connection to modems/ fiber-optic modems. Network Card: There shall be four (4) versions of the Network Card:

- a. Standard Version
- b. Port 1 RS-232 Port 2 Standard
- c. Port 1 Standard, Port 2 RS-232
- d. RS-232 only

Standard communications shall be used for direct wiring between units.

Point by point graphic identification and annunciation of all initiating devices shown on floor plans shall be provided.

#### **7.8.2 Interface with other system:**

- a. AHU/VFD – through hard wired signals to shut down incase of fire signal
- b. Stairwell pressurization - through hard wired signals
- c. Fire Suppression System – through hard wired signals
- d. Security system – through hard wired signals to unlock the door in case of fire signal.
- e. Lift - through hard wired signals.
- f. Other Electrical system - through hard wired signals.
- g. Building Automation and Management System – through hard wired PLC System.

#### **7.8.3 Fire Alarm System Components & Technical Specifications**

Fire Alarm System will consist of the following

Microprocessor based intelligent fire alarm control panel Graphical user interface software

Analog Addressable high performance optical smoke and heat sensors

Analog Addressable Laser Smoke detector

Analog Addressable Manual Pull Points

Analog Addressable Sounder, sounder cum strobes and directional sounder

Analog Addressable control modules/Output Modules

Analog Addressable input modules/Monitor Modules Short Circuit Isolators

Repeater panel/Network Repeater Panel Operator interface units

Battery Standby

#### **7.8.4 Fire alarm control panel (FACP)**

The distributed Intelligent Fire Alarm Control Panel (FACP) shall function as fully stand-alone panel. FACP shall have its own microprocessor, software and memory and should be listed under UL. Each loop shall be capable of handling minimum 125 detectors and 125 modules or more.

The memory data for panel configuration and operation shall reside in non-volatile memory (EEPROM). Removal of the board shall not cause loss of memory.

FACPs shall supervise detection circuits and shall generate an alarm in case of abnormal condition.

FACPs shall provide general-purpose inputs for monitoring such functions as low battery or AC power failure. FACPs shall provide tamper protection and commendable outputs, which can operate relays or logic level devices. Output commands shall take any of, but not limited to, maintained command, Momentary Command, Alarm Follow, or Alarm latch as required. Any relay in the FACP, which is intended to be removable, shall be supervised against removal.

Smoke detectors shall be powered using the FACP-based smoke detection circuits. FACPs shall provide for resetting smoke detectors, fault-isolation and sensor loop operation. It shall be possible to mix different fire devices within the same FACP to optimize field wiring.

FACPs shall provide monitoring and control of one floor or area or for multiple floors or areas.

FACPs shall meet the following requirements to assure the integrity and reliability of the system.

The FACP shall be UL listed independently as a fire alarm control panel.

FACP electronics shall be contained in an enclosure made of minimum 16gauge sheet steel. Access to FACP switches and electronics shall be by key-lock. Usage of no other tools should be required.

All hardware and software to allow the FACP configuration and operation to be changed shall be provided. Memory data shall be contained in non-volatile memory (EEPROM).

Alarm verification with field-adjustable time for individual smoke detector shall be provided. During the alarm verification, the panel shall retard the alarm until the end of the period. If the alarm is only a transient smoke alarm, the panel shall automatically reset the alarm. Only a verified alarm shall initiate the alarm sequence for the software zone (Logical Point Group) or point. Final time setting shall be as per approval of the fire authorities. When alarm verification is being performed on a smoke detector, the action shall be printed on the listed printer(s).

160 characters LCD display at the FACP shall be provided to indicate point in alarm or trouble. In such systems, means for manually scanning the points in trouble shall be provided and a trouble and alarm LED shall be used to indicate that there are points in alarm/trouble. The alarm/trouble LED shall only extinguish when all alarm/troubles are cleared from the loop.

It shall be possible to command test, reset and alarm silence from the FACP.

FACP switches shall allow authorized personnel to accomplish the following, independent of the central console:

Initiate a general alarm condition.

Silence the local audible alarm.

It shall be possible to acknowledge (Silence the local FACP audible without silencing the alarm indicating devices (hooters).

Reset all zones (Logical Point Group) / points, after all initiating devices have returned to normal.

Perform a complete operational test of the microprocessor and memory with a visual indication with each board.

Test all panel LEDs for proper operation without causing a change in the condition of any zone (Logical Point Group)

Walk Test

Software zones / loops shall be circuited and protected by Fault Isolation Modules which are provided along with all detector / devices.

Intelligent Smoke sensors shall report sensed levels in analog form.

Monitor modules shall be provided to monitor and address contact-type input devices.

The FACP shall be able to set dual alarms threshold for occupied and unoccupied periods. During unoccupied period, the alarm threshold shall automatically be lowered to facilitate quicker response. In addition, the FACP shall further process all analog values for pre-alarm limits to

Any time sensor value transitions beyond the secondary and higher limit value, an alarm initiation and report shall be issued.

Limits and sensor values shall be displayed, modifiable, and reported in decimal values.

The FACP shall have Drift Compensation facility to compensate for environment. The FACP shall have the ability to recalibrate Pre-alarm and Alarm limits if required, after comparing each sensor's operating characteristics with the set sensitivity. This should be carried out at least once in every 24 hours. FACP should annunciate trouble conditions when sensor(s) is beyond compensation range (excessively dirty sensor).

FACP shall have real-time clock to prevent loss of time and date in case of failure of power supplies.

The display on FACP shall provide indication for AC Power, System Alarm, System Trouble/Security Alarm, Display

Trouble and Signal Silence.

Minimum two different password levels will be provided to prevent unauthorized System control or programming.

Operator control switches for Signal Silence, lamp Test, Reset, System Test and Acknowledge shall be provided.

The FACP should be truly field programmable. This would mean that in the event of change of any logic, detector / zone sequence alteration, the operator can initiate these by use of the alpha-numeric keys on the FACP panel to reconfigure the above parameters. Panels, which require external programming devices to perform the above function, will not be acceptable.

Power supply unit of FACP shall have following characters:

The main power supply shall be 230 VAC + / - 10%, 50 Hz + /-1% and shall in turn provide all necessary power of the FACP.

It shall provide a battery charger for 24 hours for standby power using dual-rate charging technique for fast battery recharge.

It shall provide a very low frequency sweep earth fault detect circuit, capable of detecting earth faults on sensitive addressable modules.

It shall be power-limiting using Positive Temperature Coefficient (PTC) resistor.

It shall provide indication for battery voltage and charging current.

For ease of service, all wiring terminal blocks shall be plug-in type and shall have sufficient capacity for 18 to 12 AWG wire termination. Fixed terminal blocks shall not be acceptable.

#### Reports

The system shall provide the operator with system reports that give detailed description of the status of system parameters for corrective action, or for preventative maintenance programs. The system shall provide these reports via the main LCD, and shall be capable of being printed on any system printer

The system shall provide a report that gives a sensitivity listing of all detectors that have less than 75% environmental compensation remaining. The system shall provide a report that provides a sensitivity (% Obscuration per foot) listing of any particular detector.

The system shall provide a report that gives a listing of the sensitivity of all of the detectors on any given panel in the system, or any given analog/addressable device loop within any given panel.

The system shall provide a report that gives a chronological listing of up to the last 1740 system events.

The system shall provide a listing of all of the firmware revision listings for all of the installed network components in the system.

The FACP shall have HARDWARE compatible for BMS integration. The protocols supported by integration hardware shall be LONWORKS / BACnet / MODbus / JBUS / RS485 or any other open protocol.

#### **7.8.5 Repeater Panel**

The remote annunciator / repeater panel shall have 80-characters Liquid Crystal Display.

The repeater panel shall mimic all display information from the host FACP and the other FACP's on the network.

The repeater panel shall have control buttons for System Acknowledge, Signal Silence, Drill and Reset with enable key.

The repeater panel shall have status LED's for Power, Alarm, Trouble, Supervisory, and Alarm Silenced.

No programming shall be required.

Shall display device type identifiers, individual point alarm, trouble or supervisory, zone and custom alpha labels, Time and date display field.

Up to 32 remote annunciators connections per FACP shall be possible.

It should be possible to connect the remote annunciator /repeater panel, 2KM away from the main FACP

The repeater panel shall have local sounder with alarm and trouble resound.

#### **7.8.6 Intelligent Addressable Photoelectric Smoke Detectors**

Smoke detectors shall be microprocessor based, intelligent and addressable devices, and shall connect with two wires to one of the Fire Alarm Control Panel loops. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density. The detectors shall be ceiling mounted type and shall include a twist-lock base.

The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be activated remotely on command from the control panel.

The detectors shall provide address-setting by automatic polling. Systems using binary jumpers or DIP switches to set the detector address are also acceptable. The detectors shall also store an internal identifying code, which the control panel shall use to identify the type of detector.

The detectors shall provide dual alarm and power LED's. Both LED's shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel. Both LED's may be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. An output connection shall also be provided in the base to connect an external remote alarm LED.

Using software in the FACP, the detectors shall compensate for dust accumulation and other slow environmental changes, which may affect their performance. The detectors shall be listed by.

The area covered by each smoke detector shall be as per IS-2189.

#### **7.8.7 Intelligent Addressable Multi Criteria Detectors**

Multi criteria detectors shall be microprocessor based, intelligent and addressable devices, and shall connect with two wires to one of the Fire Alarm Control Panel loops.

The detectors shall integrate photoelectric (light-scattering) principal to measure smoke density and rate of rise heat sensing technology.

The detectors shall be ceiling mounted type and shall include a twist-lock base

The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be activated remotely on command from the control panel.

The detectors shall provide address-setting by automatic polling. Systems which use binary jumpers or DIP switches to set the detector address are also acceptable. The detectors shall also store an internal identifying code, which the control panel shall use to identify the type of detector.

The detectors shall provide dual alarm and power LED's. Both LED's shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel. Both LED's may be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. An output connection shall also be provided in the base to connect an external remote alarm LED.

The detector shall continually monitor any changes in sensitivity due to the environmental affects of dirt, smoke, temperature, aging and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC hand-held programming tool

Using software in the FACP, the detectors shall compensate for dust accumulation and other slow environmental changes, which may affect their performance. The detectors shall be listed by.

The area covered by each smoke detector shall be as per IS-2189.

#### **7.8.8 Intelligent Thermal (Heat) Detectors**

Thermal detectors shall be intelligent and addressable devices, and shall connect with two wires to one of the Fire Alarm Control Panel loops.

The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be activated remotely on command from the control panel.

It shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm. The integral microprocessor shall determine if an alarm condition exists and initiate an alarm based on the analysis of the data. Systems using central intelligence for alarm decisions shall not be acceptable. The detectors shall be ceiling-mounted type.

The detector shall use combined technology of rate of rise and fixed temperature type of detection

The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated remotely on command from the control panel.

The detectors shall provide address-setting by automatic polling. Systems which use binary jumpers or DIP switches to set the address shall not be acceptable.

The detectors shall provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions. In certain applications, LEDs may be selected to be polled without flashing through system programming. Both LEDs may be placed into steady illumination by the control panel, indicating that an alarm condition has been detected.

An output connection shall be provided in the base to connect an external remote alarm LED.

#### **7.8.9 Addressable Manual Call Stations (Pull Station Type)**

Each MCP shall transmit wiring information to the controller regarding its location with respect to other devices on the circuit.

The MCP shall permanently store programmable address; Addresses are downloaded from a PC, or the Program/Service Tool. The MCP's with switches or dials for address setting is also acceptable.

All decisions shall be made at the MCP allowing lower communication speed while substantially improving control panel response time.

Manual stations shall be constructed of high impact LEXAN sheet with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters.

Stations shall be suitable for surface mounting, or semi-flush mounting. And shall be installed not less than 3 ½ ft (1.1 m) and not more than 4 ½ ft (1.37 m) above floor level unless otherwise specified by applicable building codes.

#### **7.8.10 Hooters cum Strobes**

This Shall get enabled with the external control module



The audio output shall be adjustable, the tones shall be temporal or continuous type, the high setting output shall be 98 dBA and Low setting output shall be 94 dBA, Sound level of each sounder shall be at least 90 dBA measured at 10 feet from the device.

Shall support Power Saver technology which lowers in-rush current and reduces operating current, significantly reducing system power supply and battery requirements.

Shall be UL 1971-listed as signaling devices for the hearing impaired and UL 1638-listed as protective visual signaling appliances.

Sound pressure level shall be at least 15 dBA above the average ambient sound level or 5 dBA above the maximum sound level having duration of at least 60 seconds, whichever is greater, measured 4 to 5 ft (1.2m to 1.5 m) above the floor in the occupiable area.

The strobe should have smooth light distribution pattern without the spikes and voids, the entire coverage area receives consistent illumination from the strobe flash.

The flash rate of strobe shall not exceed two flashes per second (2 Hz) nor be less than one flash every second (1 Hz) throughout the listed voltage range of the appliance.

#### **7.8.11 Control Module**

Each module shall transmit wiring information to the controller regarding its location with respect to other devices on the circuit.

The CM shall permanently store programmable address; Addresses are downloaded from a PC, or the Program/Service Tool. The CM's with switches or dials for address setting is also acceptable.

All decisions shall be made at the module allowing lower communication speed while substantially improving control panel response time.

The Control Module shall provide supervised monitoring of wiring to load devices that require an external power supply to operate, such as horns, strobes, or bells. The CM shall also be used to integrate with PA system and transmit the fire message using PA speakers in event of fire. The CM shall also be used for overriding the access door status providing unrestricted exit path for evacuation in the event of fire.

Upon command from the control panel, the control module shall disconnect the supervision and connect the external power supply across the load device.

The disconnection of the supervision shall provide a positive indication to the panel that the control relay actually turned on.

The external power supply shall always be relay isolated from the communication loop, so that a trouble condition on the power supply shall never interfere with the rest of the system.

Full analog measurement of the supervised wiring shall be transmitted back to the panel and shall be used to detect impedance changes or other special test functions.

#### **7.8.12 Relay Module**

Each module shall transmit wiring information to the controller regarding its location with respect to other devices on the circuit.



The RM shall permanently store programmable address; Addresses are downloaded from a PC, or the Program/Service Tool. The RM's with switches or dials for address setting is also acceptable.

All decisions shall be made at the module allowing lower communication speed while substantially improving control panel response time.

The relay module shall be used for tripping AHU's, run staircase pressurization fans and running ventilation fans in smoke evacuation mode.

The relay shall be energisable from voltage source of 230 VAC

The relay shall have red LED, which shall illuminate when the coil is energized

The relay module shall be UL approved

The relay module shall be designed for 10,00,000 mechanical operation

#### **7.8.13 Monitor Module**

Each module shall transmit wiring information to the controller regarding its location with respect to other devices on the circuit.

The MM shall permanently store programmable address; Addresses are downloaded from a PC, or the Program/Service Tool. The MM's with switches or dials for address setting is also acceptable.

All decisions shall be made at the module allowing lower communication speed while substantially improving control panel response time.

The monitor module shall be used for monitoring potential free contacts.

#### **7.8.14 Other Devices**

**Fault Isolator:** Fault-isolation of fire zones (Logical Point Group) / circuitmodules shall be provided to enable part of a fault-tolerant loop to continue operating when a short occurs in the loop. Detectors with built in fault isolators are also acceptable.

**Response Indicator:** In addition to built-in response indicator of each detector, Secondary response indicator of LED type shall be provided outside the rooms, AFCD or wherever asked for by the Consultant, for indication of fire through detector in the room.

#### **7.8.15 Sequence of Operation**

When a fire alarm condition is detected by one of the system initiating devices, the following shall occur:

All automatic programs assigned to the alarm point shall be executed and the associated indicating devices and relays activated.

The System Alarm on appropriate unit will indicate an alert condition.

The corresponding zone(s) in alert alarm will be indicated

Second stage operation shall occur when a key is inserted into the key-operated switch of any manual pull station causing all fire alarm speakers/bells to sound the general alarm (evacuation) at a rate of 120 strokes per minute throughout the building.

If the fire alarm condition is not acknowledged at the unit within five (5) minutes of the sounding of the first stage alarm, the fire alarm system shall automatically indicate a second stage alarm causing all bells in the building to sound the general alarm (evacuation) throughout the building. Activation of the second stage shall be identified at the operator's workstation.

Evacuation message to be relayed using public address system.

Activate all control by event functions related to the alarm

Send signal to U.L. Certified monitoring central station ( not applicable currently however if required in future)

Air-conditioning Equipment to automatically shutdown

Lifts to be grounded

Fan systems, i.e., shutdown, exhaust and pressurization operations to be initiated.

Doors with hold open devices shall be signaled to release

Access controlled doors, turnstiles; barriers shall be released to open.

When a trouble condition is detected by one of the system initiating or indicating circuits, the following functions shall immediately occur:

System Trouble will be indicated on the unit and system annunciator(s).

A local trouble-sounding device in the unit and annunciator shall be activated. This sound shall be distinct from the alarm sound.

The trouble for the corresponding initiating or indicating circuit shall be indicated on the unit.

The appropriate message will appear on the LCD display.

#### **7.8.16 Cabling**

Loop Cable

The cable shall be ISI Certified

The cable color shall be preferably RED

The cable shall be 2Cx1.5 sq.mm (minimum), twisted shield, FRLS type, armoured double insulated copper cable of standard make.

If the system manufacturer recommendation for cable is different than the above specification, then cable specification shall be considered as per system manufacturer recommendation.

**Note: The system should be commissioned by trained certified engineer from the system manufacturer and the certification shall be provided for the consultant / client scrutiny or inspection before the commissioning.**

### **7.9 APPROVED MAKES OF MATERIAL**

#### **7.9.1 General**

Contractor shall use the material of Supplier(s) as indicated below unless specified otherwise in BOQ or prior approval from the Employer. All materials to be used shall be on the approved list.

The Contractor shall ensure the correct selection of the supplier(s) meeting the specifications and application duties. Before placing order for procurement, the material samples shall be verified for its suitability to the specification and application duty. However in case Employer, whose decision will be final and binding on both parties, considers that the supplier(s) model proposed by the contractor does not meet the requirement, the contractor will be required to propose an alternative supplier(s) model acceptable to the Employer.

The Contractor shall quote the rates for material and equipment's as per the list of supplier(s). In the event of contractor wanting to use alternate makes other than those stipulated, for any reason, the contractor can send a proposal after ensuring that what he proposes at least meets both the quality, and safety standard of the stipulated makes, and the financial benefit that will accrue to the Employer. He shall also stand full guarantee to his alternate proposal. The alternate supplier(s) can be used only after an approval accorded by the Employer, whose decision will be final in the matter.

#### **7.9.2 List of Approved Makes**

| <b>Particulars</b>             | <b>Brand</b>                    |
|--------------------------------|---------------------------------|
| Sprinklers                     | Viking, Tyco, Newage, Eversafe  |
| Hydrants                       | Viking, Tyco, Newage, Eversafe  |
| Fire breeching inlet           | Viking, Newage, Eversafe        |
| Flexible hose Pipe             | Tyco, Newage, Eversafe          |
| Hose Reel                      | Tyco, Newage, Eversafe          |
| Steel pipes & Fittings         | TATA, Jindal, Surya Prakash     |
| Ductile Iron Pipe and Fittings | TATA, Jindal,                   |
| Cast Iron Pipes                | Neco, Kapilansh, Saint Gobain   |
| GI Pipes                       | TATA, S.Prakash, Jindal,        |
| GI Fittings                    | Unik, Zoloto, Kirti             |
| Brass ball valves              | Zoloto, Sant, Rb, leader        |
| Strainers                      | Zoloto, Varie, Sant, Hammer     |
| CI Gate Valve                  | Zoloto, Leader, KSB, Sant       |
| CI Sluice Valve                | Zoloto, Leader, KSB, Sant       |
| CI Non return Valve            | Zoloto, Leader, KSB, Sant       |
| Flexible sprinkler connection  | Viking, Tyco, New Age, Eversafe |

|                              |                                                   |
|------------------------------|---------------------------------------------------|
| Alarm Valve                  | Viking, Tyco, New Age, Eversafe                   |
| Deluge Valve                 | Viking, Tyco,                                     |
| Transfer Pumps               | Grundfos, ITT, Crompton, Kirloskar, Willo         |
| Fire Pumps                   | Kirloskar, Crompton, Grundfos, Matherpatt,        |
| Engine Driven Pumps          | Kirloskar, Matherpatt                             |
| Centrifugal Pumps            | Kirloskar, Becon CRI or Equivalent                |
| Level Indicator/Controller   | Minilec, V.Automat, Pumptrol                      |
| HDPE Water Storage Tanks     | Sintex, Durowell Industries                       |
| Manhole covers with frames   | Raj Iron Foundry, K.K.Manhole& Gratings Ltd, NECO |
| <b>Particulars</b>           | <b>Brand</b>                                      |
| Water meter                  | Crescent, Kaycee, Kapstan, AnandAashi             |
| Electric Motors              | Kirloskar, Crompton, Siemens                      |
| Motor Controls               | ABB, L&T, Siemens                                 |
| Pressure Gauge               | H Guru, Fiebig                                    |
| Pressure Switch              | Indfoss, Switzer                                  |
| Sprinkler System Alarm Panel | Agni, Safeway, PCD                                |
| Extinguishers                | Safex, Minimax,                                   |
| Paint                        | Asian, Nerolac, Burger                            |
| Wrapping & Coating           | Pypokote, IWL                                     |
| <b>Particulars</b>           | <b>Brand</b>                                      |
| Fire Alarm Panel             | (UL/FM Approved Products) Simplex, EST3, Notifier |
| Detector and Devices         | (UL/FM Approved Products) Simplex, EST3, Notifier |

Contractor shall consider this makes only while quoting. Approval can be sought for any other make can after proper submission of sample and test certificates to client and consultant. All Electrical Material and Equipment shall be as per approved makes of material in electrical technical Specification.

**7.9.3 LIST OF APPROVED MAKES FOR FAS**

| SL.NO. | ITEM DESCRIPTION              | MAKE (S) OF MATERIALS                     |
|--------|-------------------------------|-------------------------------------------|
| 1      | PC SERVER / PC                | IBM / HP / IBM / COMPAQ                   |
| 2      | FACP                          | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 3      | SOFTWARE                      | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 4      | PHOTO ELECTRIC SMOKE DETECTOR | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 5      | HEAT DETECTOR                 | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 6      | MULTI SENSOR                  | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 7      | CONTROL MODULE                | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 8      | MONITOR MODULE                | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 9      | RELAY MODULE                  | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 10     | ISOLATOR MODULE               | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 11     | MANUAL CALL POINT             | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 12     | HOOTER CUM STROBE             | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 13     | RESPONSE INDICATOR            | EDWARDS/ FIRE FINDER / NOTIFIER / SIMPLEX |
| 14     | RED COLOUR CABLES             | TECHNOFLEX / RR CABEL/ POLYCAB/ FINOLEX   |

## **7.10 COMMISSIONING & GUARANTEE**

### **7.10.1 Scope**

Work under this section shall be executed without any additional cost. The rates quoted in this tender shall be inclusive of the works given in this section.

Contractor shall provide all tools, equipment, metering and testing devices required for the purpose.

On award of work, Contractor shall submit a detailed proposal giving methods of testing and gauging the performance of the equipment to be supplied and installed under this contract.

All tests shall be made in the presence of the Architect or his representative or any inspecting authority. At least five working days notice in writing shall be given to the inspecting parties before performing any test.

Water flow rates of all equipment and in pipe lines through valves shall be adjusted to design conditions.

Complete results of adjustments shall be recorded and submitted.

Contractor shall ensure proper balancing of the hydraulic system and for the pipes/valves installed in his scope of work by regulating the flow rates in the pipe line by valve operation. The contractor shall also provide permanent Tee connection (with plug) in water supply lines for ease of installing pressure gauge, temperature gauge & rota meters. Contractor shall also supply all required pressure gauge, temperature gauge & rotameter for system commissioning and balancing. The balancing shall be to the satisfaction of Consultant / Project Manager.

Three copies of all test results shall be submitted to the Engineer in A4 size sheet paper within two weeks after completion of the tests.

### **7.10.2 Pre-Commissioning**

On completion of the installation of all pumps, piping, valves, pipe connections, insulation etc. the

Contractor shall proceed as follows:

- a. Prior to start-up and hydraulic or any testing, the Contractor shall clean the entire installation including all fitments and pipe work and the like after installation and keep them in a new condition. All piping systems shall be flushed and drained at least once through to get rid of contaminating materials. All pipes shall be rodded to ensure clearance of debris, cleaning and flushing shall be carried out in sections as the installation becomes completed.
- b. All strainers shall be inspected and cleaned out or replaced.
- c. When the entire systems are reasonably clean, a pre-treatment chemical shall be introduced and circulated for at least 8 hours. Warning signs shall be provided at all outlets during pre-treatment. The pre-treatment chemical shall:
- d. Remove oil, grease and foreign residue from the pipe work and fittings;
- e. Pre-condition the metal surfaces to resist reaction with water or air.
- f. Establish an initial protective film;
- g. After pre-treatment, the system shall be drained and refilled with fresh water and left until the system is put into operation.
- h. Details and procedures of the pre-treatment shall be submitted to the Architect for approval.
- i. Check all clamps, supports and hangers provided for the pipes.
- j. Fill up pipes with water and apply hydrostatic pressure to the system as given in the relevant section of the specification. If any leakage is found, rectify the same and retest the pipes.

### **7.10.3 Tests and Inspections by Statutory Authorities**

As and when notified in writing or instructed by the Architect, Consultant & client, the Contractor shall submit shop drawing and attend all tests and inspections carried out by Local Fire Authorities, Fire Authority and other Statutory Authorities, and shall forthwith execute free of charge any rectification work ordered by the Architect as a result of such tests and inspections where these indicate non-compliance with Statutory Regulations. Some of these tests may take place after the issue of Practical Completion of the Main Contract and the Contractor shall make all allowances in this respect.

The Contractor shall be responsible for the submission of all necessary forms and shop drawings to the Statutory Authorities which shall conform in layout to the latest architectural plans submitted to and kept by these Authorities.

The submission shall comply with the requirements set forth in the current Codes of Practice and circular letters of the Statutory Authorities. The shop drawings to be submitted shall be forwarded to the Architect for checking before submission.

The Contractor shall allow for at least two submissions of complete sets of shop drawings to the Authorities, one to be made within six months after the award of the Contract but not less than six weeks before the inspection. The Architect may at his discretion instruct the Contractor for additional submissions to the Local Authorities whenever necessary.

The Contractor shall notify the Architect at least seven days in advance of his application for local Authority tests and inspections. On receipt of a confirmed date for test and inspection the Contractor shall inform the Architect without delay.

Any welder or electrician working on site shall be certified worker from require local authority and copy of certifies to be submitted to site office.

### **7.10.4 Final Acceptance Tests**

Following commissioning and inspection of the entire installation, and prior to issue of the Completion Certificate, the Contractor shall carry out final acceptance tests in accordance with a programme to be agreed with the Architect.

Should the results of the acceptance tests show that plant, systems and/or equipment fail to perform to the efficiencies or other performance figures as given in this Specification, the Contractor shall adjust, modify and if necessary replace the equipment without further payment in order that the required performance is obtained.

Where acceptance tests are required by the relevant Authorities having jurisdiction, these tests shall be carried out by the Contractor prior to the issue of Completion Certificate to the acceptance of the Authorities.

### **7.10.5 Rejection of Installation / Plant**

Any item of plant or system or component which fails to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site may be rejected by the Architect either in whole or in part as he considers necessary/appropriate. Adjustment and/or modification work as required by the Architect so as to comply with the Authority's requirements and the intent of the Specification shall be carried out by the Contractor at his own expense and to the satisfaction of the Authority/Architect.

After works have been accepted, the Contractor may be required to carry out assist in carrying out additional performance tests as reasonably required by the Architect/Employer.

#### **7.10.6 Warranty and Handover**

The Contractor shall warrant that all plant, materials and equipment supplied and all workmanship performed by him to be free from defects of whatsoever nature before handover to the Owner.

#### **7.10.7 Handing Over of Documents**

All testing and commissioning shall be done by the Contractor to the entire satisfaction of the Owner's site representative and all testing and commissioning documents shall be handed over to the Owner's site representative.

The Contractor shall also hand over all maintenance and operation manuals, all certificates and all other documentation as per the terms of the contract to the Owner's site representative.



## **7 B 8. SUB-SECTION**

### **TUNNEL OPERATION AND MAINTENANCE**

## **Contents**

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## 8. TUNNEL OPERATION AND MAINTENANCE

### 8.1 Typical Maintenance Schedule

| Item | Equipment                               | Cleaning Frequencies | Maintenance Frequencies                 |
|------|-----------------------------------------|----------------------|-----------------------------------------|
| 1    | Lamps                                   | 1 - 2 months         | 8 - 36 months                           |
| 2    | Lighting controls                       | 12 months            | 12 months                               |
| 3    | Jet fan overhaul                        |                      | 48 months                               |
| 4    | Axial flow fans and auxiliary equipment |                      | Minor: 4000 hours<br>Major: 25000 hours |
| 5    | Obscuration meters                      | 1 month              | Minor: 1 month<br>Major: 12 months      |
| 6    | CO monitors                             | 3 months             | 3 - 12 months                           |
| 7    | Anemometers                             |                      | 6 months                                |
| 8    | Ventilation computer                    | 1 month              | 1 month                                 |
| 9    | Ventilation switch gear                 | 24 months            | 12 months                               |
| 10   | Remote control system                   |                      | 6 months                                |
| 11   | Lights                                  | 1 week - 3 months    | 6 months                                |
| 12   | Variable message signs                  | 6 months             | 12 months                               |
| 13   | Safety barriers                         |                      | 6 months                                |
| 14   | Movable barriers                        |                      | 6 months                                |
| 15   | Traffic recording/induction loops       |                      | 3 - 12 months                           |
| 16   | Traffic computer                        | 6 months             | 1 month                                 |
| 17   | Peripheral units                        | 6 months             | 6 months                                |
| 18   | Emergency phones                        | 1 month              | 3 months                                |
| 19   | Fire Hydrants in tunnel recesses        | 6 months             | 6 months                                |

| Item | Equipment                             | Cleaning Frequencies | Maintenance Frequencies                            |
|------|---------------------------------------|----------------------|----------------------------------------------------|
| 20   | Hand fire extinguishers               | 6 months             | 12 months                                          |
| 21   | Fire hydrant main                     |                      | 6 months                                           |
| 22   | Automatic fire alarm system           |                      | 3 months                                           |
| 23   | CCTV cameras and equipment            | 1 month              | 1 month                                            |
| 24   | Public address loudspeaker system     |                      | 6 months                                           |
| 25   | Radio system                          | 12 months            | 6 months                                           |
| 26   | Overheight vehicle detectors          |                      | 6 months                                           |
| 27   | Escape doors and tunnel walls         | See Chapter 6        | 6 months                                           |
| 28   | Transformers                          |                      | 12 months                                          |
| 29   | HV switch gear                        | 12 months            | 12 months                                          |
| 30   | LV switch gear                        | 24 months            | 12 months                                          |
| 31   | Emergency switch gear and UPS systems | 12 - 24 months       | 1 - 3 months                                       |
| 32   | Batteries                             | 1 week               | 1 - 12 months                                      |
| 33   | Gulleys                               | 1 month              |                                                    |
| 34   | Sumps                                 | 1 month              |                                                    |
| 35   | Foul sumps                            | 1 - 3 months         |                                                    |
| 36   | Oil and petrol separators             | 1 month              |                                                    |
| 37   | Pumps                                 | 1 week               | 1 month                                            |
| 38   | Pump controls                         | 1 week               | 1 month                                            |
| 39   | Valve actuators                       | 1 week               | 1 month                                            |
| 40   | Road Surfacing                        | 1 week               | Minor: 1 month Medium: 12 months Major: 7-10 years |

## **7 B 9. SUB-SECTION**

### **SCHEMATIC DRAWINGS**

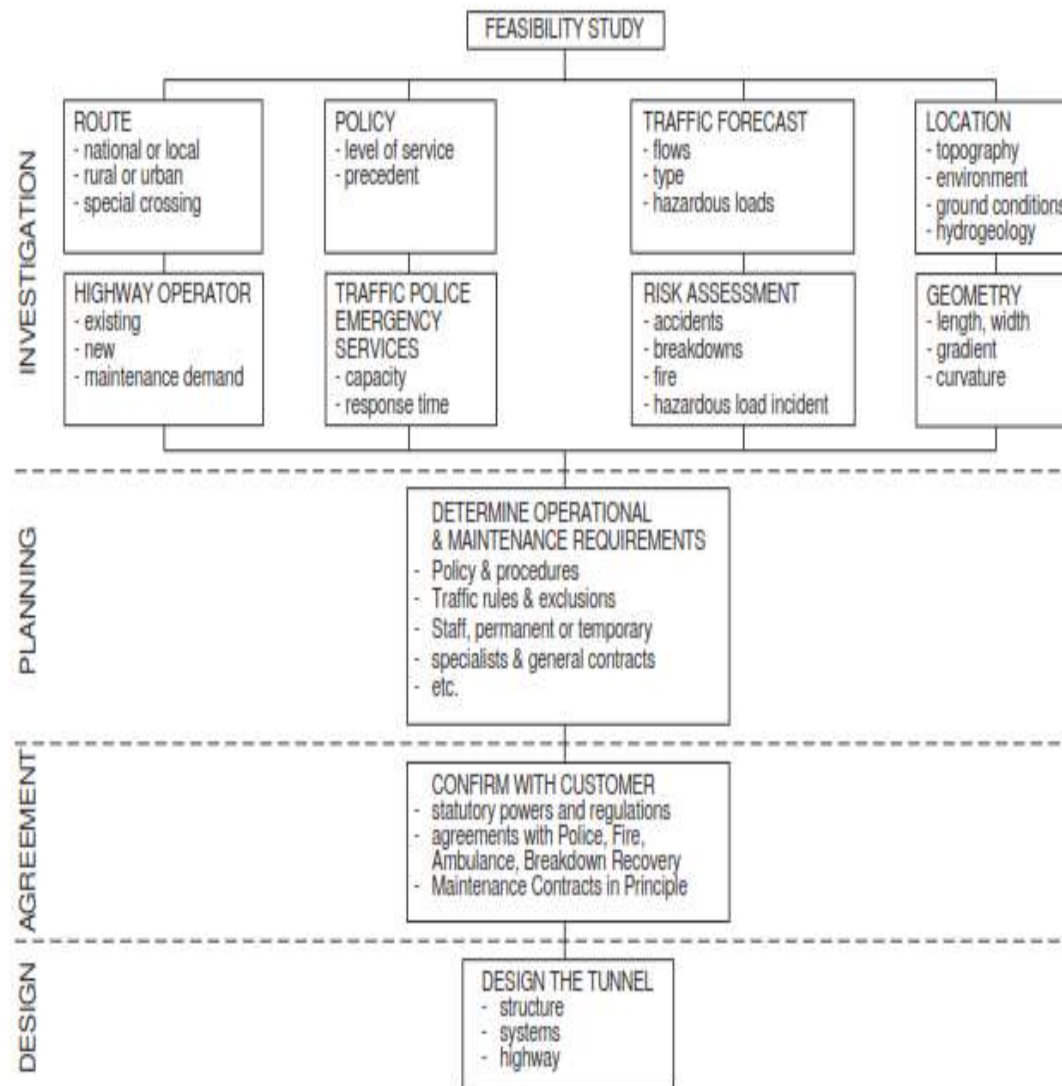
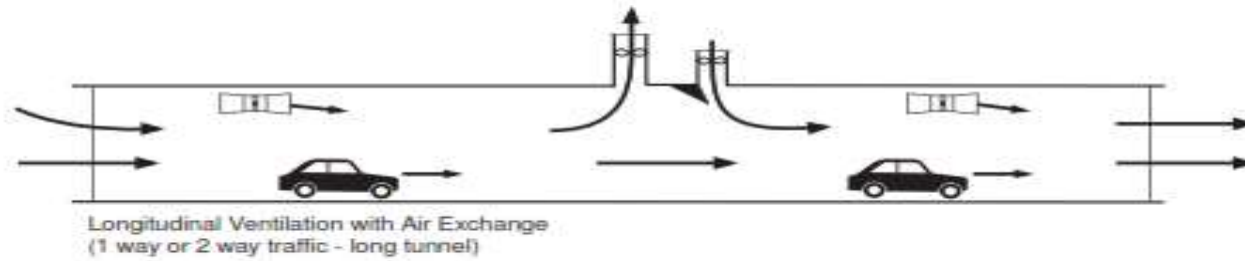
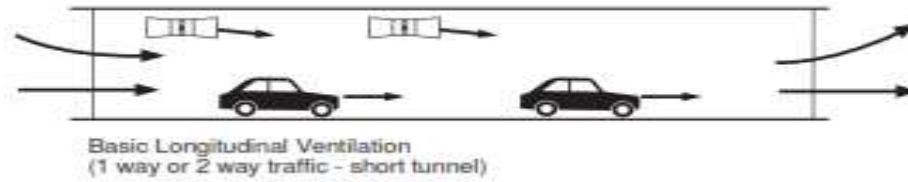
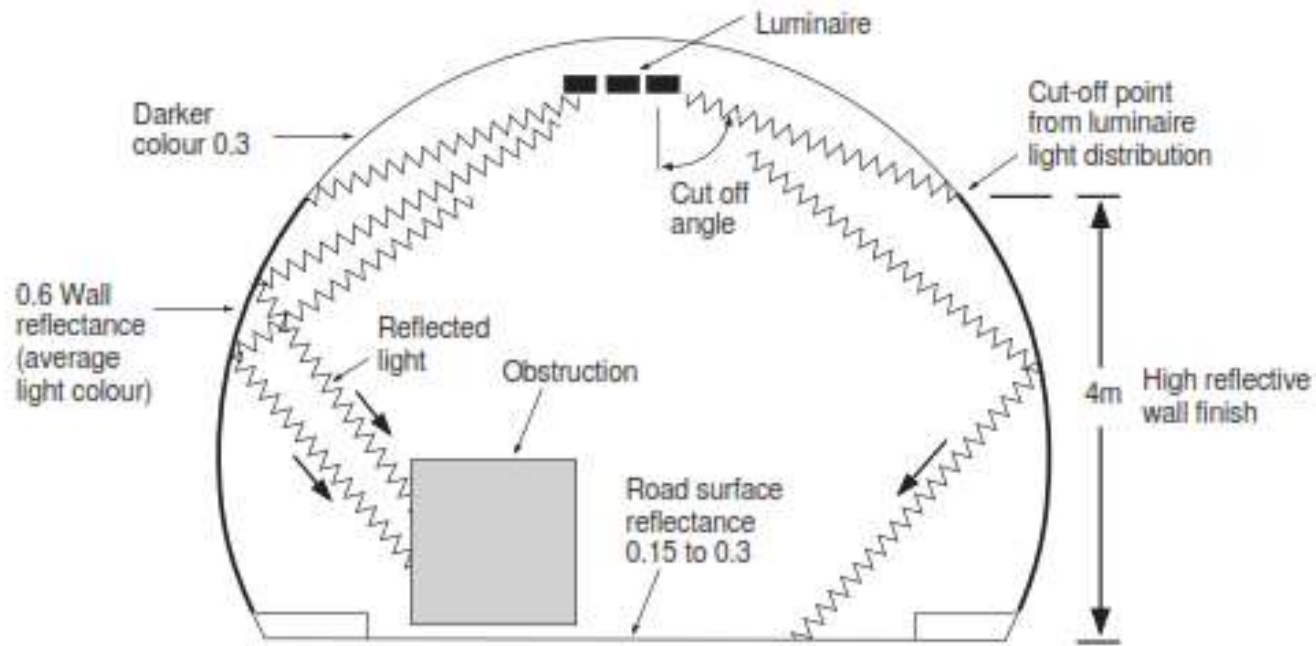


Figure 2.1

Tunnel Planning and Design Process

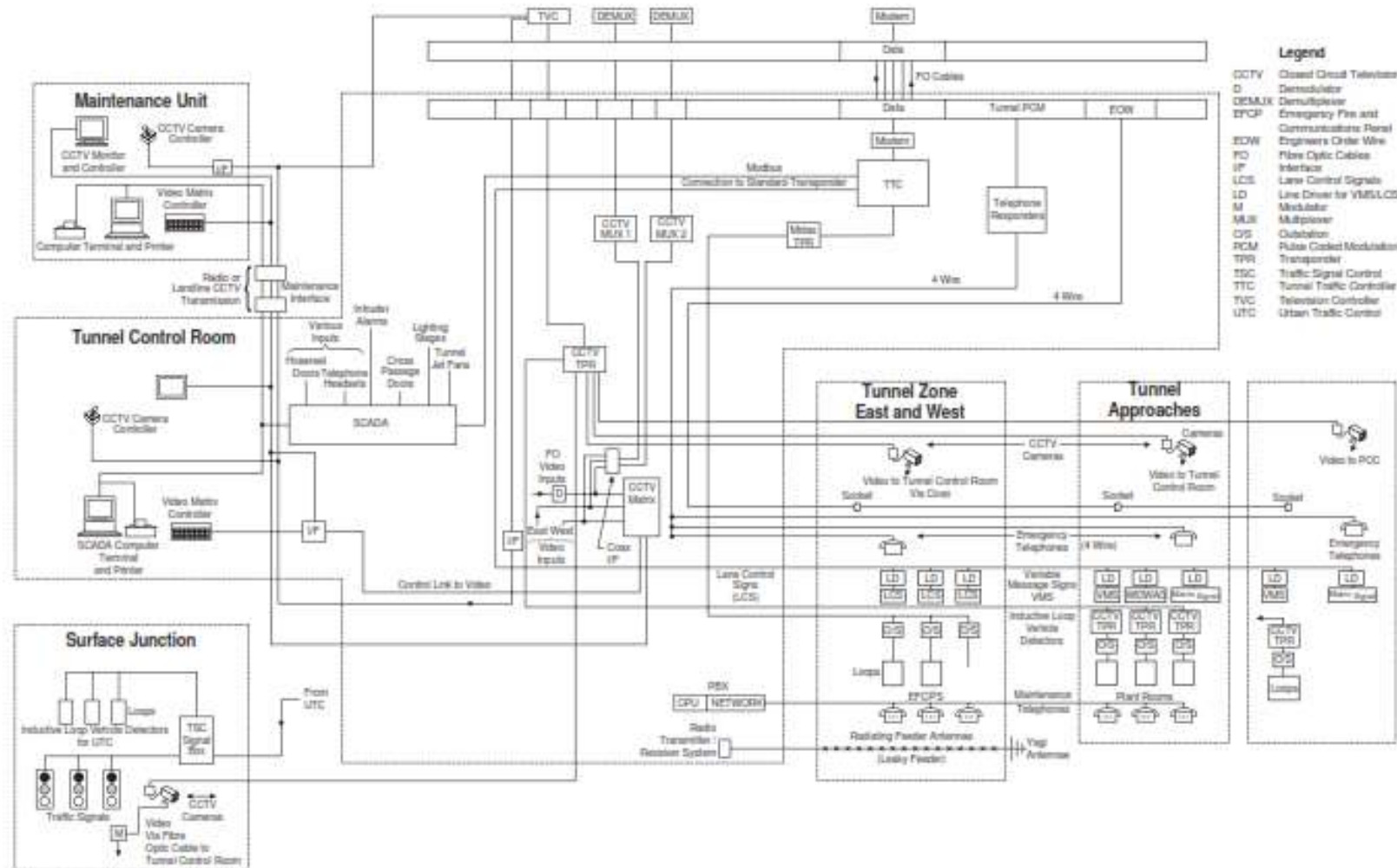


### Typical Tunnel Ventilation System

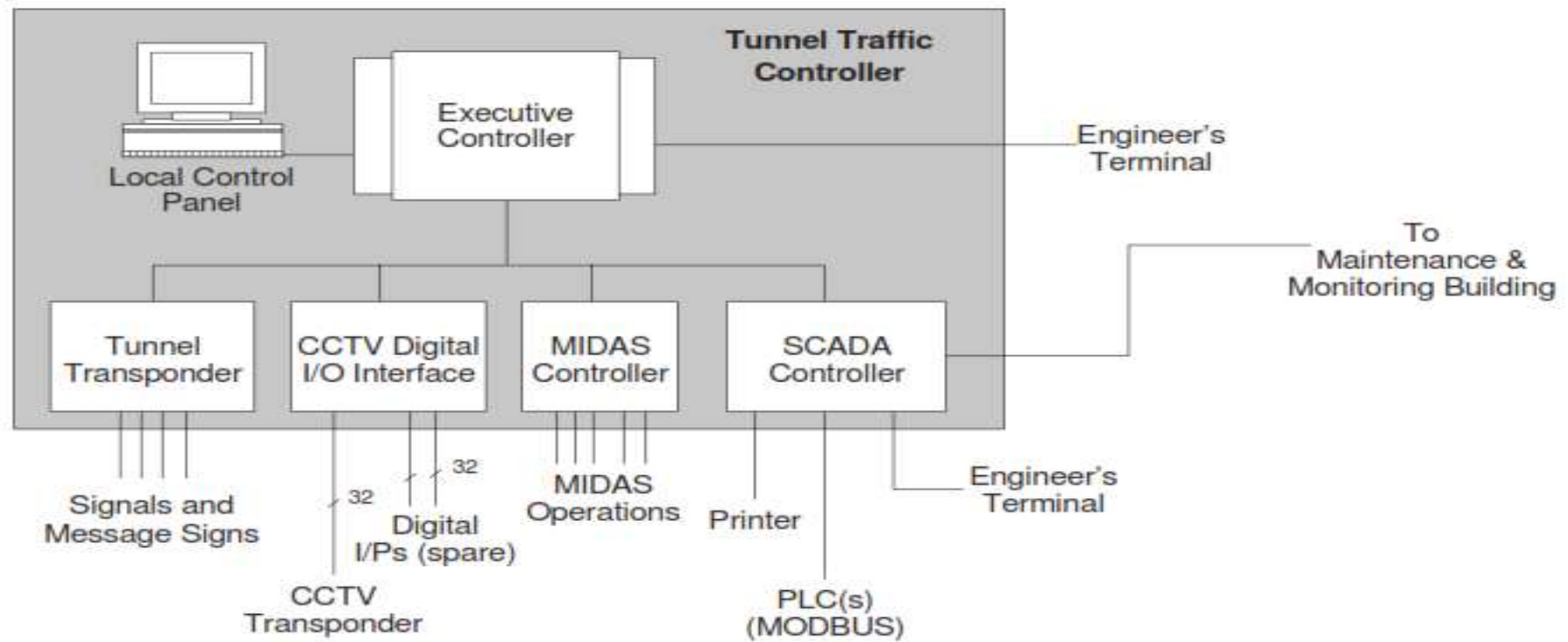


**LIGHT DISTRIBUTION**

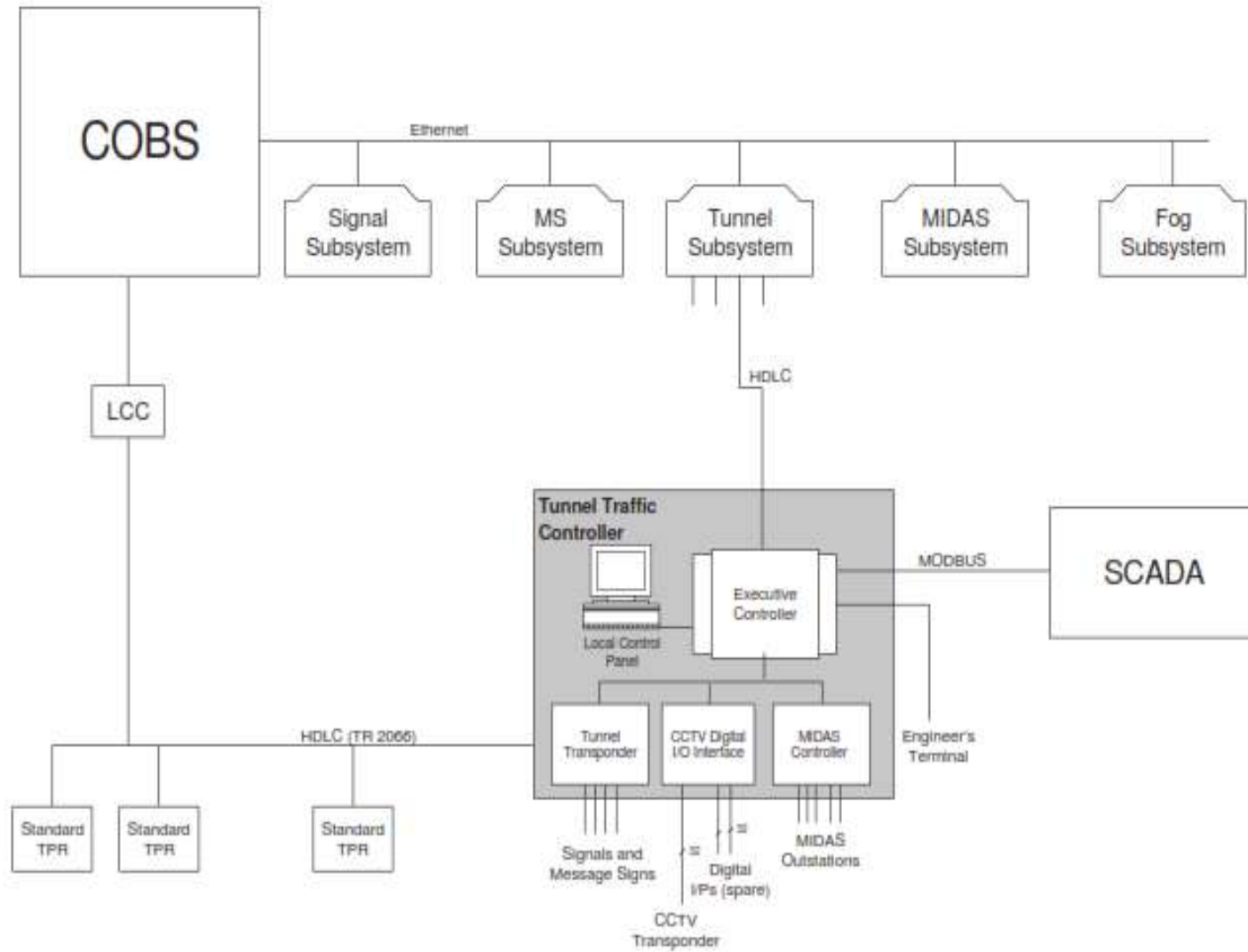




**Typical Tunnel Communication Network**



**LAN Based Subsystem – Standalone system**



**LAN Based Subsystem – Full system**

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**SECTION - S.01****1. GENERAL****1.1. General**

- 1.1.1. These Specifications contained herein shall be read in conjunction with other tender documents.

Generally the work shall be carried out as per the latest edition of "Specifications for Road and Bridge works" of Ministry of Road Transport & Highways (MORTH) as published by Indian Roads Congress and CPWD specifications - 1996/2002 with correction slips & amendments upto date to the extent they are applicable to the works covered under scope of works. However, the provision of MORTH specifications takes precedence over CPWD specifications. Further the specifications contained herein will supersede the provisions of the MORTH & CPWD specifications to the extent of their applicability.

- 1.1.2. The Work shall be carried out in accordance with the "Good for Construction" drawings and designs as would be issued to the Contractor by the Engineer duly signed and stamped by him. The Contractor shall not take cognisance of any drawings, designs, specifications, etc. not bearing Engineer's signature and stamp. Similarly the Contractor shall not take cognisance of instructions given by any other Authority except the instructions given by the Engineer in writing.

- 1.1.3. The work shall be executed and measured as per metric units given in the Schedule of Quantities, drawings etc. (FPS units where indicated are for guidance only).

- 1.1.4. Absence of terms such as providing, supplying, laying, installing, fixing etc in the descriptions does not even remotely suggest that the Contractor is absolved of such providing, supplying etc unless an explicit stipulation is made in this contract. The Employer / Engineer shall bear no costs of materials, labour, equipment, duties, taxes, octroi, cess, royalties etc., unless otherwise specified in item description.

- 1.1.5. The specifications have been divided into different sections / sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account inter-relations between various parts of works/trades. No claim shall be entertained on the basis of compartmental interpretations.

- 1.1.6. The classification of various items of works for purposes of measurements and payments shall be as per Bills of Quantities (BOQ). Except where distinguished by BOQ, the rates apply to all heights, depths, leads, lifts, sizes, shapes and locations. They also cater for all cuts and wastes. No height wise / floorwise separation shall be made for the rates. Likewise all heights of centering, shuttering, staging, formwork and scaffolding, launching trusses and other launching methods are covered by the quoted rates including multi stage propping for heights greater than one lift / floor as per drawings.

- 1.1.7. Reference to the Standard Codes of Practice.

1. The contractor shall make available at site all relevant Codes of practice as applicable.

- 2 Legend:

|      |                                          |
|------|------------------------------------------|
| ASCE | American Society of Civil Engineers      |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing Materials   |

|       |                                                                     |
|-------|---------------------------------------------------------------------|
| BS    | British Standard                                                    |
| CPWD  | Central Public Works Department                                     |
| DIN   | Deutsches Institut für Normung e.V.                                 |
| IRC   | Indian Road Congress                                                |
| IRS   | Indian Railway Standards                                            |
| IS    | Indian Standards                                                    |
| JIS   | Japanese Industrial Standard                                        |
| MORTH | Ministry of Road Transport and Highways                             |
| UIC   | International Union of Railways                                     |
| IRCEM | Institution de Retraite Complementary des<br>Employes de Particular |

## 1.1.8. Contractor to Provide

The Contractor shall provide and maintain at site throughout the period of works the following at his own cost and without extra charge, except for the items specified in the Bill of Quantities the cost being held to be included in the Contract Rates:

- 1 General works such as setting out, site clearance before setting out and on completion of works. All weather approach roads to the site office should also be constructed and maintained in good condition.
- 2 All labour, materials, plant, equipment and temporary works, over head charges as well as general liabilities, obligations, insurance and risks arising out of GCC, required to complete and maintain the works to the satisfaction of the Engineer.
- 3 Adequate lighting for night works, and also at other times whenever and wherever required by the Engineer.
- 4 Continuous & Rigid temporary fences, barricades/hoardings on both sides of the site occupied by the contractor including, guards, lights and protective work necessary for protection of workmen, supervisors, engineers, General public and any other persons permitted access to the site as approved by the Engineer. Contractor shall provide proper signages as directed.  
  
All fences, barricade/hoardings shall be as per approved drawings and painted with colour shades as specified by the Engineer. The barricading/hoardings should be of adequate height to ensure visual obstruction of work from public view.
- 5 All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc.
- 6 Design mixes and testing them as per relevant clauses of specifications giving proportion of ingredients, sources of aggregates and binder along with accompanying trial mixes. Test results to be submitted to the Engineer for his approval before adoption on works.
7. Method Statements, for each main activity of the work (temporary and permanent) to be executed detailing the purpose, scope, resources required, sequence / procedure of execution, persons responsible, time frame, safety requirements & measures, risk analysis, Inspections, and Test Procedures along with standard values / acceptable criteria etc. duly approved by the Engineer before start of that particular activity at site.
8. Contractor shall also prepare / approve and make available to the Site Engineer the work procedure for each sub-activity to be done at the site, detailing the procedure / process to be followed including work sequence, safety measures, to be followed, level of quality to be maintained, type of material to be used, type of finishing

required and responsibility assigned etc.

9. Preparation and compliance with provision of a quality assurance control programme as per Appendix II of Special Conditions of Contract.
10. Prepare and submit Standard Quantities for the purpose of billing based on the approved drawings.
11. Safe guarding the environment as per Appendix III of SCC & Appendix V of SCC.
12. Cost of safety measures and requirements of site safety plan as per Appendix VI of Special Conditions of Contract.
13. A testing laboratory as specified by the Engineer equipped with the following minimum apparatus, materials and competent trained staff required for carrying out tests, as specified in the relevant sections of the specifications/Codes:-

A testing laboratory as specified by the Engineer equipped with the following minimum apparatus, materials and competent trained staff required for carrying out tests, as specified in the relevant sections of the specifications/Codes:-

- i. 1 Set of standard sieves for testing grading of sand with mechanical sieve shaker.
- ii. Sieves with openings respectively of 4.75mm, 10mm, 20mm, 25mm, and 30mm for testing and grading of aggregates.
- iii. Digital Weighing Balance of capacity up to 10 Kg. reading up to 1 gm.
- iv. Electric Thermostat controlled oven and pans for drying of sand and aggregates.
- v. Glass measuring flasks /2, 1 liter & 2 liter capacities.
- vi. Flask for determining moisture content of sand.
- vii. Slump cone with rod and V B Apparatus, flow table to measure slump or DIN Specifications (separate sets for laboratory and at Site).
- viii. Apparatus to measure permeability of concrete as per Appendix 1700/II of MORTH Specifications.
- ix. Minimum 24 Nos. steel moulds for 150mm x 150mm x 150mm concrete test cubes. It may be necessary to provide more steel cube moulds depending upon concreting programme.
- x. 25mm dia vibrator for compaction of concrete in test cubes and also vibrating table.
- xi. Digital Concrete cube testing machine of 200 tonnes Minimum capacity with print out facility.
- xii. Work benches, shelves, desks, sinks and any other furniture and lighting as required by the Engineer.

- xiii. Abrasion, Flakiness & Impact testing Equipment for Testing coarse aggregates.
- xiv. Silt Testing Equipment.
- xv. Any other equipment specified by Engineer.
- xvi. Permeability Testing Apparatus.

Note: All the above equipment and apparatus shall be calibrated at the time of setting up and at specified intervals by NABL accredited agency.

#### 1.1.9. Quality Assurance & Quality Control

- 1 The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. The Contractor shall conform to the Quality standards prescribed, which shall form the backbone for the Quality Assurance and Quality Control system.
- 2 At the site, the Contractor shall arrange the materials, their stacking/storage in as per MORTH standards manner to ensure the quality. The Contractor shall provide all the necessary equipment and qualified manpower to test the quality of materials, assemblies etc., as directed by the Engineer. The tests shall be conducted at specified intervals and the results of tests properly documented. The cost of all such testing shall be included in the quoted rates and nothing extra shall be paid for in this regard. In addition the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surfaces.
- 3 Testing of Materials.
  - (a) The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document as per provisions of Clause 48 of General Conditions of Contract. The Contractor shall provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples, or for the collection of the samples. The test shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory having NABL certification.
  - (b) The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of the Contractor failing to arrange transportation of the samples in proper time the Engineer shall have them transported and recover two times the actual cost from the Contractor's bills.
  - (c) All testing shall be performed in the presence of Engineer or his authorised representative. Testing may be witnessed by the Contractor or his authorised representative if permitted by the Test House. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.
  - (d) Cost of all such tests shall be borne by the Contractor and nothing extra shall be payable on this account.
- 4 The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, its transportation, layout and storage of materials, all equipment including the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged and the Engineer's approval obtained prior to starting of the particular item of work. This shall however, not relieve the Contractor of his responsibilities. All materials which do not conform to these specifications shall be rejected. In the event of contractor not being able to arrange the material conforming to these specifications or in the event of failure of the contractor to

get the sources approved within the agreed schedule submitted by contractor, the Engineer shall have the powers to cause the Contractors to purchase and use such materials from any particular source, as may, in the Engineer's opinion, be necessary for the proper execution of work. Nothing extra shall be payable to the contractor on this account.

## 5 Dimensions

- 1 Figured dimensions on drawings shall only be followed and drawings to a large scale shall take precedence over those to a smaller scale. Special dimensions or directions in the specifications shall supersede all others at tender stage where as those mentioned in the construction drawings supercedes all others. All dimensions shall be checked at site prior to execution.
- 2 The dimensions where stated do not allow for waste, laps, joints, etc. but the Contractor shall provide at his own cost sufficient labour and materials to cover such waste, laps, joints, etc.
- 3 The levels, measurements and other information concerning the existing site as shown on the drawings are believed to be correct, but the Contractor should verify them for himself and also examine the nature of the ground as no claim or allowance whatsoever will be entertained on account of any errors or omissions in the levels or the description of the ground levels or strata turning out different from what was expected or shown on the drawings.

### 1.1.10. Setting out of Works

The Contractor shall set out the Works indicated in the Conditions of Contract. The Contractor shall provide suitable stones with flat tops and build the same in concrete for temporary bench marks. All the pegs for setting out the Works and fixing the levels required for the execution thereof shall, if desired by the Engineer, likewise be built in masonry at such places and in such a manner as the Engineer may direct. The Contractor shall carefully protect and preserve all bench marks and other marks used in setting out the works. The contractor will make overall layout of complete work and get it checked from engineer. The cost of all operations of setting out including construction of bench marks is deemed to be included in the quoted rates as per Bill of Quantities.

- (a) All the survey work except leveling shall work shall be carried out using total stations with one second accuracy. The leveling work shall be carried out using Auto level.
- (b) The triangulation points given by Employer/Engineer before start of work shall be maintained during execution and handed over back to Employer / Engineer after completion of work.

### 1.1.11. Materials

#### 1 Source of Materials

It shall be the responsibility of the contractor to procure all the materials required for construction and completion of the contract. The contractor shall indicate in writing the source of materials well in advance to the Engineer, after the award of the work and get it approved from the Engineer before commencing the work. If the material from any source is found to be unacceptable at any time, it shall be rejected by the Engineer.

#### 2 Quality

All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Engineer and shall comply strictly with the tests prescribed hereafter, or where tests are not laid

down in the specifications, with the requirements of the latest issues of the relevant Indian & other Standards.

### 3 Sampling and Testing

All materials used in the works shall be subjected to inspection and test in addition to test certificates. Samples of all materials proposed to be employed in the permanent works shall be submitted to the Engineer at least 45 days in advance for approval before they are brought to the site.

Samples provided to the Engineer for their retention are to be labeled in boxes suitable for storage. Materials or workmanship not corresponding in character and quality with approved samples will be rejected by the Engineer.

Samples required for approval and testing must be supplied sufficiently in advance in required quantity and number to allow for testing and approval, due allowance being made for the fact that if the first samples are rejected further samples may be required. Delay to the works arising from the late submission of samples will not be acceptable as a reason for delay in completion of the works.

Materials shall be tested before leaving the manufacturer's premises, quarry or source, wherever possible. Materials shall also be tested at site and they may be rejected if not found suitable or in accordance with the specifications, notwithstanding the results of the tests at the manufacturer's works or elsewhere or test certificates or any approval given earlier.

The contractor will bear all expenses for sampling and testing, whether at the manufacturer's premises at source, at site or at any testing laboratory or institution as directed by the Engineer subject to the provisions of Clause 1.1.9 above. No extra payment shall be made on this account.

### 4 Dispatch of materials

Materials shall not be dispatched from the manufacturer's works to the site without written authority from the Engineer.

### 5 Test certificates

All manufacturer's certificates of test, proof sheets, etc showing that the materials have been tested in accordance with the requirement of these specifications and of the appropriate Indian Standards are to be supplied free of charge on request to the Engineer.

### 6 Rejection

Any materials that have not been found to conform to the specifications or otherwise not acceptable to the Engineer will be rejected forthwith and shall be removed from the site by the Contractor at his own cost within three days or as instructed by the Engineer.

#### 1.1.12. Storing of Materials at site

All materials used in the works shall be stored on racks, supports, in bins, silos, godowns, under cover etc as appropriate to prevent deterioration or damage from any cause whatsoever to the entire satisfaction of the Engineer.

The storage of materials shall be in accordance with IS 4082 "Recommendation on stacking and storage of construction materials on site" and as per IS 7969 "Safety code for handling and storage of building materials".

The materials shall be stored in a proper manner at places at site approved by the Engineer. Should the place, where material is stored by the Contractor, be required by the Employer for any other purpose, the Contractor shall forthwith remove the material from that place at his own cost and clear the place for the use of the Employer with in the time as communicated by the Engineer and at no extra cost to the Employer.

#### 1.1.13. Water

##### 1 Water from approved source

Potable water only shall be used for the works. Contractor shall have his own source of water required for the works including curing duly approved by Engineer. However, the contractor will have to obtain necessary permission for use of such water, if any, from concerned authorities. The water shall be free from any deleterious matter in solution or in suspension and be obtained from an approved source. The quality of water shall conform to IS 456.

##### 2 Storage

The Contractor shall make his own arrangements for storing water, if necessary, in drums or tanks or cisterns, to the approval of the Engineer. Care shall be exercised to ensure that water is not contaminated in any way.

##### 3 Testing

Before starting any concreting work and wherever the source of water changes during the currency of works, the water shall be tested for its chemical and other impurities to ascertain its suitability for use in concrete and other works including curing for approval of the Engineer. No water shall be used until tested and found satisfactory.

##### 4 Cost of arranging, storing and testing of water shall be deemed to be included in the quoted rates in the Bill of Quantities and nothing extra shall be payable in this regard.

#### 1.1.14. Cement:

The grade of cement shall be as specified and conforming the relevant IS code and shall be purchased from the approved manufacturers.

Separate go-downs shall have to be provided for different grades of cement. The fresh cement should be used. The cement older than 3 months will not be allowed to use at site. The cement should be stored in a water tight shed and on wooden planks giving sufficient gaps between walls floors and cement piles.

The actual issue and consumption of cement in works shall be regulated and proper accounts maintained as provided in the relevant clause of the contract. The theoretical consumption of cement shall be worked out as per procedure prescribed in relevant clause of the contract and shall be governed by conditions laid therein.

Cement (OPC of 43/53 grade as specified in documents in paper bags or any suitable packing shall be arranged by the contractor.

#### 1.1.15. Coarse Aggregate :

Coarse aggregate in size and quality shall be conforming to the relevant IS code and as specified in the documents.

The nominal maximum size of aggregate (MSA) to be used in RCC and PSC work shall be 20mm. The other requirement shall be as per CPWD specification.

The aggregate shall be stored in such a way as to prevent mixing with foreign materials. Different sizes of coarse aggregate shall be stored in separate stock piles sufficiently away from each other in order to prevent intermixing the materials at the edges of the stock piles.

**1.1.16. Fine Aggregate:**

Fine aggregate (River sand / Manufactured sand) in size and quality shall be conforming to the relevant IS code and as specified in the documents. The quality, tests and acceptance criteria for fine aggregates shall be same as per CPWD specifications. The fine aggregate shall conform to Zone II or Zone III of CPWD specifications as per requirement of trial mix design (or any combination of the two as approved by Engineer and the decision of Engineer in this respect shall be final).

The silt content of fine aggregate (River sand / Manufactured sand) used for trial mixes shall be recorded & the silt content by volume in fine aggregate used shall neither exceed 8% nor 1% more than that of the fine aggregate used in the trial-mix.

**1.1.17. Other Materials:**

All other materials not specifically mentioned above shall be of best quality and shall conform to manufacturer's specification. Wherever, no specific code of practice of IRS/IRC/BIS is applicable, the decision of Engineer shall be final and binding.

**1.1.18. Workmanship**

- 1 All works shall be true to level, plumb and square and the corners, edges and rises in all cases shall be unbroken and neat.
- 2 Any work not to the satisfaction of the Engineer or his representative will be rejected and the same shall be rectified, or removed and replaced with work of the required standard of workmanship at no extra cost.

**1.1.19. Load testing on Completed Structures**

**1.1.19.1.** During the period of construction or within the defect liability period the Engineer may at his discretion order the load testing of any completed structure or any part thereof if he has reasonable doubts about the adequacy of the strength of such structure for any of the following reasons:

- i) results of compressive strength on concrete test cubes falling below the specified strength.
- ii) premature removal of formwork.
- iii) inadequate curing of concrete.
- iv) over loading during the construction of the structure or part thereof.
- v) carrying out concreting of any portion without prior approval of the Engineer.
- vi) honey combed or damaged concrete which in the opinion of the Engineer is particularly weak and will affect the stability of the structure to carry the design load, more so in important or critical areas of the structure.
- vii) any other circumstances attributable to alleged negligence of the contractor which in the opinion of the Engineer may result in the structure or any part thereof being of less than the expected strength.

**1.1.19.2.** All the loading tests shall be carried out by the contractor strictly in accordance with the instructions of the Engineer, IS:456 IRC Codes and as indicated hereunder. Such tests shall be carried out only after expiry of minimum 28 days or such longer period as directed by the



Engineer.

- 1.1.19.3.** The structure shall be subjected to a super-imposed load equal to the specified superimposed load assumed in the design. This load shall be maintained for a period of 24 hours before removal. During the test, struts strong enough to take the whole load shall be placed in position leaving a gap under the members as directed. The deflection due to the superimposed load shall be recorded by sufficient number of approved deflectometers capable of reading up to 1/500 of a cm and located suitably under the structure as directed by the Engineer.
- 1.1.19.4.** In such cases the portion of the work concerned shall be taken down or cut out and reconstructed to comply with the specifications. Other remedial measures may be taken to make the structure secure at the discretion of the Engineer. However such remedial measures shall be carried out to the complete satisfaction of the Engineer.
- 1.1.19.5.** All costs involved in carrying out the test ordered on the grounds as mentioned in Cl. 1.1.19.1 (i) to (iv) above, (except load and integrity test for piles) and other incidental expense thereto shall be borne by the contractor regardless of the result of the test. In case of failure of the test the contractor shall take down or cut out and reconstruct the defective work or shall take the remedial measures, as instructed, at his own cost.

If the load testing is instructed on any ground other than mentioned in para a) to g) of clause 1.1.20.1 above, then the cost of the same shall be reimbursed if the test results are found to be satisfactory.

- 1.1.19.6.** In addition to the above load tests, non-destructive tests on various elements (except on piles) such as core test and ultrasonic pulse velocity test shall be carried out by the contractor at his own expense if so desired by the Engineer. However, non-destructive testing of piles will be paid as per BOQ. Such tests shall be carried out by an agency approved by the Engineer and shall be done using only recommended testing equipment. The acceptance criteria for these tests shall be as specified by the testing agency or good engineering practice and as approved by the Engineer.

## **1.2. Preliminary Work**

### **1.2.1. Survey Work**

The said work involves at the very start of work taking-over of reference point from the Engineer, establishment of control points, triangulation points, bench marks, grid layout for all the piers and other structures maintaining horizontal and vertical control within the permissible limits, incorporating changes (if any), submission of full data in the tabulation form and survey drawings. The item is lump sum and shall be including setting and layout of various works during the progress of work and matching of the station area track alignment with the alignment of the approaches at station ends and incorporating the changes (if any). The payment for the item shall be on pro-rata basis and will be spread over the duration of the contract.

### **1.2.2. Barricading**

The work covers barricading for the work done along the median and areas affecting road traffic. Barricading for the other areas like casting yard, batching plant, storage and other working area shall be done at own cost by the contractor. The detailed scope of work is as follows:

- i) Providing and installing the barricade of the design and type as shown in the typical sketch furnished as per the approved plan firmly to the ground and maintaining it during the progress of work.
- ii) Providing adequate road safety devices. A tentative list given hereunder identifies minimum items, which may be required. However, actual numbers required will be as

per approved plan by the Engineer and clearance from the traffic department, Bangalore. The contractor shall not be paid extra for any addition to this list if required during the execution of works.

- iii) Dismantling of barricading and other temporary installations from the site and cleaning the site as per direction of Engineer upon completion and acceptance of work.

### **Measurement**

The barricading including all the required safety devices as listed under the above table shall be measured in running meter up to two decimal places.

The stage payment for providing barricade shall be as follows:

- i) 70% of BOQ rate for length of barricade provided on installation of the same.
- ii) Remaining 30% shall be paid in proportion to financial progress of the IPC's.
- iii) Once barricade is erected Contracts will not be allowed to remove / re-shift the barricade to some other location till Completion of all activities of the work in that stretch. In case Contractor shifts the barricade to some other location before completion of the all activities in that stretch, payment as covered in (i) above will not be given for such panels erected at other locations.

#### **1.2.3. Supply of Progress Photographs and Album**

The work covers the supply of digital colour photographs along with soft copy in an album to serve as a permanent record of various stages/facets of work needed for an authentic documentation as approved by the Engineer.

The photographs shall be of acceptable quality and they shall be taken by a professionally competent photographer will camera having the facility to record the date of the photographs taken in the prints and negative. The Digital camera, type and quality of photo paper shall be of standard make approved by the Engineer. Each photograph in the album shall be suitably captioned and dated.

The frequency, time and extent of coverage for each work shall be as decided by the Engineer. The rate for the supply of record photographs shall include the cost of taking the photographs, developing and obtaining the colour prints, cost of albums, mounting and captioning the photographs.

The photographs and materials including softcopies shall form a part of the records of BMRCL and the prints cannot be supplied to anybody else or published without the written permission of BMRCL.

#### **1.2.4. Supply of Video Cassette of Works**

The work consists of taking video film of important activities of the works as directed by the Engineer during the currency of the project and editing them to a video film of the duration as indicated in the item. The cassette shall be of approved make and of specified duration

**1.3. Structural Work**

- 1.3.1. Unless otherwise specified, only controlled concrete with design mix and weigh batching is to be used for the work.
- 1.3.2. Minimum cement content for various grades / elements of concrete as specified in MORTH Specifications in CPWD specification 1996 / 2002 is purely from durability point of view. Larger content of cement shall have to provided if demanded by mix design or as per the requirement of relevant codes.
- 1.3.3. Provision of cement slurry to create bond between plain / reinforced concrete surface and subsequent applied finishes shall not be paid extra.
- 1.3.4. Mix design using smaller aggregates of 10mm down shall also be done in advance for the use in the junction having congested reinforcement.
- 1.3.5. Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations or as directed by the Engineer.
- 1.3.6. All the water tanks and other liquid retaining concrete structures shall undergo hydro-testing.
- 1.3.7. Special benches shall be provided at site for stacking reinforcement bars of different sizes.
- 1.3.8. Formwork for beams of RCC works shall be designed in such a way that the formwork of the adjacent slabs can be removed without disturbing the props / supports of the beams.
- 1.3.9. Wherever there are tension / suspended concrete members which are suspended from upper level structural members, the shuttering / scaffolding of such members at lower level shall have to be kept in place till the time the upper level supporting members gain minimum required strength. Cost of such larger duration of keeping in place the shuttering / scaffolding shall be deemed to be included in the price quoted for respective structural members.
- 1.3.10. The Contractor shall incorporate seismic considerations of anchoring and isolation in the design and detailing of the finishes as directed by the Engineer. The element to be anchored shall have its motion suitably restrained whilst at the same time it shall be suitably isolated so as not to be affected by the deformations/ vibrations of the building during Construction.
- 1.3.11. Formwork shall be provided for full height at all locations. Special precautions for such tall formwork shall be taken to ensure its safety. Extra costs for providing such formwork shall be deemed to have been included in the prices quoted against relevant items.
- 1.3.12. The contractor shall carry out expeditiously and without delay the following works with in the mobilization period itself:
- a. Identify and get approved the sources of various major constitution materials.
  - b. Material testing and mix designs of concrete as contemplated in the specifications.
  - c. Setting up of full fledged site laboratory as per the requirements of these specifications.
  - d. Setting up concrete batching & mixing plant.
  - e. Site office for the use of the Engineer's staff .
  - f. Contractor's site office setup.
  - g. Casting yard with complete facilities.
  - h. Any other pre-requisite items required for final execution.
- 1.3.13. Casting yard shall have following minimum facilities:
- a. Casting beds as required.
  - b. Sets of form work / moulds as required.
  - c. All handling facilities for precast elements like over gantry, etc.

- d. Curing arrangements as required.
- e. Stacking arrangements for material and precast elements.
- f. Storing arrangement of materials.
- g. Proper drainage and all weather approach roads.

1.3.14. The load testing of spans / piles etc. shall be done using certified and calibrated dial gauges only. Use of levelling instruments for measuring deflections shall not be allowed

#### 1.4. Guarantees and Maintenance:

The Contractor shall guarantee and undertake to maintain and rectify the various components of the Civil Works for their successful performance for the periods as specified in other documents. The Contractor shall indemnify the Engineer for a similar period against any damage to property and injury to persons on account of any defective work or maintenance carried out by the Contractor. The format and text of the Guarantee and the Indemnity Bond shall be as followed in CPWD or as approved by the Engineer.

1.4.1. Responsibility for Shop drawings, Samples and Mock-ups :

Approval of shop drawings, samples and mock-ups for the various components shall not absolve the Contractor of his responsibility of completing the work to the specifications, standards, tests for performance and guarantees given in these documents and to a quality of finish as desired by the Engineer.

1.4.2. Cleaning:

Surfaces on which finishes are to be provided shall be cleaned with water jets or oil free compressed air or power tools with wire brushes and detergents all as approved by the Engineer.

#### 1.5. Applicable Codes, Standards & Publications For Structural & Architectural Work

The important Codes, Standards and Publications to Contract are listed here under:

| A                   | General                                                                                               |
|---------------------|-------------------------------------------------------------------------------------------------------|
| IS:875 (Part 3)     | Code of practice for design loads (other than earthquake) for buildings and structures                |
| IS:1322             | Bitumen felts for water proofing and damp-proofing                                                    |
| IS:1893             | Criteria for earthquake resistant design of structures                                                |
| IS:2572             | Code of Practice for construction of hollow concrete block masonry                                    |
| IS:3414             | Code of practice for design and installation of joints in buildings                                   |
| IS:6408 (Parts 1,2) | Recommendations For Modular Co-Ordination In Building Industry - Tolerances                           |
| IS:10958            | General check list of functions of joints in building                                                 |
| IS:11817            | Classification of joints in buildings for accommodation of dimensional deviations during construction |
| IS:11818            | Method of test for laboratory determination of air permeability of joints in buildings                |
| IS:12440            | Precast concrete stone masonry blocks                                                                 |
| CPWD                | Specifications 1996.                                                                                  |
| BS:476 (Part 7)     | Method for classification of the surface spread of flame of products                                  |
| BS:476 (Part 20)    | Method of determination of the fire resistance of elements of construction (general principles)       |
| BS:476 (Part 22)    | Methods for determination of the fire resistance of non-load bearing elements of construction         |
| BS:5215             | Specification for one-part gun grade polysulphide-based sealants                                      |

|                         |                                                                                                                   |
|-------------------------|-------------------------------------------------------------------------------------------------------------------|
| BS:5606                 | Guide to accuracy in building                                                                                     |
| BS:6093                 | Code of practice for the design of joints and jointing in building construction                                   |
| BS:8200                 | Code of practice for the design of non-load bearing external vertical enclosure of building                       |
| ASTM C 332              | Specification for light weight aggregate for insulating concrete                                                  |
| SP 7                    | National Building Code of India                                                                                   |
| SP 23 (S&T)             | Hand Book on Concrete Mixes                                                                                       |
|                         |                                                                                                                   |
| <b>B</b>                | <b>Bitumen</b>                                                                                                    |
| IS:702                  | Industrial Bitumen                                                                                                |
| IS:3384                 | Specification for bitumen primer for use in waterproofing and damp-proofing                                       |
|                         |                                                                                                                   |
| <b>C</b>                | <b>Building Construction Practices</b>                                                                            |
| IS:1838 Parts I and II. | Specifications for preformed fillers for expansion joint in concrete pavements and structures.                    |
| IS:1946                 | Code of Practice for use of fixing devices in walls, ceilings, and floors of solid construction.                  |
| IS:6509                 | Code of Practice for installation of joints in concrete pavements.                                                |
| IS:11134                | Code of Practice for setting out of buildings.                                                                    |
| IS:11433                | Parts I and II. Specifications for one part Gun grade polysulphide based joint sealant.                           |
| IS:12200                | Code of Practice for provision of water stops at transverse contraction joints in masonry and concrete dams       |
|                         |                                                                                                                   |
| <b>D</b>                | <b>Cement</b>                                                                                                     |
| IS:269                  | 33 grade ordinary Portland cement                                                                                 |
| IS:455                  | Portland Slag Cement                                                                                              |
| IS:650                  | Specification for standard sand for testing cement.                                                               |
| IS:1489 (Part 1)        | Portland pozzolana cement: Flyash based                                                                           |
| IS:1489 (Part 2)        | Portland pozzolana cement: Calcined clay based                                                                    |
| IS:3535                 | Method of Sampling Hydraulic Cements                                                                              |
| IS:4031                 | (Parts 1 to 13) Methods of physical tests for hydraulic cement.                                                   |
| IS:4032                 | Method of chemical analysis of hydraulic cement.                                                                  |
| IS:6925                 | Methods of test for determination of water soluble chlorides in concrete admixtures.                              |
| IS:8042                 | White Portland Cement                                                                                             |
| IS:8112                 | Specification for 43 grade ordinary Portland cement.                                                              |
| IS:12269                | Specification for 53 grade ordinary Portland cement.                                                              |
| IS:12330                | Specification for sulphate resistant Portland cement.                                                             |
|                         |                                                                                                                   |
| <b>E</b>                | <b>Concrete</b>                                                                                                   |
| IS:456                  | Code of practice for plain and reinforced concrete.                                                               |
| IS:457                  | Code of practice for general construction of plain and reinforced concrete for dams and other massive structures. |
| IS:460 (Parts I to III) | Specification for Test Sieves                                                                                     |
| IS:516                  | Methods of test for strength of concrete.                                                                         |
| IS:1199                 | Methods of sampling & analysis of concrete.                                                                       |
| IS:1200                 | Method of measurement of building and civil engineering                                                           |
| IS:1343                 | Code of practice for prestressed concrete                                                                         |
| IS:1607                 | Method of Test Sieving                                                                                            |
| IS:2386                 | Parts I-VIII. Methods of tests for aggregates for concrete.                                                       |
| IS:2430                 | Methods of Sampling of Aggregates of Concrete                                                                     |
| IS:2438                 | Specification for roller pan mixer                                                                                |

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| IS:2514         | Specification for concrete vibrating tables                                                                                      |
| IS:2571         | Code of practice for laying in-situ cement concrete flooring                                                                     |
| IS:2645         | Specifications for integral cement water proofing compounds                                                                      |
| IS:2722         | Specifications for portable swing batchers for concrete (double bucket type)                                                     |
| IS:2770         | Methods of testing bond in reinforced concrete part I pull out test                                                              |
| IS:3025         | Methods of sampling and test (physical and chemical) for water & waste water                                                     |
| IS:3370         | Code of practice for concrete structures for storage of liquids                                                                  |
| IS:3935.        | Code of practice for composite construction                                                                                      |
| IS:4326         | Code of practice for earthquake resistant construction of building                                                               |
| IS:6925.        | Methods of test for determination of water soluble chlorides in concrete Admixtures                                              |
| IS:7242         | Specifications for concrete spreaders                                                                                            |
| IS:7251         | Specifications for concrete finishers                                                                                            |
| IS:7861         | Parts I & II. Code of practice for extreme weather concreting.                                                                   |
| IS:7969         | Safety code for handling and storage of building materials                                                                       |
| IS:8989         | Safety code for erection of concrete framed structures                                                                           |
| IS:8142         | Methods of test for determining setting time of concrete by penetration resistance                                               |
| IS:9103         | Specifications for admixtures for concrete                                                                                       |
| IS:9013         | Method of making, curing and determining compressive strengths of accelerated cured concrete test specimens                      |
| IS:9284         | Method of test for abrasion resistance of concrete                                                                               |
| IS:10262        | Recommended guidelines for concrete mix design.                                                                                  |
| MORTH           | Specifications for Road and Bridge Works, Ministry of Road Transport and Highways (Roads Wing)                                   |
| IRS             | Concrete Bridge Code                                                                                                             |
| IRC 21-2000     | Standard Specifications and Code of Practice for Road Bridges Section III – Cement Concrete (Plain & Reinforced)(First Revision) |
| IRC:18-2000     | Design criteria for Prestressed Concrete Road Bridges (Post – Tensioned Concrete)                                                |
| ASTM - C - 94   | Ready Mix Concrete                                                                                                               |
| IS 4926:2003    | Ready Mixed Concrete – Code of Practice                                                                                          |
| ASTM – C - 1240 | Specifications for Silica Fume for use in Hydraulic Cement and Mortar                                                            |
|                 |                                                                                                                                  |
| <b>F</b>        | <b>Construction Plant and Machinery.</b>                                                                                         |
| IS:1791         | Specification for batch type concrete mixers.                                                                                    |
| IS:2505         | General requirements for concrete vibrators: Immersion type.                                                                     |
| IS:2506         | General requirements for screed board concrete vibrators.                                                                        |
| IS:3366         | Specification for pan vibrators.                                                                                                 |
| IS:3558         | Code of Practice for use of immersion vibrators for consolidating concrete.                                                      |
| IS:4656         | Specifications for form vibrators for concrete.                                                                                  |
| IS:4925         | Specification for concrete batching and mixing plant.                                                                            |
| IS:11993        | Code of Practice for use of screed board concrete vibrators.                                                                     |
|                 |                                                                                                                                  |
| <b>G</b>        | <b>Formwork</b>                                                                                                                  |
| IS:4990         | Specifications for plywood for concrete shuttering work.                                                                         |
| IRC:87          | Guidelines for the design and erection of false work for road bridges.                                                           |
| IS:806          | Code of practice for use of steel tubes in general building construction.                                                        |
| IS:1161         | Specification of steel tubes for structural purposes.                                                                            |

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| IS:1239                      | Specification for mild steel tubes. Tubulars and other wrought steel fittings.                                                                                                                                                                                                            |
| <b>H</b>                     | <b>Gypsum and Gypsum Board</b>                                                                                                                                                                                                                                                            |
| IS:2095                      | Gypsum plaster boards                                                                                                                                                                                                                                                                     |
| IS:2542 (Part 1/Sec 1 to 12) | Methods of test for gypsum plaster, concrete and products: plaster and concrete                                                                                                                                                                                                           |
| IS:2542 (Part 2/Sec 1 to 8)  | Methods of test for gypsum plaster, concrete and products: Gypsum products                                                                                                                                                                                                                |
| IS:2547 (Part 1)             | Gypsum building plaster: Excluding premixed lightweight plaster                                                                                                                                                                                                                           |
| IS:2547 (Part 2)             | Gypsum building plaster: Premixed lightweight plaster                                                                                                                                                                                                                                     |
| <b>I</b>                     | <b>Handling and Storage</b>                                                                                                                                                                                                                                                               |
| IS:4082                      | Recommendation of Stacking and Storage of construction materials                                                                                                                                                                                                                          |
| IS:8348                      | Code of practice for stacking and packing of stone slabs for transportation                                                                                                                                                                                                               |
| <b>J</b>                     | <b>Instruments For Testing Cement and Concrete</b>                                                                                                                                                                                                                                        |
| IS:5513                      | Specification for vicat apparatus.                                                                                                                                                                                                                                                        |
| IS:5514                      | Specification for apparatus used in Le-Chatelier test.                                                                                                                                                                                                                                    |
| IS:5515                      | Specification for compaction factor apparatus.                                                                                                                                                                                                                                            |
| IS:7320                      | Specification for concrete slump test apparatus.                                                                                                                                                                                                                                          |
| IS:7325                      | Specification for apparatus to determine constituents of fresh concrete.                                                                                                                                                                                                                  |
| IS:10080                     | Specification for vibration machine.                                                                                                                                                                                                                                                      |
| IS:10086                     | Specification for moulds for use in tests of cement and concrete.                                                                                                                                                                                                                         |
| IS:10510                     | Specification for vee-bee consistometer.                                                                                                                                                                                                                                                  |
| <b>K</b>                     | <b>Joint Fillers</b>                                                                                                                                                                                                                                                                      |
| IS:1838 (Part 1)             | Preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type): Bitumen impregnated fiber                                                                                                                                                  |
| <b>L</b>                     | <b>Paints and Coatings</b>                                                                                                                                                                                                                                                                |
| IS:102                       | Ready mixed paint, brushing, red lead, non-setting, priming                                                                                                                                                                                                                               |
| IS:109                       | Ready mixed paint, brushing, priming, plaster, to Indian Standard Colour No. 361 and 631 white and off white.                                                                                                                                                                             |
| IS:347                       | Varnish, shellac, for general purpose.                                                                                                                                                                                                                                                    |
| IS:2074                      | Ready mixed paint, air drying, red oxide-zinc chrome, priming                                                                                                                                                                                                                             |
| BS:6496                      | Specification for powder organic coatings for application and stoving to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with powder organic coatings |
| BS:EN:10152                  | Specification for electrolytically zinc coated cold rolled steel flat products. Technical delivery conditions                                                                                                                                                                             |
| ASTM A 164-71                | Specification for electrodeposited coatings of zinc on steel                                                                                                                                                                                                                              |
| <b>M</b>                     | <b>Pigment for Cement</b>                                                                                                                                                                                                                                                                 |
| BS:1014                      | Specification for pigments for Portland cement and Portland cement products                                                                                                                                                                                                               |
| <b>N</b>                     | <b>Reinforcement &amp; Structural Steel</b>                                                                                                                                                                                                                                               |
| IS:280                       | Mild steel wire for general engineering purposes                                                                                                                                                                                                                                          |
| IS:432                       | Part I. Mild steel and medium tensile steel bars. Part II Hard drawn steel wire.                                                                                                                                                                                                          |

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| IS:814   | Parts I & II. Electrodes for metal arc welding of structural steel.                                            |
| IS:815   | Classification coding of covered electrodes for metal arc welding of structural steels                         |
| IS:816   | Code of Practice for use of metal arc welding for general construction in mild steel.                          |
| IS:1566  | (Part I) Specifications for hard-drawn steel wire fabric for concrete reinforcement.                           |
| IS:1786  | Specification for high strength deformed steel bars and wires for concrete reinforcement.                      |
| IS:2502  | Code of Practice for bending and fixing of bars for concrete reinforcement.                                    |
| IS:2629  | Recommended practice for hot-dip galvanising of iron and steel.                                                |
| IS:2751  | Code of Practice for welding of mild steel plain and deformed bars for reinforced concrete construction.       |
| IS:4759  | Hot-dip zinc coating on structural steel and other allied products.                                            |
| IS:5525  | Recommendations for detailing of reinforcement in reinforced concrete works                                    |
| IS:9417  | Recommendations for welding cold-worked steel bars for reinforced concrete construction.                       |
| IS:14268 | Uncoated stress relieved low relaxation steel class 2 for Pre-stressed concrete                                |
| IS:226   | Structural steel (Standard Quality)                                                                            |
| IS:800   | Code of practice for use of structural steel in general building construction.                                 |
| IS:813   | Scheme of symbols for welding.                                                                                 |
| IS:814   | Covered electrodes for metal arc welding of structural steel. (Part I & Part II)                               |
| IS:816   | Code of practice for use of metal arc welding for general construction in mild steel.                          |
| IS:822   | Code of practice for inspection of welds.                                                                      |
| IS:961   | Structural steel (High Tensile)                                                                                |
| IS:1024  | Code of practice for use of welding in bridges and structures subject to dynamic loading.                      |
| IS:1161  | Steel tubes for structural purposes.                                                                           |
| IS:1182  | Recommended practice for radiographic examination of fusion welded butt joints in steel plates.                |
| IS:2062  | Structural steel (Fusion welding quality)                                                                      |
| IS:3757  | Specification for high tensile friction grip bolts.                                                            |
| IS:5624  | Specification for foundation bolts.                                                                            |
| IS:3600  | Code of practice for testing of fusion welded (Part I) joints and weld metal in steel.                         |
| IS:4923  | Hollow steel sections for structural use.                                                                      |
| IS:6227  | Code of practice for use of metal arc welding in tubular structure.                                            |
| IS:801   | Code of practice for use of cold formed light gauge steel structural members in general building construction. |



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| IS:811            | Specifications for cold formed light gauge structural steel sections.                         |
| IS:8500           | Structural Steel Micro alloyed (Medium and high strength qualities)                           |
| IS:8910           | General requirements of supply of weldable structural steel                                   |
| IS:9595           | Recommendations for metal arc welding of carbon & carbon-Manganese steels                     |
| IS:7205           | Safety Code for erection of Structural Steel Works                                            |
|                   |                                                                                               |
| <b>O</b>          | <b>Aggregates</b>                                                                             |
| IS:383            | Coarse and fine aggregates from natural sources for concrete.                                 |
|                   |                                                                                               |
| <b>P</b>          | <b>Scaffolding</b>                                                                            |
| IS:2750           | Specification for steel scaffoldings                                                          |
| IS:3696 (Part 1)  | Safety Code of scaffolds and ladders: Scaffolds                                               |
| IS:3696 (Part 2)  | Safety Code of scaffolds and ladders: Ladders                                                 |
| IS:4014 (Part 1)  | Code of practice for steel tubular scaffolding: Definition and materials                      |
| IS:4014 (Part 2)  | Code of practice for steel tubular scaffolding: Safety regulations for scaffolding            |
| IRC:87            | Guidelines for the design and erection of falsework for road bridges                          |
|                   |                                                                                               |
| <b>Q</b>          | <b>Sealants</b>                                                                               |
| IS:10959          | Glossary of terms for sealants for building purposes                                          |
| IS:11433 (Part 1) | One part grade polysulphide base joint sealant: General requirements                          |
| IS:11433 (Part 2) | One part grade polysulphide base joint sealant: Methods of test                               |
| IS:13055          | Methods of sampling and test for anaerobic adhesives and sealants                             |
| BS:5889           | Specification for one part gun grade silicone-based sealants.                                 |
|                   |                                                                                               |
| <b>R</b>          | <b>Wood</b>                                                                                   |
| IS:303            | Plywood for General Purposes                                                                  |
| IS:848            | Synthetic resin adhesives for plywood (phenolic and aminoplastic)                             |
| IS:1141           | Seasoning of Timber - Code of Practice                                                        |
| IS:1328           | Veneered decorative plywood                                                                   |
| IS:1659           | Block Boards                                                                                  |
| IS:2046           | Decorative thermosetting synthetic resin bonded laminated sheets                              |
| IS:2202 (Part 1)  | Wooden flush door shutters (solid core type): Plywood face panels                             |
| IS:2202 (Part 2)  | Wooden flush door shutters (solid core (type): Particle face panels and hardboard face panels |
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| <b>S</b><br>IRC:83Part-II<br><br><b>T</b><br>IRC:83 Part-III<br>IS 4985<br><b>U</b><br>IS :2911 PART-I<br>IRC:78 | <b>Bearings</b><br>Standard specifications and code of practice for road bridges<br>Elastomeric Bearings<br>Standard specifications and code of practice for road bridges<br>Pot Bearings<br><b>UPVC Pipe For Drainage</b><br>Unplasticized PVC Pipes for portable water supplies<br><b>PILING</b><br>Bored Cast in-situ Concrete Piles<br>Standard specifications and code of practice for road bridges<br>Foundation And Substructure |
| <b>V</b>                                                                                                         | <b>All Indian Railway Standards</b>                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>W</b>                                                                                                         | <b>MOST Specifications for Road and Bridge works (latest Revision)</b>                                                                                                                                                                                                                                                                                                                                                                  |
| <b>X</b>                                                                                                         | <b>CPWD Specifications (latest Revision)</b>                                                                                                                                                                                                                                                                                                                                                                                            |

**1.6. Temporary Work**

- 1.6.1. All designs for temporary work shall conform to and comply with all the requirements given in the latest editions of the relevant Indian Standard specifications and codes of practice and other technical Specifications as detailed in this tender.
- 1.6.2. For all work for which the contractor has to submit design for approval and proof checked by third party of the Employer, the same shall be got prepared by the contractor from approved consultants who are specialised in this field. For particular item of scaffolding, staging and shuttering, use of any proprietary method of staging should be supplemented with proper designs of such system after getting approval from the Engineer.
- 1.6.3. The contractor shall assess with due care the supplementary site investigations needed to verify all topographical, hydrological and other site data indicated in the tender and also collect such additional site data/geo-technical data as may be necessary for doing the job and safety of structure.
- 1.6.4. The Engineer at his discretion may order any supplementary site geo-technical investigation after award of the contract for verification and evaluation of any relevant data including geo-technical data, and no claim for extra payment on this account of variation of site data so evaluated shall be tenable subject to other relevant provisions of the tender elsewhere.

**SECTION - S.02****2. EARTHWORK**

- 2.1.** These specifications shall be read in conjunction with the MORTH and CPWD specifications 1996/2002 with latest edition and correction slips upto date and other relevant specifications described in the section 1 of these specifications.

- 2.2.** Results of the sub-surface investigations conducted at the Project Site are enclosed with the tender document. This information about the soil and sub-soil water conditions is being made available to the Contractor in good faith and the Contractor is advised to confirm / obtain details independently as may be considered necessary by him before quoting rates in the tender.

No claim whatsoever on account of any discrepancy between the sub-surface conditions that may be actually encountered at the time of execution of the work and those given in these Tender Documents shall be admissible to the Contractor under any circumstances whatsoever.

- 2.3.** Excavation of rock may be carried out by chiselling, jack hammers, crowbars, wedging and using cutting machine or by any other method approved by the Engineer. Use of non-explosive demolition compounds shall also be permitted.

Open blasting is not permitted for the works under scope of this contract but at discretion of the Engineer, Controlled blasting may be permitted only in very special cases where all alternative methods have failed to achieve the satisfactory results. The Blasting, if permitted, shall be carried out within the pre-defined fixed period to be decided in consultation with Traffic Police and approved by Engineer. Contractor shall be responsible for arranging and implementing an effective & approved system for informing the timing of the blasting to the Public including blowing a Siren on a regular basis. Contractor shall take all necessary precautions to prevent flying of blasted stones outside the excavation pit and damage to adjacent structures etc by controlling spacing and quantity of explosive charge and covering the sufficient area of blasting by steel plates loaded with adequate number of sand bags.

All operations of controlled blasting shall be carried out under the supervision of a responsible, authorised, competent and experienced blasting agent / foreman. Contractor shall be responsible for any damage arising out of blasting operation to the Employer / Engineer, workmen, public or any property. Contractor shall obtain all necessary permission from Traffic Police and other concerned authorities for blasting as required. Non granting of permission for blasting by concerned authorities will not be considered as reason for delay or any claim thereof.

- 2.4.** Excavation for all works and for materials required for filling shall be to the exact width, length and depth shown on the drawings or as directed by the Engineer. Where the nature of soil or the depth of the trench and season of the year, do not permit vertical sides, the contractor at his own expense shall put up the necessary shoring, strutting, planking or any other approved protection measures with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

The construction barricading / fence in general will have a maximum width of 8.0 m (outside to outside of barricading). This can be increased at specific locations with prior approval of Engineer. The Contractor shall submit method statements for approval of Engineer demonstrating how this will be achieved at site. If required, driving of rolled section / sheet pile of suitable size into the soil shall be done to retain earth as directed by Engineer. Measurement of plan area of excavation for payment shall be permitted only up to the end of PCC under foundations.

If excavation is carried out to greater depth than required beyond the level specified, for any reason whatsoever, such volume shall be made good by filling with PCC M10 having coarse aggregates 40 mm and below, graded, and brought to level to receive the levelling course below foundations. If excavation is carried out to greater width and length, such extra width and length shall be filled in by well consolidated earth / sand or if the Engineer thinks it is necessary for the stability of the work, by masonry or concrete as he may direct. No extra payment will be made on this account.

Propping shall be undertaken when any foundation or stressed zone from an adjoining structure is within a line of 1 vertical to 2 horizontal from the bottom of the excavation.

All excavations shall be carried out in conformity with the directions laid hereunder and in a manner approved by Engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilised as decided upon, beforehand.

**2.5.** The last 200mm depth of excavation shall be done not earlier than 36 hours before laying the levelling course below foundations.

**2.6.** The Contractor shall make provision for all shoring, de-watering, dredging, bailing out or draining water whether subsoil or rain or other water and the excavation shall be kept free of water while concrete work is in progress and until the Engineer considers the work well set (Refer IS:3764 Safety Code for Excavation Work). The sides of trenches shall be kept vertical and the bottom level throughout or properly stepped as directed by the Engineer. No extra payment shall be made on this account.

**2.6.1.** De-watering shall be carried out by suitable means with adequate stand-by arrangements as may be approved by the Engineer. The level of ground water shall be maintained at least 300 mm below the lowest level of excavation during the laying of foundations. The Contractor shall be deemed to have satisfied himself with regard to feasibility of all aspects of de-watering including site constraints due to existing structures. Though the method of de-watering is left to the contractor, he shall be required to submit method statement of de-watering scheme including requisite justifications to the Engineer and seek his prior written approval.

Approval of the Engineer, however shall not relieve the contractor of the responsibility of adequacy and appropriateness of de-watering and protection arrangements for the quality and safety of the work. The contractor shall satisfy the Engineer as to the capacity of the drains or disposal site to take the required quantity and flow of water to be pumped out at various stages of excavation. The Contractor shall obtain necessary approvals of local bodies for discharging and disposal of the pumped out water. All the de-watering pumps shall therefore also have dedicated D.G. Power supply which shall start automatically in case of failure of electrical supply. Monitoring of water table shall be done using electronic probes or by other suitable methods.

**2.7.** The Contractor shall erect and maintain during progress of works temporary fences / barricading around the work area with all safety measures. The dangerous excavations, excavations near habitations, public movement areas and all works along the roads, shall be, provided with proper caution signs and marked with red lights, reflectors at night to avoid accidents. The contractor shall take all adequate protective measures to see that excavation operations do not affect or damage adjoining structures. Payment for the same shall be made at the quoted rates for the items in the BOQ and nothing extra shall be payable.

**2.8.** Excavation material required for filling shall be stacked or dumped where indicated by the Engineer. Excavated material not required for filling and any surplus material shall be removed and spread on the site anywhere within the premises and as directed by the Engineer or carted away from the site as directed by the Engineer. Dumping of this surplus material shall be in an environmental friendly manner using dumper with tarpaulin or suitable

cover, placer etc. and according to the levels/grades as indicated by the Engineer. Levelling

and Compaction, if required, at the dumping ground shall also be carried out. The cost of such removal and spreading shall be borne by the Contractor and deemed to be included in the Contract Rates. Necessary approval from the local authorities for carting and dumping surplus material is to be obtained by the contractor at his own cost.

- 2.9.** The Contractor shall notify to the Engineer when the excavation is completed and no base or Concrete or Masonry shall be laid until the Engineer has inspected and approved of the soil conditions obtained for each individual footing or the full raft area.
- 2.10.** The Contractor shall ensure the stability of the excavation so that the surrounding ground and all adjoining structures and plants will be safe against settlement, subsidence and damage and that there is no risk of injury to personnel.
- 2.11.** In case any underground structures / utilities, that need to be protected (like underground sewer lines etc.) are encountered, the Contractor shall bring the same to the notice of the Engineer immediately and shall take all such steps as the Engineer may instruct for protection of such structures. Such protective measures shall be done at the Contractor's cost. If any damage occur to such structures / utilities which were required to be protected during execution, the same shall be made good by contractor at his own cost otherwise client will arrange to make it good at the risk and cost of Contractor.
- 2.12.** The Contractor is free, within the framework of rules and regulations of the local authorities, to deal with the surplus earth in any manner suitable to him. The Contractor may dispose off the surplus earth from the project site to a place/ places as may be permitted by the Engineer/ appropriate authority/ body. The transportation of the surplus earth shall be done by mechanical means only. The Contractor shall at his own cost obtain necessary clearances/ permissions statutory or otherwise needed for the purpose. Dumpers may be used for transporting slushy, material excavated from pile boring / well boring / pile cap / Open Foundation with precautions for non spillage of muck.
- 2.13.** In case earth is used for backfilling in foundation and plinth, it shall be got approved from the Engineer. In the foundation the backfilling shall be done in layers not more than 200mm thick and shall be thoroughly watered and consolidated by approved method. The rate for backfilling in foundation using earth is deemed to have been included in the excavation rate even when dewatering may be required to be carried out.
- 2.14.** In case sand is used for backfilling in foundation and plinth, it shall be got approved by the Engineer. In the foundation the backfilling shall be done in layers not more than 200 mm thick and shall be thoroughly watered and consolidated by approved method. The rate for backfilling using sand in foundation is deemed to have been included in the excavation rate.
- 2.15.** For open foundation resting on rock, if sound rock is located at shallow depths, the contractor is required to cut the rock (of all type or strength) to a depth so that open foundation with a minimum earth cushion of 500mm can be accommodated.

**2.16. Measurements & Payment**

Payment for excavations in soil and/or rock, including providing and installing shoring / strutting, dewatering, pumping and bailing out water shall be made as per the quoted rate of the respective items of excavation as specified in BOQ. However unless stated otherwise, the quoted rates for concrete in foundation (upto ground level) shall be deemed to include the cost of shoring, strutting, dewatering and backfilling using earth or sand wherever required with compaction of the same.

Measurements of excavation shall be solid measurements or actual volume of the materials prior to its removal. Measurements shall be of the exact length, width as indicated in the drawings and depth, measured vertically according to the Engineer's drawing or his

instruction. No separate payment shall be made for shoring, dewatering, dredging, bailing, extra excavation required for side slopes and/or benching, ramps, space for providing side shutters and props etc.

The measurements for the removal of the excavated material shall be recorded at site of work before it is loaded in trucks and admissible deductions, if any, shall be made depending upon the type of material.

For excavation of existing road maximum limit of measurement for payment shall be from the existing ground level to the bottom of rubble soling. Measurement shall be those for the minimum works as ordered/plan dimensions as shown in the drawing and actual depth measured at site. All excavation shall be measured net and rate shall not allow for any additional for working space.

The measurement for backfilling shall be based on actual difference of levels before filling and after leveling.

**SECTION - S.03****3. STRUCTURAL CONCRETE: PLAIN, REINFORCED & PRESTRESSED**

These specifications shall be read in conjunction with the MORTH and CPWD specifications 1996/2002 with correction slips / amendments upto date, and other relevant specifications described in the Section 1 of these Specifications.

**3.1. Materials**

Before bringing to the site, all materials for concrete including their source shall be approved by the Engineer. All approved samples shall be deposited in the office of the Engineer before placing orders for the materials with suppliers. The materials brought on to the works shall conform in every respect to the approved samples.

In case of change in type and/or source of any approved material, the contractor shall inform the Engineer and fresh samples shall be deposited with Engineer. Prior approval of Engineer will have to be obtained before using such material at site. The contractor shall check fresh consignment of materials as it is brought on to the works to ensure that they conform to the specifications and/or approved samples.

The Engineer shall have the option to have any of the materials tested at any time to find out whether they are in accordance with specifications at the contractor's expense. All bills vouchers and test certificates which in the opinion of the Engineer are necessary to convince him as to the quality of materials or their suitability shall be produced for his inspection when required.

Any material which has not been found to conform to the specifications and not approved by the Engineer shall be rejected forthwith and shall be removed from the site by the contractor at his own cost within the time stipulated by the Engineer. In the event of contractor not being able to arrange the material conforming to specifications or in the event of failure of the contractor to get the sources approved within the agreed schedule submitted by contractor, the Engineer shall have the powers to cause the Contractors to purchase and use such materials from any particular source, as may, in the Engineer's opinion, be necessary for the proper execution of work. Nothing extra shall be payable to the contractor on this account.

Contractor shall also ensure that all constituents of exposed concrete shall be taken from same sources to achieve a uniform colour and texture.

**3.1.1. Cement****3.1.1.1. The cement used shall be of the following types :**

- a) 43 grade Ordinary Portland Cement conforming to IS: 8112.
- b) 53 grade Ordinary Portland Cement conforming to IS:12269.

For piling and foundation work, type of cement shall be as mentioned in section S-08 on Pile Foundations herein.

**3.1.1.2. Whenever possible all cements of each type shall be obtained from one constant source throughout the contract. Cement of different types shall not be mixed together. Different brands of cement, or the same brand of cement from different sources, shall not be used without prior approval of the Engineer.****3.1.1.3. Packaged cement shall be delivered to the site in original sealed bags which shall be labeled with the weight, name of manufacturer, brand and type including date of manufacture. Cement received in torn bags shall not be used.**

Contractor may obtain cement in bulk and store it in suitable silos of adequate capacity. Each type of cement shall be stored in a separate silo and it shall be ensured, that cements of different quality are not mixed up.

- 3.1.1.4.** All cement shall be fresh when delivered. Cement older than 3 months from the date of manufacture shall not be used.
- 3.1.1.5.** In fair faced elements, the cement used in the concrete for any complete element shall be from a single consignment. All cement for exposed concrete shall be from the same approved source and uniform in colour.
- 3.1.1.6.** With each and every delivery of cement consignment, the contractor shall provide manufacturer's certificate that the cement conforms to the relevant Indian standard. The contractor shall provide complete facilities at site for carrying out the following tests:
- a) Setting time by Vicat's apparatus as per IS: 4031 and IS: 5513.
  - b) Compressive strength of cement as per IS: 4031, IS: 650, IS: 10080.
- 3.1.1.7.** Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO<sub>3</sub>), shall in no case exceed 2.5 percent and 3.0 percent when tri-calcium aluminate per cent by mass is upto 5% or greater than 5% respectively.

### 3.1.2. Aggregates

Aggregates from natural sources shall be in accordance with IS:383. The contractor shall submit to the Engineer certificates of grading and compliance for all consignments of aggregate. In addition at site from time to time, the contractor shall allow for carrying out such tests and for supplying test records to the Engineer. The aggregates shall be procured from approved sources only as directed by the Engineer from time to time.

For fair faced concrete, the contractor shall ensure that aggregates are free from iron pyrites and impurities, which may cause discoloration. Aggregates shall be stored on paved areas in different compartments according to their nominal size.

#### 3.1.2.1. Fine Aggregates

The fine aggregate to be used for the work should be of River sand / Manufactured sand conforming to Zone – II as per IS – 383 / clause 2.1.1. The quality and acceptance criteria should be followed as per IS – 383 / 1970 with latest correction slips. The decision of Engineer in this respect shall be final. The silt content of fine aggregate used for trial mixes shall be recorded & the silt content in fine aggregate used shall not exceed 8%. The tests acceptance criteria for fine aggregates shall be same as per CPWD specifications.

#### 3.1.2.2. Coarse Aggregates

The coarse aggregate shall be crushed stone.

Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, non porous, durable, clean and free from soft, friable, thin plate, elongated or flaky pieces and any deleterious material.

Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregates of uniform quality can be maintained over the said period of the works, the grading of aggregates shall be controlled by obtaining the coarse aggregates in different sizes and blending them in correct proportions as and when required.

All coarse aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS:2386, Parts I to VIII.



The maximum size of coarse aggregates shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20 mm.

### 3.1.3. Water

#### 3.1.3.1. Water used in the works shall be potable water and free from deleterious materials. Water used for mixing and curing concrete as well as for cooling and/or washing aggregate shall be fresh, clean and free from injurious amounts of oil, salts, acids, alkali, other chemicals and organic matter.

Water shall be from the source approved by the Engineer and shall be in accordance with clause 5.4 of IS: 456 However, chloride content in water shall not exceed 500 mg/litre and Sulphate content shall not be more than 4 percent.

Whenever the source of water changes, the water shall be tested for its chemical and other properties / impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such Tests shall be borne by the contractor.

### 3.2. Blending Of Aggregates

In order to obtain optimum workability, individual aggregates of nominal size 20 mm, 10 mm, 4.75 mm and 2.36 mm will be blended in such a way that the grading curve for all in aggregates will be a smooth curve from size 0.15 mm to 20 mm falling within the established envelope grading curve. Contractor shall establish envelope grading curve for each grade of concrete for given maximum size of aggregates and get it approved by Engineer before finalising the mix design.

### 3.3. Admixtures

#### 3.3.1. Chemical admixtures are not to be used until permitted by the Engineer. In case their use is permitted, the type, quantity/dosage and method of use of any admixture proposed by the Contractor shall be submitted to the Engineer for approval. The minimum cement content specified shall not be reduced on account of the use of the Admixtures.

#### 3.3.2. The contractor shall further provide the information concerning each admixture to the Engineer as per Para 1012.1 of MORTH Specifications.

#### 3.3.3. In reinforced concrete works, the chloride content of any admixture used shall not exceed 2 percent by weight of the admixture as determined in accordance with IS:6925 and the total chloride and sulphate contents in concrete mix shall not exceed 0.15 and 4.0 percent respectively by weight of cement.

#### 3.3.4. The admixtures when used shall conform to IS:9103. The suitability of all admixtures shall be verified by trial mixes.

#### 3.3.5. The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.

#### 3.3.6. Retarding admixtures when used shall be based on lingosus-Phonates with due consideration to clause 5.2 and 5.3 of IS:7861.

### 3.4. Batching Plants, Mixers And Vibrators

#### 3.4.1. Unless otherwise specified in the schedule of items, for all structural concreting work the Contractor shall provide automatic weigh-batching plant of suitable capacity. The plant used shall conform to IS:4925. The batching plants should have printing facilities to printout records

of each batch in the format approved by the Engineer.

- 3.4.2. The Contractor shall provide Concrete mixers (IS:1791 – Batch type concrete mixers, IS:2438 - Roller Pan Mixer) and Vibrators (IS:2505 - Concrete Vibrators Immersion Type, IS:2506 - Screed board concrete vibrators, IS:4656 - Form Vibrators for Concrete) supplied by recognized manufacturers.

### 3.5. Grade Of Concrete

The concrete is designated as follows:

Concrete M 25 / 20

The letter M refers to the mix

The number 25 represents the characteristic compressive strength of 15cm cubes at 28 days in MPa (Mega Pascals : 1 MPa : 10 kg/cm<sup>2</sup> approximately). M25 concrete thus has a characteristic strength of 250 kg/cm<sup>2</sup>. Other mix design will also be denoted in same way.

The number 20 represents the nominal size of the coarse aggregates in mm.

### 3.6. Mix Design

It is the complete responsibility of the Contractor to design the concrete mixes by approved standard methods and to produce the required concrete conforming to the specifications and the strength, workability requirements approved by the Engineer. Mix Design should be such as to satisfy all the parameters specified in MORTH specifications.

Mix Design once approved must not be altered without prior approval of Engineer. However, should the contractor anticipate any change in quality and/or change in source of future supply of materials than that used for preliminary mix design, he should inform the Engineer quite in advance and bring fresh samples sufficiently in advance, to carry out fresh trial mixes. Design mix will indicate by means of graphs and curves etc., the extent of variation in the grading of aggregates which can be allowed.

#### Limits of Water and Cement Contents

Maximum water/cement ratio

- |    |                                 |   |      |
|----|---------------------------------|---|------|
| a) | For RCC members including piles | - | 0.40 |
| b) | For PSC members                 | - | 0.40 |

#### Cement Content

Notwithstanding to the stipulations in any code, Cement content in concrete shall not be less than 400 kg/ cum for RCC work and 400 kg/ cum for PSC work under normal exposure. In case of piling work minimum cement content shall be as specified under the section "Pile Foundations". However, maximum cement content shall be limited to 540 kg/ cum of concrete. Ordinary Portland Cement (OPC) of 43 and 53 grade conforming to IS: 8112 and IS: 12269 respectively shall be used. For pre-stressed concrete, cement conforming to OPC 53 grade cement shall be used. However for nominal mixes, CPWD specifications will be followed. "Cement" means Ordinary Portland Cement and excludes the additions as mentioned in para 5.2 of IS 456

As regards trial mixes, acceptance criteria, acceptance specification, lot size, sampling and testing and sampling size for piling work, PSC girders (cast-in-situ and pre-cast post-tensioned) and general work, the requirement of the relevant codes, standards and directions

of the Engineer shall be followed. For piling work OPC+GGBS is to be followed.

### 3.7. Additional Tests For Concrete

As frequently as the Engineer may require, additional tests shall be carried out of concrete in addition to mandatory test specified in MORTH Specifications, CPWD specifications 1996/ relevant IS Code.

#### 3.7.1. Permeability test for Concrete :

The concrete will be verified for permeability by the following procedure and shall confirm to IS:3085-1965 - 'Permeability of Cement Mortar & Concrete'. Section 1716.5 of MORTH Specifications and DIN 1048.

- 1 The Engineer shall select random batches of concrete for examination at his discretion and sampling will generally be done at the point of discharge from the mixer and at placing point.
- 2 From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.
- 3 At least two cylinders shall be made on each day's concreting until 60 cylinders have been made for each grade of concrete.
- 4 All cylinders shall be made, cured, stored, transported and tested in accordance with clause 1716.5 of MORTH Specifications. The tests shall be carried out in a laboratory having NABL certification.
- 5 Test Procedure

The permeability of concrete will be verified by the following procedure:

- S
  - i. Prepare a cylindrical test specimen 150 mm dia and 160mm high.
  - ii. After 28 days of curing, test specimen will be fitted in a machine such that the specimen can be placed in water under pressure up to 7 bars. The typical machine shall be similar to one shown in Appendix 1700/II of MORTH.
  - iii. At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.
  - iv. After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.
  - v. The water penetration in the broken core is measured with scale and the depth of penetration assessed in mm (max permissible limit 25 mm).
- 6 Acceptability Criteria

The concrete shall pass the permeability test if it is properly compacted and is not considered permeable when tested as above.

No extra payment shall be made for this test and cost of the same should be included in the quoted rate for concrete work.

### 3.8. Batching of Concrete Ingredients

Unless permitted by the Engineer, all concreting shall be produced in computerized automatic weigh batching plant having printing facilities to print out records of each batch and installed at site. Under exceptional circumstances Ready Mixed Concrete (RMC) manufactured in computerized automatic weigh batching plant (as per specifications described above) by the approved agencies using the constituent materials from approved sources and approved mix

design may also be used with prior approval from Engineer. Nothing extra shall be paid for such RMC used in the work including transportation, placing in position etc. However, in such cases the RMC production & transportation will have to be directly supervised by the qualified personnel of the contractor. (Contractor has to setup his own batching plant(s).RMC from market will be permitted only in exceptional circumstances and to be decided by the Engineer.)

### **3.9. Placing Temperatures**

During extreme hot or cold weather, the concreting shall be done as per procedures set out in IS:7861, Parts I & II.

The placing temperature of concrete shall be as low as possible in warm weather and care shall be taken to protect freshly placed concrete from overheating by sunlight in the first few hours of its laying. The time of day selected for concreting shall also be chosen so as to minimise placing temperatures. In case of concreting in exceptionally hot weather the Engineer may at his discretion specify the use of ice either flaked and used directly in the mix or blocks used for chilling the mixing water. In either case, the Contractor shall not be paid extra for cost of ice, additional labour involved in weighing and mixing etc. All salt and saw dust shall be removed from ice before use. Quality of water used for making ice shall confirm to IS:456.

### **3.10. Transporting, Placing, Compacting And Curing**

Transporting, placing, compacting and curing of concrete shall be in accordance with IS: 456.

#### **3.10.1. Transporting**

The method of transportation used should efficiently deliver the concrete to the point of placement without significantly altering its desired properties with regard to water-cement ratio, slump, segregation and homogeneity.

The mix after discharging from the automatic computerized weigh batching plant/mixer shall be transported by agitating transit mixers, buckets, pumps etc. or as approved by the engineer without causing segregation and loss of cement slurry and without altering its desired properties with regard to water cement ratio, slump, air content, cohesion and homogeneity. It should be ensured that the concrete is moved to its final destination before it attains the initial set.

The revolving-drum truck bodies of approved make shall be used for transporting the concrete. The number of revolutions at mixing speeds, during transportation, and prior to discharge shall be specified and agreed upon. Reliable counters shall be used on revolving-drum truck units. Standard mixer uniformity tests, conforming to ASTM standards C 94 "Standard Specifications for Ready Mix Concrete", shall be carried out to determine whether mixing is being accomplished satisfactorily.

#### **3.10.2. Water, Admixtures and Slump**

The amount of water required for proper concrete consistency shall take into account the rate of mixing, length of haul, time of unloading, and ambient temperature conditions.

Additions of water to compensate for slump loss should not be resorted to nor should the design maximum water-cement ratio be exceeded. Additional dose of retarder be used to compensate the loss of slump at contractor's cost, when permitted by Engineer. Retempering water shall not be allowed to be added to mixed batches to obtain desired slump.

#### **3.10.3. Placing**

The method of placing shall be such as to prevent segregation by providing windows in the formwork for pouring concrete or by Tremie pipe. The thickness of horizontal layers shall not exceed 300 mm. High velocity discharge of concrete causing segregation of mix shall be avoided. The concrete shall be placed in the forms gently in such a way that the segregation does not take place. The concrete shall not be dropped from a height exceeding 2.0m. Each layer of concrete shall be compacted fully before the succeeding layer is placed and separate batches shall follow each other close enough to ensure that the succeeding layer shall be placed and fully compacted before the layer immediately below has taken initial set. (The temperature to be maintained during pouring of concrete shall be refer to IS 7861 part 1 & 2.)

For piers and pier heads, portal columns, concreting is to be carried out in single stage i.e in first stage concreting will be from kicker to just below pier head bottom and second stage of concreting will be pier head including shear key and cross girder (for all heights) by using tremie / pumps at the rate not more than 1.5m / hr or as approved by the Engineer).

Concreting of any portion or section of the work shall be carried out in one continuous operation and no interruption of concreting work will be allowed without approval of the Engineer.

#### 3.10.4. Compaction

Internal (needle) and surface (screed board) vibrators of approved make shall be used for compaction of concrete.

Internal vibrators shall be used for compaction of concrete in foundations, columns, buttresses arch section, slabs etc, and if required surface vibrators shall also be used. Depending on the thickness of layer to be compacted, 25 mm, 40 mm, 60 mm and 75 mm dia internal vibrators will be used. The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until:

- i. Air bubbles cease to come to surface.
- ii. Resumption of steady frequency of vibrator after the initial short period of drop in the frequency, when the vibrator is first inserted.
- iii. The tone of the vibrated concrete becomes uniform.
- iv. Flattened, glistening surface, with coarse aggregates particles blended into it appears on the surface.
- v. After the compaction is completed, the vibrator should be withdrawn slowly from the concrete so that concrete can flow in to the space previously occupied by the vibrator. To avoid segregation during vibration the vibrator shall not be dragged through the concrete nor used to spread the concrete. The vibrator shall be made to penetrate, into the layer of fresh concrete below if any for a depth of about 150 mm. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.
- vi. To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.
- vii. A sufficient number of standby vibrators shall be kept readily accessible to the place of deposition of concrete to assure adequate vibration in case of breakdown of those in use.
- viii. Form vibrators whenever used shall be clamped to the sides of formwork and shall not be fixed more than 450 mm above the base of the new formwork and concrete shall be filled not higher than 230mm above the vibrator. The formwork must be made specially strong and watertight where this type of vibrator is used.

Care must be taken to guard against over vibration especially where the workability of the concrete mix is high since this will encourage segregation of the concrete.

- ix. Plain concrete in foundations shall be placed in direct contact with the bottom of the excavation, the concrete being deposited in such a manner as not to be mixed with the earth. Plain concrete also shall be vibrated to achieve full compaction.
- x. Green concrete shall be protected from the direct sun light and hot winds as per the methods approved by Engineer. Such method should be got approved from the Engineer before start of concreting operations.

Concrete placed below the ground shall be protected from falling earth during and after placing. Concrete placed on ground containing deleterious substances shall be kept free from contact with such ground and with water draining there from during placing and for a period of seven days or as otherwise instructed thereafter. Approved means shall be taken to protect immature concrete from damage by debris, excessive loading, abrasion, vibrations, deleterious ground water, mixing with earth or other materials, and other influences that may impair the strength and durability of the concrete.

#### 3.10.5. Field Control

Sampling at both, truck discharge and point of final placement shall be employed to determine if any changes in the slump and other significant mix characteristics occur. However, for determining strength of concrete, cubes shall be taken from the placement end of line.

#### 3.10.6. Curing

- i. Curing of concrete shall be complete and continuous using potable water free from chlorides and sulphates water that is free of harmful amounts of deleterious materials that may attach, stain or discolor the concrete as per IS 456. Minimum wet curing will be for seven days by ponding water followed by moist curing by spraying water which shall be maintained up to a total period of at-least 14 days from the date of casting.
- ii. Immediately after compaction and completion of any surface finishes the concrete shall be protected from the evaporation of moisture by means of polythene sheathing, wet hessian or other material kept soaked by spraying. As soon as the concrete has attained a degree of hardening sufficient to withstand surface damage moist curing shall be implemented and maintained for a period of at least 14 days after casting.
- iii. Method of curing and their duration shall be such that the concrete will have satisfactory durability and strength and members will suffer a minimum distortion, be free from excessive efflorescence and will not cause undue cracking in the works by shrinkage.
- iv. Steam curing with approved methodology can be adopted if required, for precast segments. No extra payment will be made for adopting steam curing.
- v. Water based curing compounds may be permitted with specific approval of Engineer. However it is required to be proved that by using such curing compound, the concrete shall not have less strength than concrete cured by water curing. It shall not leave any discolorations on the structural concrete. It shall be applied as per the provisions of clause 1713.3 of MORTH specifications. No extra payment will be made for the same.

#### 3.11. Construction Joints

Construction joints in all concrete work shall be made as directed by the Engineer. Where vertical joints are required, shuttering shall be fixed as directed To ensure that the concrete

does not take natural slope.

Before fresh concrete is placed against a vertical joint, the old concrete shall be chipped, cleaned and moistened.

No separate payment shall be allowed to the Contractor for forming joints or chipping and cleaning them. When a horizontal construction joint is formed, provision shall be made for interlocking with the succeeding layer by the embedment of saturated wooden blocks or wooden strips beveled on four sides to facilitate their removal. Prior to the next pour the wooden pieces shall be loosened and removed in such a manner as to avoid injury to the concrete.

Construction joints in concrete walls and slabs for liquid retaining structures shall be prepared in a similar manner to normal construction joints. If use of metal, rubber or plastic water stops is specified, this shall be cast into joints. Measures shall be taken by the Contractor to ensure that no displacement or distortion of water stops takes place during placing of concrete. The construction joints shall ensure proper bond and leak proof joint.

### **3.12. Cracks**

If cracks, which in the opinion of the Engineer may be detrimental to the strength of the construction, develop in concrete construction, the Contractor at his own expense shall test the structure as specified in clause 1.1.16 of 'Loading Tests' of these Specifications. If under such test loads the cracks develop further, the Contractor shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto.

If cracks develop in the concrete construction, which in the opinion of the Engineer, are not detrimental to the stability of the construction, the Contractor at his own expense shall grout the cracks with neat cement grout or with other composition as directed by Engineer and also at his own expense and risk shall make good to the satisfaction of the Engineer all other works such as plaster, moulding, surface finish, which in the opinion of the Engineer have suffered damage either in appearance or stability owing to such cracks. The Engineer's decision as to the extent of the liability of the Contractor in the above matter shall be final and binding.

External crack width shall be restricted to 0.2mm on all viaduct structures. If crack width is more than 0.2mm or in the opinion of Engineer may be detrimental to concrete construction, the contractor should test the structure at his own expense.

### **3.13. Defective Concrete**

Should any concrete be found honeycombed or in any way defective, such concrete shall be cut out partially or wholly by the Contractor and made good at his own expense. If Engineer feels that repaired structure will not be having same strength or shape or uniformity with other exposed surface as original desired structure / original structure, the same shall be rejected by Engineer and required to be dismantled and disposed off by contractor at his own cost, as instructed by Engineer. Decision of the Engineer shall be final binding in this regard.

### **3.14. Exposed Faces, Holes And Fixtures**

On no account shall concrete surfaces be patched or covered up or damaged concrete rectified or replaced until the Engineer or his representative has inspected the works and issued written instructions for rectification. Failure to observe this procedure will render that portion of the works liable to rejection.

Holes for foundation or other bolts or for any other purposes shall be moulded, and steel angles, holdfasts or other fixtures shall be embedded, according to the drawing or as instructed by the Engineer.

**3.15. Finishes**

Unless otherwise instructed, the face of exposed concrete placed against formwork shall be rubbed down immediately on removal of the formwork to remove irregularities. The face of concrete for which formwork is not provided other than slabs shall be smoothed with a float to give a finish equal to that of the rubbed down face, where formwork is provided. The top face of a slab which is not intended to be covered with other materials shall be leveled and floated to a smooth finish at the levels or falls shown on the drawings or as directed. The floating shall be done so as not to bring an excess of mortar to the surface of the concrete. The top face of a slab intended to be surfaced with other material shall be left with a spaded finish. Faces of concrete intended to be plastered shall be roughened by approved means to form of a key.

**3.16. Concrete For Flooring On Grade**

Concrete for flooring on grade shall be placed in alternate bays not exceeding more than 4 m x 4m or as specified in the drawings including forming the joints or adjacent bays. The stiff mix shall be thoroughly vibrated and finished to receive the floor finish.

**3.17. Grouting Of Base Plates & Bolt Holes****3.17.1. Mixing**

Dry grout should be mixed in a mechanical mixer: the conventional 200/400-litre capacity concrete mixer can be used to mix four bags of dry grout; alternatively, paddle type mortar mixers can be used. The quantity of grout to be mixed at one time should not exceed that amount which can be placed in approximately 10 to 15 minutes.

**3.17.2. Batching**

Batching of grout by fraction of a bag is not allowed. The quantity of mixing water should be the minimum commensurate with workability, compaction, and filling of the grout in all corners and crevices. Mixing should be done for a minimum of three minutes to obtain a fluid grout of uniform consistency.

**3.17.3. Cleaning and preparation of the surface**

The base concrete should be clean and strong, and its surface should be properly hacked; all dust should be removed by suction or compressed air. The surface should be thoroughly wetted with water for several hours. Before the grout is poured, all free water should be removed and the flat surfaces coated with a thin cement slurry.

**3.17.4. Restraint**

Heavy back-up blocks of timber or concrete should be fixed on all sides of the base plate to prevent escape of the grout, when poured through the openings provided in the base plate. Adequate restraint must be ensured on all the sides for a period of 7 days to obtain effective expansion and shrinkage compensation.

**3.17.5. Curing**

The grout should not dry out where external restraint is provided in the form of form-work, the top opening and all stray openings should be covered with wet sack for at least 7 days.

**3.17.6. Placing and Compaction**

The grout should be placed quickly and continuously either through the holes in the base plates or from one side only to ensure complete filling without entrapment of air. Grout should be properly spread and compacted by rodding. Excessive vibration should be avoided.

Below the bed plates, the grout should be compacted using long pieces of doubled-over



flexible steel strapping or chains. The forward and backward movement of the strap or chain will assist in the flow of the grout into place. Steps must be taken to keep the grout in full contact with the underside of the bedplate until the grout sets; maintaining a small head of fresh grout in the forms.

#### 3.17.7. Shrinkage Compensated Grout

Shrinkage compensated grout or non-shrinkable grout of Associated Cement Companies Limited or any other approved manufacturer (*Fosroc, Roff, Sikka*, etc) should be used. The batching shall be as per the manufacturer's specifications, other procedures being as above.

### 3.18. Pre-Cast Concrete

The provision in this section shall be considered supplementary to general provisions for reinforced concrete works.

#### 3.18.1. Handling and Storage

The pre-cast units shall be stored as directed by the Engineer. The area intended for the storage of pre-cast units should be surfaced in such a way that no unequal settlement can occur.

To prevent deformation of slender units, they should be provided with supports at fairly close intervals and should also be safeguarded against tilting. Lifting and handling positions should conform to the Engineer's directions and drawings. In addition, location and orientation marks should be put on the members, as and where necessary. During erection the precast units should be protected against damage caused by local crushing and chafing effects of lifting and transport equipment.

#### 3.18.2. Temporary Supports and Connections

Temporary supports provided during erection should take into account all construction loads likely to be encountered during the completion of joints between any combination of precast and in-situ concrete structural elements. The supports should be arranged in a manner that will permit the proper finishing and curing of any in-situ concreting and grouting associated with the precast member being supported when the gaps of joints have to be filled with concrete or mortar. They should first be cleaned and faces of the joints should be wetted. The mixing, placing and compacting of cement and mortar should be done with special care. Mortar of a dry consistency should be in the proportion of 1:1½ (1 part of cement to 1½ parts of sand) and should be placed in stages and packed hard from both sides of the joint.

#### 3.18.3. Tolerances

The following tolerances apply to finished precast products at the time of placement in the structure. The forms must be fabricated / constructed to give a casting well within these limits:

- 1 Overall dimensions of members should not vary by more than  $\pm 6$  mm per 3 m length with a maximum variation of  $\pm 20$  mm.
- 2 Cross-sectional dimensions should not vary by more than the following :
  - $\pm 3$  mm for sections less than 150 mm thick
  - $\pm 4$  mm for sections over 150 mm & less than 450 mm
  - $\pm 6$  mm for sections over 450 mm to 1000 mm
  - $\pm 10$  mm for sections over 1000 mm
- 3 Deviation from straight line in long sections should not be more than + 6 mm up to 3 m, + 10 mm for 3 m to 6 m, + 12 mm for 6 m to 12 m.

### 3.19. Additional Specifications For Pumped Concrete

**3.19.1. Coarse Aggregates**

The maximum size of coarse aggregate shall be limited to one-third of the smallest inside diameter of the hose or pipe used for pumping. Provision shall be made for elimination of over-sized particles by screening or by careful selection of aggregates. To obtain proper gradation it may be necessary to combine and blend certain fractional sizes of aggregates. Uniformity of gradation throughout the entire job shall be maintained.

The quantity of coarse aggregate shall be such that the concrete can be pumped, compacted and finished without difficulty.

**3.19.2. Fine aggregates**

The fine aggregate to be used for the work should be of River sand / Manufacturer Sand conforming to Zone – II as per IS – 383 / clause 2.1.1. The quality and acceptance criteria should be followed as per IS – 383 / 1970 with latest correction slips. The decision of Engineer in this respect shall be final. The silt content of fine aggregate used for trial mixes shall be recorded & the silt content in fine aggregate used shall not exceed 8%. The tests acceptance criteria for fine aggregates shall be same as per CPWD specifications.

**3.19.3. Pumping of concrete**

Only approved pumping equipment, in good working condition, shall be used for pumping of concrete. Concrete shall be pumped through a combination of rigid pipe and heavy-duty flexible hose of approved size and make. The couplings used to connect both rigid and flexible pipe sections shall be adequate in strength to withstand handling loads during erection of pipe system, misalignment, and poor support along the lines. They should be nominally rated for at least 3.5 Mpa pressure and greater for rising runs over 30 m. Couplings should be designed to allow replacement of any section without moving other pipe sections, and should provide full cross section with no construction or crevices to disrupt the smooth flow of concrete.

All necessary accessories such as curved sections of rigid pipe, swivel joints and rotary distributors, pin and gate valves to prevent backflow in the pipe line, switch valves to direct the flow into another pipe line, connection devices to fill forms from the bottom up, extra strong couplings for vertical runs, transitions for connecting different sizes of pipe, air vents for downhill pumping, clean-out equipment etc, shall be provided as and where required. Suitable power controlled booms or specialized crane shall be used for supporting the pipe line. Pipe line can be replaced whenever it is not workable, because of the erosion and thickness reduction of pipe line walls.

**3.19.4. Planning**

Proper planning of concrete supply, pump locations, line layout, placing sequence, and the entire pumping operation for a particular pour shall be made and got approved. The pump should be as near the placing area as practicable, and the entire surrounding area shall have adequate bearing strength to support concrete delivery pipes. Lines from pump to the placing area should be laid out with a minimum of bends. For large placing areas, alternate lines should be installed for rapid connection when required. Standby power and pumping equipment should be provided to replace initial equipment, should breakdown occur.

The placing rate should be estimated so that concrete can be ordered at an appropriate delivery rate.

As a final check, the pump should be started and operated without concrete to be certain that all moving parts are operating properly. A grout mortar should be pumped into the lines to provide lubrication for the concrete, but this mortar shall not be used in the placement. When the form is nearly full, and there is enough concrete in the line to complete the placement the pump shall be stopped and a go-devil inserted and shall be forced through the line by water under pressure to clean it out. The go-devil should be stopped at a safe distance from the

end of the line so that the water in the line will not spill into the placement area. At the end of placing operation, the line shall be cleaned in the reverse direction.

### **3.20. Additional Specifications For Concrete**

3.20.1. Any of the following shall be permitted to be used as part replacement of Ordinary Portland Cement with the approval from Engineer.

- Microsilica / silica fume
- Fly Ash
- Ground Granulated Blast Furnace Slag (GGBS)

However the cement content excluding any mineral admixtures shall not exceed 450kg / cum except with the prior approval from Engineer

Also cement contents + binder should not be less than 400 kg / cum of concrete

The water / (cement + binder) ratio should generally not exceed 0.33, but in no case more than 0.40.

3.20.2. In order that the performance of the completed structure be consistent with the requirements and assumptions made during planning and design, stringent quality assurance measures shall be taken. The methods and procedures of Quality System shall follow the guidelines contained in IRC:SP:47 - 1998. Q-4 class of Quality Assurance shall be adopted for the 'Materials' and 'Workmanship' items.

3.20.3. The temperature of concrete at the time of placement shall not exceed 30° C. The temperature of concrete at the mixing stage should be lower, to allow for rise in temperature during transport. When considerable distance of transport is involved, particular attention should be paid to ensure retention of slump as targeted for placement.

3.20.4. Use of Microsilica / silica fume/ ALCCOFINE 1203 or equivalent

- (a) Mineral admixture in the form of microsilica or condensed silica fume shall be permitted in the design mix. It shall comply with ASTM C 1240 " Specifications for Silica Fume for use in Hydraulic Cement Concrete and Mortar". It shall be obtained from proven, reliable and approved manufacturer/supplier to the satisfaction of the Engineer.
- (b) Adequate and complete dispersal of the micro silica during the concrete mixing shall be ensured.
- (c) When microsilica is used in powder form the contractor shall take all precautions against potential health hazards during handling of the material.
- (d) Chilled water and / or ice shall be used in the concrete mix depending on the ambient temperature, dimensions of the concrete element, rate of pouring and design mix constituents.
- (e) Special profuse curing arrangements shall be made for dissipation of the heat of hydration. The water curing shall be continued for a period of 14 days.
- (f) The concrete design mix and arrangement for mixing, transportation, and curing of concrete shall be subject to the approval of the Engineer.

3.20.5. Use of Fly Ash

- a) Use of well-graded Fly Ash from an approved source may be permitted subject to satisfying the design criteria and requirement of mix design. Combination of mineral admixture and fly ash may also be used to improve upon the durability of concrete and getting the early strength as required. However, the contents of fly ash or fly ash + mineral admixture in the mix shall not be more than 35% of the total cementitious material (cement + fly ash or Cement + fly ash + mineral admixture as the case may be). The maximum allowable content of the fly ash or fly ash + mineral admixture shall be limited to 150 kg per cum of concrete mix.
- b) Saving in the cement contents due to this vis a vis the mix design without the using Fly Ash shall be passed on to the Employer.
- c) Fly Ash shall be conforming to IS:3812 (Part – 1):2003 and IS : 269-1989. Contractor shall have to make sure of availability of Fly Ash of consistent quality and in required quantity.
- d) The physical requirements for Fly Ash are as under:

| S. No. | Characteristics                                                                            | Requirement                                                                         |
|--------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1      | Fineness-specific surface in m <sup>2</sup> /kg by Blaine's permeability method, (minimum) | 320                                                                                 |
| 2      | Particles retained on 45 microns IS sieve (wet sieving) in percent, (maximum)              | 34                                                                                  |
| 3      | Lime reactivity – Average compressive strength in N/mm <sup>2</sup> (minimum)              | 4.5                                                                                 |
| 4      | Compressive strength at 28 days in N/mm <sup>2</sup> (minimum)                             | Not less than 80 percent of the strength of corresponding plain cement mortar cubes |
| 5      | Soundness by autoclave test – Expansion of specimen in percent (maximum)                   | 0.8                                                                                 |

- e) Source of Fly - Ash

To ensure the good quality of fly ash for use in concrete, the following sources of ash should be avoided:

- (i) Ash from plants burning different coal or blends of coal
- (ii) Ash from plants burning other fuels (wood chips, tyres trash) blended with coal
- (iii) Ash from start-up or shut down phases of operation
- (iv) Ash from plants not operating at a "Steady State"
- (v) Ash that is handled and stored using a wet system
- (vi) Unprocessed ash from power plant without electrostatic precipitator (ESP)

- f) Drying and Conditioning of Fly Ash  
When used in as a partial replacement for Portland cement in ready mix concrete, fly ash must be in dry form and as such requires no processing, provided above source control is maintained.
- g) Quality Control  
Fly Ash in concrete should be as consistent and uniform as possible. Fly Ash to be used in concrete should be monitored by quality assurance/quality control (QA/QC) programmed on lot basis. These procedures include performing tests for fineness by wet sieving at 45-micron sieve and loss on ignition (LOI) so that the consistency of a Fly Ash source can be certified.

Contractor shall have to evolve a suitable mix design on Fly Ash or fly ash + micro silica / silica fume (as the case may be) for the specified compressive/flexural strength and also demonstrate the suitability of the mix by field tests.

Concrete mixes are designed by selecting the proportions of the mix components that will develop the required strength, produce a workable consistency concrete that can be handled and paved easily, attend sufficient durability under exposure to in service environmental conditions. Procedures for proportioning Fly Ash or fly ash + micro silica / silica fume (as the case may be) concrete mixes differ slightly from those called conventional concrete mixes.

One mix design approach commonly used in proportioning Fly Ash or fly ash + micro silica / silica fume (as the case may be) concrete mixes is to use mix design with all Portland Cement. Increase the total cementitious materials content (normally by 12%) remove some of the Portland Cement and then add Fly Ash or fly ash + micro silica / silica fume (as the case may be) to compensate for the cement removed. Also, water content should be reduced by 5%. The ACI mix proportioning guidelines recommend a separate trial mix for each 5% increment in the replacement of Portland cement by Fly Ash.

When Fly Ash is used as a separately batched material, trial mixes should be made using a water (cement + fly ash) W/C + F ratio, sometimes referred to as the water cementitious ratio, instead of the conventional W/C ratio.

Also relaxation shall be given in such cases from 28 days strengths as 56 days strength shall also be tested for compliance. Minimum cement content should be 250 kg per cum. of concrete.

- h) It shall be the responsibility of the contractor to procure and to transport and to store the Fly Ash to batching plant site. Contractor may also have to make necessary modifications in the batching plant to enable use of Fly Ash in the concrete mix.
- i) **Fly Ash handling and Storage**  
When Fly Ash is used as cementitious material, the contractor should handle Fly Ash in the same manner as Portland cement, except that Fly Ash must be stored separately from the Portland cement. Loading, transportation, unloading including handling of the Fly Ash shall be done in eco-friendly manner so as not to pollute / degrade the atmosphere. The safety of the persons handling the Fly Ash should be ensured as per the approved norms.
- j) **Curing**  
Slower strength development of concrete containing Fly Ash may require that the moisture is retained in the concrete for a longer period of time than what is normally required for conventional concrete. Proper application of a curing compound should retain moisture in the concrete for sufficient period of time to permit strength development. Normal curing practices should be adequate for concrete containing Fly Ash.  
Scheduling of pavement construction should allow adequate time for the desired or specified gain prior to the placement of traffic loads.

### 3.20.6 Use of Ground Granulated Blast Furnace Slag (GGBS)

GGBS Conforming to IS : 12089 – 1987 (Reaffirmed 1999) will be used.

**3.21. Measurement**

Measurement shall be made for the finished volume of reinforced cement concrete (excluding lean concrete) only. All linear dimensions shall be measured correct to 1cm & restricted to design dimensions, and the volume calculation will be correct to two decimal places in cubic metres.

No deduction shall be made for volume of steel embedded in concrete or for voids not exceeding 0.03 cum in volume.

In case of pile caps, the quantity of concrete of piles, which has gone into the pile caps shall not be deducted.

**SECTION - S.04****4. FORM WORK****4.1. General**

These specifications shall be read in conjunction with the MORTH specifications and CPWD specifications 1996 / 2002 with correction slips / amendments upto date, and other relevant specifications described in the section 1 of these specifications.

**4.2. Materials**

Formwork shall be of timber, plywood (including marine plywood), steel or any other suitable material capable of resisting damage to the contact faces under normal conditions of erecting forms, fixing steel and placing concrete. The selection of materials suitable for formwork shall be made by the Contractor based on the quality consistent with the specified finishes and safety. For designated areas prominently in public view like piers, piers caps, portals, viaduct (cast-in-situ or pre-cast), parapet, columns etc., only steel shuttering shall be used. The material shall be approved by the Engineer before erected at site. However, the entire responsibility of planning, designing, erecting, dismantling, shifting and safety of false work lies with the contractor.

All formwork and formwork supports (centering, props, scaffolds, ladders etc.) shall be in structural steel only and preferably of pipes conforming to IS:806, IS:1161, IS:1239, IS:2750. Wooden ballies shall not be permitted as props/formwork supports. All props shall be properly braced using x & k bracings. Ladders to be used at site should have treads and shall be fabricated from structural steel. Wooden / bamboo / aluminium / pipe ladders shall not be permitted.

**4.2.1. Timber**

Timber used for formwork shall be easily workable with nails without splitting. It shall be stable and not liable to warp when exposed to sun and rain or wetted during concreting.

**4.2.2. Plywood**

Plywood used for formwork shall be minimum 12 mm thick. Shuttering quality plywood complying with IS:4990 and of make approved by the Engineer. Suitable stiffeners and walers shall be provided depending on the shuttering design.

**4.2.3. Steel**

Steel formwork shall be made of minimum 4 mm thick black sheets stiffened with angle iron frame made out of M.S. angles 40 mm x 6 mm supported at suitable spacing.

**4.3. Design & Drawings**

All temporary works such as formwork, falsework, staging, launching girder, cantilever form traveler scheme etc. shall be designed by the Contractor. The permissible stresses in materials of formwork, falsework, staging, launching girder & cantilever form traveler shall be same as for permanent structure. All calculations and drawings of the same including construction sequence shall be checked and verified by independent agency appointed by contractor. Only after the checking of the same, the calculations and drawings (along with soft copy in CD ROM) shall be submitted to Engineer for approval well in advance of work.

All temporary works shall be also inspected by the independent agency and independent report shall be submitted to Engineer. All temporary works shall be robust, safe and constructed such a way that the concrete can be properly placed and thoroughly compacted to obtain the required shape, position and level subject to specified tolerances. It is the

responsibility of the Contractor to obtain the results required by the Engineer, whether or not some of the work is sub-contracted. Approval of the temporary works by the Engineer shall not diminish the Contractor's responsibility for the satisfactory performance of the same, nor for the safety and co-ordination of all operations.

For pier formwork, it shall be ensured that total deflection (taking account of combined deflection of plate, stiffness, walers or any other supporting arrangement) shall not be more than 3mm.

All the formwork, launching truss and cantilever form traveler and other selected temporary works shall be tested for the load including factor of safety for which the truss/formwork is designed before use in works at no extra cost

The design of false work should be such as to facilitate easy and safe access to all parts for proper inspection.

Methodology for removal of form should be planned as a part of total form work design process.

In case of pre-stressed concrete work, careful consideration shall be given to re-distribution of loads due to pre-stressing.

#### **4.4. Formwork For Exposed Concrete Surfaces**

The facing formwork, unless indicated otherwise in drawings, or specifically approved by the Engineer in writing, shall generally be made with materials not less than the thickness mentioned below for different elements of the structure:

- 1 Plain slab soffit, and sides of beams, girders, joists and ribs and side of walls, fins, parapets, pardis, sun-breakers, etc shall be made with:
  - a. Steel plates not less than 4mm thick of specified sizes stiffened with a suitable structural framework and fabricated true to plane
  - b. Timber planks of 20mm actual thickness and of specified surface finish, width and reasonable length,
  - c. Plywood not less than 12mm thick (IS:4990 - Specification for Plywood for Concrete Shuttering Work) stiffened with a suitable timber frame work or 3mm thick plywood with a 20mm timber plank backing, of specified sizes stiffened with a suitable timber framework and bracing. At joints 6mm/10mm sponge to be provided.
- 2 Bottoms of beams, girders and ribs, sides of columns shall be made with
  - a. Steel plates not less than 5mm thick of specified sizes stiffened with a suitable structural framework, and fabricated true to plane
  - b. Timber planks of 35mm actual thickness and of specified surface finish, width and reasonable length,
  - c. Plywood not less than 12mm thick (IS:4990), of specified sizes stiffened with a suitable timber framework.
- 3 For Precast segments, piers, pier heads, portals etc. suitable steel form work is to be used unless otherwise specified by Engineer.



**4.5. Formwork For Sloped Surfaces**

- 1 Forms for sloped surfaces shall be built so that the formwork can be placed board-by-board immediately ahead of concrete placement so as to enable ready access for placement, vibration, inspection and finishing of the concrete.
- 2 The formwork shall be built in such a way so that the boards can be removed one by one from the bottom up as soon as the concrete has attained sufficient stiffness to prevent sagging. Surfaces of construction joints and finished surfaces with slopes steeper than 2 horizontal:1 vertical shall be formed as required herein.

**4.6. Formwork For Curved Surfaces**

- 1 The contractor shall interpolate intermediate sections as necessary and shall construct the forms so that the curvature will be continuous between sections. Where necessary to meet requirements for curvature, the form lumber shall be built up of laminated splices cut to make tight, smooth form surfaces.
- 2 After the forms have been constructed, all surface imperfections shall be corrected and all surface irregularities at matching faces of form material shall be dressed to the specified curvature.

**4.7. Erection Of Formwork**

The following shall apply to all formwork:

- 1 To avoid delay and unnecessary rejection, the Contractor shall obtain the approval of the Engineer for the design of forms and the type of material used before fabricating the forms. (Ref. ACI 347 Formwork for Concrete or equivalent I.S. Code).
- 2 All shuttering planks and plates shall be adequately backed to the satisfaction of the Engineer by a sufficient number and size of walers or framework to ensure rigidity during concreting. All shutters shall be adequately strutted, braced and propped to the satisfaction of the Engineer to prevent deflection under deadweight of concrete and superimposed live load of workmen, materials and plant, and to withstand pouring rate and vibration.
- 3 Vertical props shall be supported on wedges or other measures shall be taken so that the props can be gently lowered vertically during removal of the formwork. Props for an upper level shall be placed directly over those in the level immediately below, and the lowest props shall bear on a sufficiently strong area. Care shall be taken that all formwork is set plumb and true to line and level or camber or better where required and as specified by the Engineer.
- 4 Provision shall be made for adjustment of supporting struts where necessary. When reinforcement passes through the formwork care should be taken to ensure close fitting joints against the steel bars so as to avoid loss of fines during the compaction of concrete.
- 5 If the formwork is held together by bolts, these shall be so fixed that no iron will be exposed on surfaces against which concrete is to be laid and within the concrete cover to the steel reinforcement. In any case wires shall not be used with exposed concrete formwork. The Engineer may at his discretion allow the Contractor to use tie-bolts running through the concrete and the Contractor shall decide the location and size of such tie-bolts in consultation with the Engineer. The tie bolts shall be so designed that their removal on de-shuttering does not leave any embedment within the concrete cover to steel reinforcement. Holes left in the concrete by these tie-bolts shall be filled by the concrete repair material and the methodology as approved by the Engineer at no extra cost.

- 6 Provision shall be made in the shuttering for beams, columns, and walls for a port hole of convenient size so that all extraneous materials that may be collected could be removed just prior to concreting.

- 7 Formwork shall be so arranged as to permit removal of forms without jarring the concrete. Wedges, clamps and bolts shall be used wherever practicable instead of nails.

The formwork for beams and slabs shall be so erected that forms on the sides of the beams and the soffit of slabs can be removed without disturbing the beam bottoms or props under beams.

- 8 Surfaces of forms in contact with concrete shall be oiled with a mould oil of approved quality form releasing agent. If required by the Engineer the contractor shall execute different parts of the work with different mould oils to enable the Engineer to select the most suitable. The use of mould oil which results in blemishes of the surface of the concrete including diesel, burnt oil and any other lubricating oil shall not be allowed. Mould oil shall be applied before reinforcement has been placed and care shall be taken that no oil comes in contact with the reinforcement while it is being placed in position. The formwork shall be kept thoroughly wet during concreting and the whole time that is left in place. Nothing extra shall be paid to contractor for oiling the moulds.

- 9 Immediately before concreting is commenced, the formwork and other related arrangements shall be carefully examined to ensure the following:

- a Removal of all dirt, shavings, sawdust and other refuse by brushing, washing and compressed air / vacume cleaning.
- b The tightness of joints between panels of sheathing and between these and any hardened core.
- c The correct location of tie bars, bracing and spacers, and especially connections of bracing.
- d. Adequate cover blocks are in place
- e. Straightness and plumbness of the form work
- f. Side supports / restraints for the form work are enough and robust
- g. Construction joint (wherever applicable) is properly prepared
- h That all wedges are secured and firm in position.
- i That provision is made for traffic on formwork not to bear directly on reinforcing steel.
- j. Pouring platform along with its approach from ground is robust and safe for workers movement.
- k. Arrangement for vibrators for compaction of concrete
- l. Sequence of concrete pouring is well defined and is agreed upon by the Engineer and is explained to concrete pouring team
- m. The Pouring area is well lit.
- n. Curing arrangements are well planned and agreed upon by the Engineer.
- o. The green concrete protection measures from sun & rain etc. are in place.

- 10 The Contractor shall obtain the Engineer's approval for dimensional accuracies of the work and for the general arrangement of propping and bracing. (IS:3696 - Safety Code of Scaffolds and Ladders, IS:4014 Steel Tubular Scaffolding I & II). All scaffolding and staging shall be either of steel tubes or built up section of rolled steel with adequate bracing at several levels in each perpendicular direction connecting each prop. In addition to this diagonal bracing should be provided in elevation ideally at 45 degrees or between 30 and 60 degree. The Contractor shall be entirely responsible for the adequacy of propping, and for keeping the wedges and other locking arrangements undisturbed through the de-centering period. (IS:8989 Safety code for erection of concrete framed structures)

- 11 Formwork shall be continuously watched during the process of concreting. If during concreting any weakness develops and formwork shows any distress the work shall be stopped and remedial action as directed by the engineer shall be taken.
- 12 Staging for portal girder and cross girder (in station zone) shall be in the form of portal frame. It shall be ensured that minimum two lanes of traffic with a restricted height of 4.5m can ply underneath it with adequate protection to portal legs from moving traffic.

#### 4.8. Concrete Finishes

This section deals with the surface of concrete on which forms had been fixed while concreting.

##### 4.8.1. Formed Surface

Allowable deviation from plumb or level and from the alignment profile, grades and dimensions shown on the drawings is defined as "tolerance" and is to be distinguished from irregularities in finishes as described herein. Tolerances in concrete construction are specified elsewhere.

The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawings or as hereinafter specified. In the event of finishing not being definitely specified herein or in the drawings, finishes to be adopted shall be as directed by the Engineer.

Completed concrete surface shall be tested, where necessary to determine whether surface irregularities are within the limits specified hereinafter.

Surface irregularities are classified as "Abrupt" or "Gradual". Offsets caused by displaced or misplaced form sheathing, or form sections or by loose knots or otherwise defective timber form will be considered as abrupt irregularities, and shall be tested by direct measurements. All other irregularities shall be considered as gradual irregularities and will be tested by use of template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template shall be 150 cm for testing of formed surfaces and 300 cm for testing of unformed surfaces.

The classes of finish for formed concrete surfaces are designated by one of the symbols F1, F2, F3 and F4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

**Finish F1:** This finish applies to surfaces where roughness is not objectionable, or surface that will otherwise be permanently concealed. Surface treatment shall be the repair of defective concrete, correction of surface depressions deeper than 25 mm and filling of tie rod holes. Form sheathing will not leak mortar when concrete is vibrated. Forms may be manufactured with a minimum of refinement.

**Finish F2:** This finish is required on surfaces permanently but not prominently exposed to public view for which other finishes are not specified except F1. Forms shall be manufactured in a workmanlike manner to the required offsets or bulges. Surface irregularities shall not exceed 5mm for abrupt and 8mm for gradual irregularities measured with a 1.5 m template.

**Finish F3:** This finish is required for coarse textured concrete surfaces intended to receive plaster, stucco or wainscoting. Surface irregularities shall not exceed 5mm for both abrupt and gradual irregularities.

**Finish F4:** This finish is designated for surfaces prominently exposed to public view where appearance is also of special importance. This shall include piers of bridges, viaducts, beams, parapets, railings and decorative features on the structure and on the bridges. To meet with requirements for F4 finish, forms shall be manufactured in a skilful, workmanlike manner, accurately to dimensions. There should be no visible offsets, bulges or

misalignment of concrete. At construction joints, the forms shall be rightly set and securely anchored close to the joint. Abrupt and gradual irregularities shall not exceed 3mm. Irregularities exceeding this limit shall be reduced by grinding to a level of 1:20 ratio of height to length. Jute bag subbing or sand blasting shall not be used.

#### 4.8.2. Unformed Surfaces

The classes of finish for unformed surfaces are designated by symbols U1, U2, U3 and U4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

**Finish U1:** This finish applies to unformed surfaces that will be concealed permanently or otherwise where a screeded surface finish meets the functional requirements. Finish U1 is also used as the stage of finishes for U2 and U3. Finishing operations shall consist of sufficient levelling and screeding to produce an even uniform surface. Surface irregularities shall not exceed 10mm.

**Finish U2:** This is floated finish, and used on all outdoor, unformed surfaces. Finish U2 is also used as the second stage of finish for U3. Floating to be performed manually or mechanically on stiffened screed surface shall be minimum to produce textured surface. If finish U3 is to be applied, floating shall be continued till a small amount of mortar without excess water is brought to the surfaces so as to permit effective trowelling. Surface irregularities shall be removed as directed by the Engineer.

**Finish U3:** This is a trowelled finish and shall be used for tops of parapets, etc prominently exposed to view. When the floated surface has hardened sufficiently, steel trowelling shall be started. Steel trowelling on hardened, floated surface shall be performed with firm pressure to produce a dense uniform surface free from blemishes and trowel marks and having slightly glossy appearance. Surface irregularities shall not exceed 5mm.

**Finish U4:** This is a steel-trowelled finish, similar to finish U3, except that light surface pitting and light trowel marks such as obtained from the use of machine trowelling will be acceptable, provided that surface irregularities do not exceed the limits specified for finish U3.

Unformed surfaces which are nominally level shall be sloped for drainage as shown on drawings or as directed by Engineer unless the use of other slopes or level surface is indicated on drawings. Narrow surface such as tops of parapets, walls and kerbs shall be sloped approximately 1cm per 30cm of width. Broader surface such as roadways, platform and decks, shall be sloped approximately half centrimeter per 30cm of width. Finishes of floor and roof slabs shall be sloped, if required, by the Engineer.

#### 4.9. Exposed Concrete Work

Exposed concrete surfaces shall be smooth and even, originally as stripped without any finishing or rendering. Where directed by the Engineer, the surface shall be rubbed with carborundum stone immediately on striking the forms. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made true to their sizes, shapes and positions and to produce the surface patterns desired. No honeycombing shall be allowed. Honeycombed parts of the concrete including the other surface defects in the concrete shall be removed by the Contractor as per the methods, which do not affect the strength of adjoining Concrete and as approved by the Engineer.

Part of defective concrete thus removed shall be re-cast using fresh concrete of same grade or approved quality concrete repair material depending upon the size, location, thickness of the defective concrete and structural behavior of the member having defective concrete as instructed by the Engineer without extra cost,. For the purpose the Contractor shall prepare a comprehensive work procedure and get it approved from the Engineer. Nothing extra shall be

paid for repair of the concrete. Contractor shall ensure that no air bubbles are formed on the exposed surface. Concrete pouring sequence, vibration methodology etc shall be planned to avoid air bubbles. All materials, sizes and layouts of formwork including the locations for their joints shall have prior approval of the Engineer.

#### **4.10. Age Of Concrete At Removal Of Formwork**

In accordance with CPWD Specifications 1996 / 2002 or IS:456. The Engineer may vary the periods specified if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

#### **4.11. Stripping Of Formwork**

The work of form work removal should be planned and a definite scheme of operation worked out. Formwork shall be removed carefully without jarring the concrete, and curing of the concrete shall be commenced immediately. Concrete surfaces to be exposed shall, where required by the Engineer, be rubbed down with carborundum stone or bush-hammer to obtain a smooth and even finish. Where the concrete requires plastering or other finish later the concrete surface shall be immediately hacked lightly all over using approved methods and as directed by the Engineer. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms.

#### **4.12. Reuse Of Forms**

The Contractor shall not be permitted reuse of timber facing formwork brought new on the works for more than 5 times for exposed concrete formwork and 8 times for ordinary formwork. 5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. The Engineer may at his absolute discretion order rejection of any forms he considers unfit for use for a particular item irrespective of no of times the shuttering has been used and order removal from the site of any forms he considers unfit for use in the Works. Used forms brought on the site will be allowed proportionately fewer uses depending upon its condition and as decided by the Engineer. Use of different quality boards or the use of old and new boards in the same formwork shall not be allowed. If any other type of special or proprietary form work is used, the number. of times they can be used will be determined by the Engineer.

#### **4.13. Formwork For Precast/ Prestressed Concrete**

- 1 The provisions in this section shall be considered supplementary to the general provisions stated above and additional Technical Specifications for pre cast segments. Precast concrete members and panels shall be made in accurately constructed moulds, on a properly prepared casting bed. All aspects of the making, curing and erection of precast units shall be subject to the approval of the Engineer.

The contractor shall submit detailed drawings of formwork for the approval of the Engineer. Finishing with cement mortar shall not be allowed.

- 2 The formwork should be so designed that it does not restrain the shrinkage movements and possible shortening due to pre-stress of the concrete. The formwork shall be of sturdy construction with special considerations to shutter vibrators when used. All edges and joints of the formwork should be designed and sealed so that no cement grout can escape and there is no wedging or keying to the concrete. The effect of curing on the formwork should be given special consideration. Depending on care, curing, erection and maintenance of the formwork after stripping, the following number of uses can be made with different types of formwork.

|                                                                    |                                   |
|--------------------------------------------------------------------|-----------------------------------|
| Plywood with timber backed formwork                                | - As per satisfaction of Engineer |
| Steel moulds                                                       | -do-                              |
| Number of uses of shuttering to be as per approval of the Engineer |                                   |

In case concrete moulds can be satisfactorily provided by the contractor, the Engineer's approval shall be obtained before use on the works.

### 3 Stripping

As soon as the pre-cast units have attained sufficient strength, the formwork shall be stripped. The pre-cast unit shall be lifted uniformly out of the formwork without being subjected to tilting or restraint effects.

#### 4.14. Special Architectural Finishes

Special approved architectural finishes like grooves, logos, engravings/projections in inset and out set as per the approved design shall be provided by fixing monolithic rubber forms or any other approved material fixed on the entire surface of the form work. The shore hardness of the rubber shall be  $600 \pm 5A$  to ensure strength, flexibility and elasticity. The rubber shall be cold cured (preferably polyurethane based) and fixed to the formwork under controlled conditions in shade and air temperature not exceeding 280 C.

The form liners should be shrinkage free, solvent free and should be impervious to abrasion by Concrete, resistant to concrete pressure and heat resistant upto 700 C dry heat. Formwork liner fixation should be factory made under close tolerances and stage inspections.

- 4.15. If proprietary system of formwork is used, detailed information as given in Annexure 4.1 herein shall be furnished to Engineer for approval before use.

#### 4.16. Measurement

Unless stated otherwise, the rate for concrete in plain concrete, reinforced concrete or in prestressed concrete shall be deemed to include the cost of all formwork / shuttering, staging, launching etc.

**ANNEXURE 4.1****INFORMATION TO BE SUPPLIED BY MANUFACTURERS OF PROPRIETARY SYSTEMS OF FORM WORK****1. GENERAL**

- 1.1 The information which the manufacturer is required to supply shall be in such detail as to obviate unsafe erection and use of equipment due to the intention of the manufacturer not having been made clear or due to wrong assumptions on the part of the user.
- 1.2 The user shall refer unusual problems of erection/assembly not in keeping with intended use of equipment, to the manufacturer of the equipment.

**2. INFORMATION REQUIRED**

- 2.1 The manufacturers of proprietary systems shall supply the following information;
- a. Description of basic functions of equipment.
  - b. List of items of equipment available, giving range of sizes, spans and such like, with manufacturer's identification number or other references.
  - c. The basis on which safe working loads have been determined and whether the factor of safety given applies to collapse or yield.
  - d. Whether the supplier's data are based on calculations or tests. This shall be clearly stated as there may be wide variations between results obtained by either method.
  - e. Instructions for use and maintenance, including any points which require special attention during erection, especially where safety is concerned.
  - f. Detailed dimensional information, as follows:
    - i. Overall dimensions, depths and widths of members.
    - ii. Line drawings including perspectives and photographs showing normal uses.
    - iii. Self weight.
    - iv. Full dimensions of connections and any special positioning and supporting arrangements.
    - v. Sizes of members, including tube diameters and thicknesses of material.
    - vi. Any permanent camber built into the equipment.
    - vii. Sizes of holes and dimensions giving their positions.
    - viii. Manner of fixing including arrangements for sealing joints.
    - ix. Method of de-stripping, storing & shifting.
  - g. Data relating to strength of equipment as follows:
    - i. Average failure loads as determined by tests.
    - ii. Recommended maximum working loads for various conditions of use.
    - iii. Working resistance moments derived from tests.
    - iv. Working shear capacities derived from tests.
    - v. Recommended factors of safety used in assessing recommended loads and deflections based on test results.
    - vi. Deflections under load together with recommended pre-camber and limiting deflections.
    - vii. If working loads depend on calculations, working stresses should be tested. If deflections depend on theoretical moments of inertia or equivalent moments of inertia rather than tests, this should be noted.
    - viii. Information on the design of sway bracing against wind and other horizontal loadings.
    - ix. Allowable loading relating maximum extension of bases and/or heads.
    - x. Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions.

**SECTION - S.05****5. REINFORCEMENT****5.1. General**

These specifications shall be read in conjunction with the MORTH specifications and CPWD specifications 1996/2002 with correction slips / amendments upto date, and other relevant specifications described in the section 1 of these specifications.

Any steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications and shall be of tested quality under the ISI Certification Scheme.

All reinforcement work shall be executed in conformity with the drawings supplied and instructions given by the Engineer and shall generally be carried out in accordance with the relevant Indian Standard Specifications IS:2502- Bending and Fixing of Bars for Concrete Reinforcement.

Only TMT reinforcing bars of grade Fe500 (0.2% proof stress / yield stress not less than 500 Mpa) confirming to IS:1786 – 1985 shall be supplied and used as reinforcement steel for the permanent work

The reinforcement steel shall be from primary producers and no re-rolled steel shall be supplied and used. The contractor will produce copy of original challan / voucher as a proof of having purchased the steel reinforcement from approved manufacturers or their authorised distributors.

The steel reinforcement shall be brought to the site in bulk supply of 10 tonnes or more as decided by the Engineer. All reinforcement shall be stored horizontally above ground level on platforms, skids or other approved supports, clear of any running or standing water. Proper drainage of platform shall be provided. Steel reinforcement shall be stored in such a way as to avoid distortion and prevent deterioration by corrosion. Bars of different diameters shall be stored separately. A record shall be kept of the batch numbers of reinforcement deliveries in such a form that the part of works in which particular reinforcement is used can be readily identified.

**5.2. Inspection & Testing**

Every bar shall be inspected before assembling on the works and any defective pitted, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out.

No work shall be commenced without the Engineer's approval of the bar bending schedule.

Manufacturer's test Certificate shall be supplied for each lot of supply brought at site of work by the contractor.

Specimens sufficient for three Tensile Tests for each different size of bar, bend and rebend physical tests for each consignment delivered shall be sampled and tested by the Contractor before use at site. Test results shall be duly supported by Graph. Batches shall be rejected if the average results of each batch are not in accordance with the relevant specifications / codes and the rejected steel shall be removed from the site of work by the contractor at his own cost within a week's time from the written order from the Engineer.

**5.3. Bar Bending And Bar Bending Schedule**

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule. Bent bars are not straightened for use in any manner that will injure the material. No laps should be allowed for Pre-cast segments and Piers, Pier caps. However mechanical couplers are to be used without extra cost.



Prior to starting bar bending work, the Contractor shall prepare bar bending schedule from the structural drawings supplied to him and get the same approved by Engineer. Any discrepancies and inaccuracies found by the Contractor in the drawings shall be immediately reported to the Engineer whose interpretation and decision there to, shall be final.

#### **5.4. Couplers for reinforcement above 16 mm in dia & Laps**

As far as possible bars of the maximum length available shall be used. Payment for reinforcement shall be made only for reinforcement shown in such drawings and laps are not payable. For bars having larger diameter more than 16 mm mechanical couplers shall be provided at the locations approved by the Engineer and no lap shall be permitted. No extra payment on account of providing mechanical couplers shall be paid.

Welding in lieu of lap is not permitted unless specified in the drawings or as instructed by the Engineer.

#### **5.5. Spacing, Supporting And Cleaning**

All reinforcement shall be placed and maintained in the positions shown on the drawings.

The Contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape, size and strength M.S. Chairs and spacer bars shall be used to ensure accurate positioning of reinforcement.

Cover blocks shall be cast well in advance and shall consist of approved proprietary pre-packaged free flowing mortars (Conbextra HF of Fosroc or equivalent) having the strength same as that of concrete for the member for which they are to be used. They shall be circular in shape for side cover and square for bottom cover. Cover blocks shall be cast and compacted using plate vibrator or any other approved method and shall be cured so as to achieve the desired strength. The cost of cover blocks and chairs/spacers shall be deemed to have been included in the rates.

Bars must be cleaned before concreting commences of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete. Any reinforcement which is certified as corroded by the Engineer shall be removed from the site.

The HYSD bars shall be provided using cement and inhibitor using following procedure:

- a) Cleaning of steel by wire brush for dust and rust.
- b) Apply one coat of Cement slurry [1 kg cement & 600 cc of inhibitor solution (Patent No. 109784/67)] by dipping or brushing. Allow it to dry for 24 hours in shade. The water is not to be used. The inhibitor solution is prepared in ionised water

No extra payment shall be made for the same.

18 Gauge G.I. wire shall be used for binding reinforcement as well as for tying cover blocks with reinforcement.

#### **5.6. Welding**

- 1 Wherever specified all lap and butt welding of bars shall be carried in accordance with IS:2571. Only qualified welders duly tested and certified by the contractor shall be permitted to carry out such welding.
- 2 For cold twisted reinforcement welding operations must be controlled to prevent supply

of large amounts of heat larger than that can be dissipated. The extreme non twisted end portion shall be cut off before welding. Electrodes with rutile coating should be used.

- 3 Bars shall be free from rust at the joints to be welded.
- 4 Slag produced in welding after each run should be chipped and removed by brush.
- 5 Electrode should not be lighted by touching the hot bar.
- 6 The welding procedure shall be approved by the Engineer and tests shall be conducted to prove the soundness of the welded connection.

#### 5.7. Provision of Future Cathodic Protection for Corrosion Control:

In order to provide Cathodic Protection in future, all reinforcement shall be tack welded using electrodes compatible with the types of bars at the specified intervals in the drawings. As a guideline, all reinforcing bars shall be tack welded at each ends or at a distance not more than 6m along length to the bars intersecting in other direction. The tack welding shall be checked for the electrical continuity before concreting. This shall be measured and paid separately. There is no separate payment on account of providing welding. However, steel used shall be paid in the relevant BOQ.

#### 5.8. Measurement

The measurement shall be done by weight in MT based on bar bending schedule using the standard sectional weight of various bars as indicated below:

| S. No. | Bar Dia (mm) | Standard sectional weight in Kg. / m |
|--------|--------------|--------------------------------------|
| 1      | 6            | 0.222                                |
| 2      | 8            | 0.395                                |
| 3      | 10           | 0.617                                |
| 4      | 12           | 0.888                                |
| 5      | 16           | 1.578                                |
| 6      | 18           | 2.000                                |
| 7      | 20           | 2.466                                |
| 8      | 22           | 2.980                                |
| 9      | 25           | 3.854                                |
| 10     | 28           | 4.830                                |
| 11     | 32           | 6.313                                |
| 12     | 36           | 7.990                                |
| 13     | 40           | 9.864                                |
| 14     | 45           | 12.490                               |

Payment of reinforcement steel shall be made for the length of the reinforcement bars of different diameter as per approved bending schedule (to be prepared by the contractor on the basis of approved drawing) including authorised chairs / spacer bars, lap/butt welding wherever required as per Clause 5.4. However, if standard laps are provided, they will be measured separately for the length shown in the drawing or for measured length of bars. In case the actual reinforcement provided in any member is less than the quantity calculated based on drawings/ bar bending schedule (with the approval of engineer), the same shall be adjusted for the purpose of payment.

Payments shall not be made for butt welding and reinforcement bars used for lifting, hooks, handling, etc., as cost towards these is deemed to be included in the accepted rate of the item.

**SECTION - S.06****6. PRESTRESSING**

Structural concrete containing prestressed steel reinforcement to introduce pre-compression is termed as prestressed concrete.

**6.1. General**

The prestressed concrete work shall generally conform to IS:1343 “Code of Practice for Prestressed Concrete” and Section 1800 of MOST Specifications. The Concrete, Formwork and Non- tensioned reinforcement shall conform to relevant clauses in Section 3, 4, and 5 of this specification. The work shall be carried out in accordance with the drawing and these specifications or as approved by the Engineer.

The prestressing steel shall be un-coated stress relieved low relaxation seven-ply strand conforming to IS: 14268. All prestressing steel shall be free from splits, harmful scratches, surface flaws, piping and other surface defects likely to impair its use in prestressed concrete. The prestressing steel shall be stored in a manner such that they do not come in contact with dirt, water, greasy and other harmful materials. The contractor shall furnish the test certificate for each bundle of strands bought if required by the Engineer, he shall get tested at his cost samples of strands in specified bundles in an approved laboratory.

The land for setting up casting yard / Construction Depot as required shall be arranged by the contractor at his own cost.

The precast pre-tensioned elements shall be cast by the Contractor in the pre-casting yard. After 28 days of casting, the girders shall be transported to site and erected at appropriate position by the Contractor. The Tenderers are advised to visit the station sites as well as site of proposed pre-casting yard and assess the physical condition of the route for transportation of the elements. The Department shall allocate the premises of pre-casting yard for a specific period to the successful bidder on “as is where is” basis.

Concrete and un tensioned steel for the construction of prestressed concrete members shall conform to the requirements of sections respectively in so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

Contractor shall ensure that different components of prestressing such as jacks, bearing plates, wedges, anchorages, strands and HDPE ducts are compatible to one another and the same shall be exchanged in between all the suppliers to ensure the same.

**6.1.1. Scope of Work:**

The general scope of work will include:

- i. Providing and placing cement concrete with all ingredients and admixtures if and as required.
- ii. All arrangements needed to keep the reinforcement bars, pre-tensioned strands and sheathing in position with due spacing & cover blocks
- iii. Providing steel shuttering, staging, scaffolding, erection & eventual removal.
- iv. Providing and placing in position and fixing permanent specialized bearings with the super structure, with their anchor bolts as per detailed specifications/instructions as stipulated, supplemented by manufacturer's specifications and directions of Engineer including grouting of holes etc. if any, with suitable grouts as approved by the Engineer.
- v. Installation of expansion joints in stages over the viaduct deck as per approved

- drawings and as per manufacturer's specifications/directions of Engineer.
- vi. Fixing/embedding all necessary electrical or other fixtures which shall be supplied by the dept. free of cost at site.
  - vii. Providing and mixing cement concrete with all ingredients and admixtures if and as required.
  - viii. Casting, curing, with steam/water as necessary, stacking at casting yard including all handling, re-handling and interim storage operations as required for precast girders.
  - ix. Loading at casting yard, transportation to site in accordance with the prevailing traffic rules and regulations, unloading and stacking at site for precast girders.
  - x. Provision of necessary & suitable packing to maintain the required gap between precast girders.
  - xi. Protection of reinforcement, required to be left for Integration of the precast unit with top deck slab cast in place and bending the reinforcement to required shape after precasting & till their embedment in concrete.
  - xii. Transporting precast segment to the location of placement, hoisting & placing in correct position, including all handling operations.
  - xiii. The operation of placing precast segment over brackets/pier arms on teflon/neoprene pads/tar paper including the cost of all operations involved, appropriate setting of superstructure.
  - xiv. Fixing/embedding any fixture supplied by the Employer.
  - xv. The handling, carriage and storage of HT strands as per manufacturers specification.
  - xvi. The H.T. strands will be procured by the Contractor. The extra pieces of HT strands cut after the stressing of the cable will be the liability/property of the Contractor.
  - xvii. Cost of all other items of materials, plants and equipment and works (not specifically excluded above) for proper prestressing operation of the strands in accordance with the provisions contained elsewhere in the tender documents will be included in the cost of this item.
  - xviii. Providing/supplying and operating etc. of jacks and power pumps for prestressing, recording of data, tabulating the same in necessary formats for submission. The item will also include corrective measures that may be necessary and required by the Engineer.

## 6.2. Materials

### 6.2.1. Sheathing

All prestressing sheathing ducts shall be in the form of corrugated HDPE ducts (107mm ID for 19K15, 85mm ID for 12K15 & 19T13 etc) conforming to IRS Concrete Bridge Code-1997 (Addendum & corrigendum Slip No.5 Dated 19.11.2001 with modifications as stated below). The material for the ducts shall be high-density polyethylene with more than 2 percent carbon black to provide resistance to ultra-violet degradation and shall have the following properties:

|                                             |   |                                                                    |
|---------------------------------------------|---|--------------------------------------------------------------------|
| Density (IS 2530)                           | : | 0.94 – 0.96 g/cm <sup>3</sup> at 230C                              |
| Tensile Strength at yield (BS EN ISO 527-3) | : | 20-26 N/mm <sup>2</sup>                                            |
| Shore Hardness D (BS EN ISO 2039-1)         | : | 3 sec –60 min<br>15sec –58min                                      |
| Elongation at Yield (BS EN ISO 527-3)       | : | 7 %(min)                                                           |
| Melt Flow Index (MFI) ( IS:2530 )           | : | 0.4 - 0.6 g / 10 minutes(Temperature 190° C under a mass of 5 kg.) |

Charpy Impact strength of notched specimen (BS EN ISO 179)

|                      |   |                      |
|----------------------|---|----------------------|
| At 23 <sup>0</sup> C | : | 10 kJ/m <sup>2</sup> |
| -40 <sup>0</sup> C   | : | 4 kJ/m <sup>2</sup>  |

Coefficient of Thermal Expansion for 20<sup>0</sup>C – 80<sup>0</sup>C (DIN 53 752 ) : 1.50 x 10<sup>-4</sup> / °C

Environmental Stress Crack Resistance (ASTM D-1693) at 70<sup>0</sup> C : 192 Hrs

The thickness of the wall shall be 2.3 ± 0.3mm as manufactured and minimum 1.5mm after loss in the compression test, for duct size upto 160mm OD.

The ducts shall be corrugated on both sides. The duct shall transmit full tendon strength from the tendon to the surrounding concrete over a length not greater than 40 duct diameters. Material and formulation of sheathing ducts shall conform to test and acceptance criteria of Appendix 1B of IRC:18-2000.

These ducts shall be joined by adopting any one or more of the following methods, as convenient to suit the individual requirements of the location, subject to satisfactory pressure tests, before adoption.

- Screwed together with male and female threads
- Joining with thick walled HDPE shrink couplers with glue. This can also be used for connection with trumpet, etc
- Welding with electro-fusion couplers.

The joints shall be able to withstand an internal pressure of 0.5 bar (0.05 MPa) for 5 minutes as per water loss test procedure given in Appendix-B of IRS Concrete Bridge Code-1997 (Addendum & corrigendum Slip No.5 Dated 19.11.2001).

The initial acceptance tests such as bond test, compression test are required to be performed as acceptance criteria for system. In addition to above, friction test as given in FIB bulletin No-7 are also required to be performed as acceptance criteria. Test conducted by supplier in the past shall not be regarded as acceptance criteria.

The routine test such as workability test, transverse load rating test, tension load test and water loss test shall be applicable for both post threading and pre - threading system of cables. Loads to be imparted on the 107mm ID sheathing during transverse load rating test and tension load test shall be extrapolated from values given for smaller dia sheathing. At least 3 samples for one lot of supply (not exceeding 3000 metre length) shall be tested.

#### 6.2.2. Anchorages

##### 6.2.2.1. Anchorages shall be procured from authorised manufacturers only. Anchorages shall conform to BS:4447.

Load transfer test and anchorage efficiency shall be conducted as defined in FIP-1993. Engineer in-charge shall select at random, the required anchorage / wedges sample from completed lots for testing by the manufacturer. The concrete unit of required size/R/F will be made by contractor using same design mix of concrete which will be required for the load transfer test. The load transfer test shall be conducted at the strength of concrete at which stressing are proposed in the drawings.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

After completion of pre-stressing and grouting of cable in PSC girders, the extra length pre-stressing strands projecting outside the anchorage are required to be cut at the anchor end and anchor end is to be sealed.

##### 6.2.2.2. Swages of prestressing strand shall develop a strength of at least 95 per cent of the specified breaking load of the strand.

##### 6.2.2.3. Un tensioned Steel reinforcement, around anchorages shall be furnished by prestressing system supplier. Requirement of the same should be job specific and based on edge distance of anchorage and strength of concrete at the time of stressing of cables as defined in drawings. The same R/F shall be provided in unit required for load transfer test.

Minimum 3 tests each are required to be conducted for load transfer test and anchorage efficiency test. The manufacturer shall complete the required testing and determine compliance the result with FIP-1993 recommendations before transporting the lot to site.

#### 6.2.3. Prestressing Steel

Uncoated stress relieved low relaxation steel conforming to IS: 14268, class - 2 shall be used. Nominal dia shall be 15.2 mm with minimum breaking strength of 260.7 KN and minimum 0.2 % proof load of 234.6 KN. Various tests as recommended in IS: 14268 shall be conducted before transporting the lot to site. Apart from 1000 hrs relaxation test conducted by manufacturer, at least two such tests are required to be conducted by independent agency in the beginning of the project.

##### 6.2.3.1. Prestressing Strands/Wires Storage

All high tensile steel for prestressing work shall be stored about 30cm above the ground in a suitably covered and closed space to protect it from dampness. It shall also be invariably wrapped in gunny cloth or tar paper or any other suitable material, as per approval of Engineer. Even if it is to be stored in an area at the site for the short time during transportation it shall be suitably covered. Protection during storage and repacking or application of washable protective coating to the H.T. steel shall be given by the contractor at no extra cost if the packing of H. T. Strand/wire during unloading and storage / handling in the stores gets damaged.

The objectives are to keep the materials clean and free from detrimental corrosion and mechanical damage. Storage facilities and procedures for transporting material on site shall not permit tendons to be kinked or notched.

Stock piling of H. T. Steel on the work site shall not be allowed any time, specially before and during the monsoon.

Strand shall be stored in large diameter coils. The internal diameter of the coil generally

Engineer-in-Charge or his authorized representative shall always have an easy access to the store-yard for inspecting the H.T. Wire / strands / Bars and satisfying themselves regarding the condition thereof. Any modification regarding storage suggested by Engineer shall scrupulously be followed by the contractor. During monsoon days, H.T wires/strands shall be kept in reasonable air tight store, if required by the Engineer, at no extra cost.

#### 6.3. Testing of Prestressing Steel and Anchorages

All materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

All strand to be transported to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be transported shall be like-wise identified.

All samples submitted shall be representative of the lot to be furnished and in the case of strand, shall be taken from the same master roll. The Contractor shall furnish samples of at least 5.0m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or type to be used, shall be furnished along with short lengths of strands as required.

All equipment must be used in accordance with the specification of the manufacturer and must at all times be maintained in good condition.

The type of jack used should correspond with the type of strand used. It must also be checked that the jacks have the necessary stroke for the stressing of the strands/wires on the particular job. Pressure tests on jacks must be executed with pressures 10% higher than the

maximum operating pressure. The combined jack and pump system should be checked for correct behavior.

#### **6.4. Workmanship**

##### **6.4.1. Concreting for Precast Boxes**

Unless otherwise mentioned hereunder, the concrete shall be prepared, mixed and placed in position in accordance with the particular specifications given earlier. The Contractor shall maintain a record of the proportions of mix at the batching plant and produce the same for checking by Engineer-in-Charge whenever required.

The contractor shall take care in placing reinforcement cage so that cables / strands are not disturbed and the minimum cover as recommended in the drawing is available.

The reinforcement protruding at the ends of each girder shall be bent to the shape so as to match with the reinforcement of end cross diaphragm. The protruding reinforcement shall be coated with cement wash. Finished concrete shall have rough finish on top for proper bond with cast-in-situ top slab at site.

##### **6.4.2. Forms for Precast Prestressed Boxes**

The pre-tensioned girders shall be cast at casting yard. The contractor shall clean, thoroughly, the steel forms of all dirt, mortar and other matter such as chips, blocks etc. prior to using them. The contractor shall check the accuracy of alignment and rectify the inconsistencies, if any, of the forms and steel casting bed. Contractor shall also take care of bulkheads including positioning of jacks which may become necessary to suit the design requirement of the precast girders or as instructed by Engineer-in-Charge.

##### **6.4.3. Cleaning**

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance.

Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing carborundum powder. However, the tendons shall not be brought to a polished condition.

##### **6.4.4. Straightening**

High tensile strand shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

The packing of prestressing strand shall be removed only just prior to making of cable for placement. Suitable stands shall be provided to facilitate uncoiling of strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

##### **6.4.5. Post-Tensioning**

Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks. Pull-in or push-in of the prestressing strands shall be mechanized,

The locationing of prestressing cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons.

Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars so that they do not get disturbed during concreting.

The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.

Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.

The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete, which adheres to bearing or wedging surfaces, shall be removed immediately.

#### 6.4.6. Cutting

Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel. The location of flame cutting of strand shall be kept beyond 75 mm of where the tendon will be gripped by the anchorage or jacks.

In post-tensioning, the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

#### 6.4.7. Protection of Prestressing Steel

Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer. The prestressing steel of the end block will also be protected against corrosion by the method approved by the Engineer. Nothing extra shall be paid for the same

#### 6.4.8. Sheathing

The joints of all sheathings shall be water-tight. Special attention shall be paid to the junction at the anchorage end, where the sheathing must tightly fit on the protruding trumpet end of anchorage and thereafter sealed preferably with adhesive water proof tape as per approved manufacturer.

The sheathing and all joints shall be water-tight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

#### 6.4.9. Grout Vents

Grout vents of at least 20 mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacing of consecutive vents do not exceed 20m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0 MPa without the loss of water, air pressure or grout.

#### 6.4.10. Anchorages



All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning. Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the anchorage assembly.

The anchorages shall be recessed from the concrete surface as per drawings.

After the prestressing operations are completed and prestressing strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 microns per coat and entire recess shall be filled with concrete or non-shrink/pre-packaged mortar or epoxy concrete.

#### **6.5. Post-Tensioning**

Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

Parallel measurement of prestressing force by load cell in combination with direct reading of pressure gauge shall be preferred. In any case such parallel measurements by load cell shall be made for at least 10% of the cables stressed during any tensioning operation

The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows:

- a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.
- b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5kg/sq.cm until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.
- c) If the elongation at 1.05 times the Specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken, in succession, to determine the cause of this discrepancy :
  - i) Check the correct functioning of the jack, pump and leads.
  - ii) Detention the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Retension the cable if free.
  - iii) Re-establish the modulus of elasticity of steel for the particular lot from an

approved laboratory. Contractor may suggest other remedial measure for approval of the Engineer.

If the required elongation is still not obtained, further finishing operations as cutting or sealing, should not be undertaken without the approval of the Engineer.

- d) When stressing from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in Appendix 1800/II of MOST Specification.

- e) Any breakage of individual strand / groups of strands during tensioning shall require immediate destressing of all strands and replacement of the all the strands by fresh strands.

#### **6.6. Grouting of Prestressed Tendons**

Prior to grouting, all cables shall be tested with water pressure of 0.5 Bar (0.05 MPa) for approximately 5 minutes, to investigate leakages and connectivity of ducts. Where directed by the Engineer, the Contractor shall perform full scale site test to determine the adequacy of grout mix, equipment and grouting method. The Contractor shall submit a method statement detailing the test procedure.

All other aspects of grouting of cables shall be governed by. MORTH Specifications. A record of grouting operations shall be maintained in the format as given in Appendix 1800/IV of MORTH Specifications.

#### **6.7. Supervision**

All prestressing and grouting operations shall be undertaken by trained personnel only. A representative of supplier of the prestressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

#### **6.8. Tensioning Equipment**

All tensioning equipment shall be procured from authorised manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power-driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements:

- (i) Jack & pump shall be got calibrated from a laboratory having NABL certification prior to use and then at intervals not exceeding 3 months.
- (ii) As one pair of pre-stressing tendon is generally stressed simultaneously, the equipment used should be able to work in tandem.
- (iii) The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.
- (iv) Before initial use & subsequently at suitable intervals the prestressing equipment shall be checked to determine any variation from normal values during use. So far as these variations depend upon external influence (e.g. temperature in case of oil jacks) they shall be taken in to account
- (v) The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete; and

- (vi) Means shall be provided for direct measurement of the force by use of dynamometers or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the linear measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.

All dynamo meters and pressure gauges including a master gauge shall be calibrated by an approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

Pressure gauges shall be concentric scale type gauges accurate to within two per cent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 per cent of its breaking load, the gauge is reading between 50 percent and 80 percent of its full capacity.

Suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

Provision shall be made for the attachment of the master gauge to be used as a check whenever requested for by the Engineer.

#### **6.9. Safety Precautions During Tensioning**

Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

The operations of the jacks and the measurement of the elongation associated operations shall be carried out in such a manner and such a position that the safety of all concerned is ensured.

A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

During actual tensioning operation, warning sign shall be displayed at both ends of the tendon.

After prestressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without express approval of the Engineer.

No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon which has been affected by welding, weld spatter or heat shall be rejected.

#### **6.10. Tolerances**

Permissible tolerances for positional deviation of Prestressing tendons in cast-in-situ construction shall be limited to the following

- |                                                    |        |
|----------------------------------------------------|--------|
| a) Variation from the specified horizontal profile | : 5 mm |
| b) Variation from the specified vertical profile   | : 5 mm |
| c) Variation from the specified position in member | : 5 mm |

#### **6.11. Tests And Standards Of Acceptance**

The materials shall be tested in accordance with these Specifications and shall meet the

prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

#### **6.12. Quality Control and Testing Materials**

The contractor shall carry out all tests of materials in order to guarantee the specified quality in accordance with the relevant clauses of this specification.

##### **6.12.1. Curing of Precast Girders**

The pre-tensioned girders shall be subjected to steam curing. Temperature gradients within the elements must be minimised as curling, warping and similar defects may be introduced into the concrete by differential thermal movement. The contractor shall maintain steam curing record of the girder in an approved proforma. For the observations of temperature, thermocouples, thermistors, immersion thermometers etc. shall be used by the contractor.

The contractor shall observe the following precautions during steam curing process:

- i) Rate of rise of temperature in the concrete does not exceed 15 C/hour in the first 3 hours.
- ii) Thereafter, the rate of rise and fall of temperature of concrete does not exceed 35 C/hour.
- iii) The temperature of concrete does not exceed 80 C.

In order to avoid thermal cracking, exposure to ambient temperature should not take place while the temperature of the concrete is more than 40°C above ambient temperature.

Wet curing of the above element shall continue constantly for a period of 14 days, after the steam curing is over.

##### **6.12.2. Tests of Precast Pretensioned Elements**

One unit of each type of precast element shall be load tested upto to failure but its quantity shall not be measured for payment.

Prior to carrying out load tests, if required, the contractor shall submit arrangement of testing, loading etc. and shall carry out any modifications, if needed, on the existing testing arrangement to the satisfaction of Engineer-in-Charge at no extra cost. The contractor shall submit a report containing test results and observations etc. to the department.

##### **6.12.3. Shop drawings and design calculations for construction procedures**

The contractor shall submit according to a schedule, complete details and information concerning the method, materials, equipment and procedures he proposes to use. These shall be called "Method statements". Method Statements shall be submitted sufficiently in advance of the start of superstructure field construction operations, so as to allow the Employer's Representative adequate review period, which shall not be less than 30 days. The submittals shall invariably include step-by-step casting, lifting, curing, stacking, transportation and erection procedure. The contractor's Method Statements shall also include all calculations, drawings and information as may be relevant. The following points are specifically highlighted.

- Accommodating block-outs, openings and protrusions. Protruding re-bars may be needed (track starter rebars, for example). Anchorages and inserts for OHE poles, Signalling equipment and cable routing supports shall also be included where needed in precast beams.
- Adjusting to changes in girder length, curve, inclination and camber as shown in

- Detailed Design Drawings issued by Employer.
- Adjusting the profile to take into account design camber values
  - Stripping without damage to the concrete
  - The form design shall provide a tapered portion at both end for bearing of electrometric bearing.
  - Forms shall not be removed until the concrete has attained adequate strength. Care should be exercised in removing the forms to prevent spalling and chipping of the concrete.
  - All side, bottom and end forms for precast beams shall be constructed of steel.
  - Forms shall be of sufficient thickness, with an adequate external bracing and stiffeners, and shall be sufficiently anchored to withstand the forces due to placement and vibration of concrete.

No tie bolt is permitted for casting of precast beam. Joints in the forms shall be designed and maintained for mortar tightness. The grade and alignment of forms shall be checked each time they are set and shall be maintained during the casting of concrete.

### **6.13. Measurements For Payment**

Prestressed Concrete shall be measured in -cubic metres based on theoretical cross-sectional area and length. The volume occupied by mild steel reinforcement / HYSD bars, high tensile steel, sheathing and anchorages shall not be deducted.

Measurement for transportation of precast member/segment shall be measured in tonnes based on standard density of concrete equivalent to 2.4 t/cum including the weight of rebars, sheathing ducts, embedments etc.

High tensile (prestressing) steel shall be paid for separately and measured as actually incorporated in finished work i.e end of live end wedges to dead end wedges. (The rate shall include its length including additional length of cables for attaching jacks or additional length at dead end).

From the length so measured its weight shall be calculated in tonnes on theoretical basis based on the standard weight per m length and paid for.

Actual length of sheathing provided in permanent works shall be measured and paid for separately. All the accessories required for grouting operations, protection of sheathing, couplers for sheathing, samples for testing including testing shall all be deemed to be included in the item of sheathing and shall not be paid for separately.

Actual numbers of anchorages used shall be measured and paid for separately. Making of recess and filling the same, protection by painting with epoxy and furnishing samples for testing including testing shall all be deemed to be included in the item of anchorages and shall not be paid for separately. The rate shall also include payments, if any to be made to the supplier of the prestressing system who has to monitor, ensure and certify the correctness of all the arrangements/operations.

### **6.14. Rate**

The contract unit rate for cast-in-situ / precast prestressed concrete shall cover the cost of all materials, labour, tools and plant required for mixing, placing in position, vibrating and compacting, finishing as per directions of the Engineer, curing and other incidental expenses for producing concrete of specified strength to complete the structure or its components as shown on the drawings and according to specifications. The contract unit rate shall also include the cost of making, fixing and removing of all centering and forms required for the work unless otherwise specified in the Contract. The shuttering shall have to be of steel plates and arrangement has to be designed and provided to ensure that there is no obstruction to traffic during construction. Design calculations shall be submitted for approval for all temporary construction which may be required to complete the work.

For precast concrete members, the rate shall include the cost of all items as mentioned above and materials, labour, tools and plants required for casting bed, curing (water or steam), handling equipments, steel moulds, transportation of elements within casting yard ( i.e to curing tank or stacking yard etc). However, the cost of transporting the segments from casting yard to launching site, launching arrangements, application of epoxy including temporary bar prestressing etc will be paid separately as per BOQ.

The contract unit rate for high tensile steel shall cover the cost of all items as mentioned above including material, labour, tools and plant including plant required for manufacturing, placing, tensioning, anchoring and grouting the high tensile steel in the prestressed concrete as shown on the drawings and as per specifications herein above or as directed by the Engineer.

**SECTION - S.07****7. (A) STRUCTURAL STEEL WORKS**

- 7.1.** These specifications shall be read in conjunction with the CPWD specifications 1996 and other relevant reference specifications described in the section 1 of these specifications.

The Contractor will provide all materials and equipment required to complete the works in every respect, whether such materials are required as part of the permanent structures or temporary for fabrication or erection or maintenance including specifically structural steel plates, flats, bars, welding rods, rivets, bolts and nuts, paint, welding sets in the shop and at site, all workshop facilities, derricks, cranes, pulley blocks, wire ropes, hemp or manila ropes, winches, erection cleats and temporary braces or supports and all other materials required to deliver the Works complete in every respect.

All labour required for fabrication and erection for any cleaning, making good, rectifying, hauling, painting and for any other ancillary work required to complete fabrication and erection.

The Contractor shall observe all safety requirements for erection of structural steelwork as covered in IS:7205.

**7.2. Drawings :**

- 7.2.1.** The Engineer will supply to the Contractor profile drawings showing sizes of all structural members and typical connection details.
- 7.2.2.** Should there be any discrepancy in the drawings the Contractor is to refer the matter to the Engineer. The Contractor shall further provide a drawing showing the accurate setting out to line and level of all the anchor bolts intended for the work in sufficient time for their inclusion in the work so as to maintain the building program.
- 7.2.3.** The Contractor is to prepare all the necessary fabrication shop drawings and these shall be submitted to the Engineer in duplicate and be approved by him before fabrication is commenced. All such drawings shall show the dimensions of all parts, method of construction, welding and bolting. A further set of all approved fabrication drawings shall be supplied by the Contractor for use of the Engineer as required.
- 7.2.4.** Approval by the Engineer of drawings or any other particulars submitted by the Contractor shall not relieve the Contractor of full responsibility for any discrepancies, errors or omissions therein. The Contractor shall at his own expense supply such additional copies of his working drawings as are required for the use of the interested parties.

**7.3. Material:**

**7.3.1. Structural Steel**

All structural steel shall be of tested quality and shall conform to one of the following standards:

- IS:226 Structural steel (Standard Quality)
- IS:2062 Structural steel (Fusion welding quality)
- IS:961 High Tensile Structural Steel (Ordinary)
- IS:1161 Steel Tubes for Structural purposes
- IS:4923 Hollow Steel Sections for Structural use

The Contractor shall supply to the Engineer copies of the manufacturer certificate that the steel brought to the site for incorporation in the works is of a quality fully complying with the specification. If required by the Engineer, the Contractor shall arrange for testing of the steel samples as per IS:1608 - 1599.

**7.3.2. Welding Electrodes:**

Welding electrodes used for the works shall conform to IS:814/latest and shall be supplied by manufacturer approved by the Engineer and shall be of the grade approved by the Engineer. All Electrodes shall be kept under dry conditions. Any electrode which has part of its flux coating broken away or is damaged shall be rejected.

**7.3.3. Bolts and Nuts:**

Bolts and nuts used for the works shall unless otherwise specified be black bolts and nuts supplied by manufacturer approved by the Engineer and shall conform to IS:1367.

For the truss hot-dip galvanized (@ 300gm/sqm) bolt sleeve of mild steel grade 'B' conforming to IS:2062 and 4 dia 12mm anchor bars welded to same as per detailed drawing and instruction of the Engineer shall be provided. The length and diameter of sleeve shall be 300mm and 60mm respectively. The sleeve shall receive hexagon head bolt IS:1363 (part –I) –ISO 4016-M20x90-8.8. Hexagon head bolt shall be provided with galvanized spring washer as per the detailed drawing and instruction of the Engineer.

**7.3.4. Washers**

Plain washers shall be made of mild steel conforming to IS:5369 (1975), unless otherwise specified. One washer shall be supplied with each bolt and, in case of special types of bolts, more than one washer as needed for the purpose shall be supplied. An additional double coil helical spring washer, conforming to IS:6755 (1980), shall be provided for bolts carrying dynamic or fluctuating loads and those in direct tension. Tapered washers, conforming to IS:5372 (1975) and IS:5374 (1975), shall be used for channels and beams respectively wherever required.

7.3.5. For all other material required for the works, the approval of the Engineer shall be obtained by the Contractor prior to the use of the material in the works.

**7.4. Workmanship and Fabrication :**

7.4.1. For all the works, workmanship shall be of first class quality, throughout, in conformity with IS:800-latest, and true to line, level and dimension as shown in the drawings or instructed by the Engineer.

7.4.2. All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly at top and bottom without being drawn or caulked. The component parts shall be so assembled that they are neither twisted nor otherwise damaged as specified cambers if any shall be provided. Drilling done during assembling shall not distort the metal or enlarge holes. The butting surfaces at all joints shall be so cut and milled so as to butt in close contact throughout the finished joints.

7.4.3. Cutting shall be done automatically. Hand flame cutting will not be permitted.

7.4.4. The edges and ends of all cut/sheared flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground.

7.4.5. Holes for bolts shall be drilled to conform to clause 10 of IS:7215 (1974). Punching of holes will not be permitted. All drilling shall be free from burrs. No holes shall be made by gas cutting process.

7.4.6. All welding for the works shall be carried out by first class welders and shall be in accordance with IS:816, IS:819, IS:1024, IS:1261, IS:1323 and IS:9595. The Engineer may at his discretion order periodic tests of the welder and/or of the welds produced by them. All such tests, shall be carried out by the Contractor at his cost.



- 7.4.7. Safety requirements should conform to IS : 7205, IS : 7273 and IS : 7269 as applicable and should conform to safety, economy and rapidity.
- 7.4.8. As much work as possible shall be welded in shops. The pieces shall be manipulated to ensure down hand welding for all shop joints as far as possible. All parts to be welded shall be arranged so as to fit properly on assembly. After assembly and before the general welding is to commence the parts are to be tack welded with small fillet or butt welds as the case may be. The tack welding must be strong enough to hold the parts together but small enough to be covered by the general welding. The welding procedure shall be so arranged that the distortion and shrinkage stresses are reduce to a minimum.
- 7.4.9. All joints required in structure to facilitate transport or erection shall be shown on the drawings or as specified by the Engineer. Should the Contractor need to provide joints in locations other than those specified by the Engineer he shall submit his proposals and obtain the prior sanction of the Engineer for such joints. The lengths of structural shall be the maximum normally available in the market jointing of shorter length in order to make up lengths required shall not be permitted.
- 7.4.10. Each piece of steel work shall be marked distinctly before delivery, indicating the position and direction in which it is to be fixed. Three copies of a complete marking plan are to be supplied to the Engineer before erection commences.
- 7.4.11. In the case of welded fabrication any distortion remaining in the member after welding operations are completed shall be rectified by and/or at the expense of the Contractor to the approval of the Engineer.
- 7.4.12. All members of trusses and lattice girders shall be straight throughout their length, unless shown otherwise on the drawings, and shall be accurately set to the lines shown on the drawings. Sheared edges of gussets or other members to be straightened and dressed where necessary.
- 7.4.13. Templates and jigs used throughout the work shall be all steel. In cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether they are fit to be used as parts of the finished structure.
- 7.4.14. Apart from the requirements of welding specified under the above sub clauses, sections above, the Contractor shall ensure the following requirements in the welded joints.
- i) Strength-quality with parent metal.
  - ii) Absence of defects
  - iii) Corrosion resistance of the weld shall not be less than that of parent material in an aggressive environment.
- 7.4.15. No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening. Nuts and bolts shall always be tightened in a staggered pattern and, where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.
- 7.5. Testing of Welds :**
- 1 Butt welds - Radiographic testing of 5% of welds as per IS 1182.
  - 2 Fillet welds - Ultrasonic testing of 5% of welds.
  - 3 All welded connections shall be inspected as per IS:822
  - 4 All welds shall be tested by "dye penetration test" as per current practices.
  - 5 Agency for testing of weld shall be approved by the Engineer prior to testing.
  - 6 Defected welds shall be repaired or replaced as decided by the Engineer. The repaired or replaced welds shall be tested using the same methods as above. Additionally, when defective welds are found, the cause of the defective welding shall be determined and the contractor shall institute immediate corrective action.
  - 7 No extra payment shall be made for the tests indicated above.

**7.6. Protection of Steel Works (IS:8629):**

- a) Sand blasting where specified shall be carried out in accordance with IS:1477.
- b) Painting work shall be carried out in accordance with IS:8629 (Parts I to III). Painting shall be applied under the temperature requirement specified by the manufacturer.
- c) The steel work, prior to delivery, shall be cleaned from scale, rust, dirt and grease etc., but means of chipping, scraping and wire brushing using skilled operators as described in the painting systems below. The cleaning shall proceed each day over the extent of surfaces which can be painted on that day. The paint shall be applied by brushing or spraying as per approval of the Engineer.
- d) Paint brushes round/oval and flat shall be conforming to IS:487 and IS:384 codes respectively, if painting with brushing is approved by Engineer.
- e) The spraying equipment shall be compatible with the paint material, fitted with necessary gauges and controls and approved by the Engineer.
- f) Site weld locations shall be left free from paint within 50mm of the weld position, and contact surfaces in connection using High Strength Friction Grip Bolts shall not be painted. Immediately after completion of erection all damaged paint shall be scraped off and made good to the approval of the Engineer.
- g) The Steelwork specialist shall also clean down and apply one coat of primer to all site bolts, site bolted connections and site weld locations and the paint work generally shall be left in sound condition for any subsequent painting.
- h) All paints and primers shall be of best quality and in original sealed containers as packed by the paint manufacturer conforming to the relevant Indian Standards and shall be procured directly from the manufacturers. All paint to be used shall be stored under cover in such conditions as will preserve it from extreme of temperature and the paint shall be used and applied strictly in accordance with the manufacturer's instructions.
- i) In addition, the following specification shall apply to the shop painting of contact and inaccessible surfaces:
  - a. Surfaces to be painted shall be thoroughly cleaned from scale, rust, dirt, grease etc. by means of sand/grit/shot blasting or other equivalent means.
  - b. Surfaces which are to be brought permanently into close contact or made inaccessible either in the shops or upon erection shall, after cleaning, be given two coats of Red Lead Priming Paint. The surfaces shall be brought into contact while the paint is still wet.
  - c. Contact surfaces in connection using High Strength Friction Grip bolts shall not be painted or oiled and shall be free from dirt, loosed scale, burrs, pits and any other defects which would prevent the solid seating of the parts and would interfere with the development of friction between them.
  - d. All enclosed surfaces of box members shall be completely sealed by oiling or by coating with an approved bitumen paint and all such members and tubes shall have their ends closed by suitable plates welded in position.
- j) Surfaces in contact during shop assembly shall not be painted. Surfaces which cannot be painted, but require protection, shall be given a rust inhibitive grease conforming to IS:958 (1975), or solvent deposited compound conforming to IS:1153 (1975) or IS:1674 (1960), or treated as specified in the drawings.
- k) Surfaces to be in contact with concrete shall not be painted.

**7.7. Erection & Site Work:**

- 7.7.1. The Contractor shall be responsible for checking the alignment and level of foundation and correctness of foundation bolt centres, well in advance of starting erection work, and shall be responsible for any consequences for non-compliance thereof. Discrepancies if any shall immediately be brought to the notice of the Engineer for his advice.
- 7.7.2. The structure should be divided into erectable modules as per the total scheme. This should be pre-assembled in a suitable yard/platform and its matching with members of the adjacent module checked by trial assembly before erection.

- 7.7.3. Immediately prior to erection any rust in the paint area shall be removed by power wire brushing to a standard equivalent to SA3.
- 7.7.4. During erection the rough handling of fabricated materials such as bending, straining or pounding with sledges shall be avoided. Any damage to the structure during transportation or erection shall be immediately rectified by the Contractor at his own cost. The straightening of bend edges of plates, angles and other sections shall be done by methods which will not cause fracture.
- 7.7.5. Following the completion of the straightening, the surface of the member shall carefully be inspected for damage and got approved by the Engineer before further use.
- 7.7.6. The Contractor shall be responsible for accurately positioning, leveling and plumbing of all steelwork and placing of every part of the structure in accordance with the approved drawings and to the satisfaction of the Engineer. All stanchion base, beam and girder bearings etc. shall be securely supported on suitable steel packs. All reference and datum points shall be fixed near the work site for facilitating the erection work.
- 7.7.7. All equipment used by the Contractor shall be sufficient for the purpose and for the erection of the steel work, in the time specified in the contract. Any lifting or erecting machinery shall be to the approval of the Engineer and shall be removed from the site if he considers such appliances dangerous or unsuitable for their functions. The approval of the Engineer shall not relieve the Contractor of the responsibilities for the loads to which the erection equipment shall be called upon to carry. Adequate arrangement shall be made to resist wind loads and lateral forces arising at the time of erection.
- 7.7.8. The Contractor is entirely responsible for the stability of the structure during erection and shall arrange that sufficient tack bolts, braces or guy ropes are used to ensure that work will remain rigid until final bolting, rivetting or welding is completed. The Contractor shall supply and fix, without extra charge, any temporary bracing which may be necessary.
- 7.7.9. All steelwork shall be erected in the exact position as shown on the drawings. All vertical members shall be truly vertical throughout and all horizontal members truly horizontal, fabrication being such that all parts can be accurately assembled and erected. No permanent bolting, welding or grouting shall be done until proper alignment has been obtained and checked by the Engineer.
- 7.7.10. At stanchion splices and at other positions where concrete cover to the steel is liable to be restricted, bolts will be placed with their heads on the outside of the members.
- 7.7.11. All field assembly bolting and welding shall be executed in accordance with the requirements for shop fabrication excepting such as manifestly apply to shop conditions only. Where steel has been delivered painted the paint shall be removed before field welding for a distance of at least 50mm on either side of the joints. The number of washers on permanent bolts shall not be more than two for the nut and one for the bolt head.

**7.8. Rectification of damaged materials :**

Any error in shop work which prevents the proper assembly and lifting up of the parts by moderate use of drift pins or reaming or cutting shall be immediately reported to the Engineer and his approval of the method of rectification obtained in writing. Wrongly fabricated material whose erection in the field necessitates extra work shall be the responsibility of the contractor. The entire costs of such operation including the replacement of defective members, if required, shall be borne by the contractor.

**7.9. Inspection :**

- 7.9.1. The contractor shall inform the Engineer of the progress in fabrication and as to when individual pieces are ready for inspection. All gauge templates necessary to satisfy the Engineer shall be supplied by the contractor. The Engineer may at his discretion check the results obtained at the contractor's works by independent tests and should the material so tested be found unsatisfactory, the cost of such tests shall be borne by the contractor.
- 7.9.2. Structural steel and components viz. bolts, nuts, washers, welding consumables, etc. should be tested for mechanical and chemical properties as per the requirement of the relevant IS or any other specified codes/standard.
- 7.9.3. During Inspection, the component/member shall not have any load or external restraint.

**7.10. Grouting of steel bases :**

- 7.10.1. Before grouting of stanchion bases, the contractor shall take the following action:
- Inform the Engineer.
  - Clean all holes, openings, recesses and the top of foundations of all dirt, mud, water, oil or other extraneous matter.
  - A frame shall be placed in position around the base plate with a provision for placing or injecting grout.
  - The contractor shall provide screed bars or mild steel flats and fix them in mortar.
  - Holes shall be provided on the stanchion bases for escape of air.
- 7.10.2. Grouting of steel beams, steel stanchions, bases and bearings and encasement of steelwork will be carried out by the contractor after the steelwork has been finally aligned and leveled and approval of the Engineer obtained.
- 7.10.3. The bolt sleeves shall be grouted as a separate operation using neat cement grout of a creamy consistency, which shall be poured in so as to completely fill the holes. "Non-shrink" cements, additives of approved makes shall be used for all grouting operations.
- 7.10.4. The space between the top of the foundations and the underside of the base plate shall be completely filled with a mix 1:2 cement sand mortar and finished flush with edge of the base plate, either:
- Mixed as a stiff mortar well rammed into place from all sides.
  - Mixed as thickly as possible consistent with fluidity and poured under a suitable head and tamped until the space has been properly filled.

**7.11. Holding down and Anchor bolts:**

- 7.11.1. The holding down and anchor bolts should conform to the requirements laid down in IS:5624 or as directed by the Engineer.
- 7.11.2. Installation: Individual bolts in groups of holding down bolts shall be positioned accurately within a tolerance of +6mm. The bolts shall be set vertically to a tolerance of not more than 1 in 250.
- 7.11.3. During the casting of concrete the contractor shall ensure that space between the bolt and sleeves is kept clean after removal of shuttering. The contractor shall provide and fix timber plugs to maintain this space in a clean condition. The projecting threads of bolts shall be protected by approved wrapping materials.
- 7.11.4. Grouting of bolt tubes shall be carried out after the steelwork or equipment have been aligned, plumbed and levelled.

**7.12. Tolerances:**

- 7.12.1. All tolerances shall be in accordance with IS:7215 unless otherwise specified.
- 7.12.2. The maximum deviation for line and level shall be + 3.0mm for any part of the structure including for location of column centres.
- 7.12.3. The maximum deviation from plumb for columns shall be +3.0mm in 10.0m height subject to a maximum of +6.0mm in a total height of 30.0m.
- 7.12.4. The deviation at the centre of the upper chord member from vertical plane running through the centre of the bottom chord shall not be more than 1/1500 of span but in no case more than 10.0mm. The lateral displacement of top chord at centre of span from vertical plane running through centre of supports shall not be more than 1/250 of the depth of truss but in no case more than 20.0mm.

**7.13. Mode of measurement :**

- 7.13.1. The pricing must include for all rolling margins, extras for length and size, allowance for waste, complete fabrication, delivery and erection, and caulking the gap between base plate and foundation, and painting as specified in the item. Unless otherwise specified, the final coats of paints, however, will be measured and paid separately on the basis of tonnage fabricated and erected.
- 7.13.2. Any temporary strutting, tying or anchor bolts, black bolts, fasteners, welding required to withstand the stresses of erection and carrying of plant are to be included in the price.
- 7.13.3. The payment for the steelwork will be for the weight of the steelwork actually erected, i.e. plates, rolled sections, shear connections, cleats, splice plates.
- 7.13.4. Dimensions of the steelwork will be taken correct to 1 mm and the net weight of metal in the fabricated structure on the basis of unit weight of the steel used in the works approved by the Engineer worked out on site or from the actual shop working drawings as decided by the Engineer. In calculating the weights of gusset plates, payment will be made for the least enclosing parallelogram or triangle. For structural sections the weight will be calculated on lengths actually used with no deduction for splay cut or mitred end. In case of imported sections, the weights chargeable shall be the weight according to the relative standards of the country of origin. Full weight of the bolts and nuts will be paid for as per Indian Standard Codes weights without any deduction for shanks, etc. No account shall be taken of the weight of weld in calculating the weight of steelwork. Erection packing plates bedded in mortar and wedges shall not be measured but shall be included in the rates. No deduction shall be made for openings less than 0.1m<sup>2</sup> in area measured in plane for bolt holes. The weight of sheet steel, plate, strips and rolled sections shall be taken from relevant Indian Standards.
- 7.13.5. Unless otherwise specified, foundation and anchor bolt assemblies shall be measured separately including nuts and washers.
- 7.13.6. The structural work which is temporary in nature and/or which is required for erection purposes shall not be measured.

**(B) Structural Steel Specifications -Painting Works****7.14.1 General****Scope of Specification**

This Specification covers the scope of painting, methods for the surface preparation, application of paints and precautions to be taken for the painting of structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding, tools, equipment and everything that is necessary for the job completion on schedule.

**Applicable Codes**

The following Specifications, Standards and Codes are included as part of this Specification. All standards and codes of practice referred to herein shall be the current editions during the currency of project including all applicable official amendments and revisions.

In case of discrepancy between this Specification and those referred to herein, this specification shall govern. In case of discrepancy between Contract drawings and this specification, the Contract drawings shall govern.

- |     |                |                                                                                                             |
|-----|----------------|-------------------------------------------------------------------------------------------------------------|
| a). | IS: 102 (1962) | : Ready Mixed Paint, Brushing, Red lead, Non Setting, Priming.                                              |
| b). | IS: 159 (1981) | : Ready Mixed Paint, Brushing, Acid Resisting for Protection against Acid Fumes, Colour as Required.        |
| c). | IS: 384 (1979) | : Brushes, Paints and Varnishes, Flat.                                                                      |
| d). | IS: 487 (1985) | : Brush, Paint and Varnish i) Oval Ferrule Bound<br>ii) Round Ferrule Bound.                                |
| e). | IS: 958 (1975) | : Temporary Corrosion Preventive Grease, Soft Film, Cold Application.                                       |
| f). | IS: 1153(1975) | : Temporary Corrosion Preventive, Fluid, Hard Film, Solvent Deposited                                       |
| g). | IS: 1477(1971) | : Code of Practice for Painting of Ferrous Metals in Building.<br>Part I –Pretreatment<br>Part II –Painting |
| h). | IS: 1674(1960) | : Temporary Corrosion Preventive Fluid, Soft Film, Solvent Deposited.                                       |
| i). | IS: 2074(1992) | : Ready Mixed Paints, Red Oxide -Zinc Chromate.                                                             |

**7.14.2 Products & Materials****Paint**

1. All paint delivered to the fabrication shop shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
2. Paint shall be stirred frequently to keep the pigment in suspension

**Storage of Paints**

1. All paints shall be stored strictly in accordance with the requirements laid down by the paint manufacturers. The storage area shall be well ventilated and protected from sparks,

flame, direct exposure to sun or excessive heat, preferably located in an isolated room or in a separate building.

- All paint containers shall be clearly labelled to show paint identification, date of manufacture, batch number, order number and special instructions in legible form. The containers shall be opened only at the time of use. Paints which have liveried, gelled or otherwise deteriorated during storage, shall not be used. Paints for which the shelf life specified by the supplier has expired shall not be used without inspection and approval by the Engineer-in-charge.

#### Execution

*Paint System (High Performance Polysiloxane System)*

Sand blasting shall be carried out in accordance with IS: 1477.

Painting work shall be carried out as follows:

| Description          | Surface                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                 |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fabrication Shop     | External Surfaces                                                                                                                                                                                                                                                                                                                                                                                                                      | Internal Surfaces                                                                                                                                                                                                                                                               |
| Surface Treatment    | Abrasive Blast to SA 2.5(ISO 8501-1:1988). If oxidation occurs between blasting and application of paint, the surface shall be re blasted to the specified standard.                                                                                                                                                                                                                                                                   | Abrasive Blast to cleaning to minimum SA 2.5 (Swedish Standard SIS 055900), Near-White blast cleaning.                                                                                                                                                                          |
| 1 <sup>st</sup> Coat | Providing & applying two component high build Zinc Rich Epoxy Primer Poly amide cured with minimum volume Solids of approximately 60% and a product weight of 2.50 kg/liter, minimum recoat interval of not more three hours at 25 deg C. The primer can be like Interzinc 52 of International Paints or approved equivalents.<br><b>DFT-75 microns</b><br>The primer shall be applied by Conventional/Airless Spray only in Shop.     | Surface Tolerant Epoxy with minimum Volume Solids of 80%, minimum overcoat interval of not more than 24 hours at 25 deg C and a product weight of 1.6kg/liter. The primer can be like Interseal 670 HS of international paints or approved equivalent<br><b>DFT-150 microns</b> |
| 2 <sup>nd</sup> Coat | Providing and applying two component Hi Build Epoxy intermediate Coat pigmented with Micaceous Iron oxide with approximate Volume Solids of 80%, minimum re-coat interval of 6 hours at 25 deg C and a product weight of approximately 2 kg/liter- like Intergard 475 HS of international paint or approved equivalent.<br><b>DFT-150 microns</b><br>The coat shall be applied by Conventional/Airless Spray only in Shop              |                                                                                                                                                                                                                                                                                 |
| Erection Site        |                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                 |
| Touch up Primer      | Power Tool Cleaning to ST 2 standards followed by Surface Tolerant Epoxy with minimum Volume Solids of 80%, minimum overcoat interval of not more than 24 hours at 25 deg C and a product weight of approximately 1.6kg/liter like Interseal 670 HS of International Paints or approved equivalent. This primer shall be applied as touch up wherever damages have occurred on account of welding or Transportation & Erection.(Stripe |                                                                                                                                                                                                                                                                                 |

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|              | Coat)-The DFT shall not be included in the Total DFT of System<br><b>DFT-75 microns</b><br>The primer shall be applied by Conventional/Airless Spray only at site                                                                                                                                                                                                                                                                                                                                 |  |
| Finish Paint | Providing and applying two components Hi Gloss Acrylic Polysiloxane Finish Paint with approximate Volume solids of 70%, The product shall hard dry in not more than 5 hours at 25 deg C and 50% R.H. like Interfine 878 of International Paints or approved equivalent. This product should exhibit Gloss Retention following 3000 hours to U.V-A florescent lamp when checked as per ASTM-523<br><b>DFT-75 microns</b><br>The paint shall be applied by Conventional/Airless Spray only at site. |  |

The total Average DFT of External Surface is 375 microns

The total Average DFT of Internal Surface is 150 microns

DFT measurements should be done in accordance with Specifications SSPC PA 2.

INTERNAL SURFACE = Internal surface are those which will become inaccessible after fabrication and are not prone to humidity and moisture from the atmosphere.

EXTERNAL SURFACE = All other surfaces which are prone to humidity and moisture from the atmosphere.

The following precautions must be taken:

- a). After abrasive blast cleaning, the first undercoat (primer coat) should be applied well before surface deterioration.
- b). Over coating intervals, application parameters shall conform to manufacturer's instruction manual.
- c). The DFT (Dry film thickness) shall be measured after completion of each coat.

- Surface Preparation

All surfaces shall be cleaned of loose substances and foreign materials. e.g. dirt, rust, scale, oil, grease, welding flux etc so that the primer coat adheres to the original metal surface. The work shall be carried out in accordance with IS: 1477 (1971) (Part I). Any oil, grease, dust or foreign matter deposited on the surface after preparation shall be removed and care shall be taken to ensure that the surface is not contaminated with acids, alkalis or other corrosive chemicals. The primer coat shall be applied immediately after the surface preparation is completed.

Before the application of any paint the surfaces to be treated shall be thoroughly cleaned freed from all scale, loose paint, rust and other deleterious matters. Oil and grease shall be removed from the surface by washing with solvents or with a detergent solution before blast cleaning operation of metal polish with metal pellets. If any traces of oil or grease remain after blasting they shall be removed by solvent cleaning and the area will be re-blasted thereafter.

All welding areas shall be given special attention for removal of weld flux slag, weld metal splatter weld head oxides, weld flux fumes silvers and other foreign objects before blasting. If deemed necessary by the Engineer in Charge, acid washing and subsequent washing with clean water shall be used.



Any rough seams will have to be ground and must be inspected and approved by the Engineer-in-charge before application of the coatings.

All structural steel to be painted shall be cleaned using blast cleaning in accordance with SA 2 1/2 Near- White Blast cleaning (equivalent Swedish Standard SIS 055900). For SA 2 1/2 the profile should be in the range of 40-70 microns and shall be measured with comparator. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are light stains in the form of spots or stripes. Finally the surface shall be cleaned with a vacuum cleaner or clean dry compressed air.

The blast cleaning shall produce a surface roughness complying with the one specified by the paint manufacturer for the primer concerned. If, cleaned surfaces are rusted or are contaminated with foreign material before painting is accomplished they shall be re-cleaned by the Contractor at his own expenses. Nothing extra shall be paid on this account.

- **Mixing of paint**

All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments, before use and during application, to maintain homogeneity. All pigmented paints shall be strained after mixing to remove skins and other undesirable matters.

1. Dry pigments, pastes, tinting pastes and colours shall be mixed and/or made into paint so that all dry powders get wetted by vehicles and lumps and particles are uniformly dispersed.
2. Additives that are received separate such as curing agents, catalysts, hardeners etc. shall be added to the paint as per the manufacturers instructions. These shall be promptly used within the pot life specified by the manufacturers and unused paint thereafter shall be discarded.
3. Thinners shall not be used unless essential for proper application of the paint. Where thinners are used, they shall be added during the mixing process and the type and quantity of thinner shall be in accordance with the instructions of paint manufacturer.

- **Paint Application**

General

- Paint shall be applied in accordance with the manufacturer recommendations, as supplemented by these Specifications. The work shall generally follow IS 1477 (1971) Part II. Prior approval of the Engineer-in-charge shall be taken in respect of all primers and/or paints, before their use in the works.
- Paint shall generally be applied by brushing except that spraying may be used for finish coats only when brushing may damage the prime coats. Roller coat or other method of paint application shall not be used unless specifically authorized.
- Paint shall not be applied when the ambient temperature is 10°C and below. For paints, which dry by chemical reaction the temperature, requirements specified by the manufacturer shall be met with. Also, paint shall not be applied in rain, wind, fog or at relative humidity of 80% and above or when the surface temperature is below dew point, resulting in condensation of moisture. Any wet paint exposed to damaging

weather conditions shall be inspected after drying and the damaged area repainted after removal of the paint.

- Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots. The film thickness shall not be so great as to detrimentally affect either the appearance or the service life of the paint.
- Each coat of paint shall be allowed to dry sufficiently before application of the next coat, to avoid damages such as lifting or loss of adhesion. Undercoats having glossy surface shall be roughened by mild sand papering to improve adhesion of subsequent coats. Successive coats of same colour shall be tinted. Whenever practical, to produce contrasts and helps in identifying the progress of the work.

#### Brush Application

- Proper brushes shall be selected for a specific work piece. Round or oval brushes which conform to IS: 487(1985) are better suited for irregular surfaces, whereas flat brushes which conform to IS: 384(1979) are convenient for large flat areas. The width of flat brushes shall not generally exceed 1.25mm.
- Paint shall be applied in short strokes depositing a uniform amount of paint in each stroke followed by brushing the paint into all surface irregularities, crevices and corners and finally smoothening or leveling the paint film with long and light strokes at about right angles to the first short strokes. All runs and sags shall be brushed out. The brush marks left in the applied paint shall be as few as practicable.

#### Spray Application

1. The spraying equipment shall be compatible with the paint material and provided with necessary gauges and controls. The equipment shall be cleaned of dirt, dried paint, foreign matter and solvent before use.
2. The paint shall be applied by holding the gun perpendicular to the surface at a suitable distance and moved in a pattern so as to ensure deposition of a uniform wet layer of paint. All runs and sags shall be brushed out immediately. Areas not accessible to spray shall be painted by brush or dauber.
3. Water trap acceptable to Engineer-in-charge shall be furnished and installed on all equipment used in spray painting.

#### Shop Painting

1. The painting system specified in Table shall be followed. Surfaces, which will be inaccessible after field assembly, shall receive the full-specified protective treatment before assembly.
2. Surfaces in contact during shop assembly shall not be painted. Surfaces which can not be painted but require protection shall be given a rust inhibitive grease conforming to IS:958-1975 or solvent deposited compound conforming to IS: 1153 (1975) or IS: 1674 (1960) or treated as specified in the drawing.

3. The shop coats shall be continuous over all edges, including ends meant for jointing at site by bolting, except where the paint could be detrimental to bolting. In such cases, no paint shall be applied within 50mm, and the unprotected surface shall be given a coat of corrosion inhibitive compound.
4. The unpainted area shall be cleaned prior to welding. The welded joint shall be cleaned and deslagged, and immediately after covered by the same paint as has been used for the remaining surface.

#### Painting at Site

Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly. Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat. Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets. Specified protective treatment shall be completed after erection.

#### Protection of Paint work

The Contractor shall provide measures as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations. Paint or paint stains, which result in other unsightly appearance on surfaces not designated to be painted, shall be removed or obliterated by the contractor at his cost.

All painted surfaces that in the opinion of the Engineer-in-charge are damaged in anyway, shall be repaired by the contractor at his cost with materials and to a condition equal to that of the requirements specified in these specifications.

Upon painted surfaces that in the opinion of any other work that would cause dust, grease or foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned.

The areas for high-strength bolts shall be protected by masking tape against undercoat application at the fabrication shop. Immediately prior to erection any rust in the paint area shall be removed by power wire brushing to a standard equivalent to SA3.

### **7.14.4 STRUCTURAL STEEL WORK-ERECTION**

#### **7.14.4.1 General**

##### **7.14.4.1.1 Scope of Specifications**

This Specification covers the delivery to site, storage and erection of structural steelwork at site. This includes plant and equipment requirements, installation of fabricated steel work in position and grouting all complete as per drawings, specifications and other provisions of the Contract.

##### **7.14.4.1.2 Submittals**

- A. Ref. Specification for Structural Steelwork Erection –General
- B. The contractor shall submit for approval a full description of his proposed erection method including sequence of erection, use of temporary supports, connection details and erection camber diagram and design calculations covering various stages of erection process.

**7.14.4.2****Execution****7.14.4.2.1****Delivery, Storage & Handling**

- A. Before the shop assembly is dismantled, all members and sections shall be appropriately marked with paint or grooved with their identification numbers as detailed in shop drawings. The Contractor's representative shall be present during all the shop assemblies ( wherever fabrication will be done ) , its dismantling and marking operations.
- B. The Contractor shall deliver the fabricated structural steel materials to site, with all necessary field connection materials, in such sequence as will permit the most efficient and economical performance of the erection work. As per scheduled programme, the Engineer may, at his discretion prescribe or control the sequence of delivery of materials.
- C. Fabricated parts shall be handled and stacked in such a way-that no damage is caused to the components. Measures shall be taken to minimize damage to the protective treatment on the steelwork. All work shall be protected from damage in transit. Particular care shall be taken to stiffen free ends, prevent permanent distortion and adequately protect all machined surfaces. All bolts, nuts, washers, screws, small plates and articles shall be suitably packed and identified.

**7.14.4.2.2****Plant and Equipment**

All erection tools and plant & equipment proposed to be used shall be efficient, dependable duly certified by independent third party and in good working condition, and the suitability and adequacy of such shall be determined by the Engineer. The Contractor shall, in his technical proposal submittal, specify the plant and equipment proposed by him for erection of structural steelwork at Site.

**7.14.4.2.3****Storage**

Materials to be stored shall be placed on skids above the ground and shall be kept clean and properly drained.

**7.14.4.2.4 Method and Sequence of Erection**

The method and sequence of erection shall have the prior approval of the Engineer. The contractor shall arrange for the most economic method and sequence consistent with the drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract. The erection of steelwork shall be planned so as to ensure safe-working conditions at all times. The Contractor shall be solely responsible for enhancing the safety of his construction activities at Site.

**7.14.4.2.5 Assembly & Erection**

- A. During erection, the members and sections shall be accurately assembled as shown in the approved shop drawings and by following the match marks. The material shall be carefully handled so that no section will be bent, broken or otherwise damaged. Hammering which will damage or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have 50% of the holes filled with bolts and balance 50% with cylindrical erection pins before bolting with high-strength bolts. Filling-up bolts shall be of the same nominal diameter as the high-strength bolts, whereas the cylindrical erection pins shall be 1 mm or larger in diameter.
- B. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.
- C. The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other damages. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the carefully planned and well supervised application of a limited amount of localized heat. Each application will be subject to the approval of the Engineer.
- D. The responsibility in respect of temporary bracing and guys shall rest with the Contractor until the structural steel is located, kept in plumb, leveled, aligned and grouted within the tolerances permitted under the Specifications, and the permanent bracing/framing system has been installed.

- E. The temporary guys, braces, false work and cribbing shall not be the property of the Engineer/Employer and will be removed by the Contractor, with the approval of the Engineer, without any charge, once the permanent framing system has been installed to the satisfaction of the Engineer and when the temporary bracing, guys etc. can be removed without any potential danger/damage to the erected structure.

#### **7.14.4.2.6 Setting Out**

- A. Positioning and leveling of all steelwork, keeping in plumb and placing of every part of the structure, with accuracy, shall be in accordance with the approved drawings and to the satisfaction of the Engineer. The Contractor shall check the positions and levels of the anchor bolts etc. before concreting and ensure that they are properly secured against disturbance during pouring operations. The Contractor shall remain responsible for correct positioning and shall set proper screed bars to maintain proper level. No extra payment shall be made on this account.
- B. No permanent field connections by bolting shall be carried out until proper alignment and guides for keeping in plumb have been attached.

#### **7.14.4.2.7 Field Bolting**

- A. Bolts shall be inserted in such a way that they remain in position under gravity, even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled all joint surfaces including those adjacent to the washers shall be free of scales. They shall be free of dirt, loose scales, burns and other defects that would prevent solid seating of the parts.
- B. Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications.
- C. All high tensile bolts shall be tightened to provide the required minimum bolt tension as per relevant Indian Standards / Specifications when all fasteners in the joint are tight,
- D. The manufacture and use of high strength friction grip bolts shall comply with the requirements of IS:3757 (1985).
- E. Load indicating bolts or washers may be used, subject to the approval of the Engineer.

**7.14.4.2.8 Holes, Cutting and Fitting**

- A. No cutting of sections, flanges, webs, and cleats, rivets, bolts, welds etc. shall be done unless specifically approved and / or instructed by the Engineer.
- B. The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract, or directed by the Engineer. Wherever such work is specified, the Contractor shall obtain complete information as to size, location and number of alterations, prior to carrying out any work.

**7.14.4.2.9 Drifting**

- A. Correction of minor misfits will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes, as necessary, to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.
- B. Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be brought to the attention of the Engineer, and approval of the method of correction obtained. The use of gas cutting torches at the erection site is prohibited.

**7.14.4.2.10 Grouting**

- A. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water, and any accumulated water shall be removed. Grouting shall be carried out under expert supervision, taking care to avoid air locks. Edges shall be finished properly.
- B. Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally aligned and leveled. Immediately before grouting, the space under steel is thoroughly cleaned. Where packings are to be left in place, they shall be placed such that they are completely covered with grout.
- C. The grout to be used shall be Non-shrink grout conbextra GP-2 of M/S Fosroc or equivalent.
- D. All steel in foundations shall be solidly encased in Portland Cement Concrete of minimum characteristic strength at 28 days as specified in the drawings, subject to a minimum of 35 N/mm<sup>2</sup>. A minimum cover of 100mm shall be provided to all steelwork where surrounding concrete is in contact with soil.

**7.14.4.2.11 Inserts And Embedments**

Various steel inserts and embedments are required under the contract to be fabricated, positioned and secured firmly into place inside the formwork prior to concrete being poured. There are also requirements of jointing, threading, bolting and welding inserts and embedments of different concrete and structural steel elements in order to establish structural continuity and connection. Great care shall be exercised by the contractor in executing all aspects of the work related to inserts and embedments, including tolerances, so that the final assembly of the concrete elements can meet satisfactorily the continuity and contiguity requirements intended in the structure.

**7.14.4.2.12 Painting after Erection**

- A. The surfaces required to remain unpainted at shop, shall be given a protective coating after the structure is erected, leveled, kept in plumb, aligned in its final position, and accepted by the Engineer. However, touch up painting, making good any damaged shop painting and completion of any unfinished portion of the shop coat shall be progressively carried out by the Contractor.
- B. Painting shall not be done in frost or foggy weather, or when humidity is such as to cause condensation on the surfaces to be painted. Before, commencing painting of steel, which is delivered unpainted, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.
- C. Surfaces, which will be inaccessible after field assembly, shall receive the full-specified protective treatment before assembly. Bolts and fabricated steel members, which are galvanised or otherwise treated, shall not be painted.
- D. The contractor shall be responsible for any damage caused to other components of the structure including the substructure. In particular, he shall take all necessary precautions to minimise concrete splash onto completed steelwork or rust staining of concrete due to erected steel work and clean and/or repair all stains and other damages to completed work prior to tests on completion.

**7.14.4.2.13 Final Cleaning up**

Upon completion of erection, and before final acceptance of the work by the Engineer, the Contractor shall remove, free of cost, all falsework, rubbish and all temporary works, resulting from or in connection with the performance of his work.

**7.14.5 ADDITIONAL SPECIFICATIONS FOR LAUNCHING**

Truss launching for longer spans:



- Preferably no road traffic blocking will be used. Multiple day/night short blocks of 1h to 1h30 maximum are acceptable to ensure safety.
- Launching scheme shown in Tender drawings is suggestive only. Contractor has to provide his own proposed launching scheme and supporting calculations with the offer.
- Contractor has to provide principles of nose/truss connection details in tender.
- Truss design composite girder requirements will govern over nose/launching equipment requirements.
- Contractor will submit and get approval from Engineer of the detailed design of the full launching equipment and scheme before starting the launching.
- Contractor will coordinate with Bangalore Traffic Police and Engineer before and during the launching contractor to develop detailed traffic diversion scheme.
- Tentative allowable bearing pressure for temporary supports foundation concrete blocks shall be assumed at 10 tonnes/sqm.
- Any necessary precaution by proper and secure fixing shall be taken by the contractor to prevent the fall of any object onto the road below during the whole erection period.
- A minimum 15m clear width (4 lanes) shall be kept during the whole construction period. These lanes can be obtained as 4 or 2+2.

**7.14.6****MODE OF MEASUREMENT**

- 1 The unit rate shall include the following :
  - i. Erection of fabricated parts (fabrication and transportation of various parts / components including HSFG bolts/nuts / washers from workshop to storage yard will be done by approved sub-contractors)
  - ii. Receiving, unloading and keeping in safe custody and upkeep of all fabricated parts including HSFG bolts/nuts / washers at storage yard.
  - iii. Loading, transportation and unloading of all fabricated structural steel materials including HSFG bolts/nuts / washers from site storage yard to erection site, handling, assembling, bolting, welding if necessary and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer.
  - iv. Tightening of HSFG bolts for the field erection of fabricated parts. However supply of HSFG bolts and its compatible nuts and washers will be arranged / supplied at the storage yard by approved sub-contractor .
  - v. Preparation of complete detailed erection drawings and detailed calculation based on suggested erection sequence and design drawings as given by Engineer or alternative scheme proposed by contractor and approved by Engineer.

- vi. Preparation of complete detailed fabrication drawings for all temporary structures such as temporary nose, staging, temporary support, bracing required for all permanent and temporary structures.
  - vii. All tools, plants and equipments / machinery
  - viii. All other consumables including fuel and lubricants etc.
  - ix. All safety and protection arrangements to be made at site / storage yards for road users, public, and workmen.
- 2** The payment for the erection work and above mentioned work will be Lump-sum.
- 3** The procurement and application of all coats of site paints on external surfaces after erection as specified will be measured in sqm and paid separately.

**SECTION - S.08****8. PILE FOUNDATIONS****8.1. General**

The piles shall be cast-in-situ reinforced concrete piles according to the approved drawings and specifications. The method of construction shall be with hydraulic drilling rigs with 4m long temporary casing and polymer slurry as decided by the Engineer.

The average basic length of the piles mentioned in the drawings is tentative. The final length of the pile shall be decided by the Engineer. It will be the responsibility of the Contractor to ensure by subsequent routine load tests that the installed length of piles is able to carry the specified safe load and the resulting deflections shall be within permissible limits. In case of failure of any pile in routine load test, the remedial measures shall be provided by the Contractor as directed by the Engineer.

**8.1.1. Piling plant and Methods**

Suggested method for piling is cast in situ-bored piles with hydraulic drilling rigs using 4m. depth casing by oscillator or vibro hammer arrangement, with polymer slurry and equipments and methodology suitable for the purpose. Bailer and chisel method shall not be used except for socketting of the piles in rock (Hydraulic rig can be used for installation of casing).

- 1 Not less than 2 weeks before any piling work is commenced the Contractor shall submit to the Engineer for approval full details of his proposed piling plant, polymer slurry mixing, handling, transporting and disposal scheme and detailed method statements for carrying out the Works.

Details of casings and concreting methods in respect of bored cast in place concrete piles are to be provided.

- 2 The Contractor shall not commence any piling until the plant and methods which he proposes to use including polymer slurry mixing, handling, transporting and disposal scheme have been approved by the Engineer but such approval shall not relieve the Contractor from any of his obligations and responsibilities under the Contract. If for any reason the Contractor wishes to make any change in the plant and methods of working which have been approved by the Engineer, he shall not make any such change without having first obtained the Engineer approval thereof.
- 3 List and nos. of equipments & accessories proposed to be used for the present job shall be submitted along with the bid and these should not be less than the list submitted for P.Q. tender. However, Contractor is bound to increase the plant & machinery to complete the work within the stipulated completion period.

**8.1.2. Records**

The Contractor shall keep complete records of all data required by the Engineer covering the fabrication, driving and installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after installation of the piles.

The following data shall be recorded during install align of pile along with any other relevant data as directed by the Engineer.

- i) Sequence of installation of piles
- ii) Dimensions of the pile, including reinforcement details and mark of the pile.
- iii) Depth bored and founding level along with a bore log indicating nature of stratum

- iv) Method of cleaning bottom of hole at founding level before commencing the concreting.
- v) Time taken in concreting
- vi) Cut-off level/working level/RL of top of concrete
- vii) No. of cement bags consumed. Slump of concrete.
- viii) Details of insertion and taking out of tremie pipes i.e their number, length and sequence.
- ix) Actual sounding before commencing the concrete.

#### 8.1.3. Programme and Progress Report

- 1 The Contractor shall inform the Engineer each day of the programme of piling for the following day and shall give adequate notice of his intention to work outside normal hours and at weekends, where approved.
- 2 The Contractor shall submit to the Engineer on the first day of each week, or on such other date as the Engineer may decide, a progress report showing the rate of progress to that date and progress during the previous week or period of all main items of piling works, as required by the Engineer.

#### 8.1.4. Setting Out

The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the satisfaction of the Engineer and shall set out, with a suitable identifiable pin or marker, the position of each pile. The setting out of each pile shall be agreed with the Engineer at least 8 working hours prior to commencing work on a pile and adequate notice for checking shall be given to the Engineer

Notwithstanding such checking and agreement, the Contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions, and alignment of the piles.

- 8.1.5. After all piles are cast in a pile cap and weak concrete is chipped out, the Contractor shall submit the drawing showing the exact location of piles with respect to the column centre line.

#### 8.1.6. Disturbances and Noise

- 1 The Contractor shall carry out the piling work in such a manner and at such times as to minimise noise, vibrations and disturbance. Noise limit as prescribed in " Building and other Construction workers Act-Schedule-VI" shall be referred
- 2 The Contractor shall take precautions adequate enough to avoid damage to existing services and adjacent structures. Fig.1 of IS:2974 (Part 1) - 1969 may be used as a guide for studying qualitatively the effect of vibration on persons and structures. In case of deep excavation adjacent to buildings/structures, proper shoring or other suitable arrangement shall be done to guard against the lateral movement of soil stratum or releasing the confining soil stress. Any such damage if caused shall be repaired by the contractor at his own cost to the entire satisfaction of the Engineer.
- 3 The Contractor shall ensure that damage does not occur to completed piling works and shall submit to the Engineer for approval his proposed sequence and timing for driving or boring piles having regard to the avoidance of damage to adjacent piles.

#### 8.1.7. Obstructions

If during the execution of the Works the Contractor encounters obstructions in the ground, he shall forthwith notify the Engineer accordingly, submit to him details of proposed methods for overcoming the obstruction and proceed according to the Engineer's instructions.

### 8.2. Scope of Work

- 8.2.1. These specifications cover the works of providing pile foundations. Work included consists of all necessary services and furnishing of all labour material, tools, plant, equipment and related items for the full and satisfactory performance of the contract, conforming to these specifications and as shown in the Contract Drawings or reasonably implied therein or any authorised conditions or alterations thereof.

- 8.2.2. The tenderer is advised to visit the site and familiarise himself with the conditions at site. The Engineer shall not be held responsible for the accuracy of the soil data, furnished in good faith with the tender.
- 8.2.3. The construction of piles shall be in accordance with the following Indian Standard Codes of Practice for Design and Construction of Pile Foundations:
- 8.2.4. IS:2911-1979 Part I Section 2 Bored Cast in-situ Concrete Piles Or IRC:78 Standard specifications and code of practice for road bridges Foundation And Substructure
- 8.2.5. With the tender, the Contractor shall submit the detailed method of construction to be adopted. For cast-in-situ concrete piles, the Contractor shall indicate the methods he proposes to concrete the piles in order to prevent necking of piles.
- 8.2.6. The Contractor shall quote rates as detailed in the Bill of Quantities and Rates. In particular:
- a. For piles, the rate quoted shall be for 'per metre length of pile .The actual length of piles will be determined from site conditions and load test results after work begins.
  - b. In case the load tests and actual site conditions reveal that the piles proposed do not, in the opinion of the Engineer provide a satisfactory and economical foundation, the Engineer at his sole and absolute discretion shall have the powers to revise the pile layout.(Dia of piles will not be changed, however number of piles may get changed)
- 8.2.7. The items of work to be carried out in piling will generally be:
- a. Boring/drilling including provision of temporary casing (including its withdrawal), empty boring, & polymer slurry,
  - b. Supplying, fabrication, tying and placement of all reinforcement.
  - c. Casting of concrete piles as per specifications.
  - d. Integrity and Load testing of piles.

### **8.3. Materials**

#### **8.3.1. General**

Unless otherwise specified in this section all materials shall conform to the requirements specified in separate sections for Concrete, Formwork and Reinforcement.

#### **8.3.2. Cement**

The cement to be used for piling and all foundation work shall be conforming to following Indian Standard Specifications:

IS: Specification for Slag Cement: IS: 455  
Cement shall be free from lumps and caking.

#### **8.3.3. Concrete Mix Design**

The concrete shall generally be of grade M35. The maximum size of coarse aggregate shall not exceed 20mm. For cast-in-situ piles concrete with a slump of 150 to 175mm (consistent with the method of concreting) will be required. Minimum cement content for design mix shall not be less than 400 kg/m<sup>3</sup> of concrete in piling. For piling, qty of cement to be used shall be as per the design mix or the minimum cement content whichever is greater.

The contractor shall submit mix design calculations and get the same approved by the Engineer well before the starting of boring of piles and carry out adequate numbers of tests to ensure the minimum specified strength as indicated in drawings.

**8.3.4. Concrete cube tests**

Concrete cubes shall be cast, tested and evaluated as specified in Section 3.

**8.3.5. Reinforcement**

- a. The reinforcement shall conform to the requirements specified in Section 5 extending for the full length of the pile and shall project 60 times bar diameters above the cut off level or as specified in the drawing. Only circular concrete cover blocks threaded on to the helix shall be used for ensuring the specified cover.
- b. Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, mechanical coupler joints shall be provided at agreed centres, designed to develop the full strength of the bar across the joint, provided with adequate extra links or stirrups in position from those of adjacent longitudinal bars, all to the approval of the Engineer.
- c. All main longitudinal bars shall be welded at lapping and to the pile cap reinforcement. The last circle of helical stirrups at each end shall be welded to main longitudinal bars. Nothing extra shall be payable on account of this. Any extra tack welding required for handling and lowering of cage in borehole shall also be done by the contractor at no extra cost.

**8.3.6. Casings and Tremie Pipes**

The casings and tremie pipes shall be in mild steel. The temporary casing plates of 4m. length and permanent liners shall have adequate wall thickness and strength to withstand driving stresses, stresses due to soil pressure, etc. Without damage or distortion all joints shall be water tight. The internal diameter of the casing shall not be less than the nominal diameter of pile.

**8.4. Cast In-Situ Bored Piles****8.4.1. General**

- a. Diameters of the piles shall be the concrete shaft diameters and shall not be less than the diameters specified in the drawing.
- b. These shall be formed by boring to the founding strata specified on the drawings or as directed at site. The sides of the boring shall be prevented from collapse by one of the following methods:
  - Providing permanent mild steel liner (cased pile)
  - Providing removable mild steel casing (uncased pile)
- c. Piles shall be constructed in a sequence approved by the Engineer. During boring, the Contractor shall, where required by the Engineer, take soil, rock or ground water samples and transport them to an approved testing laboratory or carry out soil tests as directed.
- d. The method adopted shall be chosen giving due consideration to the subsoil data, ground water conditions and to the other relevant conditions at site as well as to the presence of adjacent structures.
- e. Removable mild steel casings shall be used, only with extreme caution. Individual casings shall be joined together by screwing or any other approved method and not by direct butting with external lug connections. The inner surface of casings shall be smooth and free of all internal projections.

## 8.4.2. Boring

- (a) Boring shall be done using Rotary hydraulic drilling rigs with oscillator arrangement / equipments and methodology suitable for different kinds of strata encountered.
- (b) As a general guideline, size of cutting tool shall in no case be less than the diameter of the pile minus 75mm. However the size of cutting tool shall be chosen by contractor depending on the type of substrata and equipment employed by contractor so that executable pile shall not have diameter less than nominal diameter of pile as specified in drawing. The contractor shall also ensure that there is no reduction in poured concrete quantities. These calculations shall be based on consumption of concrete poured in bore (as recorded in pour log) and actual concrete required in bore on theoretical basis i.e. based on nominal diameter of pile and actual bore hole length (based on actual sounding of founding level). More than 5% reduction in consumption of poured concrete quantities in pile may be rejected. In general, piling shall be done by using hydraulic rig with temporary liner. Use of liner for top 4.5 meters from ground level or upto depth having N. value (Minim) 10 (to protect loose soil falling in bore hole) as directed by Engineer, is essential. No extra payment shall be made to the contractor for using temporary liner, over the item of piling as in BOQ.

- (a) Use of Polymer slurry in stabilizing sides of the pile borehole may also be necessary together with temporary or permanent casing wherever sub soil and ground water conditions are likely to cause mud flows or instability of pile bore or sand boiling. However, this will be permitted only when deemed necessary by the Engineer. In such situations the properties of Polymer used & quality control shall be as per requirement given below.

Fresh polymer slurry shall satisfy the following properties at all times :

1. Marsh Funnel value viscosity 60-70 seconds/Qt at 30<sup>0</sup> Centigrade
2. Specific gravity 1.05 to 1.07 gm/cc

After the installation of temporary casing, the drilling operation will continuously proceed together with the application of the Polymer slurry. The Polymer shall be mixed with water in proportion according to the MSDS in a separate tank. The capacity of the mixing tank shall be more than 1.5 times of the volume of the bore hole for which the Polymer is to be used.

For mixing and application of the Polymer with water, agitator & pumping arrangement fixed with mixing tank shall be used.

Boring Operation shall be handled by the shaft stabilization slurry (Polymer Slurry). The drilling Operation shall be proceed together with the mixing of the Polymer Slurry. Directly after Polymer is applied, the bucket or auger is then rotated to mix the Polymer slurry along the Pile shaft. Indirectly the Polymer is poured into a stream of water into a agitated mix tank. The water stream is then fanned over a sloping pan to facilitate lump free mixing.

Polygel is in liquid formation and can easily mixed with the freash or salty water. However, according to negative effect of saline to strength of

Concrete it has to be mixed with fresh water in the ratio of 3: 1000 in Volume. 3 liter Polygel will be poured inside the 1000 litre volume of fresh water then gently mixing inside the storage tank about 15-29 minutes in order to allow even distribution of material at at maximum performance.

Prior to preparation of mixture, care shall be given to cleanness of storage tank and PH value of fresh water is to be between 7 to 9.

The site conditions and drilling diameter of holes may affect the usage ratio of polygel inside the mixture and ratio of Viscosity.

During Concreting the Pile, the flushed Polymer fluid will be collected at storage tanks by pumping back. There is no hazardous affect for drilling fluid on environment.

The Polymer Slurry level shall not be kept below the bottom level of Steel Casing. The Slurry shall be tested periodically and the results will be submitted to the Engineer.

Prior to placing of Concrete in the borehole, make sure that heavily contaminated slurry, which could impair The free flow of Concrete from the tremie pipe has not accumulated in the bottom of the borehole. For this, the borehole shall be kept untouched after reaching the desired depth for 1 to 2 hours so as to allow the suspended particles of the polymer to settle down. then the bore hole shall be cleaned by cleaning bucket before pouring the Concrete.

The material safety data sheet for POLYGEL is attached in Annexure-4.

The POLYGEL brochure is attached in Appendix-5.

The quantum of steel required in permanent liners from the cut off level downwards shall be measured as per drawing. Though the liner might have been provided right from the level of the working platform on practical considerations, the length of the permanent liner above the cut-off level has to be necessarily removed for facilitating chipping of the top portion of the pile and for interlacing its reinforcement bars into the capping slab. There is however, no objection if the surplus pieces (if cut and removed carefully and then found reusable) are joined and are re-welded to required length for reuse in the same contract on some of the other piles. No claim / compensation shall be entertained for such cut pieces if they cannot be reused by the Contractor in the aforesaid manner.

- (c) Pumping from a bore hole shall not be permitted unless a casing has been driven into a stable stratum which prevents flow of external ground water from other strata in significant quantities.
- (d) In case of end bearing piles founded on rock, cutting of rock by hydraulic rig using diamond bits / conventional winches with chiseling will be resorted to. Scheme adopted shall be such that noise and vibration parameters specified in tender document /Environment manual are not violated. Drilling in rock shall be carried out by hydraulic rig using diamond bits. No extra payment shall be entertained for socketing in rock



except as specified in BOQ.

*The minimum socketing length shall be based on design criteria or as per IS code whichever is higher (1 dia of pile is minimum for hard rock and 2.5 dia in soft / weathered rock)*

*N – Value: The number of blows required for 30 cm of penetration of the sampler in the soil is designated as N value and is termed standard penetration blow count.*

*RQD: The length of rock sample recovered inside the core barrel is a measure of the soundness of the rock. Rock quality designation is defined as  **$RQD = l_c / l_a \times 100$** .*

*Where,*

*Lc = Total length of intact pieces which are more than 100mm long. Obvious breaks due to drilling are ignored*

*La = Total length of core advance*

- (e) On completion of boring, loose disturbed or remolded soil shall be removed from the base of bore.

#### **Penalty on mishandling of Polymer**

Mishandling of Polymer (like splashing of Polymer outside specified width of barricading or non cleaning of tyres of dumpers and transit mixers before leaving the piling site thereby making the road dirty etc.) is strictly prohibited . Noncompliance of same shall attract a penalty as follows:

- I. On first observation - Rs one lac
- II. On Second observation - Rs two lacs
- III. On third and each subsequent observation - Rs three lacs

#### **8.4.3. Concreting**

- (a) Prolonged delays in the commencement of concreting after the completion of the boring shall not be permitted. The time interval between the completion of boring and placing of concrete shall not exceed 6 hours.
- (b) The concrete shall have a minimum slump of 150 mm. Suitable precautions shall be taken for prevention of segregation. Internal vibrators shall not be used unless the Contractor is satisfied that segregation will not result because of vibration and unless the method of use has been approved by the Engineer.
- (c) The concrete for piles underwater or in drilling mud shall be placed with a tremie pipe. The tremie pipe shall not be less than 200mm diameter for 20mm aggregate. The joint between the hopper and tremie pipe as well as the joints in the tremie pipe shall be water tight and the tremie pipes shall be thoroughly cleaned after each use. .

It is essential that the water level within the pile bore be in equilibrium before commencement of concreting.

- (d) The Contractor shall ensure that heavily contaminated drilling mud has not accumulated at the base of boring since this could impair free flow of concrete from the tremie pipe.
- (e) If the specific gravity of the drilling mud at the base of the bore exceeds 1.20 the placing of concrete shall not proceed.
- (f) The first charge of concrete shall be placed in the hopper over a sliding plate of the bottom of the hopper. The charge should be adequate in volume to ensure flushing action to prevent mixing of water or drilling mud and concrete. Alternatively floating plugs of approved specification may be used before the first charge of concrete.
- (g) The tremie pipe shall at all times penetrate the previously placed concrete for minimum

depth of 2 m as a precaution against accidental withdrawal. The tremie pipe shall not be withdrawn until the completion of concreting. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the seepage water.

- (h) Spot measurements shall be taken at suitable intervals to check that the tremie pipe has an adequate penetration into previously placed concrete.
- (i) Concreting of the pile shall be in one single and continuous operation. In case of long piles of large diameter, large size mixers or more number of mixers shall be used so that the entire concreting operation is completed in not more than two hours.
- (j) The top of concrete in a pile shall be brought above the cut-off level since the top concrete is loose and is weak because of contamination with water/drilling mud. This ensures good concrete at the cut-off level.
- (k) Cut off level ( COL)

Cut off level of piles (50mm inside the pile cap) shall be as indicated in working drawings or as indicated by Engineer.

The top of concrete in pile shall be brought above the cut off level to remove all laitance & weak concrete and to ensure good concrete at cut-off level.

In case of concrete being placed by tremie method and pile cut off level being less than 1.0meter below the ground level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to a minimum of one meter above COL. Before concreting contractor shall obtain the approval of the Engineer of the height above COL up to which the concrete is to be cast.

In the circumstances where COL is below ground water level, the need to maintain a pressure should be observed & accordingly length of extra concrete above COL shall be determined by the Contractor and approval of Engineer obtained before concreting.

Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete.

- (l) When a casing is being extracted, sufficient quantity of concrete shall be maintained within the bore to ensure the pressure from external ground water and soil is adequately exceeded by the pressure of concrete. Otherwise necking of the pile may result.
- (m) No concreting shall be placed in the bore once the bottom of the casing has been lifted above the top of concrete.
- (n) While concreting the pile, the overflowing Polymer slurry from pile should be carefully pumped out to a water tight container/tank so that it does not spill over. The contaminated Polymer should be disposed off as per the methodology approved by the Engineer.
- (o) After each pile has been cast any empty bore shall be protected by putting steel cage/Jali over it and carefully backfilled as soon as possible with approved materials.
- (p) Complete boring and concreting records shall be submitted to the Engineer for each pile. The records shall include the duration of concreting, tremie lengths (individual and cumulative), tremie pipe lengths removed, theoretical sounding, actual sounding ,actual lengths of pile concreted and the volume of concrete placed, cut off level , founding levels etc. For piles with temporary casings records of sequence of casing withdrawal

and levels of concrete before and after withdrawal shall also be included in the reports.

*Generally the COL is 2.5 m below the existing ground level however, if any utility has to be placed on top of the pile cap, the COL may vary according to the requirement at that specific location.*

#### **8.5. Alignment of Piles**

- 8.5.1. Piles shall be installed as accurately as possible according to the drawings either vertically or to the specified batter. All deviations will be measured at the cut off level of the piles. The deviation from the true axis shall not be more than 1.5% for vertical piles and 4% for raker piles. Piles should not deviate in location by more than 75mm when used in groups. For single or two piles used under piers / columns, deviation shall not be more than 50mm.
- 8.5.2. The Contractor shall maintain a record of actual pile locations in the form of a drawing and submit the information to the Engineer at suitable intervals.

#### **8.6. Pile Cap**

Pile caps shall be of reinforced concrete. A minimum offset of 200mm shall be provided beyond the outer faces of the outer most piles in the group. If the pile cap is in contact with earth at the bottom, a leveling course of minimum 75 mm thickness of PCC of grade M15 shall be provided or as shown in the drawings.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. A portion of pile top may be stripped of concrete and the reinforcement anchored into the cap. Manual chipping may be permitted after three days of pile casting while pneumatic tools for chipping shall not be used before seven days after pile casting. The top of pile after stripping shall project at least 50mm into the pile cap. Concreting of the pile cap shall be carried out in dry conditions. Nothing extra will be paid for dewatering, etc. for carrying out pile cap excavation or providing concrete leveling course on building up pile cap and further substructure. Cost of all the operations and tools required for making the pile in dry condition is deemed to be included in the item.

The excavation area for the Piling / Pile cap shall be back filled and compacted and restored immediately but not later than 7 days after casting of the pile cap. Similarly the road surface should be repaired immediately after casting of column or completion of launching of superstructure (as the case may be but not later than 2 weeks). The payment for the same shall be made as per BOQ. If the area is not back filled and/or road surface is not repaired, within the time frame as above, penalty will be imposed as decided by the Engineer.

#### **8.7. Testing of Piles**

- 8.7.1. The load tests shall be in accordance with the Indian Standard Code of Practice for Design and Construction of Pile Foundations IS 2911 (Part IV) Load Tests on Piles. For initial load test, test load will be 2.5 times the theoretical designed capacity of pile. For initial load, test arrangement to be designed shall also cater for additional 25% above test load and nothing extra will be paid on this account. The payment shall be made based on relevant item included in BOQ on test load only. Permissible stresses in test arrangement (steel truss or plate girder) to cater for test load plus additional 25% load shall be within permissible stresses as per IS:800 (as for permanent structure). For test frame, steel of Grade –B conforming to IS:2062 shall be used.
- 8.7.2. Engineer will decide the locations and nos of initial load tests to be performed in different zones depending on variation in substrata but minimum two initial load tests are required to be done for different types of strata. The contractor shall undertake test piles required for initial pile load test in the initial stages of work using the same methodology and equipment's which will be subsequently used for working piles. These tests shall be undertaken well in advance of working pile. No working pile would be allowed to be undertaken till initial pile load tests have been satisfactorily completed. Non-granting of permission for pile/ pile cap by

Engineer in such respect will not be considered as reason for delay or any claim thereof. The test arrangement to be employed shall be of nature which is quick to install and remove and easily transferable. Sufficient nos of test arrangement and resources will be required to be mobilized by contractor so as to conduct required nos of initial load tests simultaneously. Vertical cyclic loading tests shall be carried out where specially needed and specified for separation of skin friction and point bearing components of the load carrying capacity of the piles.

- 8.7.3. Routine tests are performed as a check on the load carrying capacity and settlements of the pile foundations. At least one routine test shall be performed for every 100 piles unless otherwise specified by the Engineer.
- 8.7.4. Before commencing the load test the contractor shall prepare the work procedure for the same and shall make it available at site.
- 8.7.5. The Contractor shall give the Engineer at least 48 hours notice of the commencement of construction of these piles which are to be subjected to Initial Tests.
- 8.7.6. The load tests shall not normally be conducted unless the concrete is at least 28 days old. However in special circumstances, permission can be given by Engineer for prior testing.
- 8.7.7. All testing shall be done under the direction of experienced personnel conversant with the equipment and the testing procedure.
- 8.7.8. Before the commencement of the tests all the particulars regarding the test pile including boring data and concrete cube strengths shall be made available at site and shall form a part of the test report.
- 8.7.9. On completion of each load test the Contractor shall submit a report of the load test which shall include the following information.
  - a. Description of soil conditions, ground water table, actual boring and installation records, concrete cube test results.
  - b. Method of load application
  - c. Load settlement readings during loading and unloading
  - d. Time load-settlement curve
  - e. All other observations relevant to the test being conducted.
- 8.7.10. This Dynamic Integrity test using pile driving analyser or approved equivalent for pile integrity shall be performed on the sample of piles selected by the Engineer. The top of the pile shall be made accessible, chipped off up to hard concrete, levelled by trimming it back as far as practicable. The reinforcing bars of the piles tested shall be bent sideways. The test shall be performed after removal of bad/ weak concrete at top so that the wave propagation is steady through hard concrete. The test shall be carried out at minimum 3 locations on each pile in such a way that the entire cross section of the pile is evenly covered. The test shall be conducted with a minimum age of concrete of 15 days. A specialist approved agency shall be employed for the test and the tests shall generally be as per recommendations of the agency unless otherwise directed by the Engineer. A complete report indicating the graphical display of wave propagation under each flow shall be submitted along with interpretation of results showing discontinuities, cross-sectional changes or material changes if any. The results are to be co-related with Site data.
- 8.7.11. Various utilities/services are running parallel to or crossing the viaduct alignment at different locations. Known utilities enroute have been identified, listed and marked on the GAD. The contractor shall take care that all necessary precautions shall be taken for preventing any damage to it during piling / casting of pile cap. The contractor shall carryout trial probes and trial pits down to depths decided by the Engineer with the objective of locating underground utilities well in advance of the piling. The locations shall be decided by the Engineer after consultation with the contractor.

- 8.7.12. Any damage done to the utilities / services (charted or un-charted) during piling/casting of pile cap or due to any of the contractor's operations, shall be made good by the contractor at his own cost. Any demurrage / penalty levied by the utility agency in this regard will also be payable by the contractor and no claim in this regard shall be entertained by Engineer / Employer.
- 8.7.13. As the work is to be carried out in urban areas, load test by Kent ledge method is not permitted
- 8.7.14. The load test on pile:  
 (i) One load test as per IS specification to be carried out.  
 (ii) Initial pile load test (vertical and lateral load test) to be carried out at one location as per IS code  
 (iii) Routine pile load test (vertical only) to be done as per Bill of Quantities.  
 The Dynamic pile load test shall be conducted as per ASTM – D -4945 – 00 for 1.5 times the design pile load. The pile integrity test shall be done as per ASTM-D-5882-96.

#### **8.8. Defective Piles**

- 8.8.1. The Engineer reserves the right to reject any pile which in his opinion has not been constructed in accordance with the specifications.
- 8.8.2. The Contractor will not be paid for rejected piles. The increase in cost of the pile caps, tie beams and other measures adopted for strengthening as a result of rejection of defective piles shall be borne by the Contractor.

#### **8.9. Mode Of Measurement of Piles**

##### **8.9.1. Piles with casing pipe / Temporary Liners**

- 1 The Contractor shall be paid for the length of each pile as measured from the theoretical founding level (as per drawing) or as per actual whichever is less to the point of the vertical cut-off level. The Contractor's rate shall include all items of work including all temporary/permanent arrangements for boring including usage of Polymer, chiseling as specified / required, concreting, handling, form-work and grouting for precast piles, including chipping of top weak concrete, cutting off the MS liner / casing as necessary, removal of excavated earth, chipped concrete, casing / liners and Polymer slurry away from site including its treatment & final disposal, and all other items of work for the satisfactory completion of the pile foundations. Reinforcement shall be measured and paid separately.
- 2 Pile load tests initial and routine shall be measured separately and paid for separately.
- 3 Each pile integrity test shall be measured and paid for separately.
- 4 The quoted rate should include costs of tools and plants, cutting, welding MS liner, cutting shoe etc. complete.

Attention is also drawn to Para 8.4 2 (c ) above.

##### **8.9.2. Piles with Permanent Liners**

The quantity of piles with permanent steel liners (6 mm thick mild steel) required for the job shall be measured as per specifications / detailed in para 8.9.1 (1) above and paid for

separately as per the relevant item of BOQ. In case 8 mm plates are used 30% enhancement over accepted rate will be paid.

Attention is also drawn to Para 8.4 2 (c) above.

#### **8.10. As-Built Drawings**

On completion of the work, the Contractor will submit a plan showing the exact location and length of each pile as constructed at site, as well as dates of concreting, cube test results etc. The original tracings of these drawings along with soft copies shall be submitted to the Engineer.

#### **8.11 The Termination Criteria:**

The Termination of Pile for rock anchoring, Contractor shall follow any of following criteria's:-

- (A)** Contractor shall use minimum 3.6 t weight of the chisel for socket length in soft rock / hard rock. In case the Contractor uses 3.6t chisel the termination criteria shall be as follows:

The Penetration in rock in 1 hour (900 blows) with height of 1.5m is:

- a) between 20 – 40 cm, then rock will be called 'Soft Rock' and anchoring shall be 2.5 dia of Pile i.e 3.0m.
- b) less than 20cm, then rock will be called ' Hard Rock' and anchoring shall be 1 dia of Pile i.e 1.2m.

**Or**

- (B)** For the purpose of socketing of end bearing pile in soft / hard rock, the following alternative criteria can be adopted to determine the soft/hard rock.

- a. Rock will qualify as soft rock if RQD = 35% and core recovery=35% and core strength 35Mpa  $\approx 350\text{T/M}^2$ .
- b. rock will qualify as hard rock if RQD =75% and core recovery =75% and core strength 50 Mpa and above i.e. more than 500 T/ M<sup>2</sup>

Note: Termination level of pile will be decided by Engineer based on above criteria or any other Standard practice based on Energy criteria.

**SECTION – S.09****9 ROOF SHEETING****9.1 General :**

The roofing material shall consist of single skin crimp curved profiled sheeting made up of either of the below mentioned materials:

- High tensile PVDF galvalume steel
- Modified polyester coated GI sheet
- Powder Coated MS sheet
- Aluminium/Aluminium Alloy sheets

The profile and length of sheets shall be commensurate with the design and site requirements and pre-coated with approved colour.

The contractor shall prepare shop drawings based on the drawings supplied by the Engineer. These shall be submitted in five sets sufficiently in advance to the Engineer for approval. All manufacturers shall be ISO 9001:2000 accredited.

**9.2 Steel Material**

- High tensile PVDF galvalume steel as per following specifications

0.50mm (TCT excluding paint thickness) High tensile with 330 to 550 MPa yield strength, metallic hot-dipped coated with Al-Zn alloy (55% Aluminium, 43.5% Zinc, 1.5% Si ) as per AS1397 / IS15961 - (min. 150 g/m<sup>2</sup> total on both sides) with PVDF or equivalent superior quality paint system of approved color, suitable for exterior application conforming to AS/NZS 2728 type-4 / IS15965 Steel make. The sheet shall have a total coating thickness of 35 microns, PVDF paint system of 20 microns on exposed surface and 5 micron reverse polyester coat on back surface over 5 micron primer coat on both surfaces. The paint system should have stable resin & inorganic pigments for paint durability and Lead free for water harvesting. The steel sheet shall have brand marking of coated steel manufacturer (product details, date, mfg name, etc) on back side at regular interval confirming genuineness of the material. The steel sheet shall be fastened with nominal 40 µm zinc coated or nominal 25 µm Zinc-Tin alloy coated, Hex head, self-drilling screw as per AS 3566-2002 Class 3 fasteners with EPDM washer and also as per the requirement considering the profile shape and design load.

The profile sheet, fastener size etc. shall be approved by the concern authority. All the accessories like gutter/ flashing / capping shall be made from same material.

- Modified polyester coated GI sheet

The material shall be 0.60 mm TCT (Total Coated Thickness) modified polyester coated Galvanised steel. The sheets shall have a hot-dip metallic coating of Zinc (180 gms/Sq.M. zinc. Coating mass total on both sides) and have a yield strength not less than 240 Mpa as per relevant IS codes.

- Powder Coated MS sheet

The material shall be 0.60 mm TCT (Total Coated Thickness) powder coated mild steel. The sheets shall have a yield strength not less than 240 Mpa as per relevant IS codes.

- Aluminium/Aluminium Alloy sheets

The External sheet shall be 65/400 profile straight sheets or tapered sheets Aluminium Alloy: EN AW-3004-AMn1Mg1 (as per DIN 1725) with minimum ultimate tensile strength of 225 N/mm<sup>2</sup> and 0.2% Proof stress - min 200 N/mm<sup>2</sup> modulus of elasticity - 70,000 N/mm<sup>2</sup>. Profile reference shall be 65/400 with min 65mm standing seam; 400mm cover width and nominal thickness/gauge: 0.9mm.

The roofing system shall comply to the British Board of Agreement and be certified as CLASS 1 roofing by Factory Mutual Research Corporation.

#### 9.2.1 Profile

Trapezoidal profile with minimum depth of 30/40 mm with 2 to 3 small ribs at the centre to stiffen the profile. The profile shall have the seam and rib height as per the material used, thickness, purlin spacing and profile of the sheeting.

### 9.3 Coating/ Finishing

- High tensile PVDF galvalume steel

The sheet shall have a total coating thickness of 35 microns, PVDF paint system of 20 microns on exposed surface and 5 micron reverse polyester coat on back surface over 5 micron primer coat on both surfaces. The paint system should have stable resin & inorganic pigments for paint durability and Lead free for water harvesting. The steel sheet shall have brand marking of coated steel manufacturer (product details, date, mfg name, etc) on back side at regular interval confirming genuineness of the material.

- Modified polyester coated GI sheet

The sheet shall have modified polyester coating of approved colour of total thickness of 35 microns comprising of 20 microns exterior coat of modified polyester coating over top surface and 5 micron polyester backer coat over 5 micron primer coats on both surfaces

- Powder Coated Mild Steel Sheet

The sheet shall have powder coating of approved colour of total thickness of 35 microns on both surfaces.



- Aluminium /Aluminium Alloy sheeting

The outer sheet shall have PVF 2 coat system (non-clad 3004 type) or stucco embossed and colour as per requirements and specifications. The fluorocarbon (PVF2) coating system shall have 2 coats. The first coat shall be of inhibitive primer, with a dry film thickness averaging 5-7µm. Second coat shall have Fluorocarbon colour coat, with a minimum dry film thickness of 20 µm.

The exterior finish coat shall be PVF2 paint system containing at least 70% of PVF2 resin in dry paint film, as required by approved licensed coating formulate. The finish coat shall have a dry film thickness of 0.020mm. The paint finish system shall have mica particles to achieve its unique appearance, which result in a visual effect known as geometric metamerism.

In order to minimise appearance differences; all requirements shall be processed in one production run using the same batch of paint.

Standard colours will have a nominal gloss level of 20 to 35% (60o) - subject to choices of colours. A Backing Coat of nominal thickness of 0.005mm with standard colour coating. The coated finish for flashing and roofing sheet shall have the following properties:

- Humidity Resistance Blistering tested accordance to ASTM D 2247 (3000 Hours) with no blistering.
- Acid Salt Spray tested accordance to ASTM B117 (3000 Hours) with no creepage sighted.
- Formability of 0T to 2T, tested accordance to ASTM D4145.
- Pencil hardness conforming to ASTM D3363 with HB to 2T hardness grading.
- Reverse Impact tested accordance to ASTM D2794, with no loss of adhesion.
- Flame test tested to ASTM E84. Class A coating
- Specular gloss of 20 - 35%, measured at 60o and tested in accordance to ASTM D523.

#### 9.4 Fixing

If slope of roof is less than 15 degree, the end lap on roof shall be minimum 225mm and single length sheets with joint sealed with double sided self sticking tapes fixed between two sheets are recommended.

The contractor shall ensure that panel erector is familiarised with erection procedure and all the supporting members are straight, level, plumb and true (according to AISC) before starting panel erection. Panels shall be erected according to approved shop drawings. The indicative installation procedure is given below. It shall be suitably adapted based on the cladding/roof system adopted.

- Cut sheets and flashings to give clean true lines, with no distortion. Remove burrs and any lubricant.
- Cut openings in sheets for outlets, vent pipes, flues, etc. to the minimum size necessary and as per the cladding manufacturer's recommendations.
- The sheets shall be laid starting from the eaves, or from bottom upward in case of cladding (IS:3007). The sheets shall be laid from the end of the building away from prevailing wind so that exposed edges face down wind.
- Ensure that ends of sheets, and end laps are fully supported with fixings at top of lap.
- Ensure that raking cut edges at hips and valleys are fully supported.
- Remove dust and any other foreign matter before finally fixing sheets into position.
- Protect sheets adequately during fixing and up to Practical Completion against mechanical damage and disfigurement. Rectify any defects as quickly as practicable to minimise damage and nuisance.

#### **Fasteners**

- Sheets shall be crest fixed to roof purlins with no. 12-14 x 55 mm long polymer coated galvanised hex head self-drilling screws with integral washers and EPDM seals (four fasteners per support) per sheet.
- Or drill all holes and install fasteners perpendicular to the surface of the cladding. Position fasteners at regular intervals in straight lines, centred on support bearings.
- Locate fasteners centrally within holes that are oversized.
- Install fasteners to correct tightness using any special tools recommended by the fastener manufacturer. When used, screw guns must be fitted with depth sensitive devices and used at the correct speed.
- Check fastenings on completion and adjust as necessary to ensure that they are watertight and sheeting is secure but not buckled or distorted.
- Paint all cut edges to match face finish.

#### **FIXING OF STANDING SEAM SHEETS**

- Standing Seam sheets to be installed by mechanically seaming sheets to support clips with electrically operated zipping machine.
- Only roofing contractors approved by the manufacturers should be employed to install Standing Seam roofing system.

#### **STRUCTURAL MOVEMENT JOINTS**

- Leave space between sheets to coincide with structural movement joints.

- Fix movement joint cover to sheets on one side only.
- Movement joint flashing details to be in accordance to cladding manufacturers recommendations.

#### 9.4.1 Jointing Detail:

Trapezoidal profile with atleast one corrugation for side lap.

### 9.5 Accessories

The specification for capping, flashing and trims materials shall be same as that for sheeting and shall be factory formed to required shape and profile based on shop drawings. Depending on the cladding system adopted and the suitability, the accessories mentioned below shall be used.

- Extruded aluminium alloy: EN AW-6061 halters, 85mm long fixed to galvanised steel purlins, 2mm thick, with 25mm long 6.3mm dia stainless steel self-tapping fasteners
- Polyamide thermal barrier pads fixed to halter base
- Pressed aluminium alloy channel verge cap
- Pressed aluminium alloy ridge support
- Aluminium alloy Z section ridge closure
- Pressed aluminium alloy drip angle 40 x 60mm
- The aluminium clip shall be manufactured from extruded Aluminium Alloy 6061T6 with a ultimate tensile strength of not less than 340 MPa and elongation not more than 16% when tested according to ASTM B 557: 1981.
- Stainless steel self-tapping screws complete with stainless steel/EPDM bonded washers – thread type, length to suit construction detail. A minimum of 2 numbers of fixings per halter should be used.

### 9.6 Gutter

#### 9.6.1 Material description:

Outer skin: 2.0mm aluminium, plain mill finish or galvalume, GI or MS powder coated sheet as per the cladding system adopted as per the specifications mentioned above.

#### 9.6.2 Special requirements

- Gutter shall be supported by colour matched 2mm thick GI support brackets at every meter and butt jointed at (maximum) every 3 meters.
- Gutter fixings: stainless steel bolts, nuts, stainless steel & EPDM washers.
- Gutter sealing: All joints to be sealed with suitable sealant and water flow area shall be lined with waterproofed using suitable material.

**9.7 Measurement**

The sheets including special accessories such as gutters, north light curves, flashings, trims, etc. shall be measured and paid per sqm area.

No separate payment will be made for laps of sheets and accessories, bolts, nuts, washers, whitewashing, adjustable bolts and supports for gutters and other fixtures. These are assumed to be included in the quoted rates.

**9.8 Warranty Period**

The manufacturer / Supplier / fabricator/ contractor of the roofing system shall give a guarantee for 15 years with regarding to its composition, surface and tensile strength.

**SECTION - S.10****10 MISCELLANEOUS****10.1 Bearings****10.1.1 General**

This work shall consist of design supply and fixing in position of bearings for bridge / viaduct girders in accordance with details shown on drawings and to the requirements of these Specifications, Codes and Standards quoted therein and as directed by Engineer.

- 10.1.1.1 Bearing plates, assemblies and other expansion or fixed devices shall be constructed in accordance with details shown on drawings.

When bearing assemblies or plates are shown on drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade and shall be finished by grinding.

- 10.1.1.2 It shall be ensured that the bearings are set truly level and in exact position as indicated on drawings so as to have full and even bearing on the seats. This shall be checked with spirit level in both directions. Thin epoxy mortar pads (not exceeding 5 mm) may be made to meet with this requirement.

It shall be ensured that the bottoms of girders to be received on the bearings are plane at the location of these bearings and care shall be taken that the bearings are not displaced while placing the girders.

- 10.1.1.3 When elastomeric bearing pads or preformed fabric pads are to be provided, the concrete surfaces on which pads are to be placed shall be wood float finished to a level plane, which shall not vary by more than 1.5 mm from a straight edge placed in any direction across the area.

**10.1.2 Scope Of Work**

The scope of work will include:

- I Rendering necessary assistance/coordinate with the manufacturer with regard to placement/fixing of said bearings. The contractor shall ensure that these bearings are installed in accordance with the specification of the manufacturers so that the bearings perform in the desired manner, in accordance with the forces/ displacements/ rotations for which these bearings have been designed. The contractor shall liaise with the agency and will be responsible for design etc. The contractor shall furnish adequate and proper installation details for these bearings while submitting his design and detailed Engineering Drawings. The design criteria, specifications etc. as mentioned in tender documents are mandatory and no deviation to the same shall be permitted unless otherwise directed by the Engineer.
- II The contractor shall supply all the bearings in suitable packed condition (for its proper transportation and storage before placement in position) at project site to be identified by the Engineer. The price for such bearings (quoted in Schedule of Quantities) shall include all the accessories/holding down bolts/fixing arrangements (excepting reinforced concrete work in piers and girders, and finishing the surfaces of the pedestal) including grouting of holes with epoxy etc., as required.

**A. POT BEARINGS****A.1 Material specifications of Pot bearing**

The material such as PTFE (Poly Tetra Fluoro Ethylene) and lubrication to be used in Pot bearing should conform to BS:5400 Part-9.2 & BS:3784. The confined elastomer to be used shall conform to IRC:83 with a minimum IRHN of 60 +/- 5. The stainless steel shall conform to AISI:304. The Pot base ,saddle & top plate shall be of Cast steel conforming to IS:1030 Gr 280-520 W. Structural steel shall conform to grade A IS:2062-1992. The POT cylinder shall be made up of cast steel. If POT cylinder is to be made of mild steel, then it shall be made of Mild Steel conforming to Grade A of IS: 2062 - 1992 and without welding, duly certified as lamination free steel from SAIL/TISCO. No building up of thickness shall be permitted for POT cylinder. The anchor bolts shall conform to IS:1364 . All welding will be done by manual arc process and as per approved drawing shall conform to IS:816 & IS:9595 with electrode as per IS:9595. Pre-healing and post weld stress relieving shall be done as per IS:9595. Painting on non-working surface of bearing shall be as per MOST specification, cl 2006.4.5. The mating surface of Piston and cylinder shall be hardened to 350BHN (Min).

**A.1.1 ELASTOMER** - Only the required type of chloroprene viz. Neoprene - WRT, Bayprene 110 or equivalent as specified in IRC: 83(Part-II) - 1987 shall be used in the manufacture of bearings. The Chloroprene shall either be imported directly from the manufacturers or purchased from their authorised agent in India and shall give a certificate to this effect to the department and the same shall be verified from the documents of purchase. Only fresh chloroprne which has been produced not earlier than one year shall be permitted for manufacture of bearings. No reclaimed rubber or vulcassired wastes shall be used.

**A.1.1.1** The confined elastomer inside the POT will have the following properties as per Clause 2006.3(c) of MOST Specifications for Roads and Bridges which is reproduced below (Test method as per IS: 3400).

|       |                                                        |      |          |
|-------|--------------------------------------------------------|------|----------|
| (a)   | Hardness                                               | IRHD | 50+5     |
| (b)   | Tensile strength (minimum)                             |      | 15.5 Mpa |
| (c)   | Elongation at break (minimum)                          |      | 400%     |
| (d)   | Compression set (maximum)                              |      | 35%      |
| (e)   | Accelerated ageing (maximum Change from initial value) |      |          |
| (i)   | Hardness                                               | (+)  | 15 IRHD  |
| (ii)  | Tensile Strength                                       | (-)  | 15%      |
| (iii) | Elongation at Break                                    | (-)  | 40%      |

Other specifications as given in IRC-83 (Part II) for elastomeric bearings will be followed.

**A.1.1.2** The elastomer for guide-stopper bearing shall be of synthetic rubber (Chloroprene) and shall conform to all the properties specified in clause 915.2 of IRC : 83 (Part – II) – 1987.

Laminates of mild steel conforming to IS : 226 Shall only be permitted to be need. Use of any other materials like fiber glass or similar fabric as laminates shall not be permitted.

**A.1.2** Accessories other than those mentioned below will be as per IS:2062 – 1992.

- (a) Sealing ring for POT – Metallic (brass).
- (b) Wiper seal – elastomer as per IRC : 83 (Part - II) - 1987.
- (c) Dust seal – elastomer as per IRC : 83 (Part II) - 1987.

Guide stop bearings shall be fabricated as per tolerances in Table 2 of IRC:83 (Part-II)-1987.

Design of the bearing and all accessories shall be the responsibility of the Contractor and got approved from the Engineer.

**A.2 Permissible stresses in steel component of Pot bearing**

All the design requirement for Pot bearing as specified in IRC:83 Part-III has to be fulfilled with following modifications.

(a) No increase in permissible stresses in any material of bearing or bearing stress between concrete and bearing is permitted in seismic condition.

**A.3 Permissible bearing stresses in concrete**

The allowable bearing stresses in concrete as defined in IRC:83 Part-III has to be followed with following modifications.

1. No increase in permissible bearing stress between concrete and bearing is permitted in seismic condition.

**A.4 Anchor sleeve**

All the part of bearing such as anchor sleeves embedded in concrete shall be hot dip galvanized @ 300gm/ m<sup>2</sup>. The anchor sleeves has to be designed taking account of difference in elasticity of steel of sleeve and concrete. The effect of shifting of center of rotation of sleeve should be also taken into account

A.5 The contractor shall furnish along with tender documents in technical bid, the name of the manufacturer of bearings, his qualifications with all details including proof of satisfactory performance, certification and testing facilities of the bearing he proposes to use. Products of reputed manufacturers shall only be used.

A.6 The Bearings shall be measured in numbers according to their capacities. For this purpose Fixed type POT bearings, Free sliding type POT-cum-PTFE bearings, Guided sliding type POT-cum-PTFE bearings, Free or Guided PTFE Sliding Assembly, Pin Bearings or Metallic Guided bearings shall be counted separately. The rate shall include the cost of supplying, fixing, sampling and testing as required and confirming to the specifications

**A.7 Testing of Pot Bearing**

**A.7.1 Proof Load Test**

A test bearing shall be loaded to 150% of the bearing's rated design capacity and simultaneously subjected to a rotational range of 0.02 radians or design rotation, whichever is greater, for a period of one hour.

The bearing will be visually examined both during the test and upon disassembly after the test. Any resultant visual defects, such as extruded or deformed elastomer or PTFE, damaged seals, or cracked steel, shall be cause for rejection.

During the test, the steel bearing plate and steel piston shall maintain continuous and uniform contact for the duration of the test. Any observed lift-off will be cause for rejection.

All bearings will be applied with a vertical load perpendicular to the plan area of the bearings and on approved system duly approved by Engineer, to subject the bearings

to rotation. The minimum load at which the required rotation is achieved is to be determined and this value should be less than the minimum design vertical load as tabulated in the drawing.

For guide-stopper bearing, test on specially molded test pieces shall be conducted as per clause 918.4.1.2. of IRC : 83 (Part – II) – 1987 which shall be compared with Test pieces from test bearings. The variation shall be within limits specified herein.

#### A.7.2 Sliding Coefficient of Friction

For all guided and non-guided expansion type bearing, the sliding coefficients of friction shall be measured at the bearing's design capacity.

The sliding coefficient of friction shall be calculated as the horizontal load required to maintain continuous sliding of one bearing, divided by the bearing's vertical design capacity.

The test result will be evaluated as follows:-

- (a) The measured sliding coefficients of friction shall not exceed 3%.
- (b) The bearing will be visually examined both during and after the test. Any resultant visual defects, such as bond failure, physical destruction, cold flow of PTFE to the point of debonding, or damaged components shall be cause for rejection.

#### A.8 Sampling and Testing

##### A.8.1 Lot Size

Sampling, testing and acceptance consideration will be made on a lot basis. A lot shall be defined as those bearings presented for inspection at a specific time or date. A lot shall be further defined as the smallest number of bearings as determined by the following criteria.

- (b) A lot shall not exceed a single contract or project quantity;
- (c) A lot shall not exceed 25 bearings;
- (d) A lot shall consist of bearings of the same type regardless of load capacity. Bearing types shall be fixed or expansion bearings types. Guided and non-guided expansion bearing shall be considered a single type.

##### A.8.2 Sampling and testing requirements

The manufacture shall furnish the required number of samples to perform testing in accordance with Table Given below:-

Sampling and Testing Requirement

| Test                                                   | Sample Required                                  |
|--------------------------------------------------------|--------------------------------------------------|
| Proof load                                             | One production bearing per lot                   |
| Coefficient of Friction                                | One production bearing per lot                   |
| Physical Properties of elastomeric rotational elements | One elastomeric element per lot                  |
| Physical properties of PTFE sheet                      | One 10" x 15" sheet of PTFE material per project |

A minimum of thirty (30) days shall be allowed for inspection, sampling and testing of production bearings and component materials.

All exterior surfaces of sampled production bearings shall be smooth and free from irregularities or protrusions that might interfere with testing procedures.



The manufacturer shall select, at random, the required sample bearing(s) from completed lots of bearings for testing by the manufacturer. He shall complete the required testing and determine compliance with this specification before submitting the lot(s) for inspection, sampling, and acceptance consideration.

The Engineer shall select, at random, the required sample bearing(s) from completed lots of bearings.

Necessary test certificates for all raw material shall be furnished by manufacturer. Test specified in IS:1030 for cast steel shall be performed. Casting shall be ultrasonically got tested by approved testing agency.

#### A.9

#### **Fabrication Details**

The Contractor shall provide the Engineer with written notification thirty (30) days prior to the start of bearing fabrication. This notification shall include all the information shown on the shop drawings which are required as explained in subsequent section.

The finish of the mold used to produce the elastomeric rotational element shall conform to good machine shop practice.

All steel surfaces exposed to the atmosphere, except stainless steel surfaces and metal surfaces to be welded, shall be shop painted in accordance with the Contract Plans. Prior to painting, the exposed steel surfaces shall be cleaned in accordance with the recommendations of the coating's manufacturer. Metal surfaces to be welded shall be given a coat of clear lacquer, or other protective coating approved by the Engineer, if the time of exposure before welding takes place is to exceed three months, the coating shall be removed at the time of welding. No painting will be done to these surfaces prior to the completion of welding.

Stainless steel sheet shall be attached to its steel substrate with an approved epoxy to ensure complete contact and then sealed with a continuous seal weld.

The steel piston and the steel pot shall each be machined from a solid piece of cast steel.

The outside diameter of the piston shall be no more than 1mm less than the inside diameter of the pot at the interface level of the piston and elastomeric rotational element. The sides of the piston shall be beveled to facilitate rotation. Except as noted all bearing surfaces of steel plates shall be finished or machined flat in accordance with tolerance given below:

#### **Tolerances :-**

Manufacture tolerance shall be as per IRC:83 Part-III and BS:5400, section 9.2 shall be followed subject to following modification .

|                                     |                                                           |
|-------------------------------------|-----------------------------------------------------------|
| (a) Plan Dimension:                 | -0 to +5mm                                                |
| (b) Overall height:                 | -0 to +3 mm                                               |
| (c) Height of any steel component   |                                                           |
| (i) Machined                        | -0 to 0.5mm                                               |
| (ii) Unmachined                     | class 2 of IS:4897                                        |
| (d) Stainless steel sliding surface |                                                           |
| a. Flatness                         | 0.0004L , where L= length in direction of measurement     |
| b. Surface Finish                   | Ra shall be less than or equal to 0.25 µm as per IS: 3073 |

All the measurements will be taken using dial / height gauges , vernier calipers, surface finish measurement instrument etc has to be arranged by manufacturer at the workshop.

Every bearing shall have the Project Identification Number, Lot Number, and individual bearing number indelibly marked with ink on a side that will be visible after erection.

After assembly, bearing components shall be held together with steel strapping, or other means, to prevent disassembly until the time of installation. Packaging shall be adequate to prevent damage from impact as well as from dust and moisture contamination during transportation and storage.

#### **A.10 Shop Drawings**

Along with detailed design of different types of bearing , shop drawings shall be submitted .The shop drawings shall contain the following information, which is necessary for proper design and detailing of the bearings.

Quantity, type (fixed, guided expansion, non-guided expansion), and location of all bearing units.

A table containing maximum and minimum vertical and horizontal loads, design rotation requirements, and magnitudes and directions of movements.

Allowable contact stresses, maximum dimensions, and anchorage requirements at the bearing interfaces; grades, bevels, and slopes at all bearings; and allowable coefficients or friction of all sliding surfaces.

The painting system to be used on the steel components to guard against corrosion.

Any special consideration such as earthquake requirements, uplift details, or temporary attachments.

Installation scheme of pot bearing

The Contractor shall submit detailed shop drawings in conformance with the applicable requirements.

#### **A.11 Measurements**

The bearings will be counted in numbers along with bolts & washers.

### **B. ELASTOMERIC BEARINGS**

The term “bearing” in this case refers to an elastomeric bearing consisting of one or more internal layers of elastomeric bonded to internal steel laminates by the process of vulcanization. The bearing shall cater for translation and/or rotation of the superstructure by elastic deformation.

#### **B.1 Raw Material**

The raw material shall conform to the requirements laid down in clause 2005.1 of MORTH specifications.

Chloroprene (CR) only shall be used in the manufacture of bearing.

Grades of raw elastomeric of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life (e.g. Neoprene with low crystallization rates

and adequate shelf life (e.g. Neoprene WRT, Bayprene 110 Skyprene B- and Denka S-40V) shall be used.

No reclaimed rubber or vulcanized wastes or natural rubber shall be used.

The raw elastomeric content of the compound shall not be lower than 60 per cent by its weight. The ash content shall not exceed 5 percent (as per tests conducted in accordance with ASTM D-297, sub-section 10).

EPDM and other similar candidate elastomers for bridge bearing use shall not be permitted.

## **B.2 Properties**

The elastomeric shall conform to the properties specified in Clause 4.3.1 of the IRICEN publication titled "Bearings for Railway Bridges" and those specified in Table 2000-1 of the publication titled "Specifications for Road and Bridge Works", published by IRC on behalf of MORTH (Roads Wing).

The design, drawings, detailed method statement for installation & replacement of the bearings including its accessories shall be the responsibility of the Contractor. The design shall be got checked and certified by approved independent agency before submitting to the Engineer for approval

## **B.3 Fabrication and Tolerances**

Fabrication and Dimensional tolerances shall be governed by the specifications laid down in Clause 4.3.2 of the IRICEN publication & Clause 2005.2 of the MORTH specifications mentioned above.

## **B.4 Acceptance Specifications**

For inspection and testing requirement Clause 4.4 of the above mentioned IRICEN publication shall be referred with modifications of lot size as mentioned below:-

Sampling testing and acceptance consideration will be made on a lot basis. A lot shall be defined as those bearings presented for inspection at a specific time or date. A lot shall be further defined as the smallest number of bearings as determined by the following criteria.

- (a) A lot shall not exceed a single contract or project quantity;
- (b) A lot shall not exceed 50 bearings;
- (c) A lot shall consist of bearings of the same type regardless of load capacity.

Accepting and testing requirements shall also conform to the specifications laid down in Clause 2005.3 of the referred MORTH specifications.

In addition to tests mentioned above, all bearings shall also be weighed actually and compared with the theoretical weight.

All bearings shall carry a warrantee of not less than 15 years in an approved format. The contractor shall be responsible for immediate repair or replacement of the bearings in case of failure / distress to the satisfaction of the Owner at not extra cost to the Owner within the warrantee period.

Criteria for Selection of bearing manufacturer shall conform to requirement of MOST letter No-RW/NH-34057(1) / 95-(S & R) dated 2<sup>nd</sup> November, 2000. It is necessary that all manufacturers of all elastomeric bearings shall have in house facilities for carrying out Infrared Spectro-Photometry as per ASTM D-3677.

**B.5 Design**

The design of elastomeric bearings shall be as per the guidelines laid down in the UIC 772 R. Alternatively, design can also be made with latest version of Euro norm prEN1337-3 Part 3.

The design, drawings and detailed method statements for installation and replaceability of the bearings shall be checked and certified by approved independent agency before submitting to the Engineer for approval.

**B.6 Storage and Handling**

Each elastomeric bearing shall be clearly labeled or marked. The bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges.

Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather to the bearings during transport and handling prior to and during installation.

**B.7 Installation**

Installation procedure shall conform to the guidelines listed in Clause 4.5 of the IRICEN publication and Clause 2005.6 of the MORTH specifications. Cost of Non-shrink Epoxy grout below the bearing should be included in the cost of providing and installation of bearing as per BOQ.

**B.8 Measurement**

Measurement shall be done in cu.cm correct to two decimal places. All linear dimensions required to arrive at volume of elastomeric shall be measured correct to a mm. Payment shall be made for the volume of bearing as per design.

**10.2 Expansion Joints****10.2.1 Scope of Work**

The scope of work will include:

- i) Preparation of detailed engineering and installation drawings, supply and supervision during fixing of strip seal/compression seal expansion joints conforming to specifications. The expected expansion/contraction of the superstructure at the location of expansion joints are shown in relevant drawings.
- ii) Design, manufacture, providing and seating of expansion joints by the specialized agency and approved by the Engineer.
- iii) Necessary technical supervision for installation of each and every expansion joint during different stages of installation including rectification of any deficiency or defect attributable to fixing and installation will be provided by the manufacturer/supplier.
- iv) The expansion joint shall be provided for the full width of viaduct including the railing.
- v) Leak tightness of all joints shall be ensured which shall also carry a warranty of 10 years from the contractor.

10.2.2 The expansion joints provided over elevated structure decks should be so designed as to be compatible with the bearings wherever provided where the structure passes through stations, specially designed completely waterproof expansion joints should be provided.

- 10.2.3 The contractor shall submit design and drawing of compression seal expansion joints based on design criteria mentioned under “scope of Work” to the Engineer for approval. The design of expansion joint shall be done as per Revised Highways “Interim Specification for expansion joint” issued by Ministry of Road Transport vide No. RW/NH - 34059/1/96 - S & R dated 30th November 2000, IRC Codes and MOST Specification for Roads and Bridges and Sound Engineering practices.

Any modification to the design and drawings submitted by the Contractor, if suggested by the Engineer, shall be incorporated without any reservations. The design and drawings including changes approved by the Engineer shall form basis of execution and the Contractor shall undertake all necessary action for ensuring execution of work on that basis.

For design, manufacture, testing and supply of strip seal/modular strip seal expansion joints, following will be followed in order of preferences.

- (a) Details in this chapter and elsewhere in tender documents.
- (b) “Revised Interim Specifications for expansion joints” issued by MOST vide No. RW/NH – 34059/1/96/ S & R dated. 30.11.2000.
- (c) IRC Codes and MOST specifications for Roads and bridges published by Indian Road Congress.
- (d) Sound Engineering Practice (Decision of Engineer will be final in this case) which shall include specialized literature as decided by Engineer-in-Charge.

#### STRIP SEAL ELEMENT SPECIFICATION

Sealing element is made of chloroprene and must be extruded section. The working movement range of the sealing element shall be 70mm.

| Property                                                             | Specified Value   |
|----------------------------------------------------------------------|-------------------|
| Hardness*                                                            |                   |
| DIN 53505                                                            | 63+ /-5 Shore A   |
| ASTM D 2240 (Modified)                                               | 55 +/- 5 Shore A  |
| Tensile Strength*                                                    |                   |
| DIN 53504                                                            | Min 11 MPa        |
| ASTM D 412                                                           | Min 13 .8Mpa      |
| Elongation at fracture*                                              |                   |
| DIN 53504                                                            | Min 350 per cent  |
| ASTM D 412                                                           | Min 250 per cent  |
| Tear Propagation Strength                                            |                   |
| Longitudinal                                                         | Min 10 N/mm       |
| Transverse                                                           | Min 10 N/mm       |
| Shock elasticity                                                     | Min 25 per cent   |
| Abrasion                                                             | Min 220 Cu.mm     |
| Residual Compressive Strain<br>(22h/70 deg C/30 per cent Strain))    | Max 28 per cent   |
| Aging in hot air<br>(14days/70 deg C)                                |                   |
| Change in hardness                                                   | Max + 7 Shore A   |
| Change in tensile strength                                           | Max –20 per cent  |
| Change in elongation at fracture                                     | Max - 20 per cent |
| Ageing in Ozone<br>(24 h/50 pphm/25 deg<br>C/20 per cent elongation) | No cracks         |

|                                                                                                                          |                                                       |
|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| Swelling behaviour in Oil (168h/25 deg. C)<br>ASTM Oil No. 1                                                             | Max + 5 per cent<br>Max –10 Shore A                   |
| Volume Change<br>Change in hardness<br><br>ASTM Oil No. 3<br>Volume Change<br>Change in hardness<br>Cold Hardening Point | Max + 25 per cent<br>Max –20 Shore A<br>Max –35 deg C |

- Only one set of specification viz. ASTM or DIN shall be followed depending on the source of supply.

#### 10.2.4 Building Expansion Joints

Specialised expansion joints consisting of aluminium extrusions and / or elastomer suited to building applications shall be used. These will be provided for covering the structural gap at expansion joints along the horizontal faces of slabs and beams, vertical faces of retaining walls, etc. Necessary block-outs as per the manufacturer's recommendations shall be provided in the structure which shall be filled in the approved manner after placing the expansion joints.

The base of the expansion joint assembly shall be fixed onto the concrete base using anchor fasteners as per manufacturer's specifications. All aluminium in contact with concrete shall have zinc chromate finish. The joint assembly shall be capable of accommodating the specified movement without loss of cover. The expansion joint cover assemblies shall withstand a minimum 500lb point load without damage or permanent deformation.

Only proprietary imported expansion joints from reputed manufacturer's and other MORTH approved manufacturers shall be used.

#### 10.2.5 Fabrication (Pre-installation)

- The strip seal joint system and all its component parts including anchorages shall be supplied by the manufacturer /system supplier.
- The width of the gap to cater for movement due to thermal effect, prestress, shrinkage and creep, superstructure deformations (if any) and sub-structure deformations (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is to be installed, the gap dimension shall be preset.
- Each strip seal expansion joint system shall be fabricated as a single entity unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Presetting shall be done in accordance with the joint opening indicated on the drawing.
- The finally assembled joint shall then be clamped and transported to the work site.

#### 10.2.6 Handling and Storage

- (a) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.
- (b) The manufacturer/supplier shall supply all the materials of strip seal joints including sealants and all other accessories for the effective installation of the jointing.
- (c) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding.

#### 10.2.7 Supply/Installation:

Components of expansion joint such as edge beam and strip seal shall be imported from the specified foreign manufacturer / collaborator to ensure quality and performance. The joint shall be supplied and installed only by the MORTH approved manufacturer. Contractor shall furnish a warranty of trouble free performance for at least ten years and free rectification of defects / replacement, if any, during this period.

The joints shall be installed by the manufacturer/supplier (only MORTH Approved) or their authorised representative who will ensure compliance to the manufacture's instructions for installation.

Taking the width of gap for movement of the joint into account, the dimensions of the recess in the decking shall be established in accordance with the drawings or design data of the manufacturer. The surfaces of the recess shall be thoroughly cleaned and all dirt and debris removed. The exposed reinforcement shall be suitably adjusted to permit unobstructed lowering of the joint into the recess.

The shuttering in the recess will be provided in such a way that dimensions in the joint drawing are maintained. The formwork shall be rigid and firm.

Immediately prior to placing the joint, the presetting shall be inspected. Should the actual temperature of the structure be different from the temperature provided for presetting, correction of the presetting shall be done. After adjustment, the brackets shall be tightened again.

The joint shall be lowered in a pre-determined position. Following placement of the joint in the prepared recess, the joint shall be levelled and finally aligned and the anchorage steel on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side of the joint. With the expansion joint finally held at both sides, the auxiliary brackets shall be released, allowing the joint to take up the movement of the structure.

High quality concrete shall then be filled into the recess. The packing concrete must feature low shrinkage and have the same strength as that of the superstructure, but in any case not less than M40 grade. Good compaction and careful curing of concrete is particularly important. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

The neoprene seal shall be field installed in continuous length spanning the entire carriageway width to ensure proper fit of seal and enhance the ease of installation dirt, spatter or standing water shall be removed from the steel cavity using a brush, scrapper or compressed air. The seal shall be installed without any damage to the seal by suitable hand method or machine tools.

The deck surfacing shall be finished flush with the top of the steel sections. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

**10.2.8 Acceptance Criteria:**

- (i) All steel elements shall be finished with corrosion protection system.
- (ii) For neoprene seal, the acceptance test shall conform to the requirements stipulated in Table-1. The manufacturer/supplier shall produce a test certificate conducted in a recognized laboratory, in India (having NABL certification) or abroad.
- (iii) The manufacturer shall produce test certificates indicating that anchorage system had been tested in recognized laboratory having NABL certification to determine optimum configuration of anchorage assembly under dynamic loading.
- (iv) Prior to acceptance, 25 percent of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm anytime during the test. A close inspection of the underside of the joint shall not reveal any leakage.
- (v) As strip seal type of joint is specialized in nature, generally of the proprietary type, the manufacturer shall be required to produce evidence of satisfactory performance of this type of joint.

**10.2.9 Test and Standards of Acceptance**

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite certificates from the recognized testing laboratory in India having NABL Certification or abroad.

**10.2.10 Mode Of Measurement**

The measurement for expansion joints as a finished work shall be in running meters nearest to a centimetre.

**10.2.11 Rates**

The contract unit rate shall include the cost of all materials, labour, equipment, cost of transportation (overseas as well as with in country), cost of testing including cost of test samples and other incidental charges for fixing the joints complete in all respects as per specifications

**10.3 Sealants****10.3.1 General**

Joint sealing compounds shall seal joints in concrete against the passage of water, prevent the ingress of grit or other foreign material and protect the joint filler. The compound shall have good extensibility and adhesion to concrete surfaces and shall be resistant to flow and weathering.

Approved Sealant where specified on the drawings shall be provided strictly in accordance with the manufacturer's written instructions, such joints shall be formed to the correct dimensions, thoroughly cleaned and treated with recommended primer strictly in accordance with the manufacturer's written instructions prior to sealing. Wherever width of gap to be sealed is wide enough to necessitate the use of backer rod, the same shall be provided at no extra cost. The contractor shall use only competent personnel experienced in the application of sealant for such work.



Where specified in the drawings, silicon / polyurethane / polysulphides based sealants shall be of an approved manufacture. The treatment of the joint and the use of sealing compound shall be strictly in accordance with the manufacturer's written instructions. The entire work shall be carried out as per IS:3414, IS:6509, IS:11433.

Sealants shall be as follows:

Silicon sealant shall be one part gun grade type with minimum movement capability of  $\pm 25\%$  and elongation at break of 450% confirming to BS 5889 or TTS 001543A. This Sealant shall be of approved color and shall be nonstaining to the parent concrete surface.

#### 10.3.2 Ancillary Materials

The Contractor shall provide all ancillary materials such as cleaning solutions, epoxy mortar, primer, tool cleaner, bond breaker type, filler boards, back up material, backing rods, polyethylene foam, masking tapes, sealant slot former etc.

#### 10.3.3 Primer

Primer for sealants shall only be as recommended by the sealant manufacturer, Primer shall have been tested for compatibility and durability with the sealant to be used and on samples of the surfaces to be selected.

#### 10.3.4 Backdrop Material

Backdrop material shall be an expanded polyethylene of nominal density 35 kg/cum as recommended by the sealant manufacturer. It shall be of non-absorbent and non-staining material compatible with the sealant used. Tube or rod stock shall be rolled into the joint cavity.

#### 10.3.5 Bond-preventive Materials

Bond-preventive materials shall be pressure-sensitive adhesive polyethylene tape or aluminium foil.

#### 10.3.6 Equipment

The Contractor shall inter alia provide the following plant and equipment for the work.

T-paddle, follower plate, solid barrel gun, plastic nozzle, wire brush, heavy duty 500 rpm electric drill, palette knife, masking tape and paint brush for priming etc.

#### 10.3.7 Working Life

Care shall be taken to ensure that material with adequate shelf life is provided. Material whose shelf life is over shall not be used in the works and shall be removed from the site forthwith. Depending on the storage, temperature and humidity, only one unit shall be drawn from the storage.

#### 10.3.8 Curing Period

No portion of the work where sealant has been applied shall be allowed to be submerged or be wetted by any liquid for a period of 7 days after application of the sealant. This period may be modified depending on the temperature and humidity prevalent at the time.

#### 10.3.9 Environmental Requirements

The ambient temperature shall be within the limits as given by the manufacturer, when the sealants are applied. The work shall not be carried out in a dusty atmosphere or when it is

raining or when the humidity is high.

Sealants shall not be applied when the ambient temperature is below 4 degree C. When the ambient temperature is below 10 degree C but greater than 4 degree C, the sealant containers shall be stored for some hours at 21 degree C, to ease mixing and application.

#### 10.3.10 Delivery and Storage

Materials shall be delivered to the job site in the manufacturer's original unopened containers.

The containers shall include the following information on the label:

- i) Name of supplier,
- ii) Name of material,
- iii) Formula,
- iv) Lot number,
- v) Colour
- vi) Date of manufacture,
- vii) Mixing instructions
- viii) Shelf life and
- ix) Curing time

Materials shall be carefully handled and stored to prevent contamination of foreign materials to exposure to temperatures exceeding 35 degree C.

#### 10.4 Joints

The effective width to depth ratio shall be as per the table given below unless directed otherwise by the Engineer.

**Table for Joint Dimensions**

| Surfaces                       | Joint Width          | Joint Depth |                |
|--------------------------------|----------------------|-------------|----------------|
|                                |                      | Minimum     | Maximum        |
| For concrete masonry or stone: | 6 mm                 | 6 mm        | 6 mm           |
|                                | Over 6 mm upto 12 mm | 6 mm        | Equal to width |
|                                | Over 12 mm           | ½ of width  | ½ of width     |

##### 10.4.1 Surface Preparation

###### **General**

The surface of joints to be sealed shall be clean, dry, sound and free of all release agents, water repellents, laitance, oil, grease, dirt, chalk, particles of mortar, dust, loose rust, loose mill scale and other foreign substances. Oil and grease shall be removed with solvent and the surfaces shall be wiped with clean clothes.

##### 10.4.2 Concrete and Masonry Surfaces

Where surfaces have been treated with curing compounds, oil or other such materials, the materials shall be removed by sandblasting or wire brushing, Laitance, efflorescence and loose mortar shall be removed from the joint cavity. The surfaces/edges shall be repaired with epoxy mortar to give smooth and even surfaces to correct lines and levels with a uniform gap for the length to be sealed.

##### 10.4.3 Application

**Masking Tape**

Masking tape shall be placed on the finished surface on one or both sides of a joint cavity to protect adjacent finished surfaces from primer or compound smears. The masking tape shall be removed within 10 minutes after the joint shall be filled and tolled.

**10.4.4 Bond-preventive materials**

Bond-preventive materials shall be installed on the bottom of the joint cavity and other surfaces to prevent the sealant from adhering to the surfaces covered by the bond-preventive materials. The materials shall be carefully applied to avoid contamination of adjoining surfaces or breaking bond with surfaces other than those covered by the bond-preventive materials.

**10.4.5 Backstops**

The back or bottom of joints constructed deeper than specified shall be packed tightly with an approved backstop material to provide a joint of the depth specified.

**10.4.6 Primer**

The primer shall be used in accordance with the manufacturer's instructions. The primer shall be applied to the joint surfaces to be sealed only and not spill over or be applied to surfaces adjacent to the joints.

**10.4.7 Application of Sealant**

The sealant shall be gun-applied with a nozzle of proper size to fit the width of the joint indicated and shall be forced into grooves with sufficient pressure to expel air and fill the groove solidly. The sealant shall be uniformly smooth and free of wrinkles.

The plastic nozzles shall be inserted on the gun and cut to appropriate size. The sealant shall be gunned into joints using an even trigger pressure. The nozzle shall be cleaned occasionally.

The sealant shall be pressed into joints with a wet spatula and tooled within five minutes of application. The jointly shall be tooled slightly concave after the sealant is installed. The tolled joint shall present a smooth and professional joint giving the desired finish and shape. The masking tape shall be removed immediately after tooling.

Application equipment shall be cleaned with a tool cleaner, recommended by the manufacturer, after wearing PVC or rubber gloves and whilst the sealant is still in an uncured state.

**10.4.8 Cleaning**

The surfaces adjoining the sealed joints shall be cleaned of smears and other soiling resulting from the sealing application as the work progresses. Sealant adhering to, porous surfaces shall be left until is just cured and then removed by abrasion or other mechanical means.

**10.4.9 Measurement**

Measurement shall be made in running metres correct to two decimal places.

**10.5 Waterbars / Waterstops**

Where waterbars/ waterstops are shown on the drawings, the joints shall incorporate PVC waterbar/ waterstop such as "Fixostop" or approved equivalent (conforming to IS:12200). The waterbars/ waterstops shall be complete with all the necessary moulded or prefabricated

intersection pieces assembled with bends and butt joints in running lengths made by welding in an electrically heated jig. The fabrication drawing made by the manufacturer shall be submitted by the Contractor for approval of the Engineer

Jointing and fixing of waterbars / waterstops shall be carried out strictly in accordance with the manufacturer's instructions which should be enumerated in a detailed method statement and submitted for approval / comments of the Engineer. The following types of waterbars / waterstops are proposed to be used in the Work.

- (a) 'FIXOSTOP' Type 230 KD or equivalent – To be used at construction joint in base slab
- (b) 'FIXOSTOP' Type 230 KV or equivalent – To be used at expansion joint in base slab
- (c) 'FIXOSTOP' Type 240 RS or equivalent – To be used at construction joint in between wall and base slab
- (d) 'FIXOSTOP' Type 240 H or equivalent – To be used at expansion joint in base slab

Water bars / water stops shall be of approved and appropriate type obtained from approved manufacturers.

The water bars / water stops shall be installed so that they are securely held in their correct position during the placing and compacting of the concrete. Necessary supporting devices to prevent sagging of the water bars / water stops shall be provided.

Where reinforcement is present adjacent to water bars / water stops, adequate clearance shall be left between the reinforcement and water bars / water stops to facilitate compaction of the concrete.

Double headed nails may be used in the edge of the water bar / water stop outside the line of the external grooves for fixing purposes, but no other holes shall be permitted through the water bar / water stop.

A representative of the manufacturer shall be present at site during the operations of installing, jointing and embedment of water bar / water stop. He shall monitor and certify that the work is being carried out strictly as per specifications and recommended practices.

Water bars / Water stops shall be measured and paid for separately as per BOQ.

#### 10.5.1 MEASUREMENT

Water bars / Water stops shall be measured in running meters along the line they are to be laid. Laps and welding etc. shall not be measured separately. The length shall be taken in metres correct to two decimal places.

All wastages, laps and variations are deemed inclusive in the item rate quoted by the contractor and nothing extra is admissible on this account. Payment will be made only for the measured quantity incorporated in the work.

#### 10.5.2 RATE

The rate quoted shall include the cost of materials all transportation etc. and labour involved in all the operations described above.

### 10.6 Compression Seal expansion Joint

Expansion joint type described here-after is the "Compression seal" type, but alternate designs can be proposed for approval of the Engineer (e.g. elastomeric omega-shape cover joint, or any other suitable joint type.)

- 10.6.1 Compression seal joint shall consist of steel armoured nosing at two edges of the joint gap suitably anchored to the deck concrete and a preformed chloroprene elastomers or closed cell foam joint sealer compressed and fixed into the joint gap with special adhesive

binder.

#### 10.6.2 Material

10.6.2.1 Steel Nosing: The steel nosing shall be of angle section ISA 100 x 100 conforming to weldable structural steel as per IS:2062. The thickness of legs shall not be less than 12mm. The top face of the angle shall be provided with Bleeder holes of 12mm diameter spaced at maximum 100mm centre so as to ensure that there are no voids in the concrete beneath the angle.

10.6.2.2 Anchorage: The anchorage steel shall conform to IS:2062 or equivalent. The steel nosing shall be anchored to the deck by reinforcing bars or anchor plates cast in concrete or a combination of anchor plates and reinforcing bars, anchor plates and anchor loops. This shall be achieved by passing transverse bars through the loops or plates.

The minimum thickness of anchor plates shall be 12mm. Total cross sectional area of bars on each side of the joint shall not be less than 1600sq mm per m length of the joint and the centre to centre spacing shall not exceed 250mm. The ultimate resistance of each anchorage shall not be less than 600 KN/m in any direction.

Corrosion Protection: All steel section shall be protected against corrosion by hot dip galvanising or any other approved anticorrosive coating with a minimum thickness of 100 micron.

#### 10.6.2.3 Joint Seal

The sealing element shall be a preformed continuous chloroprene or closed cell foam seal with high tear strength, insensitive to soil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness. The seal should be vulcanised in a single operation for the full length of the joint required for carriageway, kerbs and footpaths, if any. The seal shall cater for a horizontal movement up to 40mm and vertical movement of 3mm.

The physical properties of chloroprene/closed cell foam sealing element shall conform to the following:

##### (a) Chloroprene Seal

It shall be preformed extruded multi-web cellular section of chloroprene of such a shape as to promote self removal of foreign material during normal service operations. Chloroprene of joint seal shall conform to clause 915.1 of IRC:83 (Part-II) and satisfy the properties stipulated in Table 1 herein above strip seal element specifications of these specifications except in respect of the working movement range of the sealing element which shall be as specified in Cl G.2.4.1 above.

##### (b) Closed Cell Foam seal:

It shall be of preformed non-extruded non cellular section made from low density closed cell, cross linked ethylene vinyl acetate, polyethylene copolymer that is physically brown using nitrogen. The material shall possess properties as indicated in the Table 2 below.

**Table-2**  
**Properties of Closed Cell Foam Seal**

| Property                                                                     | Special Value                                                                                      |
|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| (I) Density                                                                  | 41.7 – 51.3 kg/cum                                                                                 |
| (ii) Compression set on 25mm                                                 | 50% compression samples (ASTM D 3575) for 22 hours at 23 <sup>0</sup> C, 2 hour recovery; 13% set. |
| (iii) Working temperature                                                    | -70 to +70 <sup>0</sup> C.                                                                         |
| (iv) Water Temperature absorptions (total Immersion for 3 months) (ASTM3575) | 0.09766 kg/sqm                                                                                     |
| (vi) Tensile strength                                                        | 0.8 Mpa                                                                                            |
| (vii) elongation at break (ASTM D 3575)                                      | 195 +/-20%                                                                                         |

10.6.2.4 Lubricant cum Adhesive: The type and application of material used in bonding the preformed joint seal to the steel nosing and concrete shall be as recommended by the manufacturer / supplier of the seal system.

#### 10.6.3 Handling and Storage

- (i) The expansion joint material shall be handled with care and stored under cover.
- (ii) All joint materials and assemblies shall be protected from damage and assemblies shall be supported to maintain true shape and alignment during transportation and storage.

#### 10.6.4 Installation

10.6.4.1 The expansion joint shall be installed by the manufacturer / supplier or their authorised representative, who will ensure compliance of specified installation procedure and instructions.

10.6.4.2 The dimension of the joint recess and the width of the gap shall conform to the approved drawing.

10.6.4.3 Anchoring steel shall be welded to the main reinforcement in the deck maintaining the level and alignment of the joint.

10.6.4.4 Concreting of pocket/recess shall be done with great care using proper mix conforming to same grade as that of the deck concrete but no less than M30 grade in any case. The water-cement ratio shall not be more than 0.40. If needed, suitable admixtures may be used to achieve the workability. The width of pocket shall not be less than 300mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess.

10.6.4.5 At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.

10.6.4.6 Concrete or metal surfaces shall be clean, free of rust, laitance, oils, dirt, dust or other deleterious materials.

10.6.4.7 The lubricant cum adhesive shall be applied to both faces of the joint and joint seal prior to installation in accordance with the manufacturer's instructions.

10.6.4.8 The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation, which shall be between +05 to +35 degree C.

10.6.4.9 The joint seal shall be installed without damage to the seal. Loose fitting or open joints shall

not be permitted.

#### 10.6.5 Acceptance Criteria

10.6.5.1 All steel elements shall be furnished with corrosion protection system.

10.6.5.2 For the joint seal the acceptance test shall conform to the requirements stipulated in para above. The manufacturer/supplier of this type of joint shall produce a test certificate to this effect conducted in a recognized laboratory in India having NABL certification or abroad.

10.6.5.3 Prior to acceptance 25% of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at-least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm any time during the test. A close inspection of the underside of the joint shall not reveal any leakage.

#### 10.6.6 Tests and Standards of Acceptance:

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite certificates from the recognised testing laboratory of India having NABL certification or abroad.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

#### 10.6.7 Mode of Measurement

The measurement for expansion joints as a finished work shall be in running meters nearest to a centimetre.

#### 10.6.8 Rates

The contract unit rate shall include the cost of all materials (including cast-in-situ concrete), labour, equipments, cost of transportation (overseas as well as with in country), cost of testing including cost of test samples and other incidental charges for fixing the joints complete in all respects as per specifications. However the cost of covering plate over shear keys will be measured in MT and paid separately.

### 10.7 Railings

#### 10.7.1 General

Prefabricated railing as per approved drawings & details shall be erected at site and shall extend all along the full length of the viaduct and as shown in drawing. Fixing arrangements with deck shall be incorporated as per approved design & drawings.

Railing on viaduct shall not be constructed until the centering / supporting arrangement form work / supporting arrangement for the span has been released and the span is self supporting. For concrete and steel, specifications of the items of controlled concrete and reinforcement mentioned under relevant specifications shall be applicable.

Railing shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. The pockets / blackouts left for posts shall be filled up with non-shrinkable mortar.

All edges and corners shall be straight and finished to true line and level. Forms shall either be of single width boards / plates or shall be lined with suitable materials duly approved by Engineer. Form joints in plain surface will not be permitted. All mouldings, panel work and level strips shall be constructed according to the details shown in the drawings.

## 10.7.2 Metal Railings

## 10.7.2.1 General

All complete steel / aluminium railing elements, terminal sections, posts, and other fittings shall be of shape, size and designation of approved material and make as given in the item of work or as directed by Engineer. In case of steel railing all these elements shall be galvanised or painted with an approved paint. If galvanised, all elements of the railings shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by Engineer.

Aluminium sections shall be of approved quality and make and free from scratches, stains and discoloration.

The Contractor shall take every precaution against damage of the components during fixing in position.

Damaged galvanized surfaces shall be cleaned and re galvanised. Special care shall be taken to prevent staining of all products, rust, mortar, etc. before it is put into use.

## 10.7.2.2 Fixing

The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints, correct alignment and camber throughout their length.

Fixing shall be strictly as per fixing details shown in the drawings or as directed by Engineer.

If sections are not galvanised, railing shall be given one shop coat of paint, and three coats of paint after erection.

All necessary holes, chases, etc., required in fixing shall be made by the contractor and made good after installation, without any extra charge.

## 10.7.3 Cast-In-Situ Railings

## 10.7.3.1 The portion of the cement concrete railing or parapet which is to be cast in place shall be constructed in accordance with the requirements for Cement Concrete described in the respective section of RCC. Forms shall either be of single width boards or shall be lined with suitable material duly approved by Engineer. Form joints in plane surfaces will not be permitted.

All mouldings, panel work and bevel strips shall be constructed according to details shown on drawings. All corners in the finished work shall be true, sharp and clean - cut and shall be free from cracks, spalls or other defects.

## 10.7.4 Precast Railings

Precast members for railings shall be of reinforced cement concrete to be constructed in accordance with the requirements of cement concrete described in respective sections of RCC and Pre-cast concrete. The precast members shall be removed from moulds as soon as practicable and shall be kept damp for a period of at least 14 days. During this period they shall be protected from sun and wind. Any precast member that becomes chipped, marred, or cracked before or during the process of erection and fixing shall be rejected.

## 10.7.5 Measurements for Payment

Railings shall be measured as per BOQ as finished work.



**10.7.6 Rate**

Contract unit rate shall include cost of all labour, materials, tools and plant required for doing the work complete in all respects in accordance with above specifications and as shown in the drawings or as directed by Engineer.

**10.8 Epoxy**

Epoxy bonding agents for match cast joints shall be thermosetting 100 percent compositions that do not contain solvent or any non-reactive organic ingredient or pigments required for coloring. Epoxy bonding agents shall be of two components i.e., a resin and a hardener. The two components shall be distinctly pigmented. So mixing produces a third color similar to the concrete in the segments to be joined, shall be packaged in proportioned, labeled, ready-to-use containers.

Epoxy bonding agents shall be formulated to provide application temperature range that will permit erection of match cast segments at substrate temperature from 5° C to 40° C. Depending upon the ambient temperature range, the following types of epoxy are recommended for use:

- 5° to 20° C : Fast reacting
- 15° to 30° C : Medium fast reacting
- 25° to 40° C : Slow reacting

If two surfaces to be bonded have different substrate temperatures, the adhesive applicable at the lower temperature shall be used.

Epoxy bonding agents shall be insensitive to damp conditions during application. After curing, shall exhibit high bonding strength to cured concrete, good water resistivity, low creep characteristics and tensile strength greater than concrete. In addition, the epoxy bonding agents shall function as a lubricant during the joining of match cast segments, as a filler to accurately match the surface of the segments and act as a durable water tight bond at the joint.

Epoxy bonding agents shall be tested to determine their workability get time, open time, bond and compressive strength and working temperature range. The frequency of the tests shall be as stated in the Special Specifications of the Contract.

The contractor shall furnish the Engineer with samples of the material for quality assurance testing and a certification from a reputed independent laboratory having NABL. Certification indicating that the material has passes the required tests.

Specific properties of epoxy and the test procedures to be used to measure these properties shall conform to FIP requirement.

**10.8.1 Mixing and Installation of Epoxy**

Instructions furnished by the supplier for the safe storage, mixing and handling of the epoxy bonding agent shall be followed. The epoxy shall be thoroughly mixed until it is of uniform color. Use of a proper sized mechanical mixer operating at no more than 600 RPM will be required. Contents of damaged or previously opened containers shall not be used. Surfaces to which the epoxy material is to be applied shall be at least at 40°F and shall be free from oil, laitance form, release agent or any other material that would prevent epoxy from bonding to the concrete surface. All laitance and other contaminants shall be preferably removed by water rinsing, or, alternatively, by light sand-blasting. Wet surfaces shall be dried before applying epoxy bonding agents. The surface shall be at least the equivalent of saturated surface dry (no visible water).

Mixing shall not start until the segment is prepared for installation. Application of the epoxy bonding agent shall be according to the manufacturer's instructions using trowel

rubber glove or brush on one or both surfaces to be joined. The coating shall be smooth and uniform and shall cover the entire surface with a minimum thickness of 1.5 mm applied on both surfaces and 3 mm if applied on one surface. Epoxy should not be placed within 10 mm of prestressing ducts to minimize flow into ducts. A discernible bead line must be observed in all exposed contact areas after temporary post-tensioning. Erection operations shall be coordinated and conducted so as to complete the operations of applying the epoxy bonding agent to the segments, erection, assembling and temporary post-tensioning of the newly joined segment within 70% of the open time period of the bonding agent.

The epoxy material shall be applied to all surfaces to be joined within first half of the get time as shown on the containers. The segments shall be joined within 45 minutes after the application of the first epoxy material placed and a minimum required temporary prestress over the cross section should be applied within 70 percent of the open time of epoxy material. The joint shall be checked immediately after the erection to verify uniform joint width and proper fit. Excess epoxy from the joint shall be removed where accessible. All tendon ducts shall be swabbed immediately after stressing while the epoxy is still in the non-gelled condition to remove or smooth out any epoxy in the conduit and to seal any pockets or air bubble holes that have formed that joint.

If jointing is not completed with 70 percent of the open time, the operation shall be terminated and the epoxy bonding agent shall be completely removed to the maximum possible extent from the surfaces. The surface must be prepared again and fresh epoxy shall be applied to the surface before resuming joining operations. As general instructions cannot cover all situations, specific recommendations and instructions shall be obtained in each case from the Engineer.

Completed segment tolerance for segmental Box girder viaduct / bridge construction

Finished segment tolerances should not exceed the following:

|                                                      |          |
|------------------------------------------------------|----------|
| Length of match-cast segment (not cumulative)        | ± 5 mm   |
| Overall height                                       | ± 5 mm   |
| Length of totally assembled span                     | ± 10 mm  |
| Web Thickness                                        | ± 5 mm   |
| Depth of bottom slab                                 | ± 5 mm   |
| Depth of top flange                                  | ± 5 mm   |
| Overall top flange width                             | ± 5 mm   |
| Top flange width (transverse position on track side) | ± 5 mm   |
| Diaphragm thickness                                  | ± 5 mm   |
| Grade of form edge and soffit                        | ± 1.0 mm |
| Tendon hole location                                 | ± 3 mm   |
| Position of shear keys                               | ± 5 mm   |

#### **Tolerance for erection of the span**

Horizontal and vertical positions of the at-pier-segment shall be within 15 mm of the longitudinal alignment and grade.

**10.9 SHEAR KEY DEVICES****General Description of the system****General**

The shear Key is made of concrete cast in place in second pour after concrete decks are assembled.

The shear keys shall take all horizontal loads (longitudinal and transverse)

It is equipped with a system of fixation with high strength bars to one end of the deck, and with five vertical bearing taking the transverse horizontal loads and rotations.

**Description of the proposed system**

The system of fixation of the shear key to the deck is performed by high strength tensile bars installed on only one horizontal layer.

The system shall satisfy the following two main requirements.

- construction easiness
- maintenance easiness

The high strength tensile bars shall have good resilience and good resistance to fatigue as due to the rotation of the braking/acceleration loads, the bars are almost continuously loaded.

**Material Characteristics****High tensile bars**

Quality of steel: The quality of the raw material steel be according to the DIN EN 10083-1 equivalent. The chemical composition shall be such as to guarantee the following mechanical characteristics:

- Yield stress  $F_y > 1050$  MPa
- Tensile stress  $F_u > 1200$  MPa
- Elongation at breaking  $> 10\%$
- Resilience at 20°C  $> 50$  Joules:

The threading of the bars shall be made by rolling method (cold plastic deformation of the metal between two dies). The threads shall have a triangular profile H7 according to ISO 262-NFE 03053.

The tolerance of the length of the bars is  $\pm 5$ mm

Due to the repetitive loading that will be applies to the bars, tests shall be carried out to demonstrate the fatigue resistance of the bars. The test criteria shall be as follows: \_

- mean stress:  $0.57F_y$
- stress range:  $\pm 0.03$
- 4million cycles
- after 4 million cycles, no breaking at less than  $0.80F_y$
- 

**Other materials**

The repartition plates shall be of S355 JO steel quality or equivalent, and each shall include an injection pipe.

The ends of the bars shall be equipped with a protection cap filled up with grease and fixed on reparation plate by threading.

The nuts at the ends of the bars shall be spherical in order to ensure that the tensioning is axial.

The sheaths shall be made of a 2mm-thick steel.

The injection product shall be wax in order to provide a good time –resistance and to provide flexibility under the deck rotations. The product shall be equivalent as for use for protecting stay cables or tension rods.

**Elastomeric bearing system**

On the movable side of deck, one sliding elastomeric bearing shall be installed longitudinally on each side of the shear key. The sliding elastomeric bearing shall be made of one laminated elastomeric pad and one sliding plate.

On the fixing side of deck, one laminated elastomeric bearing shall be installed longitudinally on each side of the shear key. In addition, at the interface between the shear key and one laminated elastomeric bearing, adequate recesses to allow for replacement without taking out the high tensile bars shall be installed transversally.

These elastomeric bearing shall be made of polychloroprene, and manufactured according to Euronorm EN 1337-3 or equivalent.

The sliding plate shall be PTFE, with elongation at break >300% and tensile strength from 29 to 40 MPa.

**CORROSION PROTECTION****High tensile bars**

The protection against corrosion of the tensile bars shall be achieved by using wax injected in a steel tube. The bars will be protected against corrosion during transition and storage by sprayed oil or equivalent system.

**Other materials**

The upper repartition plate and the protection cap shall be sandblasted and shall receive 3 layers of coating.

The articulation room, the coupler and the lower ring shall be sandblasted and shall receive 3 layers of coating.

The articulation room and upper protection cap shall be filled up with grease.

**TRANSPORTATION & STORAGE**

The bars and the accessories shall be transported in wooden cases and in containers, or equivalent.

The bar threading shall be ring, or temporarily protected against shocks by greased tape and a steel ring, or equivalent. The protection of the threads shall be taken off just before the installation of the bars.

The bars and accessories shall be carefully stored at the job site under the following conditions:

- They should be protected from rain, and storage room shall have ventilation.
- If the bars have been kept stored for long time, it will be necessary to protect them with a layer of solvable oil or equivalent in order to protect them against corrosion.
- Before installation of the bars, if there is some corrosion, they shall be cleaned up as per the approved procedure. Acceptance of the bars shall be subject to approval of Engineer.

**INSTALLATION PROCEDURE**

The installation procedure is proposed as follows. Alternate methods can also be submitted by the contractors for approval of Engineer.

- 1- Shear key is poured before precast concrete deck segment are installed. The span must be assembled at a higher level to avoid conflicts with already built concrete key
- 2- Superstructure should have recess of 20mm for grouting by non-shrinkage grout at a later stage.
- 3- Erect the Superstructure on the temporary bearings/jacks with sliding surface at top at both ends.
- 4- Provide some arrangement to prevent deck sliding (E.g. under seismic load)
- 5- Move the girder by hand screwing /jacking bar by nearly 20mm.
- 6- At this stage vertical faced elastomeric pad is in position (resting on tubes)
- 7- Replace the temporary bearing with the permanent elastomeric bearing

- 8- Grout the gap between the girder (with hacked surface at grouting location )and the elastomeric bearing.
9. Bar stressing
10. Wax injection and capping

Note:

- a) The bars are installed after alignment check, and the bars are installed inside the spherical nut at movable end. Then the bars are pre stressed with jack. The bars are tensioned step by step (50% the other, then the remaining 50%)
- b) Injection is then made from the movable end, with heated wax through injection tube.

#### **MAINTENANCE PROCEDURE**

The system shall be such that it is possible to replace any device without any dismantling/ destruction of the concrete part of the structure.

The system shall be such that the maintenance procedure described below can be undertaken.

- a) Lateral elastomeric bearings  
For the lateral vertical bearings, a theoretical gap of 2mm shall be provided on each side of the shear key. If it is needed to change one or all of these lateral bearings, then as the deck will not be in contact on each side at a time,, the lateral bearings on the non-compressed side are taken out first. First the sliding plate is taken out, then the elastomeric bearing. Then the deck may need to be translated laterally to take out the elastomeric bearing on the compressed side. For this, steel angles can be split in the concrete support for jack or threaded bars. The needed force to distort the neoprene bearings supporting the deck will be calculated.
- b) Transversal elastomeric bearings  
Due to opening on the bearing, it will only necessary to un-stress temporarily the tie-bars to take out the bearings and replace it
- c) Pre stressed tie-bars  
Bars will be un-stressed, and taken out with the help of device provided at the movable end. The connection between the spherical nut and the protection cap will not allow the spherical nut to turn. The wax product will come out with the bar. New bars are introduced as per first installation, then tensioned and wax injection.

#### **10.9.A ROAD WORKS**

Any item not covered in Technical specifications will be executed as per KPWD Specifications.

**10.10 List of Approved Materials/Makes/Manufacturers /Likely suppliers.**

Approved Materials/Makes/Manufacturers/Likely suppliers are those who conform to the relevant Standard Specification, IS codes and other relevant codes etc. and shall be of approved by Employer/Engineer in charge.

**SECTION - S.11****11 ADDITIONAL SPECIFICATIONS FOR PRECAST SEGMENTAL CONSTRUCTION AND CAST-IN-SITU SPANS:****11.1 TYPE OF CONSTRUCTION**

The Box girder superstructure for most of the length shall be constructed by precast segmental construction with epoxy bonded joints. The prestressing cables will be internal to the concrete. The methodology of construction will be “span by span”. Only one end prestressing of permanent cables is contemplated, the other end of the cable being pre-blocked. Some spans shall be cast-in-situ spans and special spans.

The standard spans c/c of piers generally shall be 31.0 m, 28.0 m, 25.0 m, 22.0 m, 10.0 m and 16.0 m. The usual segments shall be 3 m in length except the pier segments which shall be 1.95 m each. Standard spans shall be made by either adding or subtracting usual segments of 3.0 m each. The Transition / approach spans in the stations zone shall be of different lengths depending upon the spanning arrangement and the station location and shall form part of the scope of work for stations.

Where this is not possible or advisable for some reason, the segments will be of length between 1.5 m and 3.0 m. Hence the mould / casting bed shall be adaptable to cast non-standard length of segment.

The governing weight of the segments will be of the order of 75 t. The maximum span length contemplated for precast segmental construction will be of the order of 31.0 m.

Multiple Shear keys shall be provided at segmental joints at the webs as well as at top flange and soffit slab of the box girder.

Box girder segments shall be match cast at the casting yard and later transported to location and erected in position. Post-tensioned cables shall be threaded-in-situ and tensioned from one end. Box girder shall cater to two tracks.

**11.2 MATERIAL SPECIFICATIONS****11.2.1 Cement**

Ordinary Portland Cement of 53 grade conforming to IS:8112 and IS:12269 respectively shall be used.

**11.2.2 Prestressing Steel**

The prestressing steel accessories shall be subjected to an acceptance test prior to their actual use on the works. (Guidance may be taken from BS:4447). Only multi-strand jacks shall be used for tensioning of cables. Direct and indirect force measurement device (like Pressure Gauge) shall be attached in consultation with system manufacturer.

**11.2.3 Concrete**

The 28-day concrete strengths measured on 150 mm cubes to be adopted for various structural elements have been indicated in the Bill of Quantities.

The physical and chemical properties of the constituents of concrete and so also of the green and hardened concrete shall meet the requirements of MORTH Specifications for Road and Bridge works, where relevant or where the standard specifications referred to in the Technical Specifications are silent.

#### 11.2.4 Permanent Prestressing

The permanent prestressing cables shall generally be of the type 19K15 and 12K15, as suited to 19 nos. and 12 nos. strands of 15.2 mm nominal dia. Intermediate numbers of strands may also be specified in the design, for which suitable anchorage heads shall be used. All aspects of prestressing including the system adopted shall be subject to the approval of the Engineer. The corrugated sheathing shall be of HDPE.

Maximum anchorage set-in shall be 6 mm. Maximum friction ratios shall be 0.0020 m<sup>-1</sup> and 0.17 rad<sup>-1</sup>.

#### 11.2.5 Joining of Segments with Epoxy

A minimum compressive stress of 3 kg / sqcm shall be provided uniformly over the cross-section for the closure stress on the epoxies joint until the epoxy has set.

This temporary compressive stress can be applied by temporary prestressing bars.

The curing period for application of the compressive stress, method of mixing and application of epoxy and all related aspects including surface preparation shall be as per approved manufacturer's specifications.

The Epoxy shall be spread with the help of a stubby brush to a thickness of about 1.50 mm each on both the joining surfaces.

The purpose of the epoxy joint shall be to serve as lubricant during segment positioning, to provide water proofing of the joints for durability in service conditions and to provide a seal to avoid cross-over of grout during grouting of one cable into other ducts.

Prior to grouting, all cables shall be tested with water pressure of 0.3 Mpa for approximately 3 minutes, to investigate leakages and connectivity of ducts. Since the epoxies joint is of paramount importance to ensure long-term durability of prestressing cables, this field test shall be taken as indication of the Contractor's quality of work in general and effectiveness of the epoxy joint executed by him. All other aspects of grouting of cables shall be governed by MORTH Specifications.

The epoxy shall be special purpose proprietary material for the proposed usage with proven past record. Selection shall be subject to the approval of the Engineer. It shall meet the requirements of relevant provision of FIB (International Federation of Concrete, previously "FIP - International Federation of Prestressed Concrete") and as detailed in Annexure 10.1 herein. For selection of epoxy, all tests which govern the properties of epoxy for its application and subsequently determine the durability of joint are required to be done in laboratory temperature controlled condition. Some tests for evaluating properties of epoxy are critical in the upper limit of specified application temperature range while other tests are critical for evaluating the properties in the lower limit of specified application temperature range. The tests shall be conducted in laboratories equipped to handle controlled temperature conditions. All tests shall conform to FIB requirements.

After receiving every batch, all tests (except shear modulus, instantaneous and deferred modulus in compression and water absorption, heat resistance, shear strength and solubility in water) are required to be done at the site laboratory at prevailing ambient temperature to conform to the uniformity of standard of supplied product. In case the received batch is kept at site for a period of more than three months all tests are required to be re-done.

With every erection, tests for pot life and open time are required to be done at site at prevailing ambient temperature. Nothing extra shall be payable for providing epoxy testing, applying and all related operations.



The uniform compressive stress during the curing period may be applied by approved external temporary bar prestressing (such as Macalloy or Dywidag bar systems). This shall be accomplished using short HTS bar connecting the adjoining segments. The bars shall be either anchored on temporary steel frame, or anchored on concrete blisters, or passing through dedicated holes within the trough. If concrete blisters are used, the blisters needed at slab level shall be such that they will be embedded in the secondary pour of the rail plinths (Track Works Contract). No passing through holes shall be used in soffit slab or web. Using passing-through holes in soffit slab or web filled with free low, high strength non-shrink, cement grout is not acceptable for aesthetics reasons.

In order to prevent intrusion of epoxy in sheathing, an O-ring (10-20 mm wide and 4 mm thick) of polypropylene shall be provided on both mating surfaces.

Nothing extra shall be payable for such stress application including all related works.

### **11.3 SHOP DRAWINGS AND DESIGN CALCULATIONS FOR CONSTRUCTION PROCEDURES**

#### **11.3.1 General**

The Contractor shall submit according to an acceptable schedule, complete details and information concerning the method, materials, equipment and procedures he proposed to use. These shall be called "Method Statements". Method Statements shall be submitted sufficiently in advance of the start of superstructure field construction operations, so as to allow the Engineer adequate review period, which shall not be less than 30 days. The submittals shall invariably include step-by-step erection procedure.

The Contractor's Method Statements shall also include all calculations, drawings and other information as may be relevant duly illustrated by drawings / sketches / diagrams.

#### **11.3.2 Design Calculations for Construction Procedures**

Design calculations shall be submitted by the Contractor for deflection and / or camber data for each stage of construction as required to construct the structure to its final grade. The procedure used shall account for the effect of time dependent prestress losses and creep, which will occur during the construction phase. The data for the entire viaduct, based on the Contractor's proposed erection sequence, method and schedule, shall be submitted to the Engineer for review prior to commencing construction of the pier shaft.

The Contractor shall submit to the Engineer for approved a geometric control plan which shall indicate in detail how the survey is to be performed and the Contractor's actions proposed to assure proper erection of the structure to the final grade shown on the design plans. The geometric control plan shall provide for regular monitoring of the superstructure deflections.

The Contractor shall produce calculations to ensure safety of the structure during stacking, handling, transport and erection. In case any additional reinforcement is required to be provided in any part of the structure, to ensure safety during construction, the same shall be provided by the contractor at his own cost.

Design assumptions and calculations shall be submitted for temporary prestressing, falsework, erection devices, formwork or other temporary construction which may be required to complete the work for approval of the Engineer.

Assumptions and Calculations shall also be submitted for the approval of Engineer to substantiate the system and method of permanent and temporary prestressing proposed by the Contractor.

In the sections that follow, specific recommendations for precast segmental construction for superstructure are given apart from certain special aspects of construction.

**11.3.3 Shop drawings for Precast Segmental Construction**

The Contractor shall submit detailed shop drawings for the approval of Engineer shop drawings shall be based on Execution Drawings issue by the Engineer Contractor and shall include.

- i) Fully and accurately dimensional views showing the geometry of segments including all projections, recesses, notches, openings, block-outs, blister if any and where acceptable, as well as other pertinent details.
- ii) Details of any special reinforcing required for handling of segments or for any purposes. Also all bar bending schedules shall be presented based on reinforcement schedules given in Execution Drawings issued by BMRCL.
- iii) Sheathing supports, grout tubes, vents and drains shall be shown including size, type and locations.
- iv) Details and locations of all other items to be embedded in the segments as inserts, lifting devices and post-tensioning hardware shall be shown.
- v) Prestressing system details shall include sizes and properties of tendons anchorages, plates assemblies and stressing procedure, and details locations of additional reinforcement necessary to resist anchor block stressing.
- vi) Graphs, charts or tables showing the theoretical location of each segments erected or placed shall be furnished to the Engineer for his use in checking..... erection of the superstructure. Detailed procedures for making geometric corrections shall be described.
- vii) Details of grouting equipment, grout mix design and method of mixing placing grout shall be provided.
- viii) Method of installing bearings and expansion joints shall be given including approved manufacturers recommendations.

**11.3.4 Forms for Precast Segmental Construction**

Forms for precast segmental construction shall be metal form work only shop drawings shall be submitted for all formwork for the approval of Engineer. The segments during storing / curing shall always be supported as shown in the Tender drawings or as approved by Engineer only.

In addition to the requirements of the Standard Specifications, the forms used precasting the concrete segments shall be capable of:

- Match casting for precast segmental construction.
- Producing the segments within the tolerances permitted in Annexure 1 herein.
- Accommodating block-outs, openings and protrusions, Protruding re-bars be needed at least for diaphragm segments and for second-pour plinths. Anchorages and inserts for OHE poles, signaling equipment and cable routing supports shall also be included where needed in precast segments.
- Adjusting to changes in segment geometry as shown in Execution Drawings
- By the Engineer, or for correcting previous minor casting errors to prevent accumulation.
- Adjusting the profile to take into account design camber values.
- Stripping without damage to the concrete.
- The form design shall provide a tight leak proof jointing to the previous segment. The bulkhead must be capable of connecting the sheathing in a manner to hold their position and prevent intrusion of grout.

Joints in external formwork shall be avoided as far as possible. Where sections of forms are for some reason to be joined on the exterior face of the segment, an offset in excess of 0.5 mm for flat surfaces and 1 mm for corners and bends will not be permitted.

Forms shall not be removed until the concrete has attained adequate strength. Care should be exercised in removing the forms to prevent spilling and chipping of the concrete.

All side, bottom, inside and header forms the precast segmental construction shall be constructed of steel.

Forms shall be of steel having sufficient thickness, with an adequate external bracing and stiffeners, and shall be sufficiently anchored to withstand the forces due to placement and vibration of concrete. Internal bracing and holding devices in forms shall be limited to stay bolts in webs, which can be removed from the concrete surface to permit patching following form removal. Joints in the forms shall be designed and maintained for mortar tightness. The grade and alignment of forms shall be checked each time they are set and shall be maintained during the casting of concrete.

Metal forms shall be reasonably free from rust, grease or other foreign materials. All forms shall be cleaned thoroughly prior to each casting operation. End headers shall be maintained to provide a smooth casting surface.

All formed surfaces for casting members shall be constructed and maintained to provide segment tolerances in accordance with Annexure 10.2 herein.

The faces of all forms, other than end headers, shall be properly cleaned and treated with form oil or other bond breaking coating prior to placing concrete. Between adjacent match cast segments and headers bond breaking materials shall be provided as indicated in clause 10.4.3 of these Additional Specifications. The oil or other materials used shall be of a consistency and composition to facilitate form removal. Materials which stain or react with concrete shall not be allowed. Care shall be exercised to facilitate formwork and segment removals without damage to the concrete.

#### **11.4 CASTING, HANDLING, TRANSPORTATION AND ERECTION OF PRECAST SEGMENTS.**

##### **11.4.1 General**

The Contractor shall submit detailed Method Statements for casting, handling, transportation and erection of precast segments. The superstructure shall be erected by the method indicated in the tender, or by alternate method submitted by the Contractor, subject to the approval of the Engineer. The casting procedure, curing method, stressing system, cage of reinforcement, lifting and handling details shall be successfully demonstrated on sample segment prior to casting any permanent segments.

All handling and erection plant and equipment shall be load tested by the authorized third party prior to their use at site or when specifically asked for by the Engineer. Any additional material required to cater to any temporary condition including temporary prestressing shall be borne by contractor and nothing extra will be paid on this account.

##### **11.4.2 Casting of segments**

Casting bed and forms shall be structurally adequate to support the segments without settlement or distortion. The casting bed shall be designed for the hardware needed to adjust and maintain grade and alignment. Special consideration shall be given to those parts of the forms that have to change in dimensions. To facilitate alignment or adjustment, special equipment such as wedges, screws or hydraulic jacks shall be provided. Fittings shall not interfere with stripping of forms. Grading of the forms and the deck of each segment shall

take into consideration the relative position of the member in the structure. External vibrators shall supplement the internal vibration if necessary and be attached at locations that will ensure maximum consolidation.

Details for casting bed and hardware for adjustment shall be submitted by the Contractor for the Engineer's approval. Casting of segments shall be done in a single pour.

After the first segment of each unit is cast, all succeeding segments shall be cast against previously cast segments to ensure complete bearing and proper alignment on all mating surfaces.

The anchorage system shall permit tendons to be inserted in the member after erection of segments and tensioned from one end only.

Care shall be taken to ensure that deformations of match cast segments due to thermal gradients caused by the heat of hydration of the new cast concrete are negligible. These deformations shall be prevented by properly protecting both the match cast and new cast segments with curing blankets and plastic sheeting. Both the previous segment and the new segment will be maintained at the same temperature.

Reinforcing steel shall be fabricated in cages and placed according to the Execution Drawing issued by the Engineer. Any conflict or interference with the proper location of sheathing and / or reinforcement or block-outs shall be promptly resolved and corrections made as directed by the Engineer.

All segments shall be marked on the inside with a unique identification at the time of form removal. This identification shall be used to identify each segment on shop plans, post-tensioning details and calculations and any other document pertaining to the fabrication and erection of precast concrete segments.

Positive means of holding the sheathing in its correct position shall be provided in all cases and shall be indicated on the shop drawings submitted for approval. The sheathing shall be stiffened from the inside by rubber or plastic hoses or by inflatable rubber tubes.

#### **11.4.2.1 Casting Methods**

Match cast segments may be cast by the "long line" or "short line" method. The Contractor has to select the option carefully and provide appropriate type of formwork as well as casting and handling operations. The "short line" method requires much greater precision in the work as compared to the "long line" method.

#### **11.4.2.2 The "Long Line" Method**

Tender drawings may be referred to.

The principle of the long line method is the casting of the segments, in their correct relative position, on a long line casting bed which exactly reproduces the profile of the structure. A long line is easy to set up, whilst the geometry of the segments is easily controlled. The segments shall be cast by long line method for spans curved in plan.

After stripping the forms it is not necessary to take away the segments immediately.

Substantial space may be required for the long line method of casting. The theoretical length for casting along is normally slightly more than the length of the longest span of the structure. It must be constructed on a firm foundation which will not settle or deflect under the weight of the segments. In case the structure is curved, the long line must be designed to accommodate horizontal and vertical curvature as well as twists, if any. As the forms are mobile the equipment for casting, curing, etc. would be able to move from place to place.

#### **11.4.2.3 The Short Line Method**

The short line method is mentioned here as possible alternate.

The segments are cast at the same place in stationery forms and against a neighbouring element. After casting, the neighbouring element is taken away and the last element is shifted to the place of the neighbouring element, clearing the space to cast the next element.

The space needed for the short line method, approximately three times the length of a segment for one short line entire process is centralised. Horizontal and vertical cures and twisting of the str..... are obtained by adjusting the position of the neighbouring segment and the specified formwork.

To obtain the desired structural configuration, the neighbouring segments must..... accurately positioned. Care must be taken that the formwork be sufficiently flexible allow for adaptation at the joint with the accurately positioned matching segment.

If short line method is adopted the deck segments should follow profile as given below:-

#### Suggested Deck Alignment on Vertical Curves

##### a) On Vertical Summit Curves

On vertical summit curves, deck will follow the path of straight line joining two points on adjacent piers. These two points shall have the minimum offset from rail level to deck level as specified by Engineer at all points along length of girder.

##### b) On Vertical Valley Curves

On vertical valley curves, deck will follow the path of straight line joining two points on adjacent piers. The minimum offset from rail level to deck Level as specified by Engineer shall be ensured at all points along the length ... girder.

##### c) Suggested Deck Alignment on Circular / Transition Horizontal Curves

On circular / transition horizontal curves, each segment of the deck will follow the profile of short chord line. The bottom and side form the segment to be cast are positioned to span between the still fixed end bulkhead and the previously match cast segment. The previously match cast segment shall be oriented w.r.t segment to be cast and it should be ensured that fixed bulkhead always remain perpendicular to end face of formwork.

Due to orientation of match cast segment, the length of segment towards inner side of curve will be less and towards outer side of curve will be more than segment length along centerline. The formwork to be used should have flexibility to adjust the segment length on both sides by adjusting the position of the match cast segment without any additional pieces and it shall be ensured that offset of match cast segment and segment to be cast is limited to value so calculated.

#### **Separation of Match-Cast Segments**

The Contractor shall provide equipment to be used for uniform separation of match cast segments without damage. The method as well as details of the equipment to be used for separating match cast segments shall be included in the shop drawings and duly approved by Engineer. A bond breaking material shall be used in the form of wax only on the webs and soffit slab of the previously cast segment and a newly cast segment, as well as the end headers when required. The material shall not be injurious to the concrete and shall permit removal of a segment without adhesion of the concrete.

Any breakage in segment end face during separation / handling shall not be repaired, unless specifically accepted by the Engineer, in which case repairing at end face of segment shall be done with epoxy at the time of epoxy application. Segments with excessive breakage shall be rejected. Decision of the Engineer shall be final and binding in this regard.

#### 11.4.3 Handling / Erection of Segments

The Contractor shall be responsible for the proper handling, lifting, storing, transporting and erection of all segments so that they may be placed in the structure without damage. Only HTS bar such as Macalloy or Dywidag shall be used for lifting / handling of segment at any stage of construction, with due care for fatigue considerations (multiple re-use).

Segments shall be maintained in an upright position at all times and shall be stored, lifted and/or moved in a manner to prevent torsion and differential deformation and other undue stresses. Members shall be lifted, hoisted or stored with lifting devices approved on the shop drawings.

The Contractor shall furnish calculations to establish that the stresses induced during any stage of construction shall not exceed 50% of the cube strength achieved at that stage, nor 40% of the specified 28 days cube strength. In addition, the following limitations shall be observed:

- a) The segment shall not be lifted from the casting bed till the concrete reaches a minimum 25MPa Cube strength.
- b) The age of the concrete shall not be less than 14 days at the time of its erection provided it has achieved its specified 28 day strength.

Segment shall be stacked with three point support in curing tank / stacking yard as shown in tender drawing, or as approved by the Engineer. Curing shall be done using sprinkler system (assisted by steam curing in the initial stages if adopted) and it has to be ensured that all portions of segment are water cured during water curing period.

#### 10.4.4 Cleaning , Transportation and Erection of Segments

Before transportation of segment, mating surface shall be cleaned by water rinsing of sand blasting as approved by the Engineer.

When sand blasting is employed, surface shall be abraded to an extent that:

Bond breaker such as was applied during match casting is removed.

- Bond breaker such as wax applied during match casting is removed.
- Laitance is removed so that small aggregates are just exposed.
- Cleaned surface is neither polished nor excessively rough

Top Beam method of erection has been suggested in the tender drawings and is referred to in these special specifications. The launching girder (or more accurately the “assembly truss”) is capable of supporting all the loads within permissible limits as stipulated in codes and transferring it to the temporary cross girder, which transfer the loads directly on pile cap using trestles. The launching girder envisaged is slightly greater than 2 spans. It must also be able to negotiate curves and accommodate for the camber if any of the structure. As far as practical, the movement of segments shall be done at the deck level of the already constructed portion of the continuous length so that the disturbance to traffic at the ground level is minimised. Mobile crane of adequate capacity and boom length shall be mobilised by the Contractor for transferring the segment from ground level to deck level for the purpose. The movement of the segment, over the already constructed portion of the continuous length,

may be effected by trolleys.

A suitable number of separate sets of launching girders are essential in order to proceed at the contemplated pace for completion of project in time. However, the Contractor shall furnish the construction scheme and numbers of launching girders, he proposed to deploy in order to ensure completion of project within scheduled time.

**It is emphasized that for precast segmental construction only one-end prestressing shall be used. The superstructure shall be constructed “span by span” sequentially.**

It is emphasised that the launching truss supports must be at same location as that of temporary bearings.

#### **11.5 MISCELLANEOUS**

The entire construction work shall be planned and geared towards minimising disruptions to road traffic. Also, the occupation of roads during all construction activities shall be reduced to bare minimum and subject to the approval of the Engineer. Reinforcement shall be fabricated in cages in casting yard for piles, pile caps and piers before bringing it into position, for expediting the activities.

Each element of sub-structure below bearing pedestals viz piles, pile caps, piers and pier caps shall be cast in single pour.

#### **11.6 LOAD TESTING OF LAUNCHING GIRDER**

Contractor shall conduct full scale load traveler test of all launching girder prior to using it for execution purpose. Such tests are required to be done for all the launching girders deployed for the project, even if similar design of launching is adopted.

Nothing extra will be payable for conducting such tests and the cost towards the same shall be deemed to be included in quoted rate of the respective item.

**SECTION - S.12****12 STEEL BRIDGE GIRDER ERECTION****12.1 STRUCTURAL STEEL ERECTION WORK - GENERAL****12.1.1 Scope of Specification**

This specification covers the scope of work for structural steel erection works, submittals by the Contractor, applicable codes of practice and the specifications for the materials to be used, including steel, bolts and nuts, washers etc. and the storage thereof.

**12.1.2 Scope of Work**

The scope of work for the contractor in respect of structural steel erection work shall cover, but shall not be limited to the following:

- A. Preparation of complete erection sequence drawing based on the suggested erection scheme(s) as proposed by contractor, required for all the permanent and temporary structures including launching nose / truss.
- B. Submission by the contractor, for examination by the Engineer, detailed particulars of the proposed method of erection of the superstructure steelwork, together with complete calculations relating to strength and deflection. If the erection scheme necessitates the strengthening of the permanent steel work, the contractor shall submit, for approval of the Engineer, the methods he proposes for making good the permanent steelwork after removing the temporary work. The contractor shall also submit the design and fabrication drawings incl. detailed calculations of launching nose / truss, counter weight, all temporary supports, staging, bracings etc. required for safe erection, for approval of the Engineer.
- C. Providing all construction and transport equipment, tools, tackle and consumables, materials, labour and supervision required for the erection of the structural steelwork.
- D. Receiving, unloading, checking and moving to storage yard / storage, guarding and upkeep of fabricated steelwork and other consumable materials and fasteners at site.
- E. Compiling and furnishing detailed bill of materials of fabricated parts received from the fabricator.
- F. Loading, Transportation and unloading of all fabricated structural steel materials from storage yard to erection site, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location, according to approved erection drawings and / or as directed by the Engineer.
- G. Setting out, aligning, keeping in plumb, bolting, welding and securely fixing the fabricated steel structures in accordance with the erection scheme, or as directed by the Engineer.
- H. Requisite, site planning to all fabricated steelwork, as per requirements of related specification of the painting.
- I. Carrying out all major modifications of the fabricated steel structures, as directed by the Engineer, including but not limited to the following:
  - i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
  - ii) Cutting, chipping, filing, grinding etc. as required or preparation and finishing of site connections.
  - iii) Drilling of holes which are either not drilled at all or are wrongly drilled.



**12.1.3 Submittals**

- A. On commencement of the Project, the Contractor shall submit the following:
- i) Prior to the technical submittals, the contractor shall submit the proposed overall schedule for documentation such as calculations, erection drawings, shop / working drawings for all temporary structures etc. It is highlighted that structural steel member dimensions indicated in tender drawings are tentative only, and may be modified during final design stage.
  - ii) A detailed list of all constructional Plant & Equipment, such as cranes, derricks, winches, welding sets, erection tools etc. their make, model, present condition and location, available to the contractor and the ones he will employ on the job to maintain the progress of work in accordance with the contract.
  - iii) The total number of experienced personnel of each category, like fillers, welders, riggers etc., which he intends to deploy on the work.
- B. The contractor shall submit a detailed erection programme for completion of the work in time and in accordance with contract. This will show, in a Proforma approved by the Engineer, the target programme, with details of erection proposed to be carried out in each week, details of major equipment required and an assessment of required strength of various categories of workers.
- C. The contractor shall submit complete design calculations for any alternatives sections (for permanent structure) proposed by him, for approval of the Engineer. Use of any alternative section shall be subjected to approval of the Engineer. However, no escalation in unit rates of work shall be allowed for such cases.

**12.1.4 Furnishing of information**

- A. Design drawings shall be furnished to the contractor and all such drawings shall form part of these Specifications.
- B. The Engineer reserves the right to make changes in the design drawings even after release for preparation of shop drawings to reflect addition, omission & modifications in data / details and requirements. Contractor shall consider such changes as part of these Specifications and the contract, and no claims shall be entertained on this account.
- C. Design drawings, approved by the Engineer, will show as appropriate the salient dimensions, design loads, sizes of members, location of openings at various levels and other necessary information required for the preparation of fabrication drawings, designs and erection details.
- D. It shall be clearly understood that the drawings of the Engineer are design drawings. The typical details of connection, cuts, notches, bend etc where shown in the design drawings are only for general guidance of the contractor. The contractor shall design and develop all such details based on the design forces and functional requirements.
- E. In case of variations between design drawings and specifications, the decision of the Engineer shall be final. Should the contractor, find any discrepancy in the information furnished by the Engineer, same shall be immediately brought to the notice of Engineer for resolution. The contractor shall obtain clarifications on discrepancies from Engineer before proceeding with the work.
- F. No detailed erection or shop drawings for temporary structures will be accepted for examination by the Engineer unless the same, have first been completely checked by the contractor's qualified structural engineer (independent agency to be appointed by contractor) and are accompanied by an erection plan showing the location of all pieces detailed. The contractor shall check and ensure that detailing of connections is carefully

planned to obtain ease in erection of structures, including field-welded connections and / or bolting.

- G. No fabrication work shall be started by the contractor without prior approval of Engineer on the relevant drawings. Approval by the Engineer of any of the drawings shall not relieve the contractor of his responsibility to provide correct design of connections, workmanships, fit of parts, details, materials and errors or omissions of all work shown thereon. The approval of Engineer shall constitute approval of the size of members, dimensions and general arrangement, but shall not constitute approval of the connections between members and other details.
- H. Drawings, for approval, shall be submitted by the contractor in an orderly manner commensurate with erection sequence and approved construction programme.
- I. The contractor shall furnish ten prints of all approved final drawings including soft cop in CD ROM for interface / field use and record purpose.
- J. The drawings prepared by the Contractor, and all subsequent revisions thereof shall be at the cost of the Contractor, and no separate payments shall be made for the same. Revisions shall incorporate all modifications, field changes, substitutions etc. effected. The rates / prices quoted for fabrication work shall be deemed to include the cost of such drawing work.
- K. All the drawings shall be prepared in metric units. The drawings should preferably be of A-1 standard size, and the details shown therein shall be clear and legible. These drawings shall include but shall not be limited to the following:
  - i) Assembly drawings, giving exact sizes of the sections to be used and identification marks of the various sections.
  - ii) Shop details of temporary structures together with detailed calculations.
  - iii) Detailed shop drawings for proper co-ordination with the concrete components to which the steel members shall be connected, as required.
  - iv) Any other drawings or calculations that may be required for proper completion of the works and clarification of the works of substituted parts thereof.
  - v) All 'as-built' drawings.

#### 12.1.5 Applicable Codes of Practice

The following specifications, standards and codes are included as part of this Specification. All Standards, specifications, codes of practice current on the date of signing of agreement and referred to herein shall be applicable.

- |    |               |                                                                                       |
|----|---------------|---------------------------------------------------------------------------------------|
| 1. | IS:800 (1984) | Code of Practice for General Construction in Steel.                                   |
| 2. | IS:808 (1989) | Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle sections.             |
| 3. | IS:800 (1984) | Covered Electrodes for Manual Metal Arc Welding of Carbon & Carbon - Manganese Steel. |
| 4. | IS:816 (1969) | Code of Practice for Use of Metal Arc welding for General Construction in Mild Steel. |
| 5. | IS:817 (1969) | Code of Practice for Training and Testing of Metal Arc Welders.                       |

6. IS:919 (1993) ISO System of Limits & Fits (Part 1 & Part 2)
7. IS:1148 (1982) Hot Rolled Rivet Bars (upto 40 mm) for Structural Purposes.
8. IS:1182 (1983) Recommended Practice for Radio Graphic Examination of Fusion Welded Butt joints in steel plates.
9. IS: 1363 (1992) Hexagon Head Bolts, Screws and Nuts of Product grade C. (Part 1 to Part 3)
10. IS:1364 (1992) Hexagon Head Bolts, Screws and Nuts of Product grade A & B. (Part 1 to Part 5)
11. IS: 1367 (1991) Technical Supply Conditions for Threaded Steel Fasteners.
12. IS: 1852 (1985) Rolling & Cutting Tolerances for Hot-Rolled Steel Product
13. IS: 1977 (1975) Structural Steel (Ordinary Quality)
14. IS: 2016 (1967) Plain Washers
15. IS: 2062 (1992) Steel for General Structural Purposes.
16. IS: 2595 (1978) Code of Practice for Radio Graphic Testing.
17. IS: 3600 (1985) Methods of Testing Fusion Welding joints (Part 1 to Part 9)
18. IS: 3613 (1974) Acceptance Tests for Wire Flux Combinations for Submerged Arc Welding
19. IS: 3658 (1981) Code of practice for Liquid Penetrant Flow, Detection.
20. IS: 3757 (1985) High Strength Structural Bolts
21. IS: 4000 (1992) High Strength Bolts in Steel Structures Code of Practice.
22. IS: 4353 (1967) Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steel.
23. IS: 4943 (1968) Assessment of Butt and Fillet Fusion Welds in Steel Sheet, Plate and Pipe.
24. IS: 5334 (1981) Code of Practice for Magnetic Particle Flow Detection of Welds.
25. IS: 5369 (1975) General requirements for Plain Washers and Lock Washers.
26. IS: 5372 (1975) Taper Washers for Channels.
27. IS: 5374 (1975) Taper Washers for I Beams
28. IS: 6623 (1985) Specifications for High Strength Structural nuts.
29. IS: 6649 (1985) Specifications for hardening and tempering washers for high strength structural nuts.
30. IS: 6755 (1980) Double Coil Helical Spring Washers
31. IS: 7215 (1974) Tolerances for Fabrication of Steel Structure.

- |                                 |                                                                                                      |
|---------------------------------|------------------------------------------------------------------------------------------------------|
| 32. IS: 7318 (1974)<br>(Part I) | Approval Test for Welders when welding procedure approval is not required - fusion welding of steel. |
| 33. IS: 8500 (1974)             | Structural steel - Micro alloyed (Medium and high Strength Qualities)                                |
| 34. IS: 8910 (1978)             | General requirements of Supply of Weldable Structural Steel.                                         |
| 35. IS: 9595 (1980)             | Recommendations for Metal Arc Welding of Carbon & Carbon - Manganese Steels.                         |

#### **12.1.6 Storage of Materials**

##### **12.1.6.1 General**

All materials shall be so stored as to prevent deterioration, and to ensure the preservation of their quality and fitness for the work. If required by the Engineer, the materials shall be stored under cover the suitably painted for the protection against weather. Any material, which has deteriorated or has been damaged shall be removed from site and replaced by new members, as directed by the Engineer at no extra cost and time.

- A. Steel to be used in fabrication shall be stored in separate stacks clear of the ground, section wise and lengthwise.
- B. The storage area shall be kept clean and properly drained. Structural steel shall be so stored and handled to such a manner that members are not subjected to excessive stresses and damage. Girders and beams shall be placed in upright position. Long members shall be supported on closely spaced skids to avoid unacceptable deflection.

##### **12.1.6.2 Storage Yard**

- A. The Contractor shall be required to establish a suitable yard, at an approved location at site for storing the fabricated steel structures and other materials which will be delivered to site. The yard shall have proper facilities such as drainage and Lighting including access for cranes, trailers and other heavy equipments.
- B. The Contractor shall have been deemed to have visited the site, prior to submission of his tender, to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc., all of which shall be carried out by the Contractor at his own cost and as directed by the Engineer.

##### **12.1.6.3 Covered Store**

All field connection materials, paints etc. shall be stored on racks and platforms, off the ground in a properly covered building by the Contractor.

#### **12.2 FIELD BOLTS**

- 1. Requirements stipulated under bolting shall apply for field bolts. Field bolts, nuts and washers shall be supplied by the authorized fabricators of the structural member in excess of the nominal numbers required. Only HSFG bolts of class 8.8 shall be used.
- 2. At the time of assembly the surfaces in contact shall be free of paint or any other applied finish, oil, dirt, loose rust, loose scale, burrs and other defects which would prevent solid seating of the parts or would interface with the development of friction between them.

3. In any other surface condition, including a machined surface, is specified, it shall be the responsibility of the Contractor to work within the slip factor specified for the particular case.
4. Each bolt and nut shall be assembled with washers of appropriate shape, quality and number in cases where plane parallel surfaces are involved. Such washers shall be placed under the bolt head or the nut, whichever is to be rotated during the tightening operation. The rotated nut or bolt head shall be tightened against a surface normal to the bolt axis, and the appropriate tapered washer shall be, used when the surfaces are not parallel. The angle between the bolts axis and the surface under the non-rotating component (i.e., the bolt head or the nut) shall be  $90 + 3$  degree. For angles outside these limits, a tapered washer shall be placed under the non-rotating component. Tapered washers shall be correctly positioned.
5. No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening. Nuts and bolts shall always be tightened in a staggered pattern and where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.
6. If, after final tightening, a nut or bolt gets slackened off for any reason, the bolt, nut and washer or washers shall be discarded and not used again.

### 12.3 STRUCTURAL STEEL WORK PAINTING WORKS

#### 12.3.1 General

##### 12.3.1.1 Scope of specification

This Specification covers the scope of painting, methods for the surface preparation, application of paints and precautions to be taken for the painting of structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding, tools, equipment and everything that is necessary for the job completion on schedule.

##### 12.3.1.2 Applicable Codes

The following Specifications, Standards and Codes are included as part of this Specification. All standards and Codes of practice referred to herein shall be the current editions during the currency of project including all applicable official amendments and revisions.

In case of discrepancy between this Specification and those referred to herein, this specification shall govern. In case of discrepancy between Contract drawings and this specification, the Contract drawings shall govern.

- |    |                 |   |                                                                                                    |
|----|-----------------|---|----------------------------------------------------------------------------------------------------|
| a) | IS: 102 (1962)  | : | Ready Mixed Paint, Brushing, Red lead, Non Setting, Priming                                        |
| b) | IS: 159 (1981)  | : | Ready Mixed Paint, Brushing, Acid Resisting for Protection against Acid Fumes, Colour as required. |
| c) | IS: 341 (1973)  | : | Brushes, Paints and Varnishes, Flat                                                                |
| d) | IS: 384 (1979)  | : | Brush, paint and varnish i) Oval Ferrule Bound ii) Round Ferrule bound                             |
| e) | IS: 487 (1985)  | : | Temporary Corrosion Preventive Grease, Soft film, Cold Application                                 |
| f) | IS: 958 (1975)  | : | Temporary Corrosion Preventive, Fluid, Hard film, solvent deposited.                               |
| g) | IS: 1153 (1975) | : | Temporary Corrosion Preventive, fluid, hard film, solvent deposited                                |
| h) | IS: 1477 (1971) | : | Code of practice for painting of Ferrous metals in building                                        |

Part I – Pretreatment

Part II – Painting

- i) IS: 1674 (1960) : Temporary corrosion preventive fluid, soft film, solvent deposited.  
j) IS: 2074 (1992) : Ready mixed paints, red oxide - Zinc Chrome, Priming

**12.3.2 Products and Materials****12.3.2.1 Paint**

- All paint delivered to the site shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
- Paint shall be stirred frequently to keep the pigment in suspension.

**12.3.2.2 Storage of Paints**

- All paints shall be stored strictly in accordance with the requirements laid down by the paint manufacturers. The storage area shall be well ventilated and protected from sparks, flame, direct exposure to sun or excessive heat, preferably located in an isolated room or in a separate building.
- All paint containers shall be clearly labeled to show, paint identification, date of manufacture, batch number, order number and special instructions in legible form. The containers shall be opened only at the time of use. Paints which have liveried, gelled or otherwise deteriorated during storage, shall not be used. Paints for which the shelf life specified by the supplier has expired shall not be used.

**12.3.3 Execution****12.3.3.1 Painting system**

- Painting work shall be carried out as detailed in Table 11.1 follows:

**TABLE 11.1**  
**PAINTING SPECIFICATIONS**

| DESCRIPTION                           | GENERAL SURFACE                                                                                                                                                         |                                                                                                                                                                      |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                       | EXTERNAL SURFACES                                                                                                                                                       | INTERNAL SURFACES                                                                                                                                                    |
| FABRICATION SHOP<br>Surface Treatment | Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning                                                                                        | Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning                                                                                     |
| 1 <sup>st</sup> Under - Coat          | Inorganic zinc silicate primer (self curing solvent type) DFT – 75 µm shall be Berger Zinc Anode 11 or approved equivalent. The primer should be applied by spray only. | Epoxy Zinc phosphate primer polyamide cured DFT-35µm                                                                                                                 |
| 2 <sup>nd</sup> Under-Coat            | Epoxy zinc phosphate primer polyamide cured DFT - 35µm shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.    | Epoxy zinc phosphate primer polyamide cured DFT-35 µm shall be Berger Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only. |
| 3 <sup>rd</sup> Under-Coat            | Epoxy zinc phosphate primer polyamide cured DFT-35 µm shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.     | Polyamide cured coaltar epoxy coating DFT 100 µm                                                                                                                     |
| 4 <sup>th</sup> Under Coat            | Epoxy high build micaceous iron oxide coating polyamide cured DFT- 90 µm shall be Berger Epilux 4 High                                                                  | Polyamide cured coal tar epoxy coating DFT 100 µm                                                                                                                    |

|                      |                                                                                                                                                            |                          |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
|                      | Build MIO. The primer should be applied by spray or brush only.                                                                                            |                          |
| <b>ERECTION SITE</b> | <b>EXTERNAL SURFACES</b>                                                                                                                                   | <b>INTERNAL SURFACES</b> |
| Intermediate Coat    | Acrylic polyurethane finish aliphatic isocyanate cured DFT-30 µm shall be Bergerthane or approved equivalent applied by spray or brush in approved colour. | NA                       |
| Finis Coat           | Acrylic polyurethane finish aliphatic isocyanate cured DFT-30 µm shall be Bergerthane or approved equivalent applied by spray or brush in approved colour. | NA                       |

INTERNAL SURFACE = are those which will become inaccessible after fabrication.

EXTERNAL SURFACE = are those which are prone to humidity and moisture from the atmosphere.

The DFT (dry film thickness) shall be measured after completion of each coat.

### 12.3.3.2 Surface Preparation

#### 12.3.3.2.1 General

The work shall be carried out in accordance with IS: 1477 (1971) (Part 1). Any oil, grease, dust or foreign matter deposited on the surface after preparation shall be removed and care shall be taken to ensure that the surface is not contaminated with acids, alkalis or other corrosive chemicals.

All welding areas shall be given special attention for removal of weld flux slag, weld metal splatter, weld head oxides, weld flux fumes silvers and other foreign objects before blasting. If deemed necessary by the Engineer, acid washing and subsequent washing with clean water shall be used.

Any rough seams will have to be ground and must be inspected and approved by the Engineer - before application of the coatings.

The last finish paint shall be applied after structural steel erection and slab construction.

#### 12.3.3.3 Mixing and Thinning

1. All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments, before use and during application, to maintain homogeneity. All pigmented paints shall be strained after mixing to remove skins and other undesirable matters.
2. Dry pigments, pastes, tinting pastes and colours shall be mixed and / or made into paint so that all dry powders get wetted by vehicles and lumps and particles are uniformly dispersed.
3. Additives that are received separate such as curing agents, catalysts, hardeners etc. shall be added to the paint as per the manufacturers instructions. These shall be promptly used within the pot life specified by the manufacturers and unused paint thereafter shall be discarded.
4. Thinners shall not be used unless essential for proper application of the paint and approved by the Engineer. Where thinners are used, they shall be added during the mixing process and the type and quantity of thinner shall be in accordance with the instructions of paint manufacturer.

**12.3.3.4 Paint Application****12.3.3.4.1 General**

1. Paint shall be applied in accordance with the manufacturer recommendations and as supplemented by these specifications. The work shall generally follow IS:1477 (1971) (Part II). Prior approval of the Engineer shall be taken in respect of all primers and / or paints, before their use in the works.
2. Paint shall generally be applied by brushing except that spraying may be used where specified and for finish coats only when brushing may damage the prime coats. Roller coat or other method of paint application shall not be used unless specifically authorized.
3. Spraying paint shall not be adopted on red lead or zinc rich paints. Daubers may be used only when no other method is practicable for proper application in difficult accessible areas.
4. Paint shall not be applied when the ambient temperature is 10° C and below. For paints which dry by chemical reaction the temperature requirements specified by the manufacturer shall be met with. Also, paint shall not be applied in rain, wind fog or at relative humidity of 80% and above or when the surface temperature is below dew point, resulting in consideration of moisture. Any wet paint exposed to damaging weather conditions shall be inspected after drying and the damaged area repainted after removal of the paint.
5. Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots. The film thickness shall not be so great as to detrimentally affect either the appearance or the service life of the paint.
6. Each coat of paint shall be allowed to dry sufficiently before application of the next coat, to avoid damages such as lifting or loss of adhesion. Undercoats having glossy surface shall be roughened by mild sand papering to improve adhesion of subsequent coats. Successive coats of same colour shall be tinted, whenever practical, to produce contrasts and help in identifying the progress of the work.

**12.3.3.4.2 Brush Application**

1. Proper brushes shall be selected for a specific work piece. Round or oval brushes which conform to IS:487 (1985) are better suited for irregular surfaces, whereas flat brushes which conform to IS: 384 (1979) are convenient for large flat areas. The width of flat brushes shall not generally exceed 125 mm.
2. Paint shall be applied in short strokes depositing a uniform amount of paint in each stroke followed by brushing the paint into all surface irregularities, crevices and corners and finally smoothening or levelling the paint film with long and light strokes at about right angles to the first short strokes. All runs and sags shall be brushed out. The brush marks left in the applied paint shall be as few as practicable.

**12.3.3.4.3 Spray Application**

1. The spraying equipments shall be compatible with the paint material and provided with necessary gauges and controls. The equipment shall be cleaned and free from dirt, dried paint, foreign matter and solvent before use.



2. The paint shall be applied by holding the gun perpendicular to the surface at a suitable distance and moved in a pattern so as to ensure deposition of a uniform wet layer of paint. All runs and sags shall be brushed out immediately. Areas not accessible to spray shall be painted by brush or dauber.
3. Watertrap acceptable to Engineer shall be furnished and installed on all equipment used in spray painting.

#### **12.3.3.5 Shop Painting**

1. The painting system specified in Table 11.1 above shall be followed.
2. Surfaces in contact during shop assembly shall not be painted. Surfaces which can not be painted but require protection shall be given a rust inhibitive grease conforming to IS:958-1975 or solvent deposited compound conforming to IS: 1153 91975) or IS: 1674 (1960) or treated as specified in the drawing.
3. Surface to be in contact with concrete shall not be painted.
4. The shop coats shall be continuous over all edges, including ends meant for jointing at site by bolting, except where the paint could be detrimental to bolting. In such cases, no paint shall be applied within 50 mm, and the unprotected surface shall be given a coat of corrosion inhibitive compound.
5. The unpainted area shall be cleaned prior to welding. The welded joint shall be cleaned and de-staged, and immediately after covered by the same paint as has been used for the remaining surface.

#### **12.3.3.6 Protection of Paintwork**

1. The Contractor shall provide measures as necessary to prevent damage to the work and to other property or persons through all cleaning and painting operations. Paint or paint stains which result in other unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the contractor at this cost.
2. All painted surfaces that in the opinion of the Engineer are damaged in anyway, shall be repaired by the contractor at his own cost with materials and to a condition equal to that of the requirements specified in these specifications.
3. If in the opinion of Engineer, any other work would have caused dust, grease or foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned. At the time of commissioning of the work, the painting shall be completed and the surfaces shall be undamaged and clean.
4. The areas for high-strength bolts shall be protected by masking tape against undercoat application at the fabrication shop. Immediately prior to erection any rust in the paint are shall be removed by power wire brushing to a standard equivalent to SA3.

#### **12.3.3.7 Site painting**

1. After the erection of structures at the site, the contractor shall provide the necessary treatment as specified in Table 11.1 "PAINTING SPECIFICATIONS".
2. Surface which have not been shop coated, but require surface treatment shall be given necessary surface preparation and coats at site as specified in the Table 11.1 above.

**12.4 STRUCTURAL STEEL WORK-ERECTION****12.4.1 General****12.4.1.1 Scope of specification**

This Specification covers the delivery to site, storage and erection of structural steelwork at site. This includes plant and equipment requirements, installation of fabricated steel work in position and grouting all complete as per drawings, specifications and other provisions of the Contract.

**12.4.1.2 Submittals**

- A. Ref. Specification for Structural Steel work Erection - General (Clause 11.1.3 above)
- B. The contractor shall submit for approval a full description of his proposed erection method including sequence of erection, use of temporary supports, connection details and erection camber diagram and design calculations covering various stages of erection process.

**12.4.2 Execution****12.4.2.1 Delivery, Storage & Handling**

- A. Before the shop assembly is dismantled, all members and sections shall be appropriately marked with paint or grooved with their identifications numbers as detailed in shop drawings. The Contractor's representative shall be present during all the shop assemblies (wherever fabrication will be done). Its dismantling and marking operations.
- B. The Contractor shall deliver the fabricated structural steel materials to site, with all necessary field connection materials, in such sequence as will permit the most efficient and economical performance of the erection work. As per scheduled programme, the Engineer may, at his discretion prescribe or control the sequence of delivery of materials.
- C. Fabricated parts shall be handled and staked in such a way that no damage is caused to the components. Measures shall be taken to minimize damage to the protective treatment on the steelwork. All work shall be protected from damage in transit. Particular care shall be taken to stiffen free ends, prevent permanent distortion and adequately protect all machined surfaces. All bolts, nuts, washers, screws, small plates and articles shall be suitably packed and identified.

**12.4.2.2 Plant and Equipment**

All erection tools and plant and equipment proposed to be used shall be efficient, dependable, duly certified by independent third party and in good working condition, and the suitability and adequacy of such shall be determined by the Engineer. The Contractor shall, in his technical proposal submittal, specify the plant and equipment proposed by him for erection of structural steelwork at site.

**12.4.2.3 Storage**

Materials to be stored shall be placed on skids above the ground and shall be kept clean and properly drained.

#### 12.4.2.4 Method and Sequence of Erection

The method and sequence of erection shall have the prior approval of the Engineer. The contractor shall arrange for the most economic method and sequence consistent with the drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract. The erection of steelwork shall be planned so as to ensure safe-working conditions at all times. The Contractor shall be solely responsible for enhancing the safety of his construction activities at site.

#### 12.4.2.5 Assembly & Erection

- A. During erection, the members and sections shall be accurately assembled as shown in the approved shop drawings and by following the match marks. The material shall be carefully handled so that no section will be bent, broken or otherwise damaged. Hammering which will damage or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have 50% of the holes filled with bolts and balance 50% with cylindrical erection pins before bolting with high-strength bolts. Filling-up bolts shall be of the same nominal diameter as the high-strength bolts, whereas the cylindrical erection pins shall be 1 mm or larger in diameter.
- B. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.
- C. The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other damages. Distorted member shall be straightened by mechanical means or, if approved by the Engineer, by the carefully planned and well supervised applications of a limited amount of localized heat. Each application will be subject to the approval of the Engineer.
- D. The responsibility in respect of temporary bracing and guys shall rest with the Contractor until the structural steel is located, kept in plumb, leveled, aligned and grouted with the tolerances permitted under the Specifications, and the permanent bracing / framing system has been installed.
- E. The temporary guys, braces, false work and cribbing shall not be the property of the Engineer / Employer and will be removed by the Contractor, with the approval of the Engineer, without any charge, once the permanent framing system has been installed to the satisfaction of the Engineer and when the temporary bracing, guys etc. can be removed without any potential danger / damage to the erected structure.

#### 12.4.2.6 Setting Out

- A. Positioning and leveling of all steelwork, keeping in plumb and placing of every part of the structure, with accuracy, shall be in accordance with the approved drawings and to the satisfaction of the Engineer. The Contractor shall check the positions and levels of the anchor bolts etc. The contractor shall check the positions and levels of the anchor bolts etc. before concreting and ensure that they are properly secured against disturbance during pouring operations. The Contractor shall remain responsible for correct positioning and shall set proper screed bars to maintain proper level. No extra payment shall be made on this account.
- B. No permanent field connections by bolting shall be carried out until proper alignment and guides for keeping in plumb have been attached.

**12.4.2.7 Field Bolting**

- A. Bolts shall be inserted in such a way that they remain in position under gravity, even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled all joint surfaces including those adjacent to the washers shall be free of scales. They shall be free of dirt, loose scales, burns and other defects that would prevent solid seating of the parts.
- B. Holes for turned bolts to be inserted in the field shall be reamed in the field drilling and remaining for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications.
- C. All high tensile bolts shall be tightened to provide the required minimum tension as per relevant Indian Standards / Specifications when all fasteners in the joint are tight.
- D. The manufacture and use of high strength friction grip bolts shall comply with the requirements of IS: 3757 (1985)
- E. Load indicating bolts or washers may be used, subject to the approval of the Engineer

**12.4.2.8 Holes, Cutting and Fitting**

- A. No cutting of sections, flanges, webs and girders, rivets, bolts, welds etc. shall not be done unless specifically approved and / or instructed by the Engineer.
- B. The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the contract, or directed by the Engineer. Wherever such work is specified the Contractor shall obtain complete information as to size, location and number of alterations, prior to carrying out any work.

**12.4.2.9 Drifting**

- A. Correction of minor misfits will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes, as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.
- B. Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be brought to the attention of the Engineer, and approval of the method of correction obtained. The use of gas cutting torches at the erection site is prohibited.

**12.4.2.10 Grouting**

- A. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water, and any accumulated water shall be removed. Grouting shall be carried out under expert supervision, taking care to avoid air locks. Edges shall be finished properly.
- B. Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally aligned and leveled. Immediately before grouting, the space under steel is thoroughly cleaned. Where 'pickings' are to be left in place, they shall be placed such that they are completely covered with grout.

- C. The grout to be used shall be Non-shrink grout conbextra GP-2 M/S Fosroc or equivalent.
- D. All steel in foundations shall be solidly encased in Portland Cement Concrete of minimum characteristics strength at 28 days as specified in the drawings, subject to a minimum of 35 N/mm<sup>2</sup>. A minimum cover of 100 mm shall be provided to all steelwork where surrounding concrete is in contact with soil.

#### **12.4.2.11 Inserts and Embedment's**

Various steel insets and embedment's are required under the contract to be fabricated, positioned and secured firmly into place inside the formwork prior to concrete being poured. There are also requirements of jointing, threading, bolting and welding insets and embedment's of different concrete and structural steel elements in order to establish structural continuity and connection. Great care shall be exercised by the contractor in executing all aspects of the work related to inserts and embedments, including tolerances, so that the final assembly of the concrete elements can meet satisfactorily the continuity and contiguity requirements intended in the structure.

#### **12.4.2.12 Painting after Erection**

- A. The surfaces required to remain unpainted at shop, shall be given a protective coating after the structure is erected, leveled, kept in plumb, aligned in its final position, and accepted by the Engineer. However, touch up painting, making good any damaged shop painting and completion of any unfinished portion of the shop coat shall be progressively carried out by the Contractor.
- B. Painting shall not be done in frost or foggy weather, or when humidity is such as to cause condensation on the surfaces to be painted. Before, commencing painting of steel, which is delivered unpainted, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.
- C. Surfaces which will be inaccessible after field assembly, shall receive the full-specified protective treatment before assembly. Bolts and fabricated steel members, which are galvanized or otherwise treated, shall not be painted.
- D. The contractor shall be responsible for any damage caused to other..... components of the structure including the substructure in particular, he shall..... take all necessary precautions to minimize concrete splash onto complete... steelwork or rust staining of concrete due to erected steel work and clean and / or ....repair all stains and other damages to completed work prior to tests on..... completion.

#### **12.4.2.13 Final Cleaning up**

Upon completion of erection, and before final acceptance of the work by the Engineer, the Contractor shall remove, free to cost, all falsework, rubbish and all temporary works, resulting from or in connection with the performance of his work.

**12.5 ADDITIONAL SPECIFICATIONS FOR LAUNCHING**

Truss launching for longer spans:

- Preferably no road traffic blocking will be used. Multiple day / night short blocks of 1h to 1h30 maximum are acceptable to ensure safety.
- Launching scheme shown in Tender drawings is suggestive only. Contractor has to provide his own proposed launching scheme and supporting calculations with the offer.
- Contractor has to provide principles of nose / truss connection details in tender.
- Truss design composite girder requirements will govern over nose / launching equipment requirements.
- Contractor will submit and get approval from Engineer of the detailed design of the full launching equipment and scheme before starting the launching.
- Contractor will coordinate with Bangalore Traffic Police and Engineer before and during the launching contractor to develop detailed traffic diversion scheme.
- Tentative allowable bearing pressure for temporary supports foundation concrete blocks shall be assumed at 10 tonnes / sqm.
- For location of storage and fabrication yard relevant clause of N.I.T shall be referred. Contractor shall indicate and justify in tender the proposed total needed yard area for the purpose.
- Any necessary precaution by proper and secure fixing shall be taken by the contractor to prevent the fall of any object onto the road below during the whole erection period.
- A minimum 15 m clear width (4 lanes) shall be kept during the whole construction period. These lanes can be obtained as 4 or 2+2.

**MODE OF MEASUREMENT**

1. The unit rate shall include the following:

- a. Erection of fabricated parts (fabrication and transportation of various parts / components including HSFG bolts / nuts / washers from workshop to storage yard will be done by approved sub-contractors)
- b. Receiving, unloading and keeping in safe custody and upkeep of all fabricated parts including HSFG bolts / nuts / washers at storage yard.
- c. Loading, transportation and unloading of all fabricated structural steel materials including HSFG bolts / nuts / washers from site storage yard to erection site, handling, assembling, bolting, welding if necessary and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and / or as directed by the Engineer.
- d. Tightening of HSFG bolts for the field erection of fabricated parts. However supply of HSFG bolts and its compatible nuts and washers will be arranged / supplied at the storage yard by approved sub-contractor.
- e. Preparation of complete detailed erection drawings and detailed calculation based on suggested erection sequence and design drawings as given by Engineer or alternative scheme proposed by contractor and approved by Engineer.
- f. Preparation of complete detailed fabrication drawings for all temporary structures such as temporary nose, staging, temporary support, bracing required for all permanent and temporary structures.
- g. All tools, plants and equipments / machinery
- h. All other consumables including fuel and lubricants etc.
- i. All safety and protection arrangements to be made at site / storage yards for road users, public and workmen.

2. The payment for the erection work and above mentioned work will be Lumpsum.

3. The procurement and application of all coats of site paints on external surfaces after erection as specified will be measured in sqm and paid separately.

Annexure: A**EPOXY BONDING AGENTS FOR PRECAST SEGMENTAL BOX GIRDERS****A.1 Materials**

Epoxy bonding agents for match cast joints shall be thermosetting 100 percent solid compositions that do not contain solvent or any noncreative organic ingredient except for pigments required for coloring. Epoxy bonding agents shall be of two components, a resin and a hardener. The two components shall be distinctly pigmented. So that mixing produces a third color similar to the concrete in the segments the joined, and shall be packaged in proportioned, labeled, ready-to-use containers.

Epoxy bonding agents shall be formulated to provide application temperature ranges that will permit erection of match cast segments at substrate temperatures from 40° F to 115° F. If two surfaces to be bonded have different substrate temperatures, the adhesive applicable at the lower temperature shall be used.

Epoxy bonding agents shall be insensitive to damp conditions during application and, after curing shall exhibit high bonding strength to cured concrete good water resistivity, low creep characteristics and tensile strength greater than the concrete. In addition the epoxy bonding agents shall function as lubricant during the joining of the match the surface of the segments as a filler to accurately match cast segments being joined, and as a durable, watertight bond at the joint.

Epoxy bonding agents shall be tested to determine their workability, gel time, open time, bond and compression strength, shear and working temperature range. The frequency of the tests shall be as stated in the special provisions of the Contract.

The Contractor shall furnish the Engineer with samples of the material for quality assurances testing, and a certification from a reputable independent laboratory indicating that the material has passed the required tests.

Specific properties of epoxy and the test procedures to be used to measure these properties shall be as described in the following sub articles.

**A.2 Test 1 - Sag Flow of Mixed Epoxy Bonding Agent**

This test measures the application workability of the bonding agent.

Testing Method: ASTM D2730 for the designated temperature range.

Specification: Mixed epoxy bonding agent must not sag flow at 1/8 inch minimum thickness at the designated minimum and maximum application temperature range for the class of bonding agents used.

**A.3 Test 2 - Gel Time of Mixed Epoxy Bonding Agent**

Gel time is determined on samples mixed as specified in the testing method. It provides a guide for the period of time the mixing bonding agent remains workable in the mixing container during which it must be applied to the match cast joint surfaces.

Testing Method: ASTM D2471 (except that one quart and one gallon quantities shall be tested)

Specification: 30 minutes minimum on 1 quart and 1 gallon quantities at the maximum temperature of the designated application temperature range (Note: gel time is not to be confused with open time specified in Test3).

**A.4 Test 3 - Open Time of Bonding Agent**

This test measures workability of the epoxy bonding agent for the erection and post tensioning operations. As tested here, open time is defined as the minimum allowable period of elapsed time from the application of the mixed epoxy bonding agent to the precast segments until the two segments have been assembled together and temporarily post-tensioned.

Testing Method: Open time is determined using test specimens as detailed in the Tensile Bending Test (Test 4). The epoxy bonding agent, at the highest specified application temperature, is mixed together and applied as instructed in Test 4 to the concrete prisms, which shall also be at the highest specified application temperature. The adhesive coated prisms shall be maintained for 60 minutes at the highest specified application temperature with the adhesive coated surface or surfaces exposed and uncovered before joining together. The assembled prisms are then curved and tested as instructed in Test 4.

Specification: The epoxy bonding agent is acceptable for the specified application temperature only when essentially total fracturing of concrete paste and aggregate occurs with no evidence of adhesive failure.

Construction situations may sometimes requires application of the epoxy bonding agent to the precast section prior to erection positioning and assembling. This operation may require epoxy bonding agents having prolonged open time in general, where the erection conditions are such that the sections to be bonded are prepositioned prior to epoxy application, the epoxy bonding agent shall have a minimum open time of 60 minutes within the temperature range specified for its application.

**A.5 Test 4 - Three Point Tensile Bending Test**

This test performed on a pair of concrete prisms bonded together with epoxy bonding agent, determines the bonding strength between the bonding agent and concrete. The bonded concrete prisms are compared to a reference test beam of concrete 6x6x18 inches.

Testing Method: 6x 6 x 9 -inch concrete prisms of 6,000-psi compressive strength at 28 days shall be sandblasted on one 6 x 6 inch side to remove mould release agent laitance etc., and submerged in clean water at the lower temperature of the specified application temperature range for 72 hours. Immediately on removing the concrete prisms from the water, the sandblasted surfaces shall be air-dried for 1 hour at the same temperature and 50 percent relative humidity and each shall be coated with approximately a 1/16 -inch layer of the mixed bonding agent. The adhesive coated faces of two prisms shall then be placed together and held with a clamping force normal to the bonded interface of 50 psi. The assembly shall then be wrapped in a damp cloth which is kept wet during the curing period of 24 hours at the lower temperature of the specified application temperature range.

After 24 hours, curing at the lower temperature of the application temperature range specified for the epoxy bonding agent, the bonded specimen shall be unwrapped, removed from the clamping assembly and immediately tested. The test shall be conducted using the standard ASTM E78 test for flexural strength with third point loading and the standard MR unit. At the same time the two prisms are prepared of the same concrete cured for the same period and tested following ASTM C78.

Specification: The epoxy bonding agent is acceptable if the load on the prisms at failure is greater than 90 percent of the load on the reference test beam at failure.

**A.6 Test 5 - Compression strength of Cured Epoxy Bonding Agent**

This test measures the compressive strength of the epoxy bonding agent.

Testing Method : ASTM D695



Specification: Compressive strength at 77° F shall be 2,000 psi minimum after 24 hours cure at the minimum temperature of the designated application temperature range and 6,000 psi at 48 hours.

#### **A.7 Test 6 - Temperature Deflection of Epoxy Bonding Agent**

The test determines the temperature at which an arbitrary deflection occurs under arbitrary testing conditions in the cured epoxy bonding agent. It is a screening test to establish performance of the bonding agent throughout the erection temperature range.

Testing Method: ASTM D648.

Specification: A minimum deflection temperature of 122° F at fiber stress loading of 264 psi is required on test specimens cured seven days at 77° F

#### **A.8 Test 7 - Compression and Shear Strength of Cured Epoxy Bonding Agent**

This test is a measure of the compressive strength and shear strength of the epoxy bonding agent compared to the concrete to which it bonds. The "slant cylinder" specimen with the epoxy bonding agent is compared to a reference test cylinder of concrete only.

Testing Method: A test specimen of concrete is prepared in a standard 6 x12 inch cylinder mold to have a height at midpoint of 6 inches and an upper surface with a 30-degree slope from the vertical. The upper and lower portions of the specimen with the slant surfaces may be formed through the use of an elliptical insert or by sawing a full-sized 6 x12 inch cylinder. If desired 3x6 inch or 4 x 8 inch specimens may be used. After the specimens have been moist cured for 14 days the slant surfaces shall be prepared by light sandblasting, stoning, or acid etching, then washing and drying the surfaces, and finally coating one of the surfaces with a 10 mil, thickness of the epoxy bonding agent under test. The specimens shall then be pressed together and held in position for 24 hours. The assembly shall then be in a damp cloth which shall be kept wet during an additional curing period of 24 hours at the minimum temperature of the designated application temperature range. The specimen shall then be tested at 77° F following ASTM C39 procedures. At the same time as the slant cylinder specimens are made and cured, a companion standard test cylinder of the same concrete shall be made, cured for the same period, and tested following ASTM C39.

Specification: The epoxy bonding agent is acceptable for the designated application temperature range if the load on the slant cylinder specimen is greater than 90 percent of the load on the companion cylinder.

#### **A.9 Mixing and Installation of Epoxy**

Instructions furnished by the supplier for the safe storage, mixing and handling of the epoxy bonding agent shall be followed. The epoxy shall be thoroughly mixed until it is of uniform color. Use of a proper sized mechanical mixer operating at no more than 600 RPM will be required. Contents of damaged or previously opened containers shall not be used.

Surfaces to which the epoxy materials is to be applied shall be at least 40° F and shall be free from oil, laitance or release agent, or any other material that would prevent the epoxy from bonding to the concrete surface. All laitance and other contaminants shall be removed by light sand-blasting or by high pressure water blasting with a minimum pressure of 5,000 psi. Wet surfaces shall be dried before applying epoxy bonding agents. The surface shall be at least the equivalent of saturated surface dry (no visible water).

Mixing shall not start until the segment is prepared for installation. Application of the mixed epoxy bonding agent shall be according to the manufacturer's instructions using wooden trowel, rubber glove, or brush on one or both to be joined. The coating shall be smooth and uniform and shall cover the entire surface with a minimum thickness of 1/16 inch applied on

both surfaces or 1/8 inch if applied on one surface. Epoxy should not be placed within 3/8 inch of prestressing ducts to minimize flow into the ducts. A discernible bead line must be observed on all exposed contact areas after temporary post-tensioning. Erection operations shall be coordinated and conducted so as to complete the operations of applying the epoxy bonding agent to the segments, erection assembling and temporary post-tensioning of the newly joined segment within 70 percent of the open time period of the bonding agent.

The epoxy material shall be applied to all surfaces to be joined within the first half of the gel time, as shown on the containers. The segments shall be joined within 45 minutes after application of the first epoxy material placed and a minimum average temporary prestress of 40 psi over the cross section should be applied within 70 percent of the open time of the epoxy materials. At no point of the cross sections shall the temporary prestress be less than 30 psi.

The joint shall be checked immediately after erection to verify uniform joint width and proper fit. Excess epoxy from the joint shall be removed where accessible. All tendon ducts shall be swabbed immediately after stressing, while the epoxy is still in the nongelled condition, to remove or smooth out any epoxy in the conduit and to seal any pockets or air bubble holes that have formed at the joint.

If the jointing is not completed within 70 percent of the open time, the operation shall be terminated and the epoxy bonding agent shall be completely removed from the surfaces. The surfaces must be prepared again and fresh epoxy shall be applied to the surface before resuming jointing operations.

As general instructions cannot cover all situations, specific recommendations and instructions shall be obtained in each case from the Engineer.

**Annexure : B****GUIDELINES FOR PRECAST SEGMENTAL CONSTRUCTION****B.1. GUIDELINES FOR SEGMENT PRODUCTION**

Following guidelines are presented to explain the various detailed procedures involved in precast segmental construction. These are explanatory in nature. Contractor needs to go into all these details before framing his specific construction method and site controls.

**1.0 CASTING YARDS**

The major advantages of making segments in precasting yard lie in bringing factory controlled production techniques, efficiency, quality control and time savings to construction, removing casting operations from the critical path for construction and reducing the overall construction period.

The essential features of a casting yard include:

- Delivery and storage points for all materials, aggregates, sand, cement, reinforcement, post-tensioning hardware, etc.
- Concrete batch plant and delivery system.
- Rebar cage assembly areas, jigs and templates.
- Casting cells for superstructure segments.
- An area for the production of any special segments such as pier segments, abutment segments or expansion joint segments.
- Steam curing or sprinkler curing facilities.
- Control stations and survey towers for geometry control.
- Segment lifting and handling equipment.
- Segment storage areas.
- Segment loading and delivery facilities.
- Offices and concrete testing facilities.

**2.0 LONG LINE AND SHORT LINE FORMS****2.1 Long Line Casting Bed**

All segments are cast on a soffit which is as long as a full span upto coupling section in a span by span method. The soffit must be made in the profile of the structure with corrections for short and long term deflections. One or more forms and the bulkhead travel along this long line.

The obvious advantage is that all the geometry control is done when constructing the soffit thus simplifying this process during segment production and avoiding errors in geometry control in finished structure.

**2.2 Short Line Casting Bed**

With this method the form is stationary while the segments move from the casting position to the match casting position and then to storage.

Advantages of this method are:

- Space requirements are much less compared to the long line method.
- The entire manufacturing process is centralized.
- The system is extremely adaptable to geometry variations such as horizontal and vertical curvature and super elevation transition which are obtained without increase in costs.
- The forms are reusable for other projects.

### 3.0 MATCH CASTING

Fresh concrete of the new segment is cast against the already hardened concrete of the old segment. A bond breaker (usually a mixture of wax, soap and talcum powder, but there are also chemical compounds) is applied to the hardened concrete surface in order to ensure that the segments will come apart. The match casting technique to provide proper precautions are taken, the segments will come apart cleanly and upon erection, will join together perfectly with the joint being almost invisible.

The precautions are merely the careful application of the bond breaker and the avoidance of jamming protrusions which make it physically impossible to break the bond.

For correct fit at the time of erection the joint faces must not have been altered, except for a light sand blasting. This generally means that no work can be done on the joint faces and that segments must be stressed in such way that differential deformation cannot occur.

### 4.0 CASTING CURVE

The casting curve is made up of two important components:

- (1) The required geometric profile, which is actually the horizontal and vertical curvature and super-elevation shown on the plans, and
- (2) The compensation of deflections. Both the deflections which occur during construction and the long term deflections.

### 5.0 FABRICATION OF REBAR CAGE WITH POST-TENSIONING DUCTS AND HARDWARE

Prefabrication of the rebar cage preferably with post-tensioning ducts and as much as possible of the hardware installed as needed in order to achieve the required production rate. This is readily accomplished by means of custom built jigs and templates. By having several jigs it is possible to fabricate rebar cages well in advance for segment production.

The essential features for a jig are:

- Walls and floors, of steel plate or other suitable material, held rigidly by a frame to accurately define the main concrete surfaces (outside webs and slab soffits).
- Bulkhead templates cut and / or marked to the proper section size with standard post-tensioning duct locations accurately defined.
- Wing cantilever and templates marked and fitted with locators as needed for transverse post-tensioning ducts, etc.
- Spacer bars laced to the walls and floors to provide correct concrete cover to rebar.

Using a jig of this type also permits rebar, post-tensioning duct positions and any other hardware locations to be accurately fixed and marked up for repeated use. Duct profiles can be traced onto the walls to ease assembly and so on. String lines are used to check rebar, cover and duct positions from open surfaces.

Because segments can vary a little in shape from each other, contain different post-tensioning duct and anchorage arrangements, and because the rebar cage will deform in transportation from the jig to the casting cells, final adjustments must be made after placing the cage in the casting cell before start of concrete pouring in the moulds.

For pier segments, abutment segments and expansion joint segments, the typical segment jig could be modified or a separate jig made. Sometimes the pier and expansion joint segments are cast in separate casting cells. In such cases it might be convenient to fabricate the cage directly in the casting cell itself.

It is advisable to periodically check the accuracy of jigs and templates as they can deteriorate with repeated use and adjustments.

## 6.0 INSTALLATION OF POST-TENSIONING DUCTS

As mentioned above, most of the post-tensioning hardware and ducts are installed in the rebar cage. An exception to this are the anchorage and coupling heads themselves which, because of their weight, are usually installed in the form.

An accurate and smooth alignment is essential for all post-tensioning ducts. This will ensure that the required concrete compressive stress level is obtained. Variations from the required alignment will cause undesirable variations in stress level and will also increase friction. This will reduce the post-tensioning tendon force. Kinks in ducts can trap wires and strands and may lead to wire failures. Such kinks are therefore not acceptable.

Post-tensioning ducts should be securely connected to their respective anchorages. Duct locations and alignments must be checked. Curved post-tensioning ducts should be checked at intervals of 0.6 to 0.9 m and there should be no kinks or misalignments at connections with anchorages and between ducts. The position of post-tensioning ducts should be set correctly in preference to the position of reinforcing bars which should be locally adjusted in case of conflict.

Efforts should be made to avoid conflicts between the reinforcing bars and post-tensioning ducts. Integrated shop drawings showing the particular post-tensioning hardware system, ducts, reinforcing bars, and any special construction details are very helpful. These should be prepared by the Contractor.

Final adjustments of ducts and reinforcing bars should be made and inspected before the form is closed.

Final adjustments and inspection of ducts and rebar in slabs can be made any time before casting of the concrete.

Post-tensioning ducts should be securely fastened to the rebar cage, which in turn must be firmly supported against the forms by chairs and spacers in order to avoid displacement during concrete placement and compaction. Flexible post-tensioning ducts especially are likely to move when subjected to the pressure of moving concrete, vibration and buoyancy. For this reason, flexible ducts are fastened at closer spacing of about 0.3 m or so. Ducts in slabs, such as transverse deck prestressing, are less susceptible to movement but should be fastened at no more than 0.6 m intervals. Post-tensioning ducts can be secured with several layers of tying wire and/or auxiliary reinforcing support bars laced firmly to the rebar cage. The latter is preferable as it avoids distortion of the rebar cage.

## 7.0 HANDLING THE PREFABRICATED REBAR CAGE

Transportation of the rebar cage from jig to casting cell should be done carefully to avoid excessive distortion. It is preferable to use a special frame (strong back) with hangers, which can support the cage at many points.

The rebar cage should be securely fabricated with adequate tie wire to maintain as much rigidity as possible.

## 8.0 REBAR CAGE IN CASTING CELL (MOULDS)

After the form has been thoroughly cleaned out and oiled and after placement of the liners, the post-tensioning anchors are installed. The important items to watch for in case of anchor installation are orientation of the distribution plate, connection of plate to trumpet and of trumpet to duct and also the position of bursting reinforcing. Ensure that the congested anchor zone can be concreted properly without fear of honeycombing.

The orientation of the distribution plate is provided on the shop drawings, usually by providing angle offsets to the plane of the form. Based on this information, recess pockets are to be

made. In case of many repetitive uses of the form, these recess pockets will be made of steel plates. Once a steel recess pocket has been checked for dimensional accuracy, it will consistently provide the correct orientation. Wooden recess pockets are for one time use only and these need to always be checked.

The trumpet is sometimes an integral part of the distribution plate, in which case there is no installation problem. If plate and trumpet consist of 2 pieces, the joint must be made watertight by means of a seal. The connection of trumpet and duct must be watertight and must be achieved with heat shrink tapes. The alignment of trumpet and duct should be within a 2-3 degree tolerance.

The required bursting reinforcement is shown on the shop drawings to be submitted by the Contractor. The location of the bars should be strictly adhered to. Spirals should be centered properly in respect of the ducts and begin right at the distribution plate of the anchor. Dimensions for placement of hairpins are important and these should be within 25 mm. Particularly at the anchors, drawings should be integrated and show all reinforcing, tendons and hardware present in the area. All conflicts between tendons and reinforcing should be resolved on the drawing board. Spirals are supplied closely wound. These should be stretched out to the proper pitch as shown on the shop drawings.

Since anchor zones are densely reinforced, judgment should be made beforehand whether or not concreting will cause problems.

After placing the anchors, the rebar cage is placed in the cell. All post-tensioning ducts are securely connected to their respective anchorages and standard duct locations and alignments are checked. Final inspection of the tendons should be performed after the connection with anchors and match cast segments are made.

## **9.0 SETTINGS THE MATCH CAST SEGMENT**

The segment is usually set as close as possible to its desired position prior to placement of the rebar cage, then the rebar cage and ducts are properly adjusted, all inserts fixed, all post-tensioning anchorages bolted up to the forms, and the ducts taped with heat shrink tapes. In order to ensure that there will be no mortar leakage, the match cast segment shall be checked and its position fine-tuned after closing the form securely around the match cast segment.

## **10.0 PLACING CONCRETE**

Good concrete placing practice will ensure a good product. Some of the important points to be ensured are:

- (1) First, make sure that the forms are thoroughly clean, that all joints are tight and sealed, that all ducts are aligned and secure and that everything is in its proper place, the form should be lightly oiled for stripping and the face of the match cast segment given a coating of a suitable bond breaking agent.
- (2) Place the concrete in the specified sequence.
- (3) Use skips, chutes, or pumps to deliver concrete and do not let it fall from a great height, as this causes segregation and the impact can damage ducts and displace rebar, concrete placement should be in accordance with procedures and specifications approved by the Engineer.
- (4) Keep as continuous a delivery as possible, avoid holdups which can allow the concrete already placed to take on an initial set. Sometimes deliberate short waits are necessary especially after placing the bottom slab and web corner concrete so that it can stiffen just enough to take the weight of the rest of the web concrete – but be careful that this waiting is not overdone and avoid cold joints. Often, use is made of retarders in the concrete mix to simplify the casting operation.

- (5) Make proper use of internal “poker” vibrators to thoroughly consolidate the concrete. These types of vibrators should be pushed into the concrete for no more than 0.6 m or so and should slowly be withdrawn from the same location. Do not move the vibrators sideways while still in the concrete. Do not use the internal “poker” vibrators to move concrete around or to drag it from the webs into the bottom slab, as this will cause poor compaction and honeycombing. Avoid contact of the vibrator with rebar and post-tensioning ducts as this can cause damage or displacement.
- (6) Make sure concrete is thoroughly compacted, especially in awkward areas such as the corners around heavily reinforced anchorage zones and within spirals. Sound compaction is essential as for every 1% air void content, the concrete strength reduces by approximately 5%.
- (7) The finish on the top surface should be good. As this is usually the riding surface, great care is needed in finishing.

#### 11.0 CONCRETE PLACING SEQUENCES

A good placing procedure should prevent the concrete placed in the bottom of the web spilling into the bottom slab. This movement of the web concrete can easily displace rebar and ducts and can pull concrete away from heavily reinforced bottom anchorages or the web itself causing honeycombing. Some such flow of the concrete is unavoidable, but it can be minimized by using the following procedure, which is considered good practice.

Place the first concrete in the middle portion of the bottom slab, leaving about 150 to 300 mm clear of the side forms at the bottom of the webs. It is possible to do this by a delivery chute through a trap in the top slab soffit or by a chute through the bulkhead end. Place the second concrete in the webs and compact it around the bottom corners to complete the bottom slab. Compact the concrete in any bottom anchorage blister through windows in their top forms. Place the next concrete in the webs working up to the top slab. Finally place the concrete in the top slab working from the center and outside edges towards the web. Strike off the top surface and finish as described below.

#### 12.0 FINISHING THE TOP SURFACE

A good quality finish of the top surface is essential, as this, is also the riding surface. The only one opportunity to achieve this properly is in the casting operation. Grinding unevenness out of the top surface after construction is never very satisfactory for anyone as it reduces the concrete cover, takes time and costs money. In addition, it is then usually necessary to improve the skid resistance by grooving.

It is possible to achieve a good finish by mechanical means providing that the equipment is used properly by trained and experienced operators. Care is needed to make sure that all depressions are filled and all high areas removed to give a very uniform, dense and even surface. The surface must be accurate and should be as smooth as possible prior to applying the riding surface treatment. After such treatment, the surface must still be even and accurate. Undulation should not be permitted. Hand finishing has been used successfully on many segmental structures in the past. Hand finishing requires that a good strong, straight screeding board be used extending from the top of the bulkhead to the top of the match cast segment to strike off the surface to an accurate level. Mechanical screeds also work very well. Good results have been achieved with both rolling and vibratory screeds.

Mechanical screeding should be followed by a straight edge - usually a substantial, stiff aluminium beam - worked by hand and used to check and correct any low and high spots to give an accurate and straight surface from the bulkhead to the match cast segment.

After surface wetness has disappeared, the surface may be very lightly “touched up” with floats to produce a finer and smoother surface. Floats should not be used in such a way as to move concrete or disturb the accuracy of the straight surface.

When finishing a concrete surface it is important to keep the concrete live for working by proper vibration, tamping and floating and not to add water to wet any stiff areas. This will create patches of weaker surface material, which will dust and wear badly in use. In order to take advantage of workable concrete, the initial leveling and finishing should follow immediately after placement.

Be careful not to spoil the top surface when and if the concrete is to be covered for curing. (Use means to support tarps and prevent contact with top surfaces, etc.)

The top surface of the bottom slab should be finished in a similar manner although the appearance of the surface finish is not so critical, it should, nevertheless, be accurate. Mechanical screeds need not be used on the bottom slab.

### **13.0 CURING**

In order to achieve a production rate of one segment per day from one casting cell, it is essential to ensure that curing is proper and sufficient to provide the necessary strength and control of shrinkage, etc.

Curing procedures depend upon the type of concrete, its chemical hardening processes, temperature and exposure conditions. It is common practice to cover the segment with tarpaulins and apply steam to maintain a controlled temperature and humidity. Other methods have been used, including water sprinkler with timing devices.

As a general rule, the slower the concrete's heat of hydration and loss of moisture is dispersed, the better. The curing process in the casting cell cannot be more than a few hours from the completion of the casting in the evening to the start of survey and stripping the next morning. This is why a controlled environment is essential. The segment must remain covered with moist burlap even after stripping the form. Precise procedures will require to be submitted by Contractor for IC's approval.

### **14.0 STRIKING FORMS**

Striking of forms should not start until the concrete has reached the required strength. This is usually specified at 20 MPa. At this strength it is normally possible to ease off the side forms, remove the core form and pull back the match cast segment provided that the top slab is self-supporting. At this strength the segment could also be moved on its pallet but not lifted. In case the reinforcing provided is incapable of carrying the weight of the unsupported top slab at 20 MPa, then transverse post-tensioning must be stressed in full or in part. This would require a higher strength usually specified at 30 MPa. It is customary to break cylinders in order to verify that these strengths are in fact obtained.

Striking the forms should be done with care as it is very easy to cause spilling and other damage when the concrete is young.

Most casting cell forms are removable in whole pieces (Figure A.12) but it is advisable to leave removal of any special blockout forms for as long as possible as it is very easy to break the edges of blockouts.

Striking and pulling back the match cast segment should be done with particular care. If the bond breaker has not been properly applied, portions can be broken off either segment. The shear keys are especially vulnerable. Also, the movement mechanism on the pallets must be examined and understood by the stripping crew. Sometimes, the loosening of jacks and tilting of the pallet can be done in such a way as to “lift” the newly cast segment (see Figure A.13).



This motion can easily damage the shear keys and should be avoided or minimized as much as possible. The same applies when pulling the new segment away from the bulkhead.

Although the above refers specifically to the “short line” system, the same applies to the “long line” and “wet cast joint” systems of segment production.

## **B. GUIDELINES FOR HANDLING SEGMENTS**

### **1.0 HANDLING SEGMENTS**

Lifting of the segments should only be done when the concrete is at a suitable strength. Normally this means at least 30 MPa concrete and after any transverse stressing has been carried out (if this is specified to take place prior to handling).

Most methods of segmental erection use lifting holes through the top slab near the inside or outside of the webs. Special inserts or lifting loops cast into the concrete are also possible, but these require approval of the IC. A lifting frame secured with post-tensioning bars through holes in the top slab close to the webs is a good technique. By adjusting the lateral position of the local where the bars are attached to the frame, the segment can be made to hang at the crossfall required for erection.

It is not always necessary to use a lifting frame for moving the segment in the casting yard. Slings may sometimes be used. However, great care must be taken to avoid damage to the corner of the concrete by using protective hardwood shoes, etc. With span by span construction where segments are placed on a truss before jointing, it is possible to use slings for erection also.

### **2.0 STORING AND STACKING OF SEGMENTS**

Segments should be stored using three-point support in order to avoid warping with time in storage.

Double stacking is usually possible providing three points support is used. However, segments should be periodically checked for any evidence of detrimental effects resulting from double stacking.

It is essential that the Contractor's designer check the effects of localized loadings so that cracking will be avoided. Double stacking, therefore, requires that approval of the designer and Engineer.

After placing the segments in storage, other routine tasks are performed, such as transverse post-tensioning and grouting, light sand blasting of the joint faces, and repair of small defects.

## **C. GUIDELINES FOR ERECTION METHODS**

### **1.0 GENERAL**

The different types of superstructures erection systems fall into the following categories:

### **2.0 SPAN-BY-SPAN ERECTION**

This method, utilized a custom made truss to temporarily support all the segments for a complete span. The truss, which is normally longer than twice the span is usually supported on the pier footings or, in case of a higher pier, on brackets attached to the piers themselves.

There is usually a narrow cast-in-place wet joint in each structure module. This wet joint is used to correct alignment errors made during production or erection of the segments.

The sequence of erection is usually as follows:

- Lifting, rotating the segments by 90 degrees and assembling the segments by the overhead launching girder including dry matching viz. checking all lines, levels and alignment.
- Separation of the segments by some distance for applying epoxy glue to the end faces.
- Bringing the segments together and joining by applying stressing force through the temporary PT bars
- Threading in HT strands, coupling and applying about 2/3rd of the specified stressing force in the permanent PT tendons as per approved sequence. The assembled span shall be supported by the launching girder with a small vertical gap above the top plate of the POT bearing on pier cap.
- Lowering the span on the POT bearing after applying a thin coat of epoxy on the top plate of the bearing. Contractor to work out fixing procedure for the upward fixing bolts (if any) of the POT bearings in the pier segment as per recommendation of the bearing supplier.
- Carry out balance 1/3rd of PT stressing and remove temporary PT bars
- Move Launching Girder to next span and repeat the sequence,
- A typical erection rate from one launching girder shall be not more than 4 to 5 days per span. Initially this cycle time may be somewhat longer. However as the repetitive procedure continues and with the learning curve, a stabilized cycle time of 4 to 5 days per span should be achieved by the crew.

#### **D. GUIDELINES FOR ERECTION DETAILS**

##### **1.0 POST-TENSIONING**

##### **1.1.1 Temporary Post-Tensioning**

With most forms of segmental construction, it is common practice to use temporary post-tensioning to secure the erected segment or segments before the main longitudinal post-tensioning is installed the purpose is:

- (1) to provide a rapid means of transferring the weight of the segment from the lifting equipment to the structure within the allowable setting time called “open time” of the epoxy jointing material.
- (2) To allow a fairly even stress to be applied over the whole joint face in order to bed down the epoxy and let it set under uniform conditions. It is normal to provide 30-50 psi (0.21 to 0.35 MPa) average compression for this purpose. If the compression is significantly non-uniform from top to bottom, especially in cantilever construction, then the epoxy joint thickness tends to vary which, after several segments, can affect the desired alignment.
- (3) Temporary post-tensioning bars are used to control a temporary stress condition in the structure. For this case the bars can only be removed after carrying out the permanent PT. The temporary post-tensioning should be designed by the Contractor and approved by the IC within the shop drawing process. In any event, the sequence of installation, stressing and removal of the temporary post-tensioning should be clearly shown on the shop drawings and /or erection manual to be submitted by the Contractor.

It is normal practice to limit the stress in temporary post-tensioning bars to 50% of the breaking strength of the bars. This will allow many reuses of the bars and the anchors. Sometimes, however, it is necessary to exceed this figure and if so, then these bars should not be reused without the express permission for the post-tensioning bar manufacturers. If there is any doubt, it is safer not to reuse the bars.

### **1.1.2 Permanent Post-Tensioning**

Permanent post-tensioning tendons are installed and stressed as erection of segments proceeds. Internal tendons are located in ducts inside the concrete slabs and webs.

Placing, stressing and grouting of post-tensioning tendons for segmental bridges is no different from tendons used in other applications.

### **1.2 Lifting Segments for Erection**

Lifting and handling of segments was also discussed in earlier section. Clearly the method is the Contractor's choice, subject to the approval by Engineer.

### **1.3 Construction Schedule and Sequence**

The casting curve will reflect the various deformations the bridge will get if constructed in accordance with the schedule and sequence the Contractor proposed. The construction schedule and sequence are important. Once sequence and schedule are selected as a basis for the casting curve, a change of sequence or schedule or both may require a change of the casting curve and possibly even a design change. The schedule is important because once cast and under stress, concrete has the tendency to deform.

This increase in camber is caused by concrete creep. In segmental bridges where spans can be longer, this creep effect may amount to several mms. In order to compensate for these creep effects, they are calculated based on the Contractor's construction schedule.

The bridge deflections are generally calculated by the Contractor and reviewed by the . The reason is clear.

## **2.0 GUIDELINES FOR EPOXY JOINTING**

### **2.1 Purpose of Epoxy**

The purpose to use an epoxy-resin in the joint between segments is:

- to completely fill any minor surface imperfections and
- irregularities between the match cast surfaces, and , to provide a water and grout tight seals, and
- to act as a lubricant when erecting the segments
- to ensure that there is a tight fit between the surfaces so that stress is transmitted directly across the joint.

### **2.2 Types of Epoxy and Applications**

Epoxyes are formulated as two part compounds consisting of a resin and a hardener. When mixed they begin setting which can take anywhere from a few minutes to over an hour depending upon the material and ambient temperatures. For some applications, such as the span-by-span bridge construction the setting time can be increased to allow sufficient time for the erection and stressing of a complete span, which may take several hours.

The formulation, mixing, use and testing of epoxyes are covered in the technical specification separately.

Prior to application, joint surfaces must be clean, dry and free from any loose materials, oil, etc. very slight surface dampness is usually acceptable.

For on-site use, it is advisable to have all epoxy materials on hand at the time. Mixing can be done in the can using a custom made motorized stirrer unit to save time.

Application is best done by hand using wooden spatulas, using protective, disposable rubber gloves. Since the application time is short, sufficient labour should be available to coat the joint in the time allowed. Application of about 1.6 mm thickness to one face is usually sufficient.

Application to two faces is always preferred. The advantage of two-face application is that the outside layer of the epoxy, which begins curing right after application, will not be placed against adjacent concrete but against adjacent epoxy, which will get a chance to get “remixed.”

The structural function of epoxy refers, at most, to restoring the tensile stress of concrete in order to increase the “cracking moment” or provide moment capacity at a location where this capacity is not required for safety but would be good to have for durability. One such location is the joint between two segments in the deck. A wheel load placed on this joint will set up tensile stresses across the joint, which, often, are not fully resisted by compression due to the pre-stress.

When the segments are brought together and stressed, the epoxy is squeezed out. Consequently, the coating should be left about 25 mm clear around any ducts and about 12.5 mm shy of the outside edges once the segments have been joined and stressed, all epoxy should be cleaned off immediately. Leaving it to harden will only cause future difficulties. It is important to rod out all ducts so that any epoxy squeezed into them does not form an obstruction or high spot for the tendons to pass.

### **3.0 GEOMETRY CONTROL**

#### **3.1 General**

The geometry control of segmental bridge is achieved in the casting yard. The “short-line” casting system is based on making very fine adjustments to each match cast segment in the casting cell and therefore requires high precision; more so than the “long-line” system where the geometry control is mainly achieved when building the soffit in the casting yard.

Precision geometry control has nothing to do with the sizes, thickness variation or tolerances of the component pieces of the segments, important though as these are to the overall quality of the finished product. The precision is required for measuring the relative as cast position of the new segment in relation to its match cast neighbor.

The alignment is controlled by an instrument on a permanent base and a permanent target. Neither instrument nor target should be disturbed throughout the production, otherwise control must be reestablished. For this, adequate benchmarks should be maintained. The casting cell is always plumb, level and usually square so the geometry control is established mainly by positioning the old segments prescribed by the casting curve.

As the first segment is cast and the top slab has been finished, elevation bolts, A, B, C and D, as well as two centerline markers, E and F may be installed. The following morning the elevations of the tops of the bolts are recorded and the centerline is scribed onto the centerline markers. Now the segment can be rolled forward for match casting.

After the first segment is moved to the match casting position, it is reset to the instructions provided by the casting curve. The centerline will be as it was before, unless the bridge is curved. But even if the bridge is flat, it is necessary to adjust for the deflections, which occur during construction. As mentioned, the amount of adjustment to be made is determined by the casting curve, which is part of the shop drawings by Contractor. If the segment would be positioned in such a way that both centerline markers are in line with instrument and target and

the bolt elevations are the same as those measured before the segment was moved, the segment would line up exactly with the next segment to be poured.

Geometry control for segmental bridges requires highly skilled and experienced surveyor. He should be on the job daily and keep accurate records.

After the old segment is properly reset and the setup for the new segment is complete, the new segment can be cast. The following morning the surveyor marks the centerlines and records the bolt elevations of the new segment. In addition, before the old segment is moved, the elevations of its bolts and its centerline position are checked to determine if the old segment has moved during casting the new segment. It is often noted that position changes of the “old segment” occur due to settlement of the soffit rails by the segment weight, due to vibrating of fresh concrete against it, or due to forces applied to it while closing the forms.

Since, in a segmental bridge, there are a number of short segments within a span, it follows that in order to obtain the required erection tolerance (i.e, 1/100 feet or 3 mm), the precision within any pair of segments must be proportionately greater. For example, if there are 10 segments in a cantilever. Then the precision in the casting cell should be to 1/10 of 1/100 feet (0.3 mm) or 1/1000 feet. Direct reading to 1/1000 feet on elevations and offsets in the casting cell is at the limit of normal surveying equipment and measuring devices. Certain equipment enhancements, however, allow even accuracies of 1/10000 feet. Trained surveyors can consistently obtain reading with an accuracy of this order. As accuracy depend upon consistency, it is important that the same individuals make the critical “as cast” observations at the same time each day prior to stripping the forms of both the new and the old match cast segment. Usually, this is the first thing each morning before the daily crews arrive and when weather conditions are most stable from day to day.

Note that all the critical readings are those after casting. While it is important to have an accurate setup before casting, this is unlikely to remain so during the casting operation. Some movement, however slight will occur, so the true achieved geometry is recorded after casting. It is possible to compensate for casting errors by adjusting the position of the next setup and so on.

It is very important that all the information from the casting operations and the calculated “as cast” actual relative positions of the segments be carried through the field erection process as well.

This poses some practical difficulties because it is by no means as easy to obtain the same accuracy in the field as in the casting yard. However, the field setting is only required at each pier segment or start of a successive run and it is worthwhile doing this correctly. Placing a large chunk of concrete with a crane to an accuracy of a few thousandths of a foot may not be practical. In practice it is possible to use shims, packs and wedges to maneuver the segments to within an acceptable accuracy. Also, by installing supplementary transverse alignment marker while in the casting cell, the horizontal adjustment of the pier segment can be set in the field using the base line of the full segment width, thereby not relying solely upon the shorter, front to back, longitudinal centerline marks

During erection, elevations and horizontal alignment should be checked to see if they are in agreement with the calculated, as-cast position. If not, then adjustments may be necessary. Such compensations include: reorienting or rotating the cantilever after erection, calculating a compensatory setting for the next cantilever or shimming the joints. The latter should only be used as a last resort as it can unpredictably lead to “correction of corrections” and so on. Moreover it is not effective for short cantilever or deep girders.

Precision within the geometry control system is essential in order to avoid errors in the geometry of the structure. A source of error in alignment may arise from the deformation characteristics of the concrete being different from these assumed. In segmental construction, the actual deflection can differ from the theoretical just as in pre-cast girder production where identical girder can differ in camber by a few inches. However, with pre-cast segmental

construction most of the shrinkage has usually occurred during storage and the concrete has matured substantially by the time of erection.

### 3.2 Tools Normally Used for Geometry Control

1. Offsets: Centerline offsets are measured from the casting cell centerline using a metal scale fitted with a center point which sits in a punch mark on the hairpins. A spirit level should be attached to this scale so that it is set horizontal. Also, it should be held at right angles to the centerline of sight in the cell.
2. Elevations: Elevation readings on the bolts are made with a precision level placed on top of the fixed mounting, reading onto a leveling rod fitted with a scale divided down to at least 1 mm. In order to make sure the readings are taken at exactly the same point each time, the leveling rod should be fitted with a center point which sets into a punch mark in the top of the bolt.
3. Lengths: A steel tape may be used for length measurement. It is advantageous to measure lengths between the center point marks on the hairpins, the distance between adjacent hairpins and similarly along the bolt lines between the leveling punch marks. Readings should be estimated at least 0.5 mm for length.
4. Lateral offsets to the level bolts should be measured from the centerline hairpins. It is preferable to have the bolt position accurately marked on the bulkhead so that they are always at the exact required offset from the centerline.

With care and precision, the readings obtained will allow precise processing using three-dimensional coordinate geometry computations which are the most accurate when it comes to defining curved surfaces in space.

### 3.3 Geometry Control of the First Pier Segment

The first segment of a run or a cantilever in a short time method is cast between the bulkhead and temporary bulkhead. Consequently, it has no match cast segment to which its geometric position is to be referenced. When moving this segment from temporary storage into the match casting position, it is simply set to the same position it had after casting by reading the same elevation on the bolts and the same offsets on the markers. This gives a starting point from which all other segments can be subsequently referenced, assuming that there is no casting curve adjustment to be made. If there is a casting curve adjustment needed, it can be made at this time. The bolt and centerline marker readings are also used for setting the first segment in its required attitude in the erected structure.

The main feature of the first segment which, if it is a pier or abutment segment, is usually shorter than the typical segments, is to establish a transverse horizontal control line on the surface of the segment in the casting cell. This provides a greater base line length to align the segments in the field. The normal procedure is to determine either a radial line or a line parallel to the bulkhead and establish this on the center of the segment with horizontal alignment hairpins set as far out on the segment wings as possible. This requires that this line be observable on the bridge, either from above or from the ground below. In the latter case, the line has to be scribed onto the end faces of the wings and two observation stations must be established on the ground on either side of the pier.

Precise setting and checking of the first erected segment is essential since any error in its position is magnified proportional to the ratio of the length of the cantilever or continuous run of segments, and the transverse base line width.

### 3.4 Field Survey Checking during Erection

After the pier segment has been set and checked the horizontal and vertical alignment of successive segments must be checked as well. It is normal practice to calculate and measure

elevations each time after four or six segments have been erected. The horizontal alignment is also checked and should match the theoretical horizontal geometry. The only errors occurring should be slight deviations due to casting errors and corrections. The overall line should closely track the desired line.

The vertical alignment is subject to all kinds of variations due to construction loads, creep, shrinkage, temperature, post-tensioning variations and so on. The alignment should closely agree with the required alignment at the time of erection when duly corrected for these effects. It is difficult to put a precise figure on this tolerance as it depends upon the type of construction. For cantilever construction, the vertical alignment should generally be within one to two inch per cantilever length of 100 feet and similar cantilevers should behave comparably.

Any substantial variations from line and level or any trends noticed early in the construction should be subject to close study and corrective action should be taken. The latter would include checking procedures for errors, especially systematic errors, amending casting curves for future segments and shimming the joints with glass fibre matting to adjust the alignments. The latter is a “last resort”, since it causes stress concentration on the shims and prevents the joints from closing properly which will cause problems during grouting.

### **3.5 Systematic Error**

It is worthwhile giving some consideration to the implications of making a systematic error in each casting operation either as a result of a computational method error or as a physical defect of the equipment which is systematically repeated in each segment of run. The final error after “n” segments amounts to  $n(n-1) e/2$ . In other words, a systematic error of 0.6 mm in each segment would amount to an off line error of about 25 mm after 10 segments and 120 mm after 20 segments. Clearly systematic errors must be avoided and the use of proven techniques should be encouraged.

### **3.6 Temperature Effects**

#### **3.6.1 Temperature expansion and contraction**

A rise of all in temperature will cause a structure to become longer or shorter. Bearings and expansion joints are designed to accommodate this movement.

In some cases this temperature effect may cause problems during construction. After the cantilever on this fixed pier is erected a connection is made to the remainder of the structure. The connection should be able to pull the erected part of the structure over its bearings in order to take care of the temperature movement. If the connection is not strong enough, the cast-in-place splice may crack.

#### **3.6.2 Temperature Gradient**

A temperature gradient or temperature differential exists when a part of the structure has a different temperature than another part. This commonly occurs when the top slab of the box girder, which is exposed to the sun, heats up faster than the webs and the bottom, which are not directly exposed. Temperature differences of 30-40 degrees Fahrenheit can easily occur. As a consequence of this temperature differential, the top slab wants to expand, but the bottom slab does not. In case of free cantilever as shown in Figure D.10(c) it can be seen that the tips of the cantilever deflect. The amount of movement noted in the field increases of course with

the length of the cantilever. Because of this effect it does not make sense to measure elevations any time after the structure has been exposed for some length of time to sun radiation. The only suitable time for measuring elevations during erection is at sunrise. The fact that the cantilever tips move as they are exposed to the daily temperature cycle also affects the timing of casting midspan splices. The suggested way to do this is:

- 1) Connect the cantilevers at the tip by means of a strong back.
- 2) Cast the splice when the deflection at the cantilever ends is the greatest (say 3 p.m) refer Fig. D.11 enclosed
- 3) At sunrise the next day stress as many tendons as allowed by the strength of the “still green” concrete. Usually this is two or four tendons, which is enough to compress the splice so that the subsequent temperature deflection will not crack the concrete at the splice at the bottom.