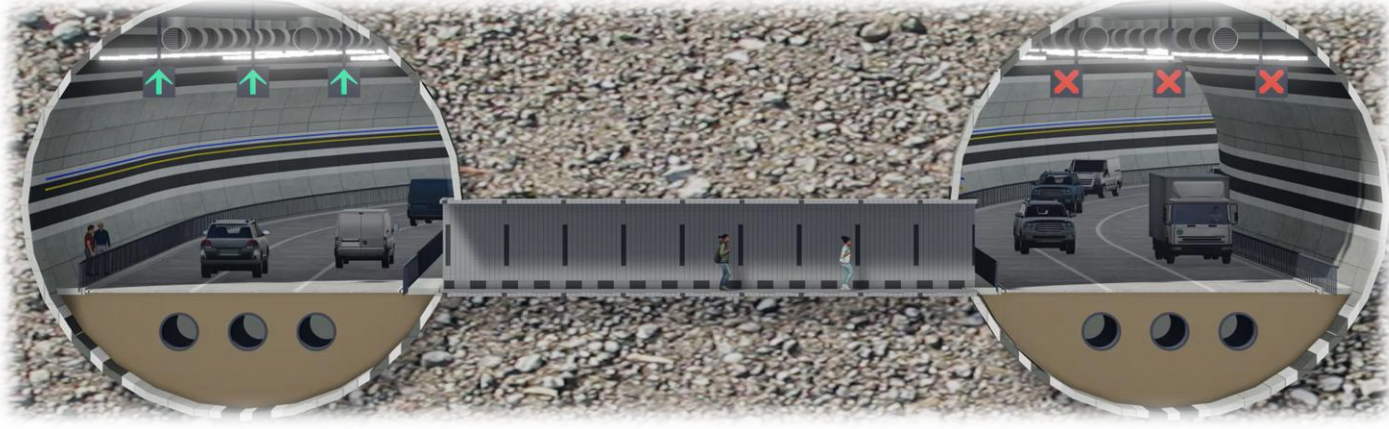
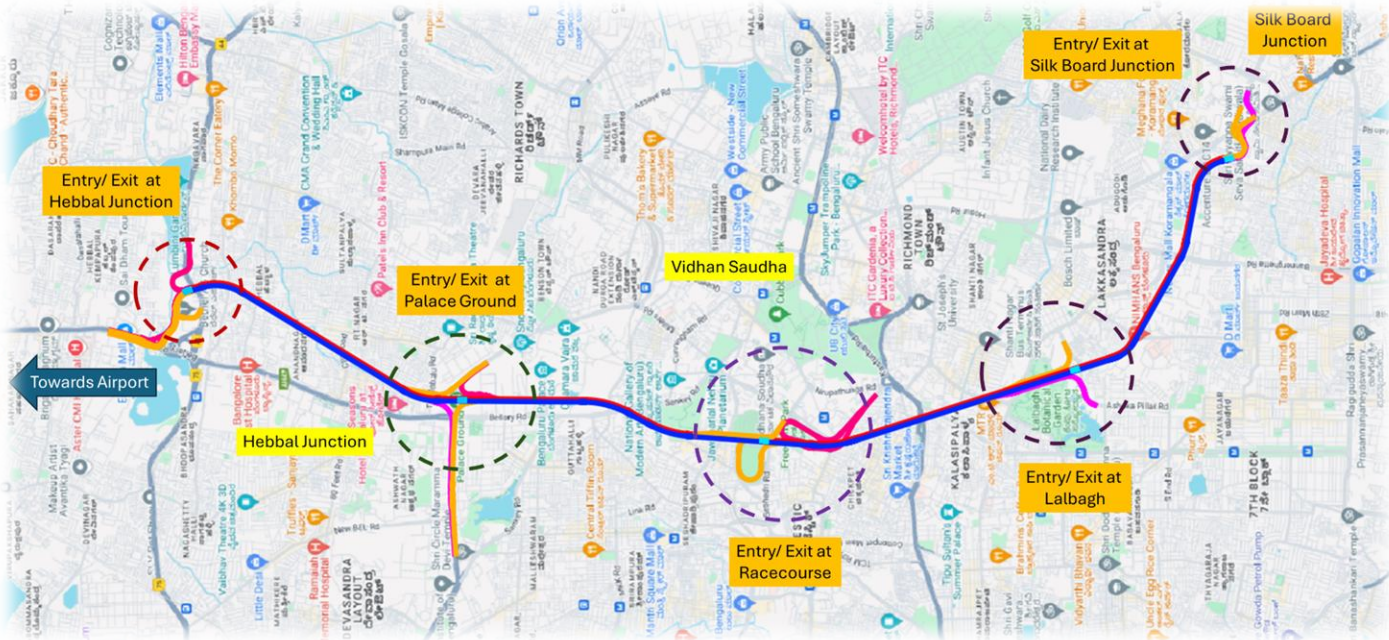




GOVERNMENT OF KARNATAKA



CONSULTANCY SERVICES FOR PREPARATION OF DPR FOR THE WORK OF CONSTRUCTION OF UNDERGROUND VEHICULAR TUNNEL FROM HEBBAL ESTEEM MALL JUNCTION TO SILK BOARD KSRP JUNCTION



FINAL DETAILED PROJECT REPORT

VOLUME - II B

STRUCTURAL DESIGN REPORT

February 2025





TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION	6
1.1 General.....	6
1.2 Project Location.....	6
1.3 Scope.....	6
CHAPTER 2: REFERENCES	7
2.1 Documents Made Available.....	7
2.2 References.....	7
2.3 Documents Submitted	8
2.4 Software	8
CHAPTER 3: BORED TUNNEL.....	9
3.1 Lining Type and Geometry	9
3.2 Design Considerations	9
3.3 Analysis Method	10
3.3.1 Muir Wood's Method	10
3.4 Materials	11
3.4.1 Pre-Cast Concrete	11
3.4.2 Reinforcement Steel.....	11
3.4.3 Partial Factor of Safety for Materials.....	11
3.4.4 Concrete Cover	11
3.4.5 Fire Resistance Design Requirements.....	12
3.4.6 Crack Width.....	12
3.5 Load Cases, Load Factors and Load Combinations.....	12
3.6 Design Summary.....	13
CHAPTER 4: NATM	14
4.1 Lining Type and Geometry	14
4.2 Design Considerations	14
4.3 Calculation for Spring Constants for NATM.....	15
4.4 Materials	15
4.4.1 Pre-Cast Concrete	15
4.4.2 Reinforcement Steel.....	15
4.4.3 Partial Factor of Safety for Materials.....	15
4.4.4 Concrete Cover	15
4.4.5 Fire Resistance Design Requirements.....	16
4.4.6 Crack Width.....	16
4.5 Load & Load Combinations.....	16
4.5.1 General.....	16
4.5.2 Nominal Loads.....	16
4.5.3 Load Factors.....	16
4.5.4 Load Combinations.....	17





4.6	Reinforcement Summary	17
CHAPTER 5: CUT & COVER		18
5.1	Geometry	18
5.2	Materials	19
5.2.1	Cast in Place Concrete	19
5.2.2	Reinforcement Steel.....	19
5.2.3	Concrete Cover	20
5.2.4	Fire Resistance Design Requirements.....	20
5.2.5	Crack Width.....	20
5.3	Load & Load Combinations.....	20
5.3.1	General.....	20
5.3.2	Nominal Loads.....	20
5.3.3	Load Factors.....	20
5.3.4	Load Combinations	21
5.4	Design Summary.....	21
CHAPTER 6: RAMP STRUCTURE		24
6.1	Materials	24
6.2	Materials	26
6.2.1	Cast in Place Concrete	26
6.2.2	Reinforcement Steel.....	26
6.2.3	Concrete Cover	26
6.2.4	Fire Resistance Design Requirements.....	26
6.2.5	Crack Width.....	26
6.3	Load & Load Combinations.....	26
6.3.1	General.....	26
6.3.2	Nominal Loads.....	27
6.3.3	Load Factors.....	27
6.3.4	Load Combinations	27
6.4	Design Summary.....	27
CHAPTER 7: NATM INTERSECTION ENLARGED SECTION		29
7.1	Geometry	29
7.2	Materials	29
7.2.1	Cast in Place Concrete	29
7.2.2	Reinforcement Steel.....	29
7.2.3	Concrete Cover	30
7.2.4	Fire Resistance Design Requirements.....	30
7.2.5	Crack Width.....	30
7.3	Load & Load Combinations.....	30
7.3.1	General.....	30
7.3.2	Nominal Loads.....	30





7.3.3	Load Factors.....	30
7.3.4	Load Combinations.....	31
7.4	Design Summary.....	31
CHAPTER 8: PAVEMENT SLAB/ROAD DECK SLAB IN TUNNEL.....		32
8.1	Geometry	32
8.2	Materials	32
8.2.1	Cast in Place Concrete	32
8.2.2	Reinforcement Steel.....	32
8.2.3	Concrete Cover	32
8.2.4	Fire Resistance Design Requirements.....	33
8.2.5	Crack Width.....	33
8.3	Load & Load Combinations.....	33
8.3.1	General.....	33
8.3.2	Nominal Loads.....	33
8.3.3	Load Factors.....	33
8.3.4	Load Combinations.....	33
8.4	Design Summary.....	34
CHAPTER 9: HANGING DUCT/ INTERMEDIATE SLAB FOR VENTILATION IN TUNNEL		35
9.1	Geometry	35
9.2	Materials	35
9.2.1	Cast in Place Concrete	35
9.2.2	Reinforcement Steel.....	35
9.2.3	Concrete Cover	35
9.2.4	Fire Resistance Design Requirements.....	36
9.2.5	Crack Width.....	36
9.3	Load & Load Combinations.....	36
9.3.1	General.....	36
9.3.2	Nominal Loads.....	36
9.3.3	Load Factors.....	36
9.3.4	Load Combinations.....	36
9.4	Design Summary.....	37
CHAPTER 10: TEMPORARY SECANT PILE.....		38
10.1	Geometry	38
CHAPTER 11: LIST OF ANNEXURES		39

[Handwritten signatures and initials]



Amelia

Adri

Rob

Emma

James



LIST OF TABLES

Table 1: Load Combinations for Structural Design	12
Table 2: Design Summary	13
Table 3: Summary of Steel Reinforcement C&C Structure (3 lane)	21
Table 4: Summary of Steel Reinforcement C&C Structure (2 lane)	22
Table 5: Summary of Steel Reinforcement C&C Structure (3 lane + median wall + 3 lane).....	22
Table 6: Summary of Steel Reinforcement C&C Structure (2 lane + median wall + 3 lane).....	23
Table 7: Summary of Steel Reinforcement RAMP Structure (3 lane)	28
Table 8: Summary of Steel Reinforcement RAMP Structure (2 lane)	28
Table 9: Summary of Steel Reinforcement RAMP Structure (1.5 lane + median wall + 1.5 lane, 2 lane + median wall + 2 lane, 3 lane + median wall + 3 lane)	28
Table 10: Summary of Steel Reinforcement NATM Intersection	31
Table 11: Summary of Steel Reinforcement.....	34
Table 12: Summary of Steel Reinforcement.....	37

[Handwritten signatures]



Amelia

Adri

Rob

Emma

James



LIST OF FIGURES

Figure 1: Typical Bored Tunnel Cross-Section	9
Figure 2: NATM Regular Cross-Section	14
Figure 3: NATM Regular Cross-Section (VCP).....	14
Figure 4: Typical Cross Section C&C Structure (3 LANE)	18
Figure 5: Typical Cross Section C&C Structure (2 LANE)	18
Figure 6: Typical Cross Section C&C Structure (3 LANE + Median Wall + 3 Lane).....	19
Figure 7: Typical Cross Section C&C Structure (2 LANE + Median Wall + 3 Lane).....	19
Figure 8: Typical Cross Section RAMP Structure (3 LANE)	24
Figure 9: Typical Cross Section RAMP Structure (2 LANE)	24
Figure 10: Typical Cross Section RAMP Structure (1.5 lane + median wall + 1.5 lane).....	25
Figure 11: Typical Cross Section RAMP Structure (2 lane + median wall + 2 lane).....	25
Figure 12: Typical Cross Section RAMP Structure (3 lane + median wall + 3 lane).....	25
Figure 13: Typical Cross Section NATM Enlarged Intersection.....	29
Figure 14: Typical Cross Section showing the pavement slab features.....	32
Figure 15: Typical Cross Section showing features of hanging duct/ intermediate slab	35
Figure 16: Typical Section of C&C & Ramp with Secant Pile	38

[Handwritten signatures]



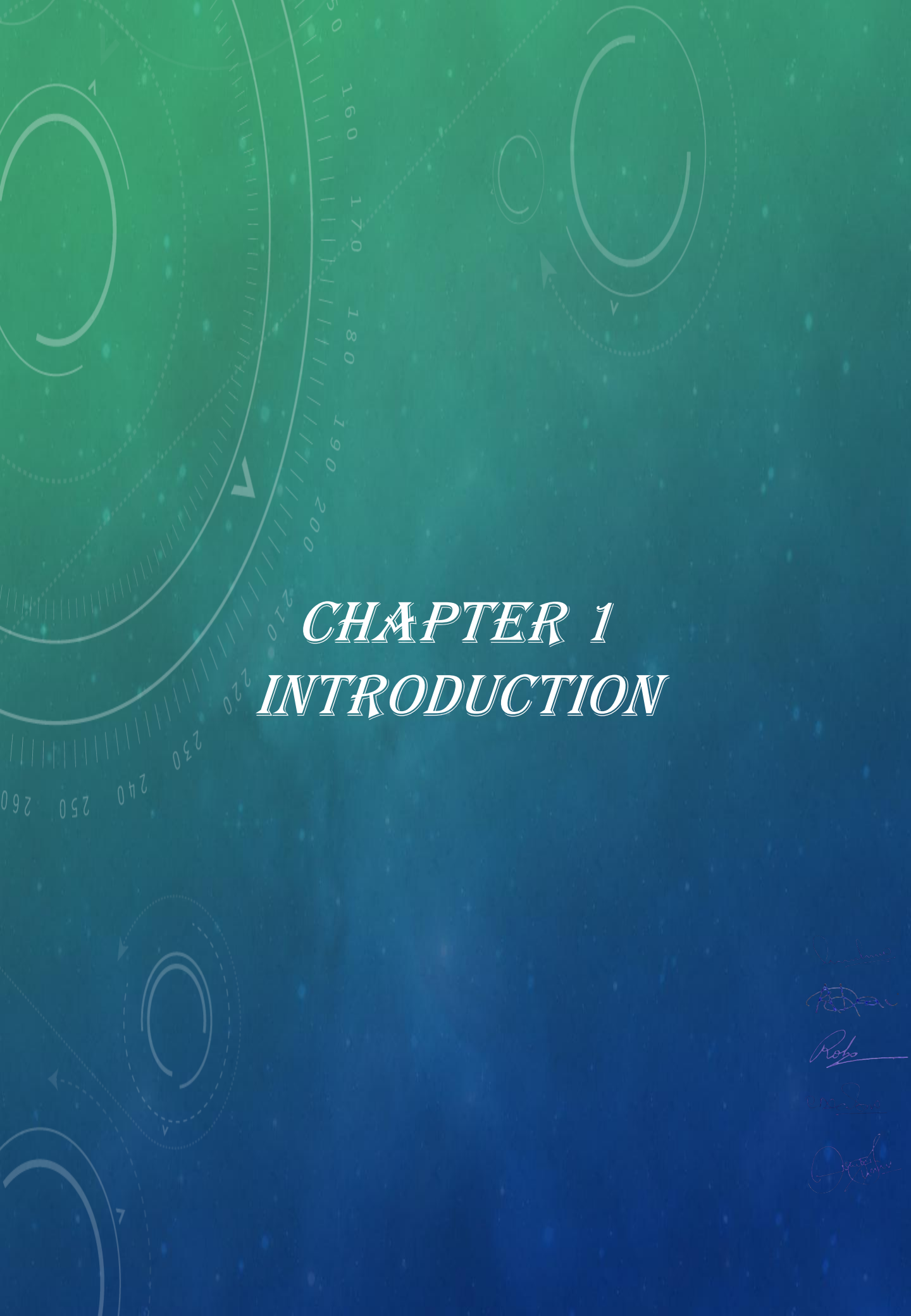
Amelia

Adri

Rob

Emma

James



CHAPTER 1

INTRODUCTION

Shahin
Rohs
Shahin
Shahin
Shahin

Amelia

Adri

Rob

Emma

James



CHAPTER 1: INTRODUCTION

1.1 General

Bruhat Bengaluru Mahanagara Palike (BBMP) intends to Construct a Underground Vehicular Tunnel for the North – South Corridor starting from Hebbal Esteem Mall junction to Silk Board KSRP Junction.

In pursuance of the above, **Rodic Consultants Pvt Ltd., New Delhi** has been appointed as consultants to carry out **Consultancy Services for Preparation of DPR for the work of Construction of Underground Vehicular Tunnel from Hebbal Esteem Mall junction to Silk Board KSRP junction.**

1.2 Project Location

The entire project is located in Bengaluru city.

The North – South Corridor starting from Hebbal Esteem Mall junction to Silk Board KSRP Junction is going to develop as Underground Vehicular tunnel having 04 connecting stretches with Entry and Exit are as below:

- Esteem Mall-Hebbal-Mekri circle-Palace Ground
- Palace Ground- Golf Course-Race Course-Palace Road Jn
- Racecourse/Chalyuka circle-Lalbagh BG
- Lalbagh Botanical Garden- Silk Board KSRP Jn

1.3 Scope

The report covers the preliminary structural design calculations for Bored Tunnel, NATM, Cut & Cover, Ramp Portion including temporary secant pile & steel waler for shaft, C&C and ramp.

[Handwritten signatures]



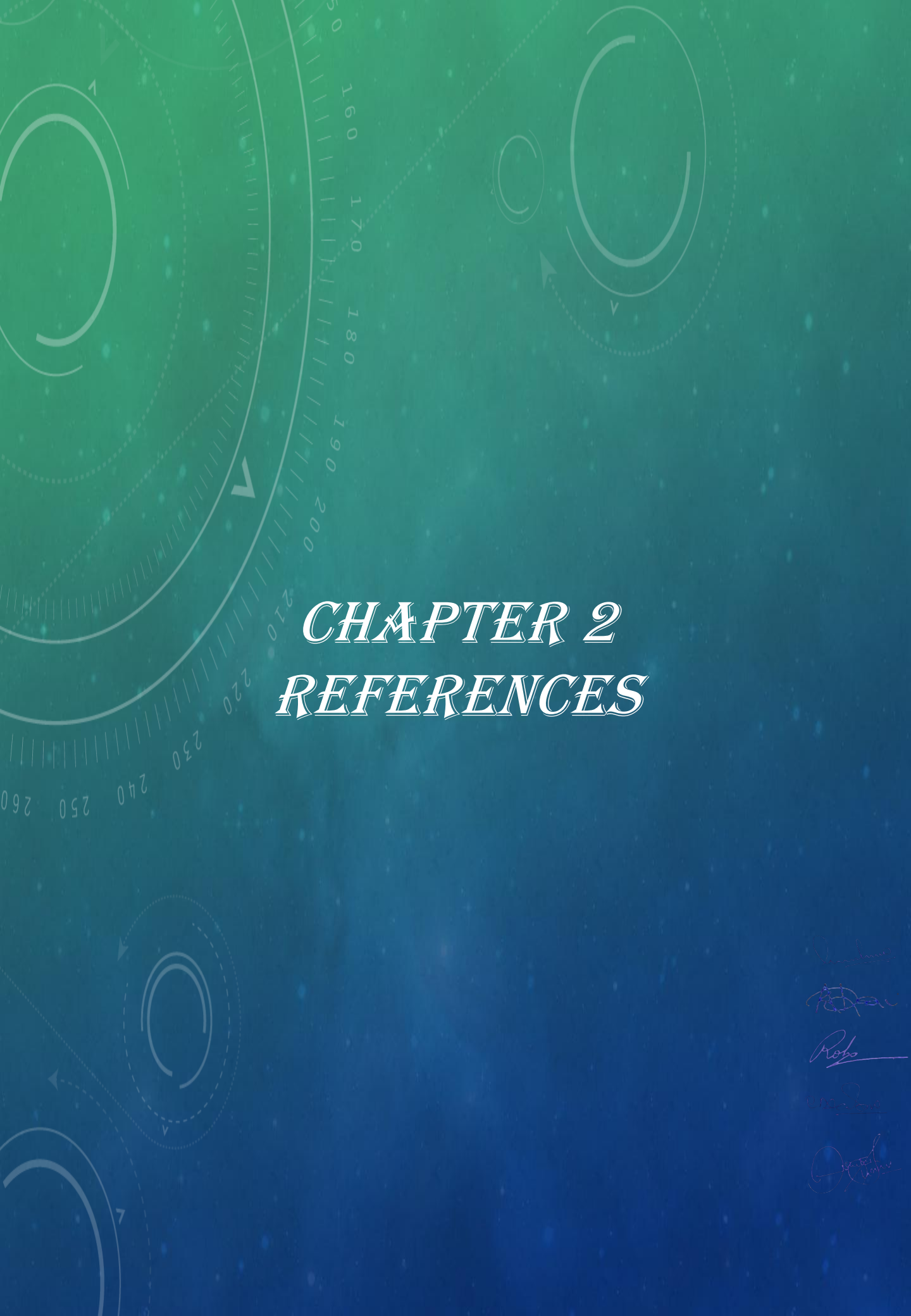
Amelia

Adri

Rob

Emma

James



CHAPTER 2

REFERENCES

Shahin
Rohs
Rohs
Shahin
Shahin

Amelia

Adri

Rob

Emma

James



CHAPTER 2: REFERENCES

2.1 Documents Made Available

- [1] Feasibility Study Report (North South Corridor)
- [2] Alignment Drawings

2.2 References

- [1] IS 456: 2000 Plain and reinforced concrete – Code of practice (Fourth Revision)
- [2] IS 800 (2007): General Construction In Steel - Code of Practice (Third Revision)
- [3] IS 4326:1993, Earthquake resistant design and construction of buildings -code of practice
- [4] IS 1893 (Part-1): 2016 Criteria for earthquake resistant design of structures
- [5] IS 2062: 2011: Hot Rolled Medium and High Tensile Structural Steel -Specification.
- [6] DIN 1045 – Concrete reinforced and pressurized concrete structures.
- [7] EN 1990: Euro code: Basis of structural design
- [8] EN 1991, Euro code 1: Actions on structures
- [9] EN 1992, Euro code 2: Design of concrete structures, Part 1-1: General rules and rules for buildings
- [10] ACI 358.1R-92 (The American Concrete Institute technical design standard, Analysis and Design of Reinforced and Prestressed Concrete Guideway Structures)
- [11] ACI 343.1R-12: Guide for the Analysis and Design of Reinforced and Prestressed Concrete Guideway Structures
- [12] ACI 544.7R16–Design and Construction of Fiber Reinforced Precast Concrete Tunnel Segments
- [13] International Tunnel Association (ITA), Volume 3, 1988: Guideline for Design of Tunnels
- [14] International Tunnel Association (ITA): Guideline for Design of Shield Tunnels
- [15] International Tunnel Association (ITA): Seismic Design and Analysis of Underground Structures
- [16] Austrian Society for Rock Mechanics: Geotechnical Underground Structures Design (Tunneling in Rock)
- [17] Seismic design and analysis of underground structures” by YMA Hashish, JJ Hook, Birger Schmidt and John I-Chiang Yao, Tunnelling and Underground Space Technology 16 (2001) 247 – 293 (ITA-AITES Accredited Material)
- [18] Muir-Wood, A.M. (1975) – The circular tunnel in elastic ground, Geotechnique 25, No. 1, 115-127.
- [19] Curtis D.J. (1976) – Discussion on the Circular tunnel in Elastic Ground, Geotechnique 26, No.1, 231-237
- [20] Wang.J., “Seismic Design of Tunnels”
- [21] Feder G. Felsbau und Bodenmechanik Veröffentlichungen – Collected and published by the Institute of Rock Mechanics and Tunneling University of Graz
- [22] Feder G. Rock mechanics Aspects of the “New Austrian Tunneling Method” (NATM), Arlberg Seminar 1980 of the American Engineering society
- [23] Austrian Standard Oenorm B2203 Part 1, Underground Works – Conventional Excavation, 2001
- [24] Duddeck H. and Erdmann J.: Structural design models for tunnels
- [25] Guidelines For Tunnel Lining Design -LTA Civil Design Division

[Handwritten signatures and initials are present in the right margin of the page.]





- [26] Austrian Society for Geomechanics: Guideline for the Geotechnical Design of Underground Structures with Conventional Excavation, 2010.
- [27] "Seismic Microzonation Manual", Ministry of Earth Science, Government of India
- [28] Williams, O. (1982). Department Of The Army, U.S Army Corps Of Engineers, Em 1110-2-2901.
- [29] Face stability Condition with Earth-Pressure-Balance Shield by G. Anagnostou & K K Vari, Tunnelling and Underground Space Technology, Vol. 11, No. 2. Pp. 165-173, 1996.

2.3 Documents Submitted

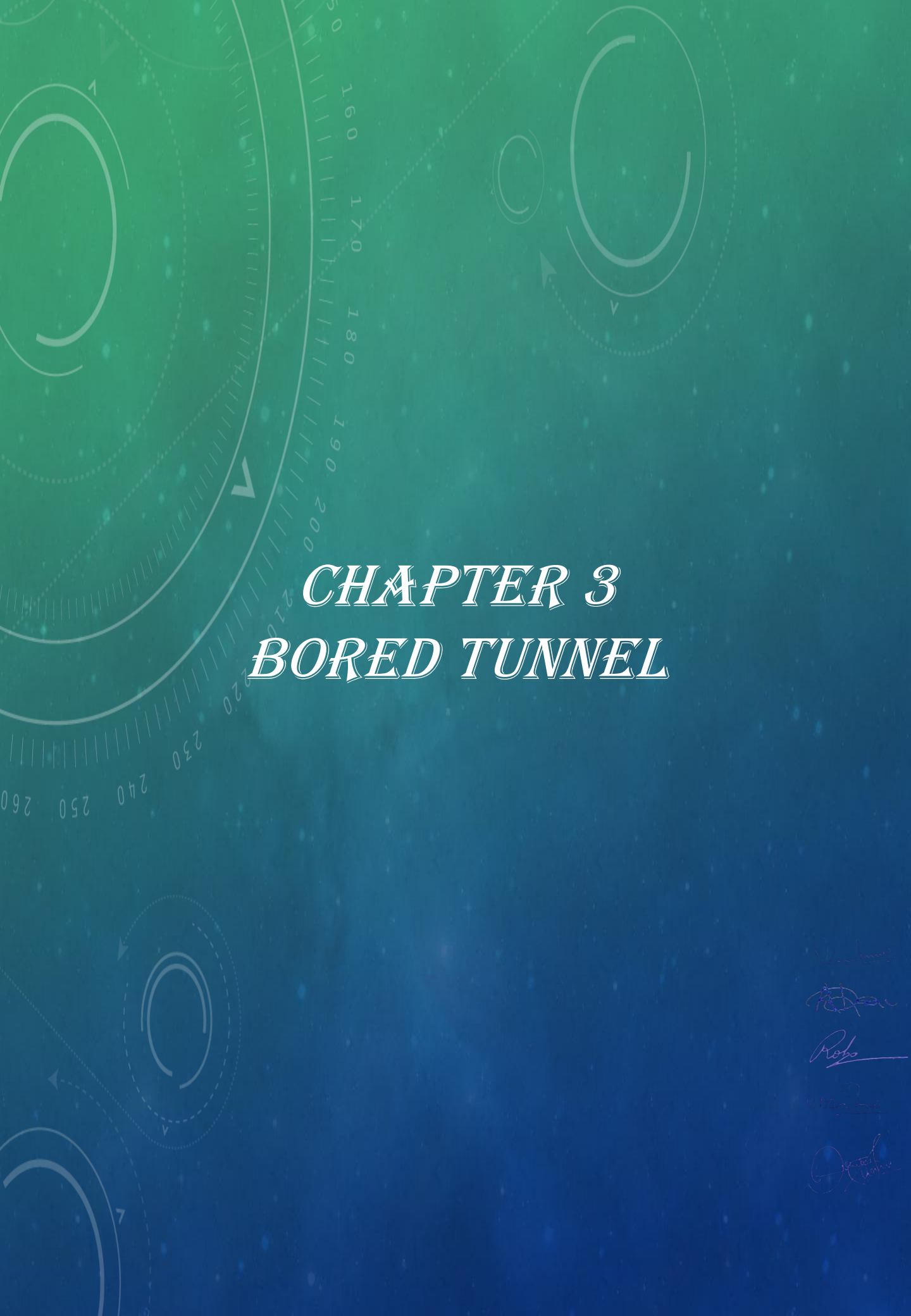
- [1] Geotechnical Interpretative Report (GIR) Report No. – I40172-GIR
- [2] Structural Design Report, Report No- I40172-Structure-DRP

2.4 Software

- [1] RS2 (Version 10) – Rocscience Software, Finite Element Analysis for Excavations and Slopes
- [2] STAAD.Pro-Structural Analysis Software
- [3] In-house Spreadsheets

[Handwritten signatures]





CHAPTER 3

BORED TUNNEL

Shahin
Rohs
Rohs
Shahin
Shahin

Amelia

Adri

Rob

Emma

James



CHAPTER 3: BORED TUNNEL

3.1 Lining Type and Geometry

The finished inner diameter for the Underground Vehicular Tunnel is considered as 13.500m with a thickness of 550mm. Universal configuration of the segment is considered with 9+1 arrangement. The typical bored tunnel cross-section is given in **Figure 1**.

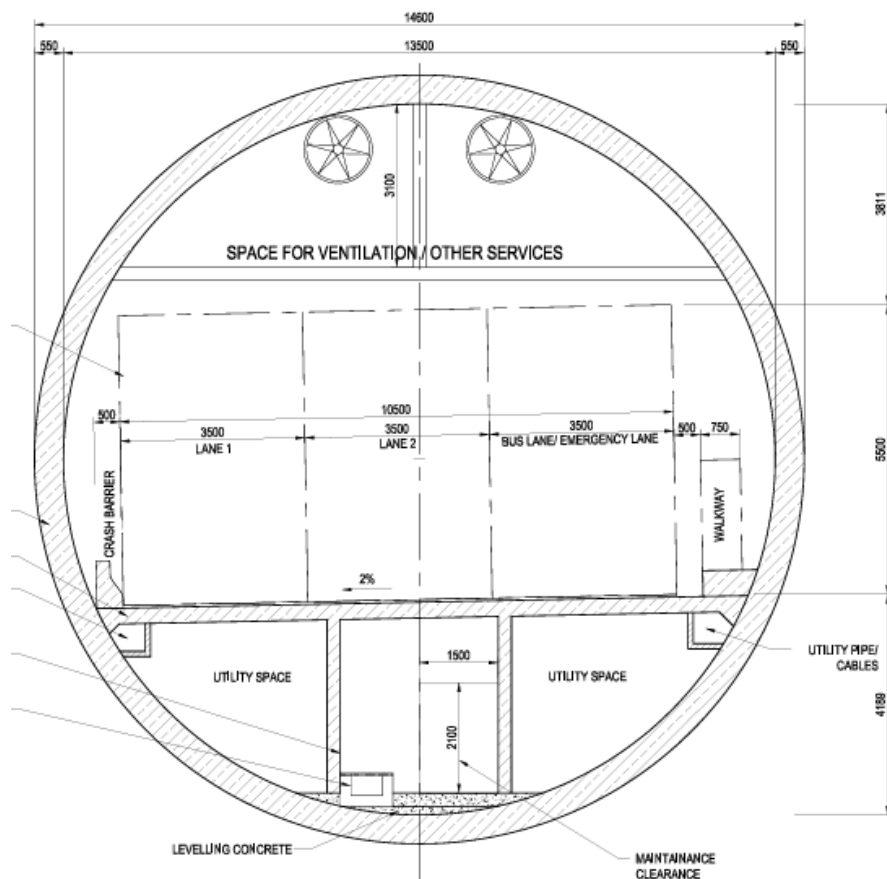


Figure 1: Typical Bored Tunnel Cross-Section

3.2 Design Considerations

The segments shall be designed to ensure that the full design life of 100 years is achieved. The design method for the analysis of the bored tunnel linings shall be done considering the interaction between the lining and the ground, the deflection of the lining and the redistribution of the loading dependent upon the relative flexibility of the lining, the variability and the compressibility of the ground, with this, the design shall take into account all additional loads, stresses and strains imposed by or on to adjacent Existing Building Structure (EBS).

The loads acting on the lining include earth pressure, water pressure, dead load, reactions, surcharge & seismic forces. The lining shall also be checked to resist the various loads arising due to handling, stacking, temporary grout load pressure, TBM thrust, Load on Bolts & erector, gasket forces etc.,

The pre-cast concrete linings are designed in accordance with IS 456. However other International Codes may be used in addition to the Indian Standard as and when required.

Ground loads upto 2R/1D above the tunnel crown has been considered. Based on the geotechnical parameters the analysis is further carried out in two cases.

1. Case 1: Elastic modulus of the soil, $E = 146\text{MPa}$
2. Case 2: Elastic modulus of the soil, $E = 1600\text{MPa}$

For detailed calculations refer **Annexure 1**.





3.3 Analysis Method

The followings methods to be considered for TBM Segmental Lining design.

1. Analytical Method Based on Curtis- Muir Wood Equations to assess the ground load on the tunnel lining.

3.3.1 Muir Wood's Method

Muir-Wood (1975) method for tunnel design shall be used to obtain the axial force and bending moment for inner lining.

A Circular lining deforms into an elliptical shape in an elastic ground. It is also assumed that a full interaction between lining and the surrounding ground exists. The Airy stress function is used in the polar coordinates (according to the stress function proposed by Morgan):

$$\varphi = (ar^2 + br^4 + cr^{-2} + d) \cos 2\theta$$

which allows the differential equations of equilibrium to take the form

$$\sigma_r = \frac{1}{r} \frac{\partial \varphi}{\partial r} + \frac{1}{r^2} \frac{\partial^2 \varphi}{\partial \theta^2}$$

$$\sigma_\theta = \frac{\partial^2 \varphi}{\partial r^2}$$

$$\tau_{r\theta} = \frac{\partial}{\partial r} \left(\frac{1}{r} \frac{\partial \varphi}{\partial \theta} \right)$$

in which

σ_r : Radial stress in the ground,

σ_θ : Tangential stress in the ground, and

$\tau_{r\theta}$: Shear stress in the ground.

Using the plane strain condition and assuming that no shear stress exists between the lining and the surrounding soil, the maximum bending moment and axial force developed in the lining can be obtained from:

$$M_{\max} = \frac{1}{3} p_d R_e^2 \xi \frac{R_s}{1 + R_s}$$

$$N_{\max} = R_e p_u \frac{1}{1 + R_c}$$

In which

$$p_d = \frac{p_v - p_h}{2}$$

$$\xi = \frac{R}{R_e}$$

$$R_s = \frac{9E_I I_I}{\lambda \xi^3 R_e^4}$$

$$p_u = \frac{p_v + p_h}{2}$$

$$R_c = \frac{R_e E_g (1 - V_I^2)}{\xi E_I t (1 + V_g)}$$

$$p_h = k p_v$$

[Handwritten signatures and initials]





$$\lambda = \frac{3E_g}{(1 + V_g)(5 - 6V_g)R_c}$$

pv : Vertical pressure of the ground

ph : horizontal pressure of the ground

Re : external radius of the lining

R : middle radius of the lining

K : coefficient of lateral earth pressure

EI : elastic modulus of the lining

II : moment of inertia of the lining

Al : cross sectional area of the lining

vl : Poisson's ratio of the lining

Eg : elastic modulus of the ground

vg : Poisson's ratio of the ground

t : lining thickness

3.4 Materials

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

3.4.1 Pre-Cast Concrete

Concrete Grade*	: M60
Charac. Compressive Strength	: 60 MPa
Young's Modulus	: 38,729 MPa
Poisson's Ratio	: 0.15
Unit Weight (RCC)	: 25 kN/m ³

*As per IS 456

3.4.2 Reinforcement Steel

The steel for structural reinforcement shall correspond to Fe 500D according to IS 1786-2008:

Young's modulus, E	200 GPa
Yield strength, fyk	500 MPa
Density γ	78.5 kN/m ³

3.4.3 Partial Factor of Safety for Materials

As per IS 456, the design strengths are obtained by dividing the characteristic strength by the material factors as defined below:

Material	Ultimate (ULS)
Concrete	1.5
Reinforcement	1.15

3.4.4 Concrete Cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural Components	Nominal Cover (mm)
1.	Inner face	40
2.	Outer Face	45

Cover means – clear cover to outermost reinforcement.

[Handwritten signatures and initials on the right margin]





3.4.5 Fire Resistance Design Requirements

For underground structures 4 hours of fire resistance criteria shall be adopted. Refer to table 16A IS 456, note that the cover adopted for slab satisfies the provided concrete cover.

3.4.6 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

For side wall and bottom slab: -

- 0.2mm for soil face
- 0.3mm for inner face

3.5 Load Cases, Load Factors and Load Combinations

the following load cases will be considered in each design section:

Load case 1: Groundwater table at the ground surface with a uniform surcharge of 60 KN/m².

Load case 2: Groundwater table at the ground surface with no surcharge.

Load case 3: No groundwater with a uniform surcharge of 60 KN/m²

Load case 4: No groundwater with no surcharge.

Load case 5: Groundwater table at extreme water level (flooding condition i.e., water at ground level + 1m) with no surcharge.

The design forces will be derived based on the following load factors.

Notes:

Load Combination 4 will be used in checking temporary works proposals and checking the structure during temporary construction stages. The imposed load is the construction-imposed load.

For checking structures at extreme water levels, the reduced partial factors of safety for water loads are to be 1.1.

Creep, shrinkage, temperature and differential settlement are not considered in combination with the lateral loads at the ultimate limit state. Creep and shrinkage effects will usually be minor for building-type structures, no specific calculation will be necessary for the ultimate limit state.

For those structural members which are load bearing during the construction stage and subsequently form part of the permanent Works, the serviceability Limit State (SLS) checks shall be carried out both for the "Construction" and "Service/optional" stages.

Table 1: Load Combinations for Structural Design

Load Comb.	Description	Dead Load	Hydrostatic Pressure	Earth Pressure	Surcharge	Seismic Load
1	Ground water table at ground surface with uniform surcharge	1.5	1.5	1.5	1.5	-
2	Ground water table at ground surface with no surcharge	1.5	1.5	1.5	-	-
3	No Ground Water with uniform surcharge	1.5	-	1.5	1.5	-
3A	No Ground Water with uniform surcharge (Seismic-	1.2	-	1.2	1.2	1.2





Load Comb.	Description	Dead Load	Hydrostatic Pressure	Earth Pressure	Surcharge	Seismic Load
	ODE, Full Slip)					
3B	No Ground Water with uniform surcharge (Seismic-ODE, NO Slip)	1.2	-	1.2	1.2	1.2
3C	No Ground Water with uniform surcharge (Seismic-MCE, Full Slip)	1.0	-	1.0	1.0	1.0
3D	No Ground Water with uniform surcharge (Seismic-MCE, NO Slip)	1.0	-	1.0	1.0	1.0
4A	No Ground Water with no surcharge (Seismic- ODE, Full Slip)	1.5	-	1.5	-	1.5
4B	No Ground Water with no surcharge (Seismic- ODE, No Slip)	1.5	-	1.5	-	1.5
4C	No Ground Water with no surcharge (Seismic- MCE, Full Slip)	1.0	-	1.0	-	1.0
4D	No Ground Water with no surcharge (Seismic- MCE, No Slip)	1.0	-	1.0	-	1.0
5	Ground water table at extreme water level with no surcharge	1.5	1.1	1.5	-	-
6	Ground water table at ground surface with uniform surcharge	1.0	1.0	1.0	1.0	-
7	Ground water table at ground surface with no surcharge	1.0	1.0	1.0	-	-
8	No Ground Water with uniform surcharge	1.0	-	1.0	1.0	-
9	No Ground Water with no surcharge	1.0	-	1.0	-	-

3.6 Design Summary

Table 2: Design Summary

Types	Main Reinforcement (mm ² /segment)	Radial Joint Reinforcement (mm ² /segment)	Circumferential Joint Reinforcement (mm ² /segment)
Type A	10-T16 / EF /segment*	10-T16 / EF (U bar) 2x14-T10 / EF (Vertical Ladder Bar) + 04-T8 Stirrups (Leg) (EF)	On Leading edge 17-T8 (long Stirrup)/8-T8 (Key Segment) 17-T8 (open Links)/ 8T8(Key Segment) 34-T8 (short Stirrups)/20T8 (key Segment) =854.51+854.51+1709.03

[Handwritten signatures and initials]



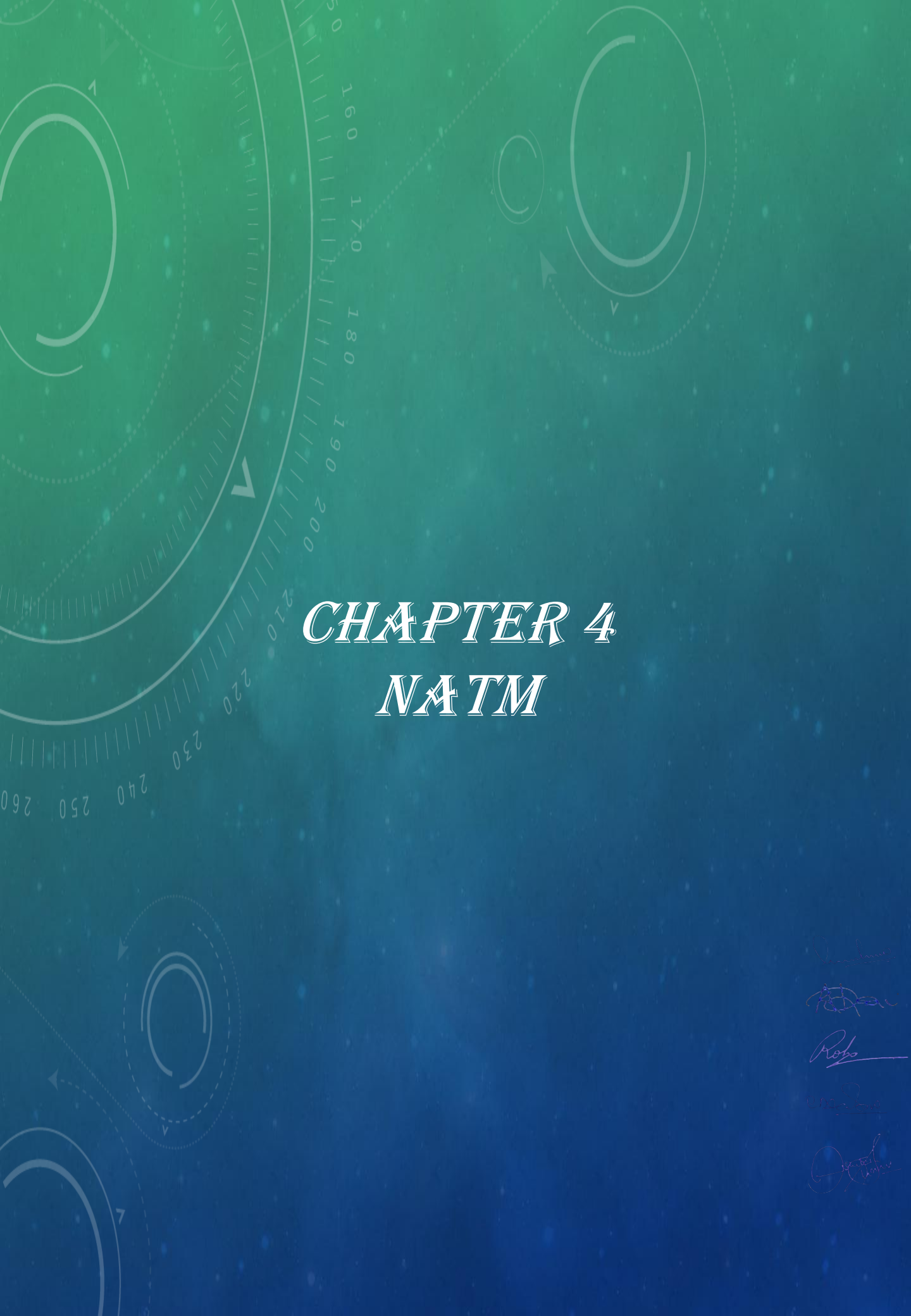
Amelia

Adri

Rob

Emma

James



CHAPTER 4

NATM

Shahin
Adan
Rohs
Shahin
Shahin

Amelia

Adri

Rob

Emma

James



CHAPTER 4: NATM

4.1 Lining Type and Geometry

As per the General arrangement, there are two types of NATM sections available. i.e., Regular Cross Section and Regular Cross Section (VCP) as shown below **Figure 2 & Figure 3**.

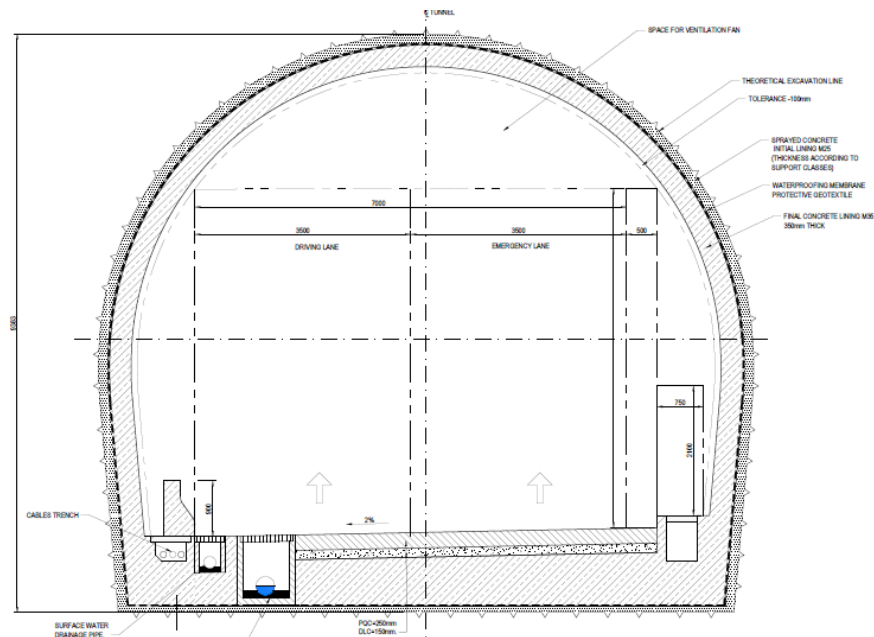


Figure 2: NATM Regular Cross-Section

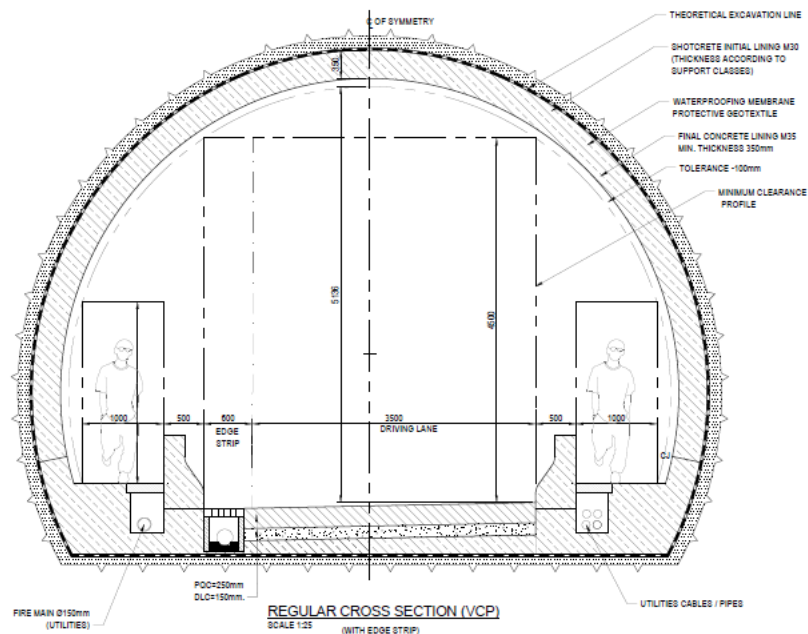


Figure 3: NATM Regular Cross-Section (VCP)

4.2 Design Considerations

The Tunnel tube is proposed to be constructed according to New Austrian Tunnelling Method (NATM) excavation in different weathering grade of rock mass. Ground excavations require the use of structural supports, to establish equilibrium and to limit the displacements around the excavation and at surface. The tunnel will be supported with primary support for temporary condition and a cast in-situ concrete as a permanent support. Primary support design has been done by considering site ground condition. The design has been performed for the combination of different load cases analyzed in STAAD, as given in **Annexure 2**.





4.3 Calculation for Spring Constants for NATM

The lining is modeled as a beam bedded by springs. Multiple beam elements are created along centroidal axis of lining subtending angle of 50 to 100 representing linear 2D structure.

Beam model spring constants are derived from modulus of sub grade reaction K_s , which is calculated from.

$$K_s = \frac{E}{(1 + \nu) \times R},$$

where:

E ... Young's Modulus of soil/rock

ν ... Poisson's Ratio of soil/rock mass

R ... Radius of Tunnel (with $R \leq 7$ m)

The spring constant of a bedding spring representing a certain area A of sub grade is derived as:

$$C_r = K_s \times A$$

The tangential spring constants K_t is calculated from:

$$K_t = \frac{0.5 * K_s}{(1 + \nu)}$$

The bending stiffness of the structural element is equal to $E_c * I_g$. The moment of inertia I_g is based on the modulus of inertia of gross concrete section about centroidal axis, neglecting reinforcement.

4.4 Materials

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

4.4.1 Pre-Cast Concrete

Concrete Grade*	: M35
Charac.Compressive Strength	: 35 MPa
Young's Modulus	: 29,580 MPa
Poisson's Ratio	: 0.15
Unit Weight (RCC)	: 25 kN/m ³

*As per IS 456

4.4.2 Reinforcement Steel

The steel for structural reinforcement shall correspond to Fe 500D according to IS 1786-2008:

Young's modulus, E	200 GPa
Yield strength, f_{yk}	500 MPa
Density γ	78.5 kN/m ³

4.4.3 Partial Factor of Safety for Materials

As per IS 456, the design strengths are obtained by dividing the characteristic strength by the material factors as defined below:

Material	Ultimate (ULS)
Concrete	1.5
Reinforcement	1.15

4.4.4 Concrete Cover

For Underground structural elements in contact with non- aggressive soil

[Handwritten signatures and initials]





Sl. No.	Structural Components	Nominal Cover (mm)
1.	Inner face	40
2.	Outer Face	45

Cover means – clear cover to outermost reinforcement.

4.4.5 Fire Resistance Design Requirements

For underground structures 4 hours of fire resistance criteria shall be adopted. Refer to table 16A IS 456, note that the cover adopted for slab satisfies the provided concrete cover.

4.4.6 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

For side wall and bottom slab: -

- 0.2mm for soil face
- 0.3mm for inner face

4.5 Load & Load Combinations

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

4.5.1 General

Unless specified otherwise the design of concrete elements shall conform to IS 456.

4.5.2 Nominal Loads

For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be considered as applicable.

Dead load (Self Weight)	DL
Superimposed Dead loads	SIDL
Live loads	LL
Earth Pressure	EP
Surcharge	SR
Hydrostatic	WP

Load and stiffness calculations are given in **Annexure 2**.

4.5.3 Load Factors

The following load factors will be considered in the Design of RAMP Structures:

i. Ultimate Limit State

The Ultimate Load of the structures must be analysed considering all relevant loads (Dead Loads as well as Imposed Loads) with an appropriate load factor.

ii. Serviceability Limit State

The Serviceability of the structures will be analysed considering all relevant loads. Main serviceability related aspects include deflections limitation and crack widths limitation.

[Handwritten signatures and initials]





4.5.4 Load Combinations

i. Applied Load Cases

The applied load cases are listed in the following:

- G_1 Self weight
- G_2 Earth pressure (submerged)
- G_3 Water pressure
- G_4 Surcharge Loads (Symmetrical)
- G_5 Earth pressure (dry)

The general format for combinations of actions for the ultimate and serviceability limit states are as stated below.

ii. Ultimate Limit State (ULS)

Calculations of ultimate limit state consider the following load combinations:

- I $=1.5 \times G_1$
- II $=1.50 \times G_1 + 1.50 \times G_2$
- III $=1.50 \times G_1 + 1.50 \times G_2 + 1.5 \times G_3$
- IV $=1.50 \times G_1 + 1.50 \times G_2 + 1.5 \times G_3 + 1.50 \times G_4$
- V $=1.50 \times G_1 + 1.50 \times G_4 + 1.50 \times G_5$

iii. Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

- I $=1.0 \times G_1$
- II $=1.0 \times G_1 + 1.0 \times G_2$
- III $=1.0 \times G_1 + 1.0 \times G_2 + 1.0 \times G_3$
- IV $=1.0 \times G_1 + 1.0 \times G_2 + 1.0 \times G_3 + 1.0 \times G_4$
- V $=1.0 \times G_1 + 1.0 \times G_4 + 1.0 \times G_5$

4.6 Reinforcement Summary

Component of Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Overt	T12-150mm c/c	T12-150mm c/c	8 mm Dia link @ 150mm x 300mm c/c
Side walls	T25-150mm c/c	T25-150mm c/c	

[Handwritten signatures and initials]



CHAPTER 5
CUT & COVER

Shirley

Alan

Rob

Chris

David

Amelia

Adri

Rob

Emma

James



CHAPTER 5: CUT & COVER

5.1 Geometry

The following Cross Sections of C&C Structures (C&C section of 2 lane, 3 lane, 2 lane + median wall + 3 lane & 3 lane + median wall + 3 lane) will be used as described in **Figure 4**, **Figure 5**, **Figure 6** and **Figure 7**. C&C Structures will have side walls, Bottom Slab and top slab with Reinforced Concrete Structure in which Bottom Slab of 1.0 m thick (2-lane), 1.2m thick (3-lane), 1.2m thick (2 lane + median wall + 3 lane) & 1.2m thick (3 lane + median wall + 3 lane) will be casted over 0.2 m thick PCC and Side wall of 1.0 m thick (2-lane), 1.2m thick (3-lane), 1.2m thick (2 lane + median wall + 3 lane) & 1.2m thick (3 lane + median wall + 3 lane) and top slab with 1.0 m thick (2-lane), 1.2m thick (3-lane), 1.2m thick (2 lane + median wall + 3 lane) & 1.2m thick (3 lane + median wall + 3 lane).

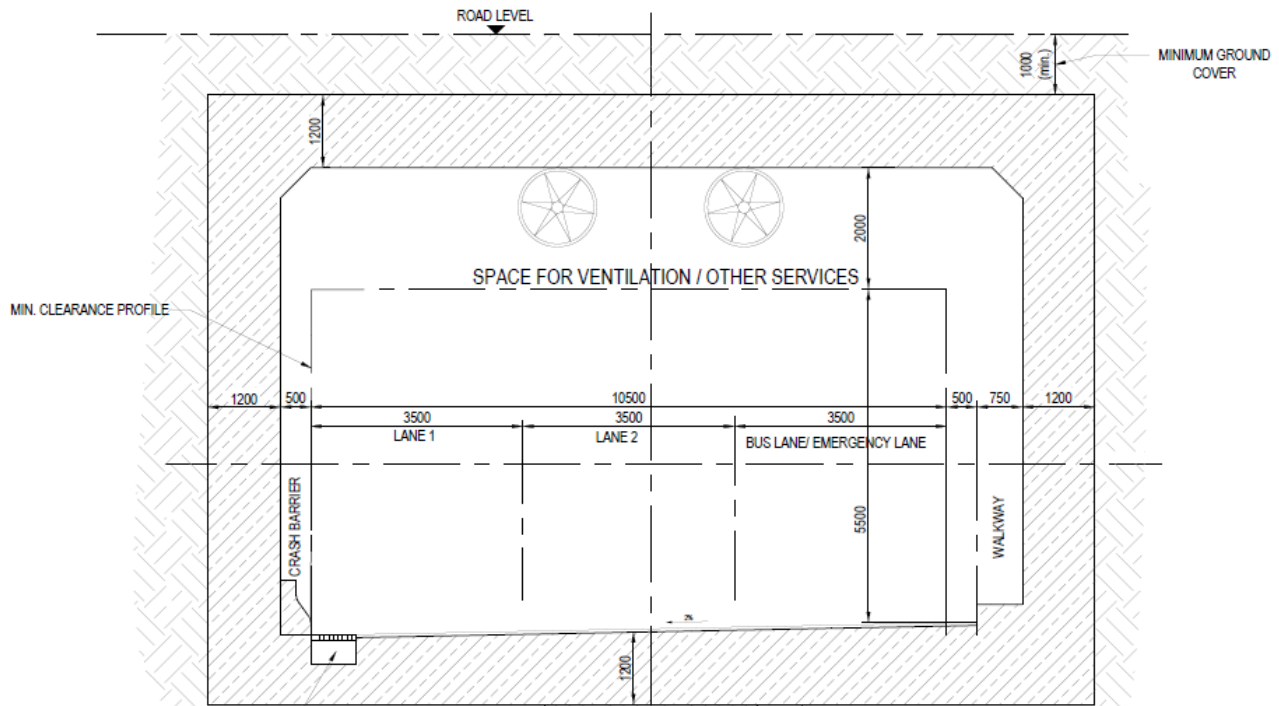


Figure 4: Typical Cross Section C&C Structure (3 LANE)

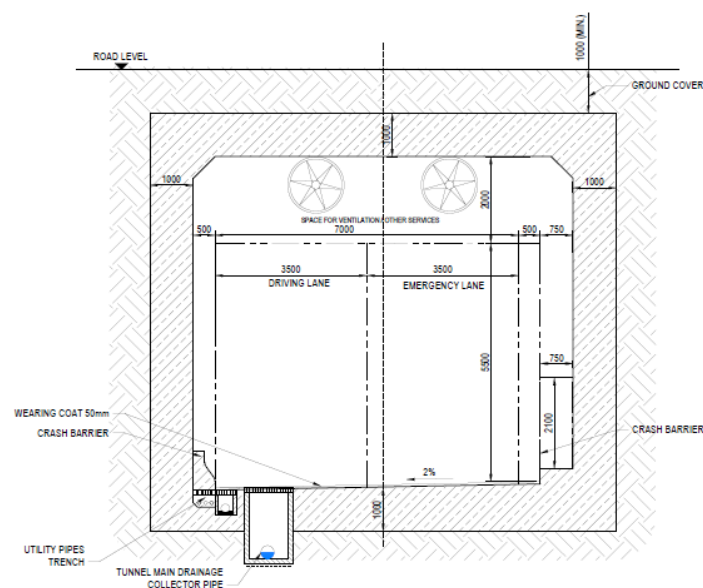


Figure 5: Typical Cross Section C&C Structure (2 LANE)

[Handwritten signatures and initials]



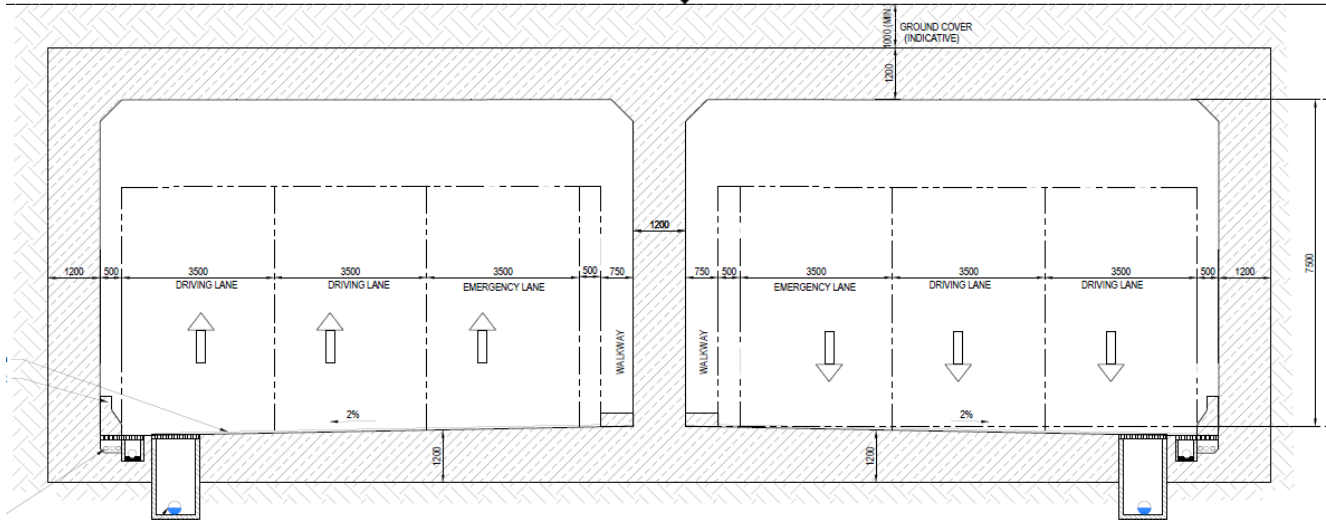


Figure 6: Typical Cross Section C&C Structure (3 LANE + Median Wall + 3 Lane)

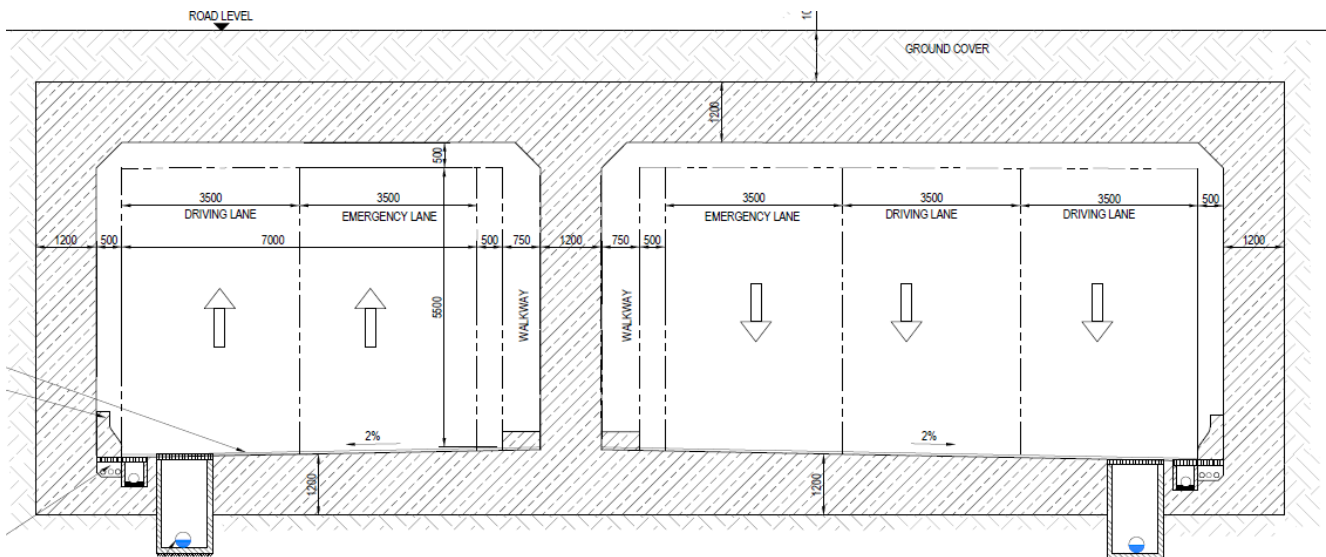


Figure 7: Typical Cross Section C&C Structure (2 LANE + Median Wall + 3 Lane)

5.2 Materials

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

5.2.1 Cast in Place Concrete

a) Bottom Slab & Wall

- Specified characteristic compressive strength $f_{ck} = 35 \text{ N/mm}^2$ (Concrete Grade M35 according to IS 456:2000)
- Young's modulus: $E = 29580 \text{ MPa}$
- Poisson's ratio: $\nu = 0.2$
- Unit weight: $Y = 25 \text{ kN/m}^3$

5.2.2 Reinforcement Steel

Only thermo-mechanically treated reinforcement bars of grade Fe500D (yield stress of 500 MPa) with minimum total elongation of 16% conforming to IS 1786 - 2008 shall be adopted. For flexural design, material properties of Fe 500 shall be used but for design of shear stirrups, strength parameters of Fe415 shall be considered.





Young's modulus

$E=200 \text{ GPa}$

Yield strength

$f_y=500 \text{ MPa}$

5.2.3 Concrete Cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural Components	Nominal Cover (mm)
1.	Base Slab (Earth face)	75
2.	Base Slab (inside face)	50
3.	Side wall (Earth face)	75
4.	Side wall (inside face)	50
5.	Top Slab (Earth face)	75
6.	Top Slab (Inside face)	50

Cover means – clear cover to outermost reinforcement.

5.2.4 Fire Resistance Design Requirements

For underground structures 4 hours of fire resistance criteria shall be adopted. Refer to table 16A IS 456, note that the cover adopted for slab satisfies the provided concrete cover.

5.2.5 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

For side wall and bottom slab: -

- 0.2mm for soil face
- 0.3mm for inner face

5.3 Load & Load Combinations

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

5.3.1 General

Unless specified otherwise the design of concrete elements shall conform to IS 456.

5.3.2 Nominal Loads

For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be considered as applicable.

Dead load (Self Weight)	DL
Superimposed Dead loads	SIDL
Live loads	LL
Seismic Loads	EQ
Earth Pressure	EP
Surcharge	SR
Hydrostatic	WP

Load and stiffness calculations are given in **Annexure 3**.

5.3.3 Load Factors

The following load factors will be considered in the Design of RAMP Structures:

iii. Ultimate Limit State

The Ultimate Load of the structures must be analysed considering all relevant loads (Dead Loads as well





as Imposed Loads) with an appropriate load factor.

iv. Serviceability Limit State

The Serviceability of the structures will be analysed considering all relevant loads. Main serviceability related aspects include deflections limitation and crack widths limitation.

5.3.4 Load Combinations

iv. Applied Load Cases

The applied load cases are listed in the following:

- G1 Self weight
- G2 Earth pressure (submerged)
- G3 Water pressure
- G4 Earth pressure (dry)
- G5 Surcharge Loads (Symmetrical)

The general format for combinations of actions for the ultimate and serviceability limit states are as stated below.

v. Ultimate Limit State (ULS)

Calculations of ultimate limit state consider the following load combinations:

- I = $1.5 \times G1$
- II = $1.50 \times G1 + 1.50 \times G2$
- III = $1.50 \times G1 + 1.50 \times G2 + 1.5 \times G3$
- IV = $1.50 \times G1 + 1.50 \times G2 + 1.5 \times G3 + 1.50 \times G5$
- V = $1.50 \times G1 + 1.50 \times G4 + 1.50 \times G5$

vi. Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

- I = $1.0 \times G1$
- II = $1.0 \times G1 + 1.0 \times G2$
- III = $1.0 \times G1 + 1.0 \times G2 + 1.0 \times G3$
- IV = $1.0 \times G1 + 1.0 \times G2 + 1.0 \times G3 + 1.0 \times G5$
- V = $1.0 \times G1 + 1.0 \times G4 + 1.0 \times G5$

5.4 Design Summary

The reinforcement summary of two different sections has been given below in Table 3, Table 4, Table 5 and Table 6. The design calculations have been given in Annexure 3.

Table 3: Summary of Steel Reinforcement C&C Structure (3 lane)

Component of C&C Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Base Slab (1200mm thk) Main Reinforcement	2-32 mm Dia bar at 100 mm c/c till 2m from support & 1-32 mm Dia bar at 100mm c/c at span	25 mm Dia bar at 100 mm c/c at support till 2m and 2-32 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100mm c/c
Base Slab Longitudinal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Top Slab (1200mm thk) Main Reinforcement	32 mm Dia bar at 100 mm c/c	25 mm Dia bar at 100 mm c/c at support till 2m and 32 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100mm c/c
Top Slab Longitudinal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	





Component of C&C Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Side Wall 1200 mm thick Vertical Reinforcement	2-32 mm Dia bar at 100 mm c/c till 2m from wall edge and 1-32 mm dia bar at 100 mm c/c at span	20 mm Dia @ 100 mm c/c	10 mm Dia link @ 200 mm c/c both ways
Side Wall 1200 mm thick Horizontal Reinforcement	20 mm Dia bar @ 200 mm c/c	20 mm Dia bar @ 200 mm c/c	

Table 4: Summary of Steel Reinforcement C&C Structure (2 lane)

Component of C&C Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Base Slab (1000mm thk) Main Reinforcement	32 mm Dia bar at 100 mm c/c	20 mm Dia bar at 100 mm c/c at support till 2m and 32 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100mm c/c
Base Slab Longitudinal Reinforcement	16 mm Dia bar @ 150 mm c/c	16 mm Dia bar @ 150 mm c/c	
Top Slab (1000mm thk) Main Reinforcement	32 mm Dia bar at 100 mm c/c	25 mm Dia bar at 100 mm c/c	10 mm Dia link @ 100mm c/c
Top Slab Longitudinal Reinforcement	16 mm Dia bar @ 150 mm c/c	16 mm Dia bar @ 150 mm c/c	
Side Wall 1000 mm thick Vertical Reinforcement	32 mm Dia bar at 100 mm c/c	20 mm Dia @ 100 mm c/c	10 mm Dia link @ 200 mm c/c both ways
Side Wall 1200 mm thick Horizontal Reinforcement	16 mm Dia bar @ 200 mm c/c	16 mm Dia bar @ 200 mm c/c	

Table 5: Summary of Steel Reinforcement C&C Structure (3 lane + median wall + 3 lane)

Component of C&C Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Base Slab (1200mm thk) Main Reinforcement	2-Layers – (40mm+32mm) Dia bar at 100 mm c/c till 2m from support & 1-25mm Dia bar at 100mm c/c at span	25 mm Dia bar at 100 mm c/c at support till 2m and 2-25 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100mm c/c
Base Slab Longitudinal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Top Slab (1200mm thk) Main Reinforcement	2 Layers – 32mm Dia bar at 100 mm c/c till 2m from support & 1-20mm Dia bar at 100mm c/c at span	20 mm Dia bar at 100 mm c/c at support till 2m and 2 Layers-32 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100mm c/c
Top Slab Longitudinal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Side Wall 1200 mm thick Vertical Reinforcement	2-Layers – (40mm+32mm) Dia bar at 100 mm c/c till 2m from support & 1-20mm Dia bar at 100mm c/c at span	20 mm Dia @ 100 mm c/c	10 mm Dia link @ 100 mm c/c both ways
Side Wall 1200 mm thick Horizontal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Median Wall 1200 mm thick Vertical	2-Layers – 20mm Dia bar at 100 mm c/c till 2m from	20 mm Dia @ 100 mm c/c	10 mm Dia link @ 100 mm c/c both





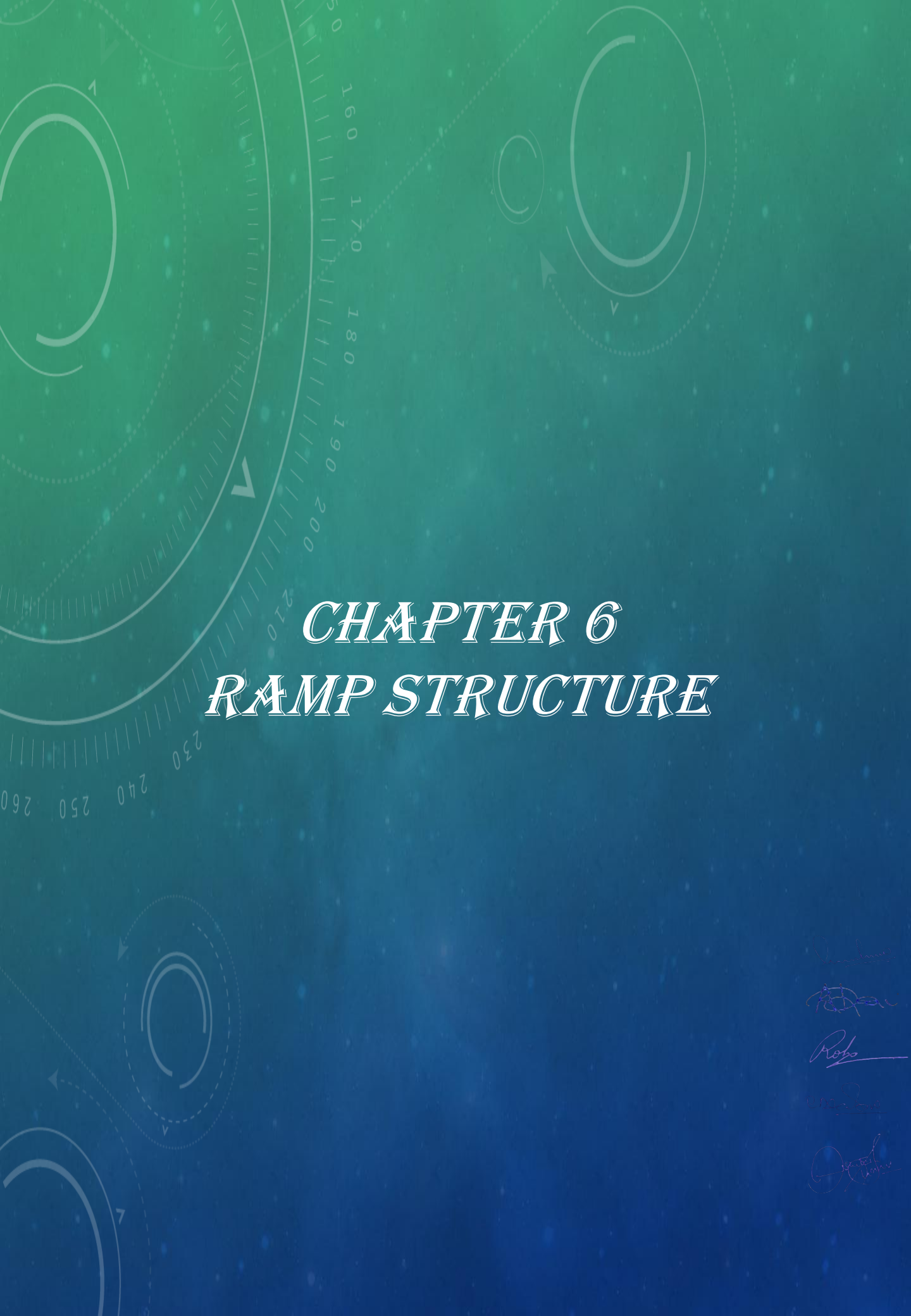
Component of C&C Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Reinforcement	support & 1-20mm Dia bar at 100mm c/c at span		ways
Median Wall 1200 mm thick Horizontal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	

Table 6: Summary of Steel Reinforcement C&C Structure (2 lane + median wall + 3 lane)

Component of C&C Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Base Slab (1200mm thk) Main Reinforcement	2-Layers – 32mm Dia bar at 100 mm c/c till 2m from support & 1-25mm Dia bar at 100mm c/c at span	25 mm Dia bar at 100 mm c/c at support till 2m and 2-25 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100mm c/c
Base Slab Longitudinal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Top Slab (1200mm thk) Main Reinforcement	2 Layers – (40mm + 32mm) Dia bar at 100 mm c/c till 2m from support & 1-20mm Dia bar at 100mm c/c at span	20 mm Dia bar at 100 mm c/c at support till 2m and 2 Layers-32 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100mm c/c
Top Slab Longitudinal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Side Wall 1200 mm thick Vertical Reinforcement	2-Layers – (40mm+32mm) Dia bar at 100 mm c/c till 2m from support & 1-20mm Dia bar at 100mm c/c at span	20 mm Dia @ 100 mm c/c	10 mm Dia link @ 100 mm c/c both ways
Side Wall 1200 mm thick Horizontal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Median Wall 1200 mm thick Vertical Reinforcement	2-Layers – 20mm Dia bar at 100 mm c/c till 2m from support & 1-20mm Dia bar at 100mm c/c at span	20 mm Dia @ 100 mm c/c	10 mm Dia link @ 100 mm c/c both ways
Median Wall 1200 mm thick Horizontal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	

[Handwritten signatures]





CHAPTER 6

RAMP STRUCTURE

Shahin

Adan

Rohs

Shahin

Shahin

Amelia

Adri

Rob

Emma

James



CHAPTER 6: RAMP STRUCTURE

6.1 Materials

The following Cross Sections of RAMP Structures (Ramp section of 2 lane, 3 lane, 1.5 lane + median wall + 1.5 lane, 2 lane + median wall + 2 lane, 3 lane + median wall + 3 lane) will be used as described in **Figure 8, Figure 9, Figure 10, Figure 11 & Figure 12** . RAMP Structures will have side walls and Bottom Slab with Reinforced Concrete Structure in which Bottom Slab of 1 m thick will be casted over 0.2 m thick PCC and Side wall of 1m with roofing C/W pipe truss and approved grade polycarbonate roofing sheets. For Ramp wall height more than 6.5m, a beam 0.6m X 0.6m Beam at 6m spacing has been proposed.

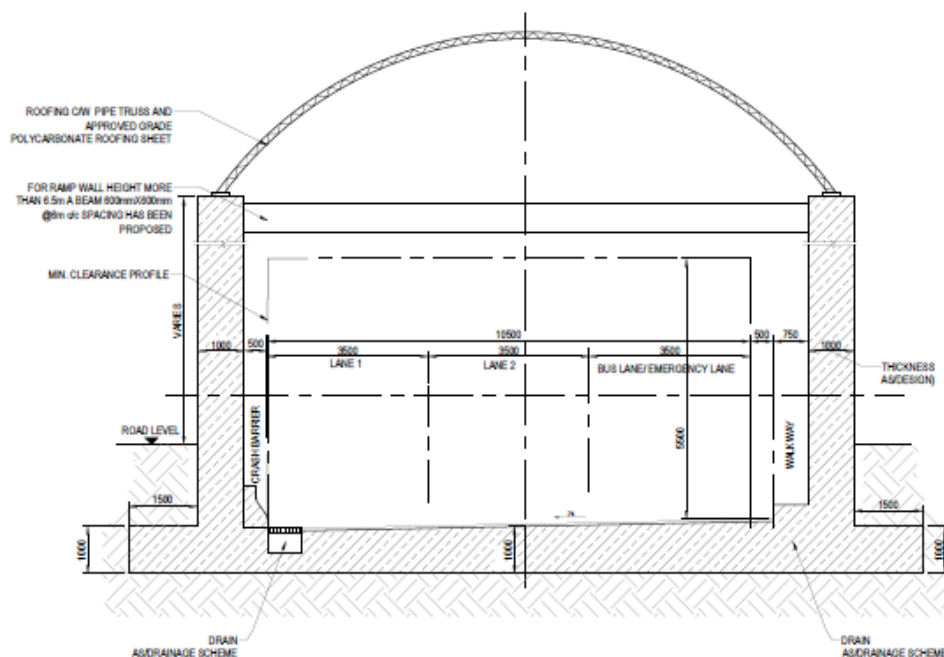


Figure 8: Typical Cross Section RAMP Structure (3 LANE)

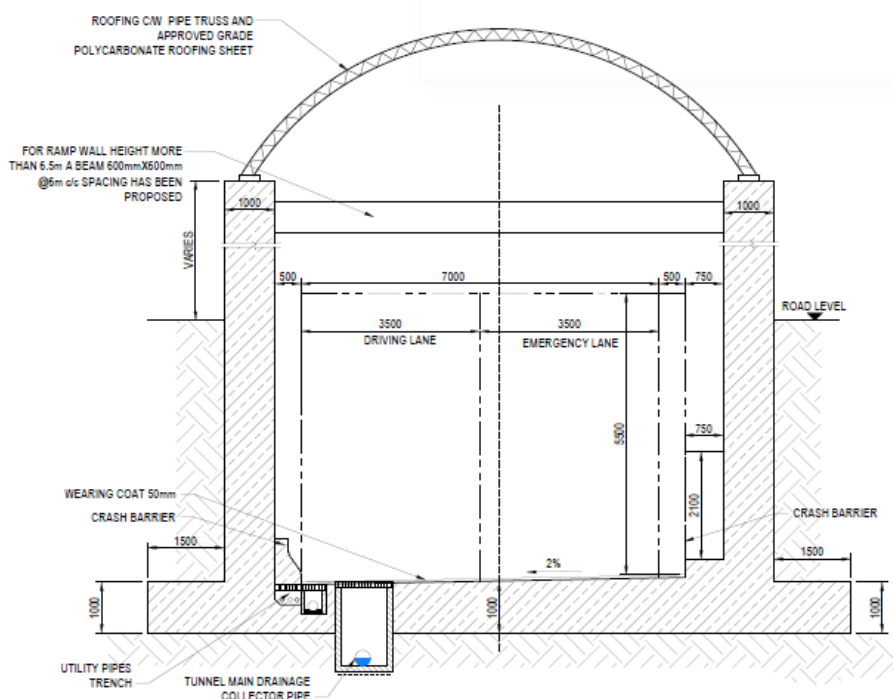


Figure 9: Typical Cross Section RAMP Structure (2 LANE)

[Handwritten signatures and initials]



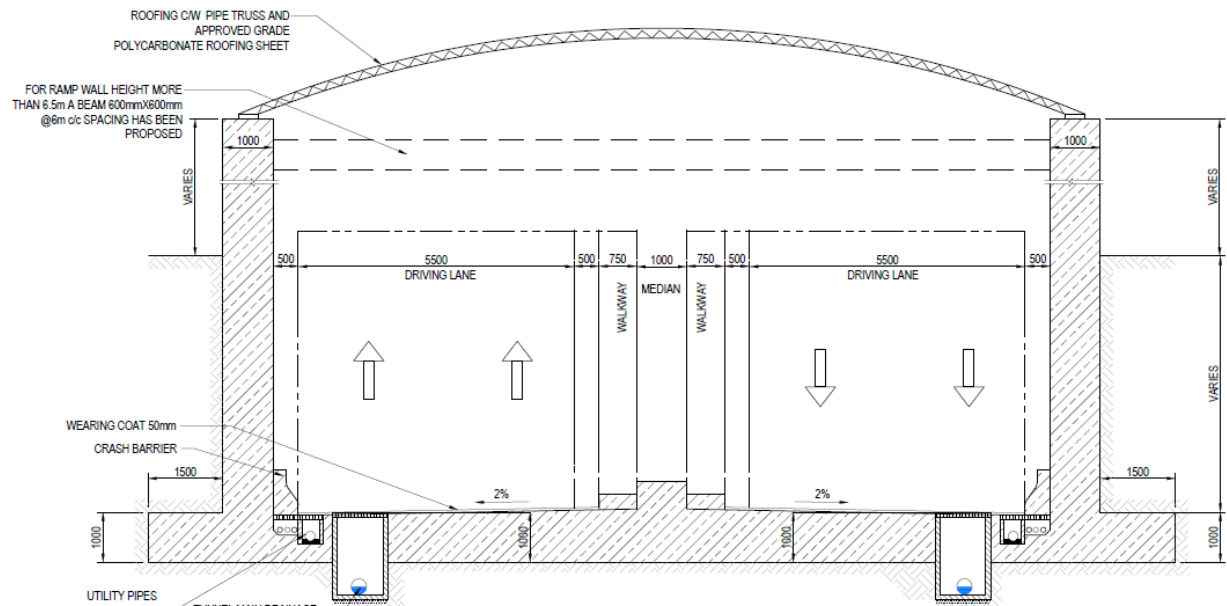


Figure 10: Typical Cross Section RAMP Structure (1.5 lane + median wall + 1.5 lane)

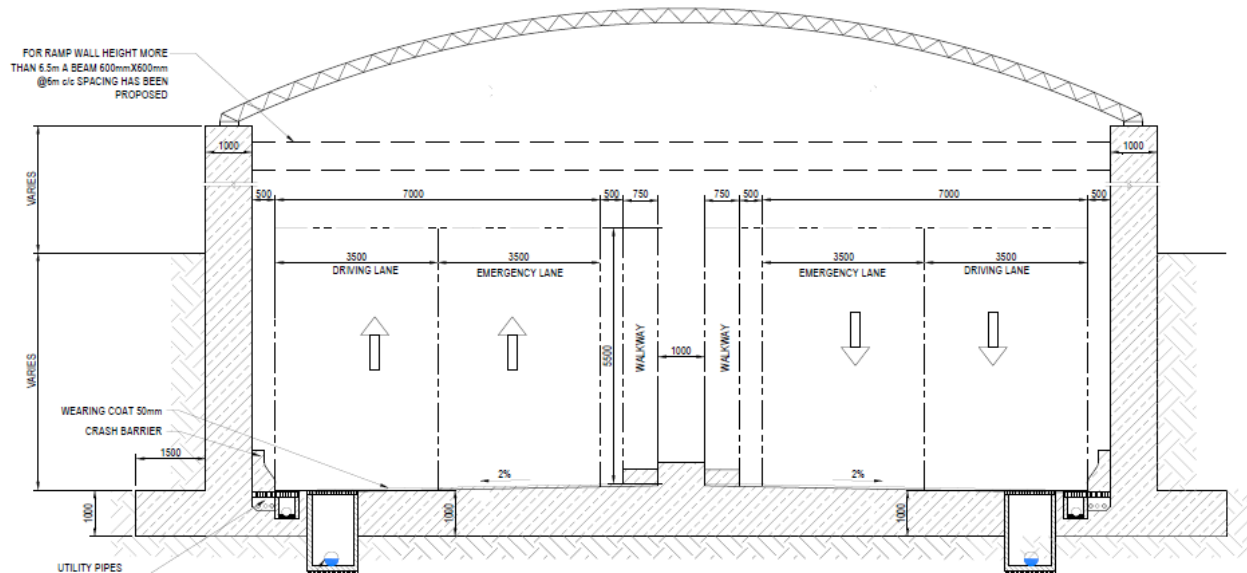


Figure 11: Typical Cross Section RAMP Structure (2 lane + median wall + 2 lane)

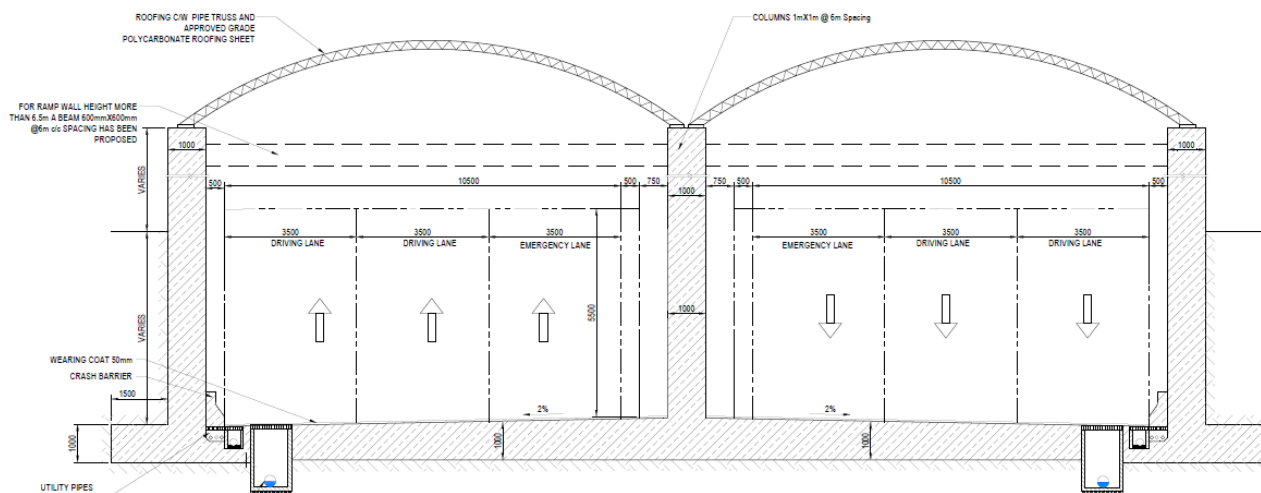


Figure 12: Typical Cross Section RAMP Structure (3 lane + median wall + 3 lane)



6.2 Materials

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

6.2.1 Cast in Place Concrete

a) Bottom Slab & Wall

- Specified characteristic compressive strength $f_{ck} = 35 \text{ N/mm}^2$ (Concrete Grade M35 according to IS 456:2000)
- Young's modulus: $E = 29580 \text{ MPa}$
- Poisson's ratio: $\nu = 0.2$
- Unit weight: $Y = 25 \text{ kN/m}^3$

6.2.2 Reinforcement Steel

Only thermo-mechanically treated reinforcement bars of grade Fe500D (yield stress of 500 MPa) with minimum total elongation of 16% conforming to IS 1786 - 2008 shall be adopted. For flexural design, material properties of Fe 500 shall be used but for design of shear stirrups, strength parameters of Fe415 shall be considered.

Young's modulus	$E = 200 \text{ GPa}$
Yield strength	$f_{yk} = 500 \text{ MPa}$

6.2.3 Concrete Cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural Components	Nominal Cover (mm)
1.	Base Slab (Earth face)	75
2.	Base Slab (inside face)	50
3.	Side wall (Earth face)	75
4.	Side wall (inside face)	50

Cover means – clear cover to outermost reinforcement.

6.2.4 Fire Resistance Design Requirements

For underground structures 4 hours of fire resistance criteria shall be adopted. Refer to table 16A IS 456, note that the cover adopted for slab satisfies the provided concrete cover.

6.2.5 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

For side wall and bottom slab: -

- 0.2mm for soil face
- 0.3mm for inner face

6.3 Load & Load Combinations

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

6.3.1 General

Unless specified otherwise the design of concrete elements shall conform to IS 456.

[Handwritten signatures and initials]





6.3.2 Nominal Loads

For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be considered as applicable.

Dead load (Self Weight)	DL
Superimposed Dead loads	SIDL
Live loads	LL
Seismic Loads	EQ
Earth Pressure	EP
Surcharge	SR
Hydrostatic	WP

Load and stiffness calculations are given in **Annexure 4**.

6.3.3 Load Factors

The following load factors will be considered in the Design of RAMP Structures:

i. Ultimate Limit State

The Ultimate Load of the structures must be analysed considering all relevant loads (Dead Loads as well as Imposed Loads) with an appropriate load factor.

ii. Serviceability Limit State

The Serviceability of the structures will be analysed considering all relevant loads. Main serviceability related aspects include deflections limitation and crack widths limitation.

6.3.4 Load Combinations

i. Applied Load Cases

The applied load cases are listed in the following:

- G1 Self weight
- G2 Earth pressure (submerged)
- G3 Water pressure
- G4 Earth pressure (dry)
- G5 Surcharge Loads (Symmetrical)

The general format for combinations of actions for the ultimate and serviceability limit states are as stated below.

ii. Ultimate Limit State (ULS)

Calculations of ultimate limit state consider the following load combinations:

- I $=1.5 \times G1$
- II $=1.50 \times G1 + 1.50 \times G2$
- III $=1.50 \times G1 + 1.50 \times G2 + 1.5 \times G3$
- IV $=1.50 \times G1 + 1.50 \times G2 + 1.5 \times G3 + 1.50 \times G5$
- V $=1.50 \times G1 + 1.50 \times G4 + 1.50 \times G5$

iii. Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

- I $=1.0 \times G1$
- II $=1.0 \times G1 + 1.0 \times G2$
- III $=1.0 \times G1 + 1.0 \times G2 + 1.0 \times G3$
- IV $=1.0 \times G1 + 1.0 \times G2 + 1.0 \times G3 + 1.0 \times G5$
- V $=1.0 \times G1 + 1.0 \times G4 + 1.0 \times G5$

6.4 Design Summary

The reinforcement summary of 1.5 lane + median wall + 1.5 lane, 2 lane + median wall + 2 lane, 3 lane

[Handwritten signatures and initials]





+ median wall + 3 lane has been provided as per the critical forces in below table with 3 lane and 2 lane ramp portions. The design calculations have given in **Annexure 4**.

Table 7: Summary of Steel Reinforcement RAMP Structure (3 lane)

Component of RAMP Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Base Slab (1000mm thk) Main Reinforcement	32 mm Dia bar at 100 mm c/c till 2m from support & 25 mm Dia bar at 100mm c/c at span	25 mm Dia bar at 100 mm c/c	10 mm Dia link @ 200mm c/c
Base Slab Longitudinal Reinforcement	16 mm Dia bar @ 150 mm c/c	16 mm Dia bar @ 150 mm c/c	
Side Wall 1000 mm thick Vertical Reinforcement	32 mm Dia bar at 100 mm c/c	20 mm Dia @ 100 mm c/c	10 mm Dia link @ 200 mm c/c both ways
Side Wall 1000 mm thick Horizontal Reinforcement	16 mm Dia bar @ 200 mm c/c	16 mm Dia bar @ 200 mm c/c	

Table 8: Summary of Steel Reinforcement RAMP Structure (2 lane)

Component of RAMP Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Base Slab (1000mm thk) Main Reinforcement	25 mm Dia bar at 100 mm c/c	25 mm Dia bar at 100 mm c/c	8 mm Dia link @ 200mm c/c
Base Slab Longitudinal Reinforcement	16 mm Dia bar @ 150 mm c/c	16 mm Dia bar @ 150 mm c/c	
Side Wall 1000 mm thick Vertical Reinforcement	25 mm Dia bar at 100 mm c/c	20 mm Dia @ 100 mm c/c	8 mm Dia link @ 200 mm c/c
Side Wall 1000 mm thick Horizontal Reinforcement	16 mm Dia bar @ 150 mm c/c	16 mm Dia bar @ 150 mm c/c	

Table 9: Summary of Steel Reinforcement RAMP Structure (1.5 lane + median wall + 1.5 lane, 2 lane + median wall + 2 lane, 3 lane + median wall + 3 lane)

Component of RAMP Structure	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Base Slab (1000mm thk) Main Reinforcement	2-Layers – (32mm + 25mm) Dia bar at 100 mm c/c till 2m from support & 1-20mm Dia bar at 100mm c/c at span	20 mm Dia bar at 100 mm c/c at support till 2m and 2-20 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100mm c/c
Base Slab Longitudinal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Side Wall 1000 mm thick Vertical Reinforcement	2-Layers – (32mm+25mm) Dia bar at 100 mm c/c till 2m from support & 1-20mm Dia bar at 100mm c/c at span	20 mm Dia bar at 100 mm c/c at support till 2m and 25 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100 mm c/c both ways
Side Wall 1000 mm thick Horizontal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	
Median Wall 1000 mm thick Vertical Reinforcement	20mm Dia bar at 100 mm c/c till 2m from support & 1-20mm Dia bar at 100mm c/c at span	20 mm Dia bar at 100 mm c/c at support till 2m and 25 mm Dia bar at 100 mm c/c at span	10 mm Dia link @ 100 mm c/c both ways
Median Wall 1000 mm thick Horizontal Reinforcement	20 mm Dia bar @ 150 mm c/c	20 mm Dia bar @ 150 mm c/c	



Amelia

Adri

Rob

Emma

James

CHAPTER 7
NATM INTERSECTION
ENLARGED SECTION

Shahin
Adan
Rohs
Shahin
Shahin

Amelia

Adri

Rob

Emma

James



CHAPTER 7: NATM INTERSECTION ENLARGED SECTION

7.1 Geometry

The following Cross Sections of NATM Structures (NATM Intersection enlarged section) will be used as described in **Figure 13**. The final lining of NATM Intersection is 700mm thick throughout the section.

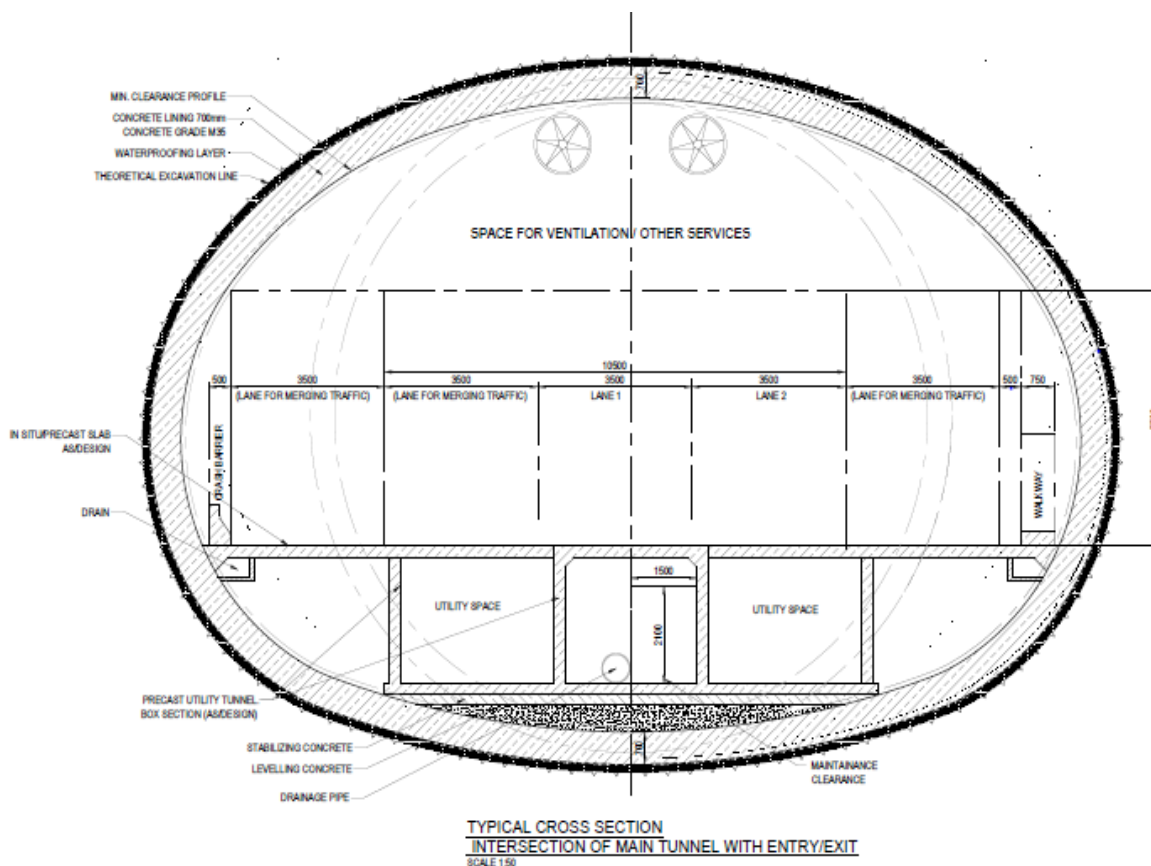


Figure 13: Typical Cross Section NATM Enlarged Intersection

7.2 Materials

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

7.2.1 Cast in Place Concrete

- Specified characteristic compressive strength $f_{ck} = 35 \text{ N/mm}^2$ (Concrete Grade M35 according to IS 456:2000)
- Young's modulus: $E = 29580 \text{ MPa}$
- Poisson's ratio: $\nu = 0.2$
- Unit weight: $Y = 25 \text{ kN/m}^3$

7.2.2 Reinforcement Steel

Only thermo-mechanically treated reinforcement bars of grade Fe500D (yield stress of 500 MPa) with minimum total elongation of 16% conforming to IS 1786 - 2008 shall be adopted. For flexural design, material properties of Fe 500 shall be used but for design of shear stirrups, strength parameters of Fe415 shall be considered.

Young's modulus	$E=200 \text{ GPa}$
Yield strength	$f_{yk}=500 \text{ MPa}$

[Handwritten signatures and initials]





7.2.3 Concrete Cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural Components	Nominal Cover (mm)
1.	Inner face	40
2.	Outer Face	45

Cover means – clear cover to outermost reinforcement.

7.2.4 Fire Resistance Design Requirements

For underground structures 4 hours of fire resistance criteria shall be adopted. Refer to table 16A IS 456, note that the cover adopted for slab satisfies the provided concrete cover.

7.2.5 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

For side wall and bottom slab: -

- 0.2mm for soil face
- 0.3mm for inner face

7.3 Load & Load Combinations

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

7.3.1 General

Unless specified otherwise the design of concrete elements shall conform to IS 456.

7.3.2 Nominal Loads

For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be considered as applicable.

Dead load (Self Weight)	DL
Superimposed Dead loads	SIDL
Live loads	LL
Seismic Loads	EQ
Earth Pressure	EP
Surcharge	SR
Hydrostatic	WP

Load and stiffness calculations are given in **Annexure 5**.

7.3.3 Load Factors

The following load factors will be considered in the Design of NATM intersection:

i. Ultimate Limit State

The Ultimate Load of the structures must be analysed considering all relevant loads (Dead Loads as well as Imposed Loads) with an appropriate load factor.

ii. Serviceability Limit State

The Serviceability of the structures will be analysed considering all relevant loads. Main serviceability related aspects include deflections limitation and crack widths limitation.

[Handwritten signatures and initials]





7.3.4 Load Combinations

i. Applied Load Cases

The applied load cases are listed in the following:

- G1 Self weight
- G2 Earth pressure (submerged)
- G3 Water pressure
- G4 Earth pressure (dry)
- G5 Surcharge Loads (Symmetrical)

The general format for combinations of actions for the ultimate and serviceability limit states are as stated below.

ii. Ultimate Limit State (ULS)

Calculations of ultimate limit state consider the following load combinations:

- I $=1.5 \times G1$
- II $=1.50 \times G1 + 1.50 \times G2$
- III $=1.50 \times G1 + 1.50 \times G2 + 1.5 \times G3$
- IV $=1.50 \times G1 + 1.50 \times G2 + 1.5 \times G3 + 1.50 \times G5$
- V $=1.50 \times G1 + 1.50 \times G4 + 1.50 \times G5$

iii. Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

- I $=1.0 \times G1$
- II $=1.0 \times G1 + 1.0 \times G2$
- III $=1.0 \times G1 + 1.0 \times G2 + 1.0 \times G3$
- IV $=1.0 \times G1 + 1.0 \times G2 + 1.0 \times G3 + 1.0 \times G5$
- V $=1.0 \times G1 + 1.0 \times G4 + 1.0 \times G5$

7.4 Design Summary

The reinforcement summary of NATM enlarged intersection has been given below in. The design calculations have given in **Annexure 7**.

Table 10: Summary of Steel Reinforcement NATM Intersection

Component of NATM Intersection	Reinforcement (Soil Face)	Reinforcement (Inside Face)	Shear Reinforcement
Overt (700mm thk) Main Reinforcement	25 mm Dia bar @ 100 mm c/c	25 mm Dia bar at 100 mm c/c	
Overt Longitudinal Reinforcement	16 mm Dia bar @ 150 mm c/c	16 mm Dia bar @ 150 mm c/c	
SideWall (700mm thk) Main Reinforcement	20 mm Dia bar @ 100 mm c/c	20 mm Dia bar at 100 mm c/c	10 mm Dia link @ 200 mm c/c
SW Longitudinal Reinforcement	16 mm Dia bar @ 150 mm c/c	16 mm Dia bar @ 150 mm c/c	
Invert (700mm thk) Main Reinforcement	32 mm Dia bar @ 100 mm c/c + 25 mm Dia bar @ 100 mm c/c	32 mm Dia bar @ 100 mm c/c + 25 mm Dia bar @ 100 mm c/c	10 mm Dia link @ 200mm c/c
Invert Longitudinal Reinforcement	16 mm Dia bar @ 150 mm c/c	16 mm Dia bar @ 150 mm c/c	



Amelia

Adri

Rob

Emma

James

CHAPTER 8
PAVEMENT SLAB/ROAD DECK
SLAB IN TUNNEL

Dr. J. S. P. S.

Dr. J. S. P. S.

Dr. J. S. P. S.

Dr. J. S. P. S.

Dr. J. S. P. S.

Dr. J. S. P. S.

Amelia

Adri

Rob

Emma

James



CHAPTER 8: PAVEMENT SLAB/ROAD DECK SLAB IN TUNNEL

8.1 Geometry

The Pavement Slab/Road Deck slab in Tunnel comprises the horizontal slab mounted by two side walls as shown in **Figure 14**. The horizontal slab shall be used for vehicle movement and the void between vertical walls and tunnel shall be used to carry Utility services. Both Horizontal slab and Vertical walls shall be of 350mm thick RCC Members.

No firm connection between the pavement slab and tunnel lining is considered. An elastomeric pad or equivalent material shall be provided at the interface between pavement slab and tunnel lining.

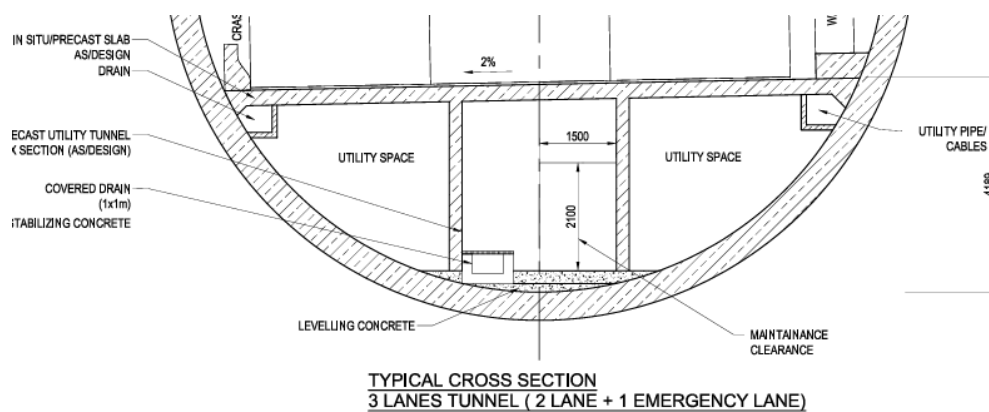


Figure 14: Typical Cross Section showing the pavement slab features

8.2 Materials

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

8.2.1 Cast in Place Concrete

a) Horizontal Slab & Wall

- Specified characteristic compressive strength $f_{ck} = 35 \text{ N/mm}^2$ (Concrete Grade M35 according to IS 456:2000)
- Young's modulus: $E = 29580 \text{ MPa}$
- Poisson's ratio: $\nu = 0.2$
- Unit weight: $Y = 25 \text{ kN/m}^3$

8.2.2 Reinforcement Steel

Only thermo-mechanically treated reinforcement bars of grade Fe500D (yield stress of 500 MPa) with minimum total elongation of 16% conforming to IS 1786 - 2008 shall be adopted. For flexural design, material properties of Fe 500 shall be used but for design of shear stirrups, strength parameters of Fe415 shall be considered.

Young's modulus $E = 200 \text{ GPa}$

Yield strength $f_{yk} = 500 \text{ MPa}$

8.2.3 Concrete Cover

For Underground structural elements in contact with non-aggressive soil

Sl. No.	Structural Components	Nominal Cover (mm)
1.	Horizontal Slab	40
2.	Side wall	40

Cover means – clear cover to outermost reinforcement.





8.2.4 Fire Resistance Design Requirements

For underground structures 4 hours of fire resistance criteria shall be adopted. Refer to table 16A IS 456, note that the cover adopted for slab satisfies the provided concrete cover.

8.2.5 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

For side wall and slab: -

- 0.3mm

8.3 Load & Load Combinations

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

8.3.1 General

Unless specified otherwise the design of concrete elements shall conform to IS 456.

8.3.2 Nominal Loads

For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be considered as applicable.

Dead load (Self Weight)	DL
Live loads (Vehicular Load as per IRC-6)	LL

8.3.3 Load Factors

The following load factors will be considered in the Design of RAMP Structures:

i. Ultimate Limit State

The Ultimate Load of the structures must be analysed considering all relevant loads (Dead Loads as well as Imposed Loads) with an appropriate load factor.

ii. Serviceability Limit State

The Serviceability of the structures will be analysed considering all relevant loads. Main serviceability related aspects include deflections limitation and crack widths limitation.

8.3.4 Load Combinations

i. Applied Load Cases

The applied load cases are listed in the following:

- G1 Self weight
- G2 Live Load

The general format for combinations of actions for the ultimate and serviceability limit states are as stated below.

ii. Ultimate Limit State (ULS)

Calculations of ultimate limit state consider the following load combinations:

- I $= 1.5 \times G1$
- II $= 1.50 \times G1 + 1.50 \times G2$

iii. Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

- I $= 1.0 \times G1$





$$II = 1.0 \times G1 + 1.0 \times G2$$

8.4 Design Summary

The reinforcement summary of 350mm thick Horizontal slab and side walls has been provided as per the critical forces in below table. The design calculations have given in **Annexure 6**.

Table 11: Summary of Steel Reinforcement

Component of Platform/Deck Slab	Reinforcement (Both Face)	Shear Reinforcement
Horizontal Slab (350mm thk) Main Reinforcement	16 mm Dia bar at 150 mm c/c	8 mm Dia link @ 300mm c/c both ways
Horizontal Slab (350mm thk) Longitudinal Reinforcement	10 mm Dia bar @ 150 mm c/c	
Side Wall (350mm thk) Vertical Reinforcement	16 mm Dia bar at 150 mm c/c	8 mm Dia link @ 300mm c/c both ways
Side Wall (350mm thk) Longitudinal Reinforcement	10 mm Dia bar @ 150 mm c/c	

[Handwritten signatures]



Amelia

Adri

Rob

Emma

James

CHAPTER 9
HANGING DUCT/INTERMEDIATE
SLAB FOR VENTILATION IN
TUNNEL

Signature
Signature
Signature
Signature
Signature

Amelia

Adri

Rob

Emma

James



CHAPTER 9: HANGING DUCT/ INTERMEDIATE SLAB FOR VENTILATION IN TUNNEL

9.1 Geometry

The Hanging duct/intermediate slab for Ventilation in Tunnel comprises a horizontal slab which is hanging by a vertical wall as shown in **Figure 15**. The void space crafted between the horizontal slab, vertical walls and tunnel shall be used to carry Ventilation Fans etc. Both Horizontal slab and Vertical wall shall be of 150mm thick RCC Members.

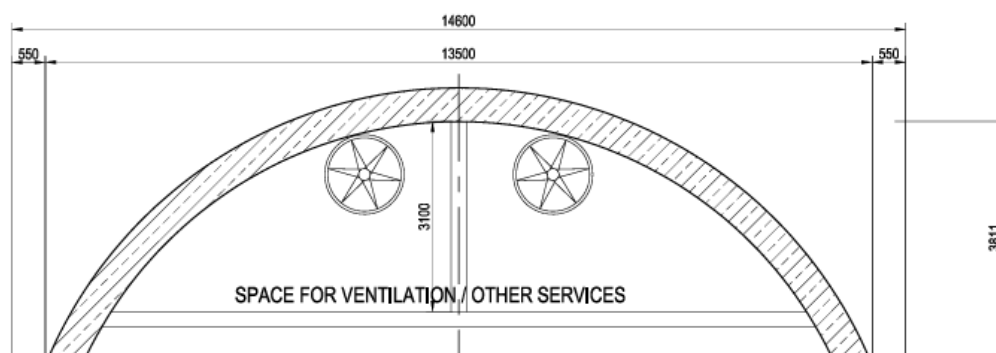


Figure 15: Typical Cross Section showing features of hanging duct/ intermediate slab

9.2 Materials

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

9.2.1 Cast in Place Concrete

a) Horizontal Slab & Wall

- Specified characteristic compressive strength $f_{ck} = 35 \text{ N/mm}^2$ (Concrete Grade M35 according to IS 456:2000)
- Young's modulus: $E = 29580 \text{ MPa}$
- Poisson's ratio: $\nu = 0.2$
- Unit weight: $Y = 25 \text{ kN/m}^3$

9.2.2 Reinforcement Steel

Only thermo-mechanically treated reinforcement bars of grade Fe500D (yield stress of 500 MPa) with minimum total elongation of 16% conforming to IS 1786 - 2008 shall be adopted. For flexural design, material properties of Fe 500 shall be used but for design of shear stirrups, strength parameters of Fe415 shall be considered.

Young's modulus $E = 200 \text{ GPa}$
Yield strength $f_{yk} = 500 \text{ MPa}$

9.2.3 Concrete Cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural Components	Nominal Cover (mm)
1.	Horizontal Slab	40
2.	Side wall	40

Cover means – clear cover to outermost reinforcement.

[Handwritten signatures and initials]





9.2.4 Fire Resistance Design Requirements

For underground structures 4 hours of fire resistance criteria shall be adopted. Refer to table 16A IS 456, note that the cover adopted for slab satisfies the provided concrete cover.

9.2.5 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

For side wall and slab: -

- 0.3mm

9.3 Load & Load Combinations

The relevant building materials, which are concrete and reinforcement steel, confirm the specifications given below.

9.3.1 General

Unless specified otherwise the design of concrete elements shall conform to IS 456.

9.3.2 Nominal Loads

For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be considered as applicable.

Dead load (Self Weight)	DL
Live loads (Air Pressure)	LL

9.3.3 Load Factors

The following load factors will be considered in the Design of Structures:

i. Ultimate Limit State

The Ultimate Load of the structures must be analysed considering all relevant loads (Dead Loads as well as Imposed Loads) with an appropriate load factor.

ii. Serviceability Limit State

The Serviceability of the structures will be analysed considering all relevant loads. Main serviceability related aspects include deflections limitation and crack widths limitation.

9.3.4 Load Combinations

i. Applied Load Cases

The applied load cases are listed in the following:

- G1 Self weight
- G2 Live Load (2.5 kPa Air Pressure)

The general format for combinations of actions for the ultimate and serviceability limit states are as stated below.

ii. Ultimate Limit State (ULS)

Calculations of ultimate limit state consider the following load combinations:

- I $= 1.5 \times G1$
- II $= 1.50 \times G1 + 1.50 \times G2$

iii. Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

- I $= 1.0 \times G1$

[Handwritten signatures and initials]





$$II = 1.0 \times G1 + 1.0 \times G2$$

9.4 Design Summary

The reinforcement summary of 175mm thick Horizontal slab and side walls has been provided as per the critical forces in below table. The design calculations have given in **Annexure 7**.

Table 12: Summary of Steel Reinforcement

Component of Hanging duct	Reinforcement (Both Face)	Shear Reinforcement
Horizontal Slab (175mm thk) Main Reinforcement	12 mm Dia bar at 150 mm c/c	-
Horizontal Slab (175mm thk) Longitudinal Reinforcement	10 mm Dia bar @ 150 mm c/c	
Side Wall (175mm thk) Vertical Reinforcement	12 mm Dia bar at 150 mm c/c	-
Side Wall (175mm thk) Longitudinal Reinforcement	10 mm Dia bar @ 150 mm c/c	



[Handwritten signatures]

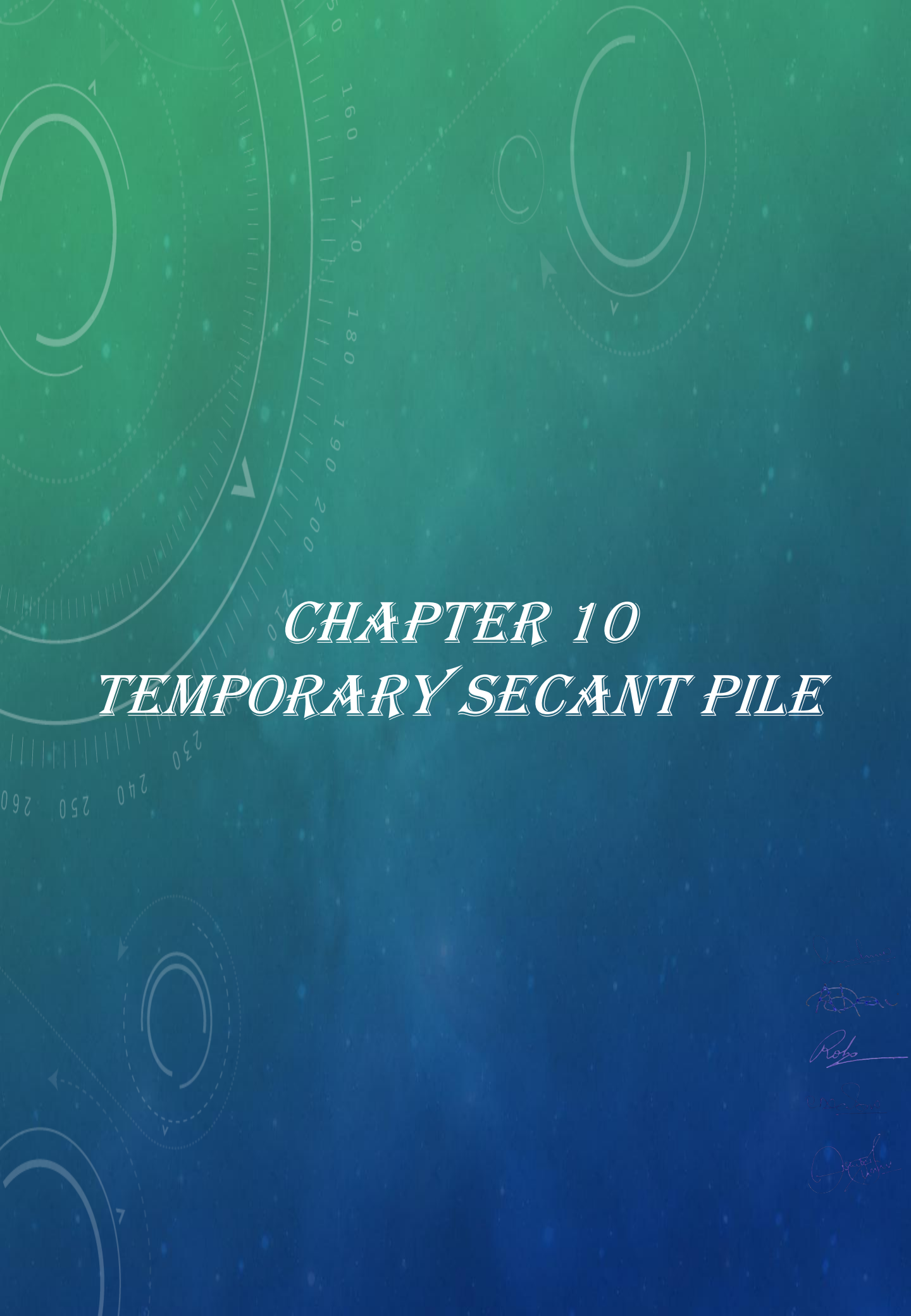
Amelia

Adri

Rob

Emma

James



CHAPTER 10

TEMPORARY SECANT PILE

Shahin
Rahman
Rohs
Shahin
Shahin

Amelia

Adri

Rob

Emma

James

10.1 Geometry

Figure 16: Typical Section of C&C & Ramp with Secant Pile

Lankar
 A. A.
 Rob
 Mrs. Jones
 Jones

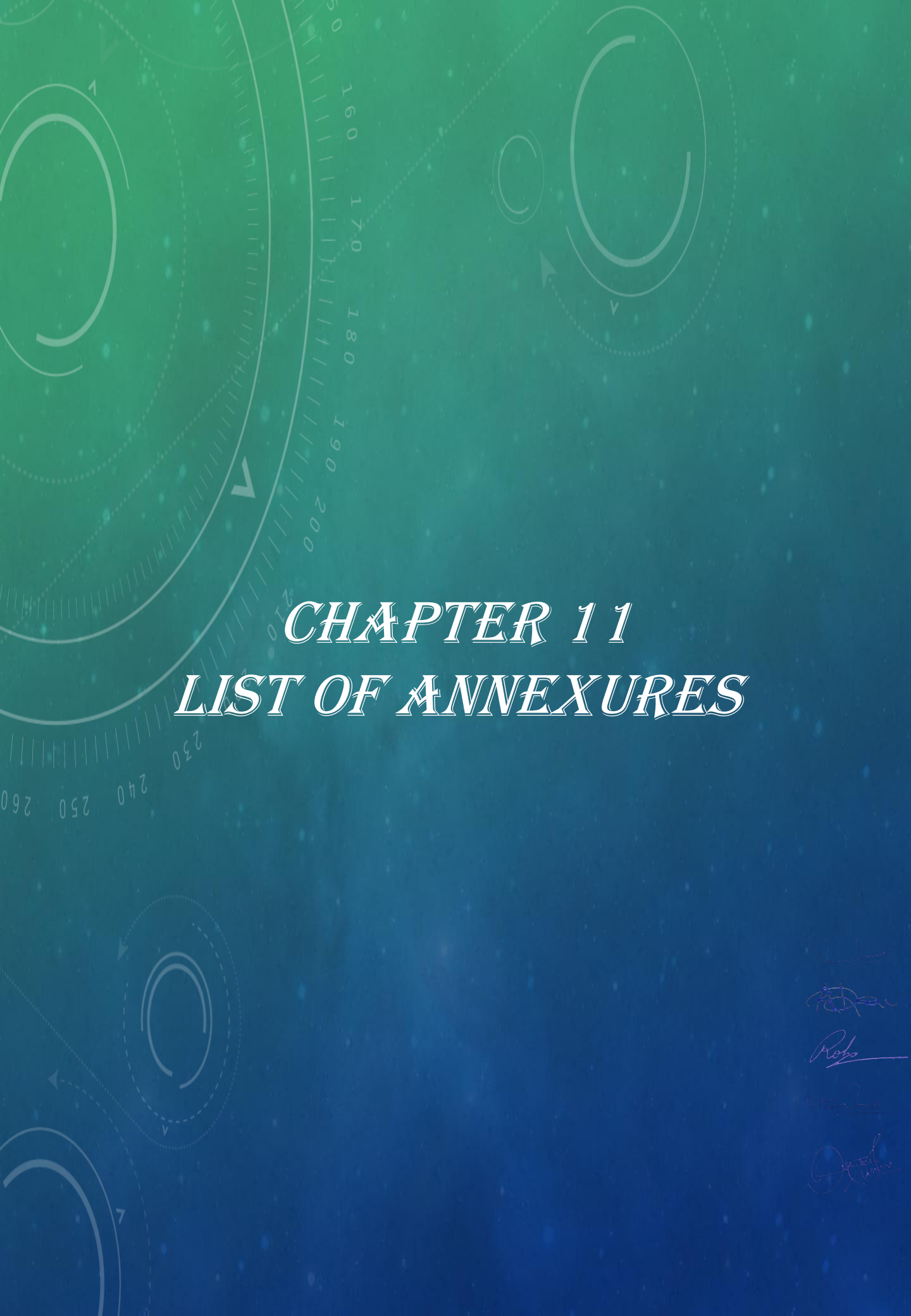
Amelia

Adri

Rob

Emma

James



CHAPTER 11

LIST OF ANNEXURES

Signature
Adan
Rohs
Signature
Signature

Amelia

Adri

Rob

Emma

James



CHAPTER 11: LIST OF ANNEXURES

Annexure – 1 - Pre-Cast Tunnel Segment

Annexure – 2 - NATM Section

Annexure – 3 - Cut & Cover Box

Annexure – 4 - RAMP Portion

Annexure – 5 - NATM Enlarged Intersection

Annexure – 6 - Pavement Slab/ Road Deck slab in tunnel

Annexure – 7 - Hanging Duct / Intermediate slab for Ventilation

Annexure – 8 - Temporary Secant Pile & Steel Waler for Shaft & C&C

Annexure – 9 - Temporary Secant Pile & Steel Waler for Ramp Portion

[Handwritten signatures]



Amelia

Adri

Rob

Emma

James



ANNEXURES

Shahin

Adan

Rohs

Shahin

Shahin

Amelia

Adri

Rob

Emma

James

ANNEXURE - 1
PRE-CAST TUNNEL SEGMENT

Signature

Signature

Signature

Signature

Signature

Amelia

Adri

Rob

Emma

James

CASE 1

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Amelia

Adri

Rob

Emma

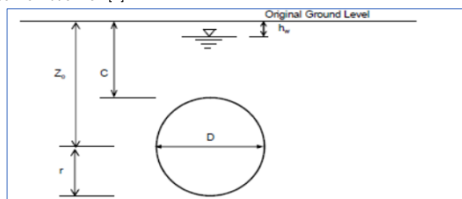
James

Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction
Calculation for	Ground Force Calculation by- Muir Wood (1975) and Curtis (1976)

TUNNEL LINING DESIGN

[Based on Muir Wood (1975) and Curtis (1976)]

Soil Formation : SM[A]



GL 898.33
RL 873.609
Centerline 876.43
Zo 21.90
Bottom Invert 869.68
Invert from GL 28.65
Cover 14.60

Load Combination Assumed

Load Combination	Dead load (DL)		Imposed load (IL)		Ground and Water loads		Seismic Loads (EQ)
	Adverse	Beneficial	Adverse	Beneficial	Adverse	Beneficial	
1.DL+IL	1.5	-	1.5	-	1.5	-	-
2.DL+EQ	1.5	0.9	-	-	-	-	1.5
3.DL+IL+EQ	1.2	-	1.2	-	1.2	-	1.2
4.Collision/Accidental	1.5	1.0	1.5	-	1.5	1.0	-

References:

- Ref 1 Muir Wood, A. M. (1975) The circular tunnel in elastic ground, Geotechnique 25, No. 1, 115 - 127
Ref 2 Curtis, D. J. (1976) Discussion on the reference above, Geotechnique 26, No. 1, 231 - 237
Ref 3 Duddeck, H., Erdmann, J. (1982) Structural design models for tunnels,
Ref 4 Tunnelling 82, International Symposium organised by Institution of Mining & Metallurgy

Notations

Symbol	Description
C	= Cover to tunnel crown
Z_0	= Depth to tunnel axis
D	= Excavated tunnel diameter
r_0	= Radius to extrados of tunnel lining
γ	= Average unit weight of overburden
k	= Constant
E	= Young's modulus for lining
$E_{c,v}$	= Young's modulus and Poisson's ratio of ground
I	= Second moment of inertia of lining per unit length of tunnel
I_e	= Effective value of I for a jointed lining
I_j	= Effective value of I at joint in a lining
M	= Bending moment in lining per unit length of tunnel
N	= Hoop (circumferential) thrust in lining per unit length of tunnel
η	= Ratio of radius of lining centroid to that of extrados
U_{max}	= Maximum radial movement of lining
h_w	= Water table from ground surface

Design Load Combination Assumed

Load Combination	Dead Load (DL*)	Hydrostatic pressure	Earth Pressure	Surcharge	Seismic Load
Case 1	1.5	1.5	1.5	1.5	-
Case 2	1.5	1.5	1.5	-	-
Case 3	1.5	-	1.5	1.5	-
Case 3 (With Seismic)	1.2	-	1.2	1.2	1.2
Case 4 (With Seismic)	1.5	-	1.5	-	1.5
Case 5	1.5	1.1	1.5	-	-
Case 6 (serviceability)	1.0	1.0	1.0	1.0	-
Case 7 (serviceability)	1.0	1.0	1.0	-	-
Case 8 (serviceability)	1.0	-	1.0	-	-
Case 9 (serviceability)	1.0	-	1.0	1.0	-

Load Combination	ULS					SLS			
	1	2	3	4	5	6	7	8	9
Load factor for Over Burden Load	1.50	1.50	1.50	1.50	1.50	1.00	1.00	1.00	1.00
Load Factor for Surcharge	1.50	1.50	1.50	1.50	1.50	1.00	1.00	1.00	1.00
Load Factor for Water	1.50	1.50	1.50	1.50	1.10	1.00	1.00	1.00	1.00
Surcharge (kN/mm2)	60.00	0.00	60.00	0.00	0.00	60.00	0.00	60.00	0.00
Water Table Below Ground Surface	0.00	0.00	21.90	21.90	-1.00	0.00	0.00	21.90	21.90
No of Segments	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
$E_{concrete}$ (MN/m2)	38,730	38,730	38,730	38,730	38,730	38,730	38,730	38,730	38,730
Thickness of lining, T			0.55	m					
Where, Concrete fcu (N/mm2)			60						
No of Segments			9	Ignoring Key Segment					
Unit weight of Water, γ_w			10	kN/m ²					
Lowest Credible Water Level			21.90	m (Assumed water table below the invert and it gives critical condition)					
ULS Load Factor			1.5						
SLS Load Factor			1						
Surcharge			60	kN/m ²					
Young's Modulus Ground			145.50	N/mm ²					
Poisson's ratio of ground			0.3						
Stiffness Modulus of Soil			195.87	N/mm ²					
Effective cohesion of the ground			0	kN/m ²					
Effective friction angle of ground			31	degree					
Poisson's ratio of Concrete v			0.15						
Existing GL			898.33	m					
Road level			873.61	m					
Road Level to Invert of Tunnel			3.929	m					
K_0			0.48						
Bulk Unit Weight of soil, γ			19.1	kN/m ³					
Depth of joint considered for reduced moment of inertia calculation			0.0	mm					








SUMMARY OF RESULTS

Dynamic calculation has been done as per Hashash Paper. The summary of forces and moments obtained are given below:

RESULT OF SEISMIC FORCES		Adopted Values		
		F(kN)	M(kNm)	V(kN)
ODE	FULL SLIP	3.00	19.00	6.00
	NO SLIP	146.91	19.00	6.00
MCE	FULL SLIP	6.00	38.00	11.00
	NO SLIP	293.81	38.00	11.00

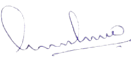
Summary of factored Forces, Moments and displacement from all 9 cases are listed below:

Load Combination		At Axis of Tunnel (per m run)			At Crown of Tunnel (per m run)			V (kN)
		N (kN)	U (mm)	M (kNm)	N (kN)	U (mm)	M (kNm)	
ULS	1	4756.46	7.76	47.41	4037.07	-7.76	-47.41	12.99
	2	4193.63	6.01	36.71	3674.89	-6.01	-36.71	10.06
	3	4412.72	14.15	86.45	2961.00	-14.15	-86.45	23.69
	4	3849.89	12.40	75.76	2598.82	-12.40	-75.76	20.75
	5	3540.65	5.72	34.93	3055.34	-5.72	-34.93	9.57
SLS	6	3288.45	4.87	29.73	2573.91	-4.87	-29.73	8.14
	7	2880.35	3.78	23.12	2365.33	-3.79	-23.12	6.33
	8	3143.80	8.91	54.41	1772.01	-8.91	-54.41	14.91
	9	2749.42	7.79	47.58	1549.72	-7.79	-47.58	13.04

Dynamic forces are now added with appropriate factors to obtain final set of forces

Load Combination			Dynamic Load Factor	At Axis of Tunnel (per m run)						Shear Force	
				SUMMARY OF FORCES		Factored Dynamic results		Final Results		Factored	Final
				N (kN)	M (kNm)	N (kN)	M (kNm)	N (kN)	M (kNm)	V (kN)	V (kN)
ULS CASE	Static	1	0	4756.5	47.4	0.0	0.0	4756.5	47.4	0.00	12.99
	Static	2	0	4193.6	36.7	0.0	0.0	4193.6	36.7	0.00	10.06
	Static	3	0	4412.7	86.5	0.0	0.0	4412.7	86.5	0.00	23.69
	Dynamic ODE FS	3A	1.2	3530.2	69.2	3.6	22.8	3533.8	92.0	7.20	30.89
	Dynamic ODE NS	3B	1.2	3530.2	69.2	176.3	22.8	3706.5	92.0	7.20	30.89
	Dynamic MCE FS	3C	1	2941.8	57.6	6.0	38.0	2947.8	95.6	11.00	34.69
	Dynamic MCE NS	3D	1	2941.8	57.6	293.8	38.0	3235.6	95.6	11.00	34.69
	Dynamic ODE FS	4A	1.5	3849.9	75.8	4.5	28.5	3854.4	104.3	9.00	32.69
	Dynamic ODE NS	4B	1.5	3849.9	75.8	220.4	28.5	4070.3	104.3	9.00	32.69
	Dynamic MCE FS	4C	1	2566.6	50.5	6.0	38.0	2572.6	88.5	11.00	34.69
	Dynamic MCE NS	4D	1	2566.6	50.5	293.8	38.0	2860.4	88.5	11.00	34.69
	Static	5	0	3540.6	34.9	0.0	0.0	3540.6	34.9	0.00	9.57
SLS	Static	6	0	3288.4	29.7	0.0	0.0	3288.4	29.7	0	8.14
	Static	7	0	2880.4	23.1	0.0	0.0	2880.4	23.1	0	6.33
	Static	8	0	3143.8	54.4	0.0	0.0	3143.8	54.4	0	14.91
	Static	9	0	2749.4	47.6	0.0	0.0	2749.4	47.6	0	13.04

Load Combination			Dynamic Load Factor	At Crown of Tunnel (per m run)						Shear Force	
				SUMMARY OF FORCES		Factored Dynamic results		Final Results		Factored	Final
				N (kN)	M (kNm)	N (kN)	M (kNm)	N (kN)	M (kNm)	V (kN)	V (kN)
ULS CASE	Static	1	0	4037.1	-47.4	0.0	0.0	4037.1	47.4	0.00	12.99
	Static	2	0	3674.9	-36.7	0.0	0.0	3674.9	36.7	0.00	10.06
	Static	3	0	2961.0	-86.5	0.0	0.0	2961.0	86.5	0.00	23.69
	Dynamic ODE FS	3A	1.2	2368.8	-69.2	3.6	22.8	2372.4	92.0	7.20	30.89
	Dynamic ODE NS	3B	1.2	2368.8	-69.2	176.3	22.8	2545.1	92.0	7.20	30.89
	Dynamic MCE FS	3C	1	1974.0	-57.6	6.0	38.0	1980.0	95.6	11.00	34.69
	Dynamic MCE NS	3D	1	1974.0	-57.6	293.8	38.0	2267.8	95.6	11.00	34.69
	Dynamic ODE FS	4A	1.5	2598.8	-75.8	4.5	0.0	2603.3	75.8	9.00	32.69
	Dynamic ODE NS	4B	1.5	2598.8	-75.8	220.4	28.5	2819.2	104.3	9.00	32.69
	Dynamic MCE FS	4C	1	1732.5	-50.5	6.0	38.0	1738.5	88.5	11.00	34.69
	Dynamic MCE NS	4D	1	1732.5	-50.5	293.8	38.0	2026.4	88.5	11.00	34.69
	Static	5	0	3055.3	-34.9	0.0	0.0	3055.3	34.9	0.00	9.57
SLS	Static	6	0	2573.9	-29.7	0.0	0.0	2573.9	29.7	0	8.14
	Static	7	0	2365.3	-23.1	0.0	0.0	2365.3	23.1	0	6.33
	Static	8	0	1772.0	-54.4	0.0	0.0	1772.0	54.4	0	14.91
	Static	9	0	1549.7	-47.6	0.0	0.0	1549.7	47.6	0	13.04







		GEOCONSULT India Pvt Ltd		ANNEXURE -1	
		A company of the GEOCONSULT group		Job no:	140172
				Page No.:	
Project:		DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Calculation for		Ground Force Calculation by- Muir Wood (1975) and Curtis (1976)			
LOAD COMBINATION 1 * ULS for Short Term * Flexible Lining * No Creep					
1. ALIGNMENT DATA					
Nominal Diameter of Tunnel		D _n	=	13.3	m
Construction Allowance		ΔD	=	100	mm
Thickness of Lining		t	=	0.55	m
Existing Ground Level:		GL	=	898.33	m
Road Level:		RL	=	873.609	m
Tunnel invert to Road Level		d	=	3.929	m
2. TUNNEL GEOMETRY					
Excavated Diameter of Tunnel		D	=	14.6	m
Internal radius of tunnel		ri	=	6.750	m
Radius of lining centroid		re	=	7.025	m
Radius to extrados of lining		ro	=	7.300	m
Distance between tunnel axis to road level			=	2.8210	m
Depth to Tunnel Axis		Zo	=	21.900	m
$\sigma'_h = K\sigma'_v$ $p_0 = \sigma'_v - \sigma'_h$					
3. LOADING					
Ave. unit weight of Water		γ _w	=	10	kN/m ³
Ave. unit weight of soil		γ _s	=	19.10	kN/m ³
Water table from ground surface		h _w	=	0	m
Height of Water Table considered in design		h _w	=	21.90	m
Effective overburden pressure		q1	=	199.3	kN/m ²
Surcharge		q2	=	60	kN/m ²
Load factor for Overburden Load		FS1	=	1.5	
Load factor for Surcharge		FS2	=	1.5	
Factored vertical stress		σ _v '	=	388.94	kN/m ²
k value		K	=	0.479	
Factored horizontal stress, σ _h ' = kσ _v '		σ _h '	=	186.3	kN/m ²
Po = σ _v ' - σ _h '		Po	=	202.6	kN/m ²
Load factor for Water		Fsw	=	1.50	
Hydrostatic water pressure		psw	=	328.50	kN/m ²
		Unfactored load at tunnel crown	=	192.9	kN/m ²
		Unfactored load at tunnel axis	=	259.3	kN/m ²
$p_* = \frac{q_1 + Kq_2}{2}$ $\tau = c' + p_* \tan \phi'$					
4. SHEAR STRENGTH OF SOIL					
Uniform loading, Pu = (q1+ kq1) / 2		Pu	=	158.53	kN/m ²
Maximum shear strength of ground, τ = c' + Pu tanΦ		τ	=	96.77	kN/m ²
$I_e = I_f + \left(\frac{4}{n}\right)^2 I_f, \quad n > 4$ $\tau = c' + p_* \tan \phi'$					
5. PROPERTIES OF GROUND AND LINING					
Young's modulus of ground		Ec	=	195865.385	kN/m ²
Poisson's ratio of ground		v	=	0.3	
Effective cohesion of the ground		c'	=	0	kN/m ²
Effective friction angle of ground		Φ	=	31	Degree
Maximum shear strength of ground,(τ = c' + Pu tanΦ)		τ	=	96.77	kN/m ²
Young's modulus of lining		E _l	=	38730	N/mm ²
Poisson's ratio of lining		v _l	=	0.15	
E of lining in plane strain condition		E ₁	=	39621	N/mm ²
Area of lining		A	=	0.55	m ²
Second moment of area of lining		I	=	0.01386	m ⁴
Total no. of segments		n=	=	9	
Reduced Lining, Ie = Ij +(4/n)^2, (n>4)		Ie =	=	0.002739	m ⁴

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu) \frac{P_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6} (2S_n + S_t) \cos 2\theta$$

$$M_d = -\frac{r_0^2}{6} (2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3} (S_n + 2S_t) \cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3} (S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI} (2S_n + S_t) \cos 2\theta + U_w + U_u$$

$$U_w = -\frac{P_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI} (2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0} (-2)(2S_n + S_t) \sin 2\theta = \frac{r_0}{3} (2S_n + S_t) \sin 2\theta$$

$$V_d = \frac{r_0}{3} (2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2v/3-4v)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4v)*(p0/2) - (2Q2 + (4-6v))\tau) / (4Q2 + 5-6v), \text{ (if } St > \tau)$$

$$St = (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]$$

$$M = -r0^2/6*(2Sn + St)*cos2\theta$$

$$Md = -r0^2/6*(2Sn + St)$$

$$N = -r0/3*(Sn + 2St)cos2\theta + Pw*r0 + No$$

$$Nd = -r0/3*(Sn + 2St)$$

$$No = \sigma_v(1+k)*r0/2 + [2Ec*r0/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Uu = -No*r0/E*A$$

$$U = -r0^4/18EI*(2Sn+St)*cos2q + Uw + Uu$$

$$Ud = -r0^4/(18E*I)*(2*Sn+St)$$

$$x=rq$$

$$dx/dq=r$$

$$V = r0/3*(2Sn+St)*sin2q$$

$$Vd = r0/3*(2Sn+St)$$

Q2	=	45.012
Sn	=	-73.08
Sn	=	-45.7
St	=	151
M	=	-47
Md	=	-47
N	=	4037
Nd	=	-359.69
No	=	1998.72
Uw	=	0.00
Uu	=	0.0
U	=	-2
Ud	=	0.01
V	=	0
Vd	=	12.988

Q2	τ	St ($\leq \tau$)	Sn	$P_w r_0$	N_0	Uw (mm)	Uu (mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	97	97	-45.7	2398	1998.72	0.00	0.00	-360	0.01	-47.4
										Vd (kN)
										13.0

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	4037.074	-7.762	-47.408	0	CROWN
10	4058.766	-7.294	-44.549	4	
20	4121.226	-5.947	-36.316	8	
30	4216.920	-3.882	-23.704	11	
40	4334.306	-1.349	-8.232	13	
45	4396.766	-0.001	0.000	13	
50	4459.225	1.346	8.232	13	
60	4576.611	3.879	23.704	11	
70	4672.305	5.944	36.316	8	
80	4734.765	7.291	44.549	4	
90	4756.457	7.759	47.408	0	
					AXIS

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signatures: Shunhua, ~~Adai~~, Rob, Ericson, David Wong

6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5 - 6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_t)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_t)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_n$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_n = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_t)\sin 2\theta = \frac{r_0}{3}(2S_n + S_t)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_t)$$

$$Q2 = Ee^* r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2v/3-4v)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4v)*(p0/2)-(2Q2+(4-6v))\tau)/4Q2+5-6v, \text{ (if } St > \tau)$$

$$St = (1+2Q2)Po/2/[1+Q2(3-2v/3-4v)]$$

$$M = -r0^2/6*(2Sn + St)*cos2\theta$$

$$Md = -r0^2/6*(2Sn + St)$$

$$N = -r0/3*(Sn + 2St)cos2\theta + Pw*r0 + No$$

$$Nd = -r0/3*(Sn + 2St)$$

$$No = \sigma_v(1+k)*r0/2 + [2Ec*r0/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Un = -No*r0/E*A$$

$$U = -r0^4/18EI*(2Sn + St)*cos2\theta + Uw + Un$$

$$Ud = -r0^4/(18E*I)*(2*Sn + St)$$

$$x = r\theta \quad dx/d\theta = r$$

$$V = 0/3*(2Sn + St)*sin2\theta$$

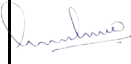
$$Vd = r0/3*(2Sn + St)$$

Q2	=	45.012
Sn	=	-56.17
St	=	-32.77
M	=	116
Md	=	-37
N	=	3675
Nd	=	-259.37
No	=	1536.21
Uw	=	0.00
Un	=	0.0
U	=	-1
Ud	=	6.01
V	=	0
Vd	=	10.058

Q2	τ	St (<= τ)	Sn	$p_w r_e$	N ₀	U _w (mm)	U _u (mm)	N _d (kN)	U _d (mm)	M _d (kNm)
45.0123	70	70	-32.8	2398	1536.21	0.00	0.00	-259	6.01	-36.7

V _d (kN)
10.1

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	3674.889	-6.011	-36.710	0	CROWN
10	3690.531	-5.648	-34.496	3	
20	3735.570	-4.605	-28.122	6	
30	3804.575	-3.006	-18.355	9	
40	3889.221	-1.045	-6.375	10	
45	3934.261	-0.001	0.000	10	
50	3979.300	1.042	6.375	10	
60	4063.946	3.003	18.355	9	
70	4132.951	4.602	28.122	6	
80	4177.990	5.646	34.496	3	
90	4193.632	6.008	36.710	0	AXIS

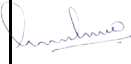








		GEOCONSULT India Pvt Ltd		ANNEXURE -1	
		A company of the GEOCONSULT group		Job no:	140172
				Page No.:	-
Project:		DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Calculation for		Ground Force Calculation by- Muir Wood (1975) and Curtis (1976)			
LOAD COMBINATION 3 * ULS for Short Term * Flexible Lining * No Creep					
1. ALIGNMENT DATA					
Nominal Diameter of Tunnel		D_n	=	13.30	m
Construction Allowance		ΔD	=	100.00	mm
Thickness of Lining		t	=	0.550	m
Existing Ground Level:		GL	=	898.33	m
Road Level:		RL	=	873.61	m
Tunnel Axis to Road Level		d	=	3.9290	m
2. TUNNEL GEOMETRY					
Excavated Diameter of Tunnel		D	=	14.600	m
Internal radius of tunnel		r_i	=	6.750	m
Radius of lining centroid		r_o	=	7.025	m
Radius to extrados of lining		r_e	=	7.300	m
Distance between tunnel axis to road level			=	2.821	m
Depth to Tunnel Axis		Z_o	=	21.900	m
$\sigma'_h = K \sigma'_v$ $p_o = \sigma'_v - \sigma'_h$					
3. LOADING					
Ave. unit weight of Water		γ_w	=	10	kN/m ³
Ave. unit weight of soil		γ_s	=	19.10	kN/m ³
Water table from ground surface		h_w	=	21.9	m
Height of Water Table considered in design		h_w	=	2.4869E-14	m
Effective overburden pressure		q_1	=	418.3	kN/m ²
Surcharge		q_2	=	60	kN/m ²
Load factor for Overburden Load		FS_1	=	1.5	
Load factor for Surcharge		FS_2	=	1.5	
Factored vertical stress		σ_v'	=	717.44	kN/m ²
k value		K	=	0.4790	
Factored horizontal stress, $\sigma_h' = k \sigma_v'$		σ_h'	=	343.6	kN/m ²
$P_o = \sigma_v' - \sigma_h'$		P_o	=	373.8	kN/m ²
Load factor for Water		F_{sw}	=	1.5	
Hydrostatic water pressure		p_{sw}	=	0.00	kN/m ²
$p_s = \frac{q_1 + K q_2}{2}$ $\tau = c' + p_s \tan \phi'$ Unfactored load at tunnel crown Unfactored load at tunnel axis					
4. SHEAR STRENGTH OF SOIL					
Uniform loading, $P_u = (q_1 + k q_2) / 2$		P_u	=	320.48	kN/m ²
		τ	=	195.62	kN/m ²
$I_s = I_1 + \left(\frac{4}{n}\right)^2 I_1, \quad n > 4$ $\tau = c' + p_s \tan \phi'$					
5. PROPERTIES OF GROUND AND LINING					
Young's modulus of ground		E_c	=	195865.3846	kN/m ²
Poisson's ratio of ground		ν	=	0.3	
Effective cohesion of the ground		c'	=	0.000	kN/m ²
Effective friction angle of ground		Φ	=	31 Degree	
Maximum shear strength of ground, $(\tau = c' + P_u \tan \Phi)$		τ	=	195.621	kN/m ²
Young's modulus of lining		E_l	=	38730	N/mm ²
Poisson's ratio of lining		ν_l	=	0.15	
E of lining in plane strain condition		E_l	=	39621	N/mm ²
Area of lining		A	=	0.55	m ²
Second moment of area of lining		I	=	0.01386	m ⁴
Total no. of segments		n	=	9	
Reduced Lining, $I_e = I / (4/n)^2, (n > 4)$		I_e	=	0.0027	m ⁴








6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_i < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{P_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_i > \tau$$

$$S_i = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_i)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_i), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_i)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_i)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_i)\cos 2\theta + U_w + U_n$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_n = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_i)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial x} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_i)\sin 2\theta = \frac{r_0}{3}(2S_n + S_i)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_i)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4\nu)*(p0/2)-(2Q2+(4-6\nu))\tau)/4Q2+5-6\nu, \text{ (if } St > \tau)$$

$$St = (1+2Q2)Po/2[1+Q2(3-2\nu/3-4\nu)]$$

$$M = -r0^2/6*(2Sn + St)*\cos 2\theta$$

$$Md = -r0^2/6*(2Sn + St)$$

$$N = -r0/3*(Sn + 2St)\cos 2\theta + Pw * r0 + No$$

$$Nd = -r0/3*(Sn + 2St)$$

$$No = \sigma'_v(1+K)r0/2 + [2Ec*r0/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Un = No*r0/E*A$$

$$U = -r0^4/18EI*(2Sn + St)*\cos 2\theta + Uw + Un$$

$$Ud = -r0^4/18EI*(2*Sn + St)$$

$$x = r\theta$$

$$dx/d\theta = r$$

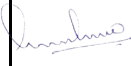
$$V = r0/3*(2Sn + St)*\sin 2\theta$$

$$Vd = r0/3*(2Sn + St)$$

Q2	=	45.012
Sn	=	-134.81
Sn	=	-92.94
St	=	279
M	=	-86
Md	=	-86
N	=	2961
Nd	=	-725.86
No	=	3686.86
Uw	=	0.00
Un	=	0.0
U	=	-3
Ud	=	0.01
V	=	0
Vd	=	23.686

Q2	τ	St (<= τ)	Sn	$p_w r_e$	N ₀	Uw (mm)	Un (mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	196	196	-92.9	0	3686.86	0.00	0.00	-726	0.01	-86.5
										Vd (kN)
										23.7

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	2961.001	-14.154	-86.453	0	CROWN
10	3004.775	-13.300	-81.239	8	
20	3130.819	-10.843	-66.227	15	
30	3323.930	-7.077	-43.227	21	
40	3560.815	-2.459	-15.012	23	
45	3686.859	-0.001	0.000	24	
50	3812.903	2.456	15.012	23	
60	4049.788	7.075	43.227	21	
70	4242.899	10.840	66.227	15	
80	4368.943	13.298	81.239	8	
90	4412.717	14.151	86.453	0	AXIS

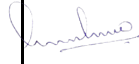








 </	
--	--








6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_c r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu) \frac{p_0}{2} - \{2Q_2 + (4-6\nu)\} \tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6} (2S_n + S_t) \cos 2\theta$$

$$M_d = -\frac{r_0^2}{6} (2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3} (S_n + 2S_t) \cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3} (S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_v (1+K) r_0}{2 + \frac{2E_c r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI} (2S_n + S_t) \cos 2\theta + U_w + U_s$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_s = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI} (2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0} (-2)(2S_n + S_t) \sin 2\theta = \frac{r_0}{3} (2S_n + S_t) \sin 2\theta$$

$$V_d = \frac{r_0}{3} (2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2v/3-4v)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4v)*(p0/2) - (2Q2 + (4-6v))\tau) / (4Q2 + 5-6v), \text{ (if } St > \tau)$$

$$St = (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]$$

$$M = -r0^2/6*(2Sn + St)*cos2\theta$$

$$Md = -r0^2/6*(2Sn + St)$$

$$N = -r0/3*(Sn + 2St)cos2\theta + Pw * r0 + No$$

$$Nd = -r0/3*(Sn + 2St)$$

$$No = \sigma_v(1+k)*r0/2 + [2Ec*r0/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Us = -No*r0/E*A$$

$$U = -r0^4/18EI*(2Sn + St)*cos2\theta + Uw + Us$$

$$Ud = -r0^4/(18EI)*(2*Sn + St)$$

$$x=rq \quad dx/dq=r$$

$$V=r0/3*(2Sn + St)*sin2q$$

$$Vd=r0/3*(2Sn + St)$$

Q2	=	45.012
Sn	=	-117.90
Sn	=	-80.00
St	=	244
M	=	-76
Md	=	-76
N	=	2599
Nd	=	-625.54
No	=	3224.35
Uw	=	0.00
Us	=	0.0
U	=	-3
Ud	=	0.01
V	=	0
Vd	=	20.755

Q2	τ	St (<= τ)	Sn	$p_w r_e$	N ₀	Uw (mm)	Us (mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	169	169	-80.0	0	3224.35	0.00	0.00	-626	0.01	-75.8
										Vd (kN)
										20.8

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	2598.815	-12.402	-75.756	0	CROWN
10	2636.540	-11.655	-71.187	7	
20	2745.163	-9.501	-58.032	13	
30	2911.585	-6.202	-37.878	18	
40	3115.730	-2.155	-13.155	20	
45	3224.354	-0.001	0.000	21	
50	3332.978	2.152	13.155	20	
60	3537.123	6.200	37.878	18	
70	3703.544	9.499	58.032	13	
80	3812.168	11.652	71.187	7	
90	3849.893	12.400	75.756	0	AXIS

Shamshad

Adar

Rob

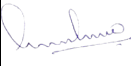
MSD

MSD

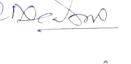
MSD

MSD

	GEOCONSULT India Pvt Ltd		ANNEXURE -1																															
	A company of the GEOCONSULT group		Job no.:	I40172																														
		Page No.:		-																														
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction																																	
Calculation for	Ground Force Calculation by- Muir Wood (1975) and Curtis (1976)																																	
LOAD COMBINATION S * ULS for Short Term * Flexible Lining * No Creep																																		
1. ALIGNMENT DATA <table> <tr> <td>Nominal Diameter of Tunnel</td> <td>D_n</td> <td>=</td> <td>13.3</td> <td>m</td> </tr> <tr> <td>Construction Allowance</td> <td>ΔD</td> <td>=</td> <td>100</td> <td>mm</td> </tr> <tr> <td>Thickness of Lining</td> <td>t</td> <td>=</td> <td>0.55</td> <td>m</td> </tr> <tr> <td>Existing Ground Level:</td> <td>GL</td> <td>=</td> <td>898.33</td> <td>m</td> </tr> <tr> <td>Road Level:</td> <td>RL</td> <td>=</td> <td>873.609</td> <td>m</td> </tr> <tr> <td>Tunnel Axis to Road Level</td> <td>d</td> <td>=</td> <td>3.93</td> <td>m</td> </tr> </table>					Nominal Diameter of Tunnel	D _n	=	13.3	m	Construction Allowance	ΔD	=	100	mm	Thickness of Lining	t	=	0.55	m	Existing Ground Level:	GL	=	898.33	m	Road Level:	RL	=	873.609	m	Tunnel Axis to Road Level	d	=	3.93	m
Nominal Diameter of Tunnel	D _n	=	13.3	m																														
Construction Allowance	ΔD	=	100	mm																														
Thickness of Lining	t	=	0.55	m																														
Existing Ground Level:	GL	=	898.33	m																														
Road Level:	RL	=	873.609	m																														
Tunnel Axis to Road Level	d	=	3.93	m																														









6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_i < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_i > \tau$$

$$S_i = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_i)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_i), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_i)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_i)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_i)\cos 2\theta + U_w + U_n$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_n = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_i)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_i)\sin 2\theta = \frac{r_0}{3}(2S_n + S_i)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_i)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2v/3-4v)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4v)*(p0/2)-(2Q2+(4-6v))\tau)/(4Q2+5-6v), \text{ (if } St > \tau)$$

$$St = (1+2Q2)Po/2/[1+Q2(3-2v/3-4v)]$$

$$M = -ro^2/6*(2Sn + St)*cos2\theta$$

$$Md = -ro^2/6*(2Sn + St)$$

$$N = -ro/3*(Sn + 2St)cos2\theta + Pw * r0 + No$$

$$Nd = -ro/3*(Sn + 2St)$$

$$No = \sigma'_v(1+k)*ro/2 + [2Ec*ro/Et*(1+\nu)]$$

$$Uw = -pw * ro^2/E * A$$

$$Un = -No * ro/E * A$$

$$U = -ro^4/18EI*(2Sn + St)*cos2\theta + Uw + Un$$

$$Ud = -ro^4/18EI*(2*Sn + St)$$

$$x = r\theta \quad dx/d\theta = r$$

$$V = r0/3*(2Sn + St)*sin2\theta$$

$$Vd = ro/3*(2Sn + St)$$

Q2	=	45.012
Sn	=	-53.35
Sn	=	-30.62
St	=	110
M	=	-35
Md	=	-35
N	=	3055
Nd	=	-242.65
No	=	1459.13
Uw	=	0.00
Un	=	0.0
U	=	-1
Ud	=	0.01
V	=	0
Vd	=	9.569

Q2	τ	St ($\leq \tau$)	Sn	$P_w r_0$	N_0	Uw (mm)	Uu (mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	65	65	-30.6	1839	1459.13	0.00	0.00	-243	0.01	-34.9
										Vd (kN)
										9.6

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	3055.345	-5.719	-34.928	0	CROWN
10	3069.978	-5.374	-32.821	3	
20	3112.114	-4.381	-26.756	6	
30	3176.671	-2.860	-17.464	8	
40	3255.860	-0.994	-6.065	9	
45	3297.996	-0.001	0.000	10	
50	3340.132	0.992	6.065	9	
60	3419.322	2.858	17.464	8	
70	3483.878	4.379	26.756	6	
80	3526.014	5.372	32.821	3	
90	3540.648	5.717	34.928	0	
					AXIS

Handwritten signature

Handwritten signature

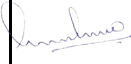
Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

	GEOCONSULT India Pvt Ltd		ANNEXURE -1																									
	A company of the GEOCONSULT group		Job no:	140172																								
		Page No.:		-																								
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction																											
Calculation for	Ground Force Calculation by- Muir Wood (1975) and Curtis (1976)																											
LOAD COMBINATION 7 * SLS for Short Term * Flexible Lining * No Creep																												
1. ALIGNMENT DATA <table> <tr> <td>Nominal Diameter of Tunnel</td> <td>D_n</td> <td>=</td> <td>13.3 m</td> </tr> <tr> <td>Construction Allowance</td> <td>ΔD</td> <td>=</td> <td>100 mm</td> </tr> <tr> <td>Thickness of Lining</td> <td>t</td> <td>=</td> <td>0.55 m</td> </tr> <tr> <td>Existing Ground Level:</td> <td>GL</td> <td>=</td> <td>898.33 m</td> </tr> <tr> <td>Road Level:</td> <td>RL</td> <td>=</td> <td>873.609 m</td> </tr> <tr> <td>Tunnel Axis to Road Level</td> <td>d</td> <td>=</td> <td>3.929 m</td> </tr> </table>					Nominal Diameter of Tunnel	D_n	=	13.3 m	Construction Allowance	ΔD	=	100 mm	Thickness of Lining	t	=	0.55 m	Existing Ground Level:	GL	=	898.33 m	Road Level:	RL	=	873.609 m	Tunnel Axis to Road Level	d	=	3.929 m
Nominal Diameter of Tunnel	D_n	=	13.3 m																									
Construction Allowance	ΔD	=	100 mm																									
Thickness of Lining	t	=	0.55 m																									
Existing Ground Level:	GL	=	898.33 m																									
Road Level:	RL	=	873.609 m																									
Tunnel Axis to Road Level	d	=	3.929 m																									







6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_c r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_t)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_t)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_t)$$

$$N_0 = \frac{\sigma_v'(1+K)r_0}{2 + \frac{2E_c r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_u$$

$$U_w = -\frac{P_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_t)\sin 2\theta = \frac{r_0}{3}(2S_n + S_t)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4\nu)*(po/2) - (2Q2 + (4-6\nu))\tau) / (4Q2 + 5-6\nu), \text{ (if } St > \tau)$$

$$St = (1+2Q2)po/2[1+Q2(3-2\nu/3-4\nu)]$$

$$M = -r0^2/6*(2Sn + St)*\cos 2\theta$$

$$Md = -r0^2/6*(2Sn + St)$$

$$N = -r0/3*(Sn + 2St)\cos 2\theta + Pw * r0 + No$$

$$Nd = -r0/3*(Sn + 2St)$$

$$No = \sigma_v'(1+k)*r0/2 + [2Ec*r0/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Uu = -No*r0/E*A$$

$$U = -r0^4/18EI*(2Sn + St)*\cos 2\theta + Uw + Uu$$

$$Ud = -r0^4/18EI*(2Sn + St)$$

$$x = r\theta \quad dx/d\theta = r$$

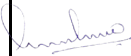
$$V = r0/3*(2Sn + St)*\sin 2\theta$$

$$Vd = r0/3*(2Sn + St)$$

Q2	=	45.012
Sn	=	-48.72
Sn	=	-46.71
St	=	101
M	=	-30
Md	=	-30
N	=	2574
Nd	=	-357.27
No	=	1332.48
Uw	=	0.00
Uu	=	0.0
U	=	-1
Ud	=	0.00
V	=	0
Vd	=	8.145

Q2	τ	St ($\leq \tau$)	Sn	$P_w r_e$	N_0	Uw (mm)	Uu (mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	97	97	-46.7	1599	1332.48	0.00	0.00	-357	0.00	-29.7
										Vd (kN)
										8.1

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	2573.907	-4.868	-29.729	0	CROWN
10	2595.453	-4.574	-27.936	3	
20	2657.493	-3.729	-22.774	5	
30	2752.542	-2.434	-14.865	7	
40	2869.138	-0.846	-5.162	8	
45	2931.177	-0.001	0.000	8	
50	2993.216	0.844	5.162	8	
60	3109.812	2.432	14.865	7	
70	3204.861	3.727	22.774	5	
80	3266.901	4.572	27.936	3	
90	3288.447	4.866	29.729	0	AXIS








GROUP GEOCONSULT India Pvt Ltd		ANNEXURE -1	
A company of the GEOCONSULT group		Job no:	140172
		Page No.:	-
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction		
Calculation for	Ground Force Calculation by- Muir Wood (1975) and Curtis (1976)		
LOAD COMBINATION 8 * SLS for Short Term * Flexible Lining * No Creep			
1. ALIGNMENT DATA			
Nominal Diameter of Tunnel	D _n	=	13.3 m
Construction Allowance	ΔD	=	100 mm
Thickness of Lining	t	=	0.55 m
Existing Ground Level:	GL	=	898.33 m
Road Level:	RL	=	873.609 m
Tunnel Axis to Road Level	d	=	3.929 m
2. TUNNEL GEOMETRY			
Excavated Diameter of Tunnel	D	=	14.6 m
Internal radius of tunnel	r _i	=	6.750 m
Radius of lining centroid	r _o	=	7.025 m
Radius to extrados of lining	r _e	=	7.30 m
Distance between tunnel axis to road level		=	2.8210 m
Depth to Tunnel Axis	Z _o	=	21.900 m
$\sigma'_h = K\sigma'_v$ $p_o = \sigma'_v - \sigma'_h$			
3. LOADING			
Ave. unit weight of Water	γ _w	=	10 kN/m ³
Ave. unit weight of soil	γ _s	=	19.10 kN/m ³
Water table from ground surface	h _w	=	0.00 m
Height of Water Table considered in design	h _w	=	21.9 m
Effective overburden pressure	q ₁	=	199.3 kN/m ²
Surcharge	q ₂	=	0.00 kN/m ²
Load factor for Overburden Load	FS1	=	1.00
Load factor for Surcharge	FS2	=	1.00
Factored vertical stress	σ _v '	=	199.29 kN/m ²
k value	K	=	0.48
Factored horizontal stress, σ _h ' = kσ _v '	σ _h '	=	95.5 kN/m ²
P _o = σ _v ' - σ _h '	P _o	=	103.8 kN/m ²
Load factor for Water	F _{sw}	=	1.00
Hydrostatic water pressure	p _{sw}	=	219.00 kN/m ²
$p_s = \frac{q_1 + Kq_1}{2}$ $\tau = c' + p_s \tan \phi'$ Unfactored load at tunnel crown Unfactored load at tunnel axis			
4. SHEAR STRENGTH OF SOIL			
Uniform loading, P _u = (q ₁ + kq ₁) / 2	P _u	=	114.16 kN/m ²
Maximum shear strength of ground, $\tau = c' + P_u \tan \Phi$	τ	=	69.68 kN/m ²
$I_e = I_f + \left(\frac{4}{n}\right)^2 I_f, \quad n > 4$ $\tau = c' + p_s \tan \phi'$			
5. PROPERTIES OF GROUND AND LINING			
Young's modulus of ground	E _c	=	195865.3846 kN/m ²
Poisson's ratio of ground	v	=	0.3
Effective cohesion of the ground	c'	=	0.000 kN/m ²
Effective friction angle of ground	Φ	=	31 Degree
Maximum shear strength of ground,(τ = c' + P _u tanΦ)	τ	=	69.683 kN/m ²
Young's modulus of lining	E _l	=	38730 N/mm ²
Poisson's ratio of lining	v _l	=	0.15
E of lining in plane strain condition	E ₁	=	39621 N/mm ²
Area of lining	A	=	0.55 m ²
Second moment of area of lining	I	=	0.0139 m ⁴
Total no. of segments	n=	=	9
Reduced Lining, I _e = I _j +(4/n) ² , (n>4)	I _e =	=	0.002739 m ⁴







6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_c r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_t)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_t)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_t)$$

$$N_0 = \frac{\sigma_v'(1+K)r_0}{2 + \frac{2E_c r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_u$$

$$U_w = -\frac{P_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_t)\sin 2\theta = \frac{r_0}{3}(2S_n + S_t)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4\nu)*(po/2) - (2Q2 + (4-6\nu))\tau) / (4Q2 + 5-6\nu), \text{ (if } St > \tau)$$

$$St = (1+2Q2)po/2[1+Q2(3-2\nu/3-4\nu)]$$

$$M = -ro^2/6*(2Sn + St)*\cos 2\theta$$

$$Md = -ro^2/6*(2Sn + St)$$

$$N = -ro/3*(Sn + 2St)\cos 2\theta + Pw * r0 + No$$

$$Nd = -ro/3*(Sn + 2St)$$

$$No = \sigma_v'(1+k)*ro/2 + [2Ec*ro/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Uu = -No*r0/E*A$$

$$U = -ro^4/18EI*(2Sn + St)*\cos 2\theta + Uw + Uu$$

$$Ud = -ro^4/18EI*(2Sn + St)$$

$$x = r\theta \quad dx/d\theta = r$$

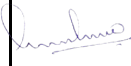
$$V = ro/3*(2Sn + St)*\sin 2\theta$$

$$Vd = ro/3*(2Sn + St)$$

Q2	=	45.012
Sn	=	-37.45
Sn	=	-33.54
St	=	77
M	=	-23
Md	=	-23
N	=	2365
Nd	=	-257.51
No	=	1024.14
Uw	=	0.00
Uu	=	0.0
U	=	-1
Ud	=	0.00
V	=	0
Vd	=	6.335

Q2	τ	St ($\leq \tau$)	Sn	$P_w r_e$	N_0	Uw (mm)	Uu (mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	70	70	-33.5	1599	1024.14	0.00	0.00	-258	0.00	-23.1
										Vd (kN)
										6.3

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	2365.330	-3.786	-23.123	0	CROWN
10	2380.860	-3.558	-21.728	2	
20	2425.576	-2.901	-17.713	4	
30	2494.085	-1.893	-11.561	5	
40	2578.124	-0.658	-4.015	6	
45	2622.840	-0.001	0.000	6	
50	2667.557	0.656	4.015	6	
60	2751.595	1.892	11.561	5	
70	2820.105	2.899	17.713	4	
80	2864.821	3.556	21.728	2	
90	2880.351	3.784	23.123	0	AXIS








	GEOCONSULT India Pvt Ltd		ANNEXURE -1																									
	A company of the GEOCONSULT group		Job no:	140172																								
		Page No.:		-																								
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction																											
Calculation for	Ground Force Calculation by- Muir Wood (1975) and Curtis (1976)																											
LOAD COMBINATION 9 * SLS for Short Term * Flexible Lining * No Creep																												
1. ALIGNMENT DATA <table> <tr> <td>Nominal Diameter of Tunnel</td> <td>D_n</td> <td>=</td> <td>13.3 m</td> </tr> <tr> <td>Construction Allowance</td> <td>ΔD</td> <td>=</td> <td>100 mm</td> </tr> <tr> <td>Thickness of Lining</td> <td>t</td> <td>=</td> <td>0.55 m</td> </tr> <tr> <td>Existing Ground Level:</td> <td>GL</td> <td>=</td> <td>898.33 m</td> </tr> <tr> <td>Road Level:</td> <td>RL</td> <td>=</td> <td>873.609 m</td> </tr> <tr> <td>Tunnel Axis to Road Level</td> <td>d</td> <td>=</td> <td>3.929 m</td> </tr> </table>					Nominal Diameter of Tunnel	D_n	=	13.3 m	Construction Allowance	ΔD	=	100 mm	Thickness of Lining	t	=	0.55 m	Existing Ground Level:	GL	=	898.33 m	Road Level:	RL	=	873.609 m	Tunnel Axis to Road Level	d	=	3.929 m
Nominal Diameter of Tunnel	D_n	=	13.3 m																									
Construction Allowance	ΔD	=	100 mm																									
Thickness of Lining	t	=	0.55 m																									
Existing Ground Level:	GL	=	898.33 m																									
Road Level:	RL	=	873.609 m																									
Tunnel Axis to Road Level	d	=	3.929 m																									








6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_c r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_t)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_t)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_c(1+K)r_0}{2 + \frac{2E_c r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_u$$

$$U_w = -\frac{P_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_t)\sin 2\theta = \frac{r_0}{3}(2S_n + S_t)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4\nu)*(po/2) - (2Q2 + (4-6\nu))\tau) / (4Q2 + 5-6\nu), \text{ (if } St > \tau)$$

$$St = (1+2Q2)po/2[1+Q2(3-2\nu/3-4\nu)]$$

$$M = -ro^2/6*(2Sn + St)*cos2\theta$$

$$Md = -ro^2/6*(2Sn + St)$$

$$N = -ro/3*(Sn + 2St)cos2\theta + Pw* r0 + No$$

$$Nd = -ro/3*(Sn + 2St)$$

$$No = \sigma'_c(1+k)*ro/2 + [2Ec*ro/Et*(1+\nu)]$$

$$Uw = -pw*ro^2/E*A$$

$$Uu = -No*ro/E*A$$

$$U = -ro^4/18EI*(2Sn + St)*cos2q + Uw + Uu$$

$$Ud = -ro^4/18EI*(2Sn + St)$$

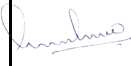
$$x = r\theta \quad dx/d\theta = r$$

$$V = ro/3*(2Sn + St)*sin2q$$

$$Vd = ro/3*(2Sn + St)$$

Q2	=	45.012
Sn	=	-89.87
Sn	=	-94.78
St	=	186
M	=	-54
Md	=	-54
N	=	1772
Nd	=	-685.89
No	=	2457.91
Uw	=	0.00
Uu	=	0.0
U	=	-2
Ud	=	0.01
V	=	0
Vd	=	14.907

Q2	τ	St (<= τ)	Sn	$P_w r_e$	N ₀	U _w (mm)	U _u (mm)	N _d (kN)	U _d (mm)	M _d (kNm)
45.0123	196	186	-89.9	0	2457.91	0.00	0.00	-686	0.01	-54.4
										V _d (kN)
										14.9
θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)						
0	1772.012	-8.908	-54.410	0	CROWN					
10	1813.376	-8.371	-51.128	5						
20	1932.480	-6.824	-41.680	10						
30	2114.959	-4.454	-27.205	13						
40	2338.802	-1.548	-9.448	15						
45	2457.906	-0.001	0.000	15						
50	2577.010	1.546	9.448	15						
60	2800.853	4.453	27.205	13						
70	2983.332	6.822	41.680	10						
80	3102.436	8.369	51.128	5						
90	3143.800	8.906	54.410	0	AXIS					








GROUP		GEOCONSULT India Pvt Ltd		ANNEXURE -1	
		A company of the GEOCONSULT group		Job no:	I40172
				Page No.:	-
Project:		DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Calculation for		Ground Force Calculation by- Muir Wood (1975) and Curtis (1976)			
LOAD COMBINATION 10 * SLS for Short Term * Flexible Lining * No Creep					
1. ALIGNMENT DATA					
Nominal Diameter of Tunnel		D _n	=	13.3	m
Construction Allowance		ΔD	=	100	mm
Thickness of Lining		t	=	0.55	m
Existing Ground Level:		GL	=	898.33	m
Road Level:		RL	=	873.609	m
Tunnel Axis to Road Level		d	=	3.929	m
2. TUNNEL GEOMETRY					
Excavated Diameter of Tunnel		D	=	14.6	m
Internal radius of tunnel		r _i	=	6.750	m
Radius of lining centroid		r _o	=	7.025	m
Radius to extrados of lining		r _e	=	7.30	m
Distance between tunnel axis to road level			=	2.8210	m
Depth to Tunnel Axis		Z _o	=	21.900	m
$\sigma'_h = K\sigma'_v$ $p_o = \sigma'_v - \sigma'_h$					
3. LOADING					
Ave. unit weight of Water		γ _w	=	10	kN/m ³
Ave. unit weight of soil		γ _s	=	19.10	kN/m ³
Water table from ground surface		h _w	=	21.90	m
Height of Water Table considered in design		h _w	=	2.4869E-14	m
Effective overburden pressure		q ₁	=	418.3	kN/m ²
Surcharge		q ₂	=	0.00	kN/m ²
Load factor for Overburden Load		FS1	=	1.00	
Load factor for Surcharge		FS2	=	1.00	
Factored vertical stress		σ _v '	=	418.29	kN/m ²
k value		K	=	0.48	
Factored horizontal stress, σ _h ' = kσ _v '		σ _h '	=	200.4	kN/m ²
P _o = σ _v ' - σ _h '		P _o	=	217.9	kN/m ²
Load factor for Water		F _{sw}	=	1.00	
Hydrostatic water pressure		p _{sw}	=	0.00	kN/m ²
$p_s = \frac{q_1 + Kq_2}{2}$ $\tau = c' + p_s \tan \phi'$ Unfactored load at tunnel crown = 351.86 kN/m² Unfactored load at tunnel axis = 418.29 kN/m²					
4. SHEAR STRENGTH OF SOIL					
Uniform loading, P _u = (q ₁ + kq ₁) / 2		P _u	=	276.11	kN/m ²
Maximum shear strength of ground, τ = c' + P _u tanΦ		τ	=	168.54	kN/m ²
$I_e = I_f + \left(\frac{4}{n}\right)^2 I_f, \quad n > 4$ $\tau = c' + p_s \tan \phi'$					
5. PROPERTIES OF GROUND AND LINING					
Young's modulus of ground		E _c	=	195865.3846	kN/m ²
Poisson's ratio of ground		v	=	0.3	
Effective cohesion of the ground		c'	=	0.000	kN/m ²
Effective friction angle of ground		Φ	=	31	Degree
Maximum shear strength of ground,(τ = c' + P _u tanΦ)		τ	=	168.537	kN/m ²
Young's modulus of lining		E _l	=	38730	N/mm ²
Poisson's ratio of lining		v _l	=	0.15	
E of lining in plane strain condition		E _l	=	39621	N/mm ²
Area of lining		A	=	0.55	m ²
Second moment of area of lining		I	=	0.0139	m ⁴
Total no. of segments		n=	=	9	
Reduced Lining, I _e = I _j +(4/n) ² , (n>4)		I _e =	=	0.002739	m ⁴

6. BENDING MOMENT, HOOP STRESS AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_c r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1 + Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_i < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5 - 6\nu}, \text{ if } S_i > \tau$$

$$S_i = \frac{(1+2Q_2)p_0}{2 \left[1 + Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_i)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_i), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_i)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_i)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_c r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_i)\cos 2\theta + U_w + U_u$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_i)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_i)\sin 2\theta = \frac{r_0}{3}(2S_n + S_i)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_i)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2v/3-4v)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4v)*(po/2) - (2Q2 + (4-6v))\tau) / (4Q2 + 5 - 6v), \text{ (if } St > \tau)$$

$$St = (1+2Q2)po/2[1+Q2(3-2v/3-4v)]$$

$$M = -ro^2/6*(2Sn + St)*cos2\theta$$

$$Md = -ro^2/6*(2Sn + St)$$

$$N = -ro/3*(Sn + 2St)cos2\theta + pw*r0 + No$$

$$Nd = -ro/3*(Sn + 2St)$$

$$No = \sigma_v(1+k)*ro/2 + 2Ec*ro/Et(1+\nu)$$

$$Uw = -pw*r0^2/E*A$$

$$Uu = -No*r0/E*A$$

$$U = -ro^4/18EI*(2Sn + St)*cos2\theta + Uw + Uu$$

$$Ud = -ro^4/18EI*(2Sn + St)$$

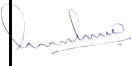
$$x = r\theta \quad dx/d\theta = r$$

$$V = ro/3*(2Sn + St)*sin2\theta$$

$$Vd = ro/3*(2Sn + St)$$

Q2	=	45.012
Sn	=	-78.60
Sn	=	-81.61
St	=	163
M	=	-48
Md	=	-48
N	=	1550
Nd	=	-599.85
No	=	2149.57
Uw	=	0.00
Uu	=	0.0
U	=	-2
Ud	=	0.01
V	=	0
Vd	=	13.037

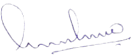
Q2	τ	St ($\leq \tau$)	Sn	$p_w r_e$	N ₀	U _w (mm)	U _u (mm)	N _d (kN)	U _d (mm)	M _d (kNm)
45.0123	169	163	-78.6	0	2149.57	0.00	0.00	-600	0.01	-47.6
										V _d (kN)
										13.0
θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)						
0	1549.718	-7.790	-47.584	0	CROWN					
10	1585.894	-7.321	-44.714	4						
20	1690.057	-5.968	-36.452	8						
30	1849.644	-3.896	-23.792	11						
40	2045.406	-1.353	-8.263	13						
45	2149.569	-0.001	0.000	13						
50	2253.732	1.352	8.263	13						
60	2449.495	3.894	23.792	11						
70	2609.082	5.966	36.452	8						
80	2713.245	7.319	44.714	4						
90	2749.420	7.789	47.584	0	AXIS					








SHEAR AT THE INTERFACE BETWEEN CONCRETE CAST AT DIFFERENT TIMES				
PROJECT:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
PID:	I40172			
Section:	Structural Design of Bored tunnel Segment			
Check for Shear Reinforcement				
Characteristic Strength of steel			500 N/mm ²	
Design Yield strength of shear reinforcement f _{ywd} =			378 N/mm ²	
Depth of the section	D =		0.550 m	
Width of the section	b _w =		1.400 m	
Effective depth	d _t =		0.486 m	
Clear cover	=		50 mm	
Characteristic Strength of concrete	f _{ck} =		60 N/mm ²	
Reinforcement Provided	A _{st} =		1440 mm ²	
	100Ast/bd		0.21 %	
Design Shear Strength of Concrete	τ _c =		0.35 N/mm ²	Table 19, IS 456
For members subjected to axial compression, design shear strength Is multiplied by δ				CI 40.2.2, IS 456
	δ = 1+3P _u /A _g f _{ck}			
Maximum axial compressive force in N	P _u =		4756000 N	
	δ =		1.3	
Design Shear Strength of Concrete	τ _c =		0.457 N/mm ²	
Maximum Shear Strength of Concrete	τ _v =		5.20 N/mm ²	Table 20, IS 456
Shear Force (By MW sheet)	V _u =		91.00 kN	
Shear Stress generated	τ _u =		0.118 N/mm ²	
Shear stress	τ _u =	0.12	<	τ _c = 0.46
NO SHEAR REINFORCEMENT REQUIRED				








**Project Title :****DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction****Job No. :****I40172 Bored Tunnel Segment design -Strestch TS04-Type A - Crack Width Check at Crown (Intrados)****CALCULATION OF CRACK WIDTHS IN CONCRETE MEMBERS** E_c ... E-modulus of concrete f_{cu} ... characteristic strength of concrete f_{ct} ... tensile capacity of concrete at reinforcement level E_s ... E-modulus of steel f_y ... characteristic strength of steel c_{min} ... min. cover to steel

h..... depth of member

d'..... distance to steel

 A_{sc}, A_{st} .. compression / tension reinforcement

s..... spacing of steel bars

N..... axial force due to service load

M..... bending moment due to service load

x..... depth of compression zone

 f_c compressive concrete stress f_s tensile steel stress ϵ_T strain at tension face w_{CR} crack width

$$N = [bx/2 f_{c-c} + ((x-d'))/x (\alpha-1) A_{sc} f_{c-c} - ((d-x))/x \alpha A_{st} f_{c-c}]$$

$$M = [bx/2 f_{c-c} \cdot (h/2 - x/3) + ((x-d'))/x (\alpha-1) A_{sc} f_{c-c} \cdot (h/2 - d') - ((d-x))/x \alpha A_{st} f_{c-c} \cdot (h/2 - d')]$$

$$\epsilon \approx ((h-x))/((d-x)) \cdot f_s / E_s - (b(h-x)^2)/(3E_s A_s (d-x))$$

$$f_s = \frac{(d-x)}{x} \alpha f_c$$

$$w_{cr} = \frac{3a_{cr} \epsilon_m}{1 + 2 \left(\frac{a_{cr} - c_{min}}{h - x} \right)}$$

$$\text{where } a_{cr} = \sqrt{c_{min}^2 + \left(\frac{s}{2} \right)^2} - \frac{d_b}{2}$$

Concrete:		Steel:	
E_c	38,730 N/mm ²	E_s	205,000 N/mm ²
f_{cu}	60.0 N/mm ²	f_y	500.0 N/mm ²
b	1,000 mm	c_{min}	40.0 mm
f_{ct}	0.55 N/mm ²	d_b	12.0 mm
α	10.6	d_{link}	8.0 mm

Calculation performed for :
long - term case**Solve Crack**PRESS BUTTON
to solve crack equationsCrack width limit **0.3**

CASE	h [mm]	d [mm]	d' [mm]	$A_{s,c}$ [mm ²]	$A_{s,T}$ [mm ²]	s [mm]	$a_{c,r}$ [mm]	N [kN]	M [kNm]	x [mm]	f_c [N/mm ²]	f_s [N/mm ²]	ϵ [*1000]	w_{CR} [mm]	f_s' [N/mm ²]	N_i [kN]	M_i [kNm]	STATUS
1	550	496	54	647	647	200	108	3288.4	29.7	803	8.0	-32.5	-0.13	0.000	79	3288.4	29.7	OK
2	550	496	54	647	647	200	108	2880.4	23.1	806	7.0	-28.5	-0.11	0.000	69	2880.4	23.1	OK
3	550	496	54	647	647	200	108	3143.8	54.4	778	7.9	-30.4	-0.12	0.000	78	3143.8	54.4	OK
4	550	496	54	647	647	200	108	2749.4	47.6	778	6.9	-26.5	-0.10	0.000	68	2749.4	47.6	OK
5	550	496	54	647	647	200	108	0.0	0.0	387	0.0	0.0	-0.61	0.000	0	0.0	0.0	OK
6	550	496	54	647	647	200	108	0.0	0.0	394	0.0	0.0	-0.60	0.000	0	0.0	0.0	OK
7	550	496	54	647	647	200	108	0.0	0.0	323	0.0	0.0	-0.75	0.000	0	0.0	0.0	OK
8	550	496	54	647	647	200	108	0.0	0.0	330	0.0	0.0	-0.73	0.000	0	0.0	0.0	OK

Handwritten signatures and initials at the bottom right of the page.



Project Title :

DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction

Job No. :

I40172 Bored Tunnel Segment design -Strestch TS04-Type A - Crack Width Check at Crown (Extrados)**CALCULATION OF CRACK WIDTHS IN CONCRETE MEMBERS** E_C .. E-modulus of concrete f_{CU} .. characteristic strength of concrete f_{CT} .. tensile capacity of concrete at reinforcement level E_S ... E-modulus of steel f_y characteristic strength of steel C_{MIN} . min. cover to steel

h..... depth of member

d'..... distance to steel

 A_{SC}, A_{ST} .. compression / tension reinforcement

s..... spacing of steel bars

N..... axial force due to service load

M..... bending moment due to service load

x..... depth of compression zone

 f_C compressive concrete stress f_S tensile steel stress ϵ_T strain at tension face w_{CR} crack width

$$N = [bx/2 f_c + ((x-d'))/x (\alpha-1) A_{sc} f_c - ((d-x))/x \alpha A_{st} f_c]$$

$$M = [bx/2 f_c \cdot (h/2 - x/3) + ((x-d'))/x (\alpha-1) A_{sc} f_c \cdot (h/2 - d') - ((d-x))/x \alpha A_{st} f_c \cdot (h/2 - d')]$$

$$f_s = \frac{(d-x)}{x} \alpha f_c$$

$$\epsilon \approx ((h-x))/((d-x)) \cdot f_s / E_s - (b(h-x)^2)/(3E_s A_s (d-x))$$

$$w_{cr} = \frac{3a_{cr} \epsilon_m}{1 + 2 \left(\frac{a_{cr} - c_{min}}{h - x} \right)}$$

$$\text{where } a_{cr} = \sqrt{c_{min}^2 + \left(\frac{s}{2} \right)^2} - \frac{d_b}{2}$$

Concrete:			Steel:		
E_C	38,730	N/mm ²	E_S	205,000	N/mm ²
f_{CU}	60.0	N/mm ²	f_y	500.0	N/mm ²
b	1,000	mm	C_{MIN}	50.0	mm
f_{CT}	0.55	N/mm ²	d_b	12.0	mm
α	10.6		d_{link}	8.0	mm

Calculation performed for :
long - term case**Solve Crack**

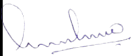
PRESS BUTTON

to solve crack equations

Crack width limit **0.2**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CASE	h [mm]	d [mm]	d' [mm]	$A_{s,c}$ [mm ²]	$A_{s,t}$ [mm ²]	s [mm]	$a_{c,r}$ [mm]	N [kN]	M [kNm]	x [mm]	f_c [N/mm ²]	f_s [N/mm ²]	ϵ [*1000]	w_{CR} [mm]		f_s' [N/mm ²]	N_i [kN]	M_i [kNm]		STATUS
1	550	486	64	647	647	200	113	3288.4	29.7	802	8.0	-33.5	-0.13	0.000	-	78	3288.4	29.7		OK
2	550	486	64	647	647	200	113	2880.4	23.1	805	7.0	-29.4	-0.11	0.000	-	68	2880.4	23.1		OK
3	550	486	64	647	647	200	113	3143.8	54.4	777	7.9	-31.4	-0.12	0.000	-	77	3143.8	54.4		OK
4	550	486	64	647	647	200	113	2749.4	47.6	777	6.9	-27.5	-0.10	0.000	-	67	2749.4	47.6		OK
5	550	486	64	647	647	200	113	0.0	0.0	399	0.0	0.0	-0.66	0.000	-	0	0.0	0.0		OK
6	550	486	64	647	647	200	113	0.0	0.0	401	0.0	0.0	-0.66	0.000	-	0	0.0	0.0		OK
7	550	486	64	647	647	200	113	0.0	0.0	390	0.0	0.0	-0.67	0.000	-	0	0.0	0.0		OK
8	550	486	64	647	647	200	113	0.0	0.0	389	0.0	0.0	-0.67	0.000	-	0	0.0	0.0		OK

		GEOCONSULT India Pvt Ltd		Annexure -2	
		A company of the GEOCONSULT group			
PROJECT:		DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Job No		I40172			
Section:		Segmental Lining - Seismic Check Calculation (O.D.E Full Slip CASE)			
Ultimate Limit State Design For Plain And Lightly Reinforced Concrete Structures					
Circular Tunnel ODE Case- Full Slip Condition					
Assumed moment magnitude	(Mw)	Refer Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	6.5	
Assumed ratio of ground motion at tunnel depth to motion at ground surface (tunnel depth 15-30m)	m	Refer Table 4 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	0.8	
Assumed ratio of peak ground velocity (cm/s) to peak ground acceleration (g)	g	Refer Table 2 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	76	
Seismic Zone	ε (*)		=	0.075	
Axial and curvature deformation					
Poisson's ratio of soil	n		=	0.30	
Density of soil	g		=	19.10	KN/m³
Apparent velocity of S-wave propagation	C _s	From Site specific study	=	147	m/s
Peak ground particle acceleration in soil	a _s [g]	m * ε	0.8*0.075	=	0.0600
Earth's gravity	g			=	9.81 m/s²
Peak ground particle velocity in soil	V _s	g * a _s /100	76*0.06/100	=	0.05 m/s
Dynamic Shear modulus of soil	G _m	Em/(2(1+U))	1 /10 x 146.709470175082 x 146.709470175082	=	56 MPa
Dynamic Young's Modulus of Soil	E _m	2G _m (1+U)	2 x 56 x (1 + 0.3)	=	146 MPa
Radius of circular tunnel (internal radius of the lining)	r			=	7.30 m
Angle of incidence	F			=	45 °,degree
Total axial strain	e ^{ab}	(Vs/Cs)*sinF *cosF +((as*g*r)/C _s ²)*cos³F	0.05/146.71*sin45*Π/180*cos45*Π/180+(0.06*9.81*7.3)/0.0456²*cos³45*Π/180	=	0.000226
Allowable compression strain of concrete	e _{allow}			=	0.003500
Ovaling deformation					
Lining thickness	t		=	0.550	m
No of Segments	n		=	9	
Grade of Concrete	Fck		=	60	MPa
Concrete Young's modulus	E _c		=	38,730	MPa
Concrete Poisson's ratio	n _i		=	0.15	
Area of the tunnel lining per unit width	A _t		=	0.550	m²/m
Ij at a joint of lining	Ij		=	0.000000	
Reduced Moment of inertia of the tunnel lining per unit width	I _r	I _r =Ij+ (4/n)²*I	(0) + ((4/9)²) * 0.55³ *1/12	=	0.002739 m4/m
Young's modulus of soil	E	I / (2*t)	0.002739/(2*0.55)	=	0.00996
				=	146 MPa
Use formulations of Penzien (2000) assuming full slip condition					
Maximum free-field shear strain of soil or rock medium	g _{max}	V _s /C _s	0.05/146.71	=	0.00031
Coefficient to calculate R ⁿ	a ⁿ	(12*E _c *I*(5-6*n))/((2r)³*G*(1-n _i ²))	(12*38729.834*0.00274*(5-6*0.3))/((2*7.3)³*3*56*(1-0.15²))	=	0.02393
Lining-soil racking ratio under normal loading only	R ⁿ	4*(1-ν)/(a ⁿ +1)	4*(1-0.3)/(0.024+1)	=	2.73
Lining diametric deflection under normal loading only	Dd ⁿ _{lining}	R ⁿ * g _{max} * 2 * r/2	2.74*0.01*2*7.3/2	=	0.006
Maximum circumferential thrust in tunnel lining	T(p/4)	(12*E _c *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4)) /((2*r)³*(1-n _i ²))	(12*38730*1000*0.003*0.007*cos2(θ+Π/4))/((2*7.3)³*(1-0.15²))	=	3.000 KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	(6*E _c *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4)) /((2*r)²*(1-n _i ²))	(6*38729.834*1000*0.003*0.007*cos2(θ+Π/4))/((2*7.3)²*(1-0.15²))	=	19.000 KNm
Maximum Shear in tunnel lining	V(0)	(24*E _c *1000*I*Dd ⁿ _{lining} *sin2(θ+p/4)) /((2*r)³*(1-n _i ²))	(24*38730*1000*0.003*0.007*sin2(θ+Π/4))/((2*7.3)³*(1-0.15²))	=	6.000 KN
Combined stress from thrust and bending moment due to earthquake	s _e	(T(p/4)/A _t +M(p/4)*(t/2)/I)/1000	(3/0.55+19*(0.55/2)/0.003)/1000	=	1.913 MPa







Use formulations of Wang (1993) assuming full slip condition						
Flexibility ratio of tunnel lining	F	$(E^*(1-n^2)*r^3) / (6*E_i*I^*(1+n))$	$(145.5^*(1-0.3^2)*7.3^3) / (6*38729.834*1^*(1+0.3))$	=	66.875	
Full slip lining response coefficient	K _i	$12^*(1-n)/(2*F+5-6n)$	$12^*(1-0.3)/(2*67+5-6*0.3)$	=	0.06	
Maximum thrust in tunnel lining	T _{max}	$K_i*E*1000*r * g_{max}/(6^*(1+n))$	$0.062*145.5*1000*7.3*0.01/6^*(1+0.3)$	=	3	KN
Maximum bending moment in tunnel cross section due to S-waves	M _{max}	$K_i*E*1000*r^2 * g_{max}/(6^*(1+n))$	$0.062*145.5*1000*7.3^2*0.01/6^*(1+0.3)$	=	19	KNm
Combined stress from thrust and bending moment due to earthquake	s _e	$(T_{max}/A_i+M_{max}*(t/2)/I)/1000$	$(2.6/0.55+18.96*(0.55/2)/1)/1000$	=	1.908	MPa
Required reinforcement			$(1.91 / 2) * 0.55 * 1000 / (2 * 0.87 * 500)$	=	605	mm ²
Characteristic compressive strength of concrete, f _{ck}				=	60.00	MPa
Characteristic axial tensile strength of concrete, f _{ctk}				=	4.10	MPa
g _c (")				=	1.56	
g _n (")				=	1.20	
g _{tot}				=	1.87	
Design value of concrete compressive strength, f _{cd} = α _{cc} * f _{ck} / γ _c				1 * 60/ 1.872	=	32.05 mpa
α _{cc} - coefficient taking account of long term effects on the compressive strength, the recommended value is 1.0						
f _{cd} > σ _e						safe
Design value of the Concrete tensile strength, f _{ctd} = α _{ct} f _{ctk,0.05} / γ _c				1 * 4.1/ 1.872	=	2.19 mpa
α _{ct} , coefficient taking account of long term effects on the tensile strength, the recommended value is 1.0						
f _{ctd} > σ _e						safe

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

**GEOCONSULT India Pvt Ltd**

A company of the GEOCONSULT group

Annexure -2**PROJECT:****DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction****Job No****I40172****Section:****Segmental Lining - Seismic Check Calculation (M.C.E Full Slip CASE)**

Ultimate Limit State Design For Plain And Lightly Reinforced Concrete Structures

Circular Tunnel MCE Case- Full Slip Condition

Assumed moment magnitude	(Mw)	Refer Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	6.5
Assumed ratio of ground motion at tunnel depth to motion at ground surface (tunnel depth 15-30m)	m	Refer Table 4 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	0.8
Assumed ratio of peak ground velocity (cm/s) to peak ground acceleration (g)	g	Refer Table 2 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	76
Seismic Zone	ϵ (*)		=	0.15

Axial and curvature deformation

Poisson's ratio of soil	n			0.30
Density of soil	g			19.10 KN/m ³
Apparent velocity of S-wave propagation	C _s	From Site specific study		146.71 m/s
Peak ground particle acceleration in soil	a _s [g]	m * ϵ	0.8*0.15	0.1200
Earth's gravity	g			9.81 m/s ²
Peak ground particle velocity in soil	V _s	g * a _s /100	76*0.12/100	0.09 m/s
Dynamic Shear modulus of soil	G _m	$\rho_m c_m^2$	1 / 10 x 146.709470175082 x 146.709470175082	56 MPa
Dynamic Young's Modulus of Soil	E _m	2G _m (1+U)	2 x 56 x (1 + 0.3)	146 MPa
Radius of circular tunnel (internal radius of the lining)	r			7.30 m
Angle of incidence	F			45 °,degree
Total axial strain	e ^{ab}	(Vs/Cs)*sinF *cosF +((as*g*r)/C _s ²)*cos ³ F	0.1/146.71*sin45* π /180*cos45* π /180+(0.12*9.81*7.3)/0.0912*2*cos ³ 45* π /180	0.000452
Allowable compression strain of concrete	e _{allow}			0.003500

ok

Ovaling deformation

Lining thickness	t		=	0.550 m
No of Segments	n		=	9.000
Grade of Concrete	Fck		=	60.0 MPa
Concrete Young's modulus	E _c		=	38,730 MPa
Concrete Poisson's ratio	ν_c		=	0.15
Area of the tunnel lining per unit width	A _t		=	0.550 m ² /m
Reduced Moment of inertia of the tunnel lining per unit width	I _r	$I_r = I_j + (4/n)^2 * I$	$(0) + ((4/9)^2) * 0.55^3 * \pi / 12$	0.002739 m ⁴ /m
Young's modulus of soil	E		$0.002739 / (2^{*}0.55)$	0.00996
			=	146 MPa

Use formulations of Penzien (2000) assuming full slip condition

Maximum free-field shear strain of soil or rock medium	g _{max}	V _s /C _s	0.1/146.71	=	0.00062
Coefficient to calculate R ⁿ	a ⁿ	$(12^*E_c^*I^*(5-6^*n))/((2r)^3^*G^*(1-n_1^2))$	$(12^*38729.834^*0.00274^*(5-6^*0.3))/((2^*7.3)^3^*56^*(1-0.15^2))$	=	0.02393
Lining-soil racking ratio under normal loading only	R ⁿ	$4^*(1-\nu)/(a^3+1)$	$4^*(1-0.3)/(0.024+1)$	=	2.73
Lining diametric deflection under normal loading only	Dd ⁿ _{lining}	R ⁿ * g _{max} * 2 * r/2	2.74*0.01*2*7.3/2	=	0.012
Maximum circumferential thrust in tunnel lining	T(p/4)	$(12^*E_c^*1000^*I^*Dd_{lining}^n)^*cos2(\theta+p/4)$	$(12^*38730^*1000^*0.003^*0.013^*cos2(\theta+\pi/4))/(2^*((2^*r)^3^*(1-n_1^2))$	=	6.000 KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	$(6^*E_c^*1000^*I^*Dd_{lining}^n)^*cos2(\theta+p/4)$	$(6^*38729.834^*1000^*0.003^*0.013^*cos2(\theta+\pi/4))/((2^*r)^3^*(1-n_1^2))$	=	38.000 KNm
Maximum Shear in tunnel lining	V(0)	$(24^*E_c^*1000^*I^*Dd_{lining}^n)^*sin2(\theta+p/4)$	$(24^*38730^*1000^*0.003^*0.013^*sin2(\theta+\pi/4))/(2^*((2^*r)^3^*(1-n_1^2))$	=	11.000 KN
Combined stress from thrust and bending moment due to earthquake	s _e	$(T(p/4)/A_t + M(p/4)^*(t/2)/I)/1000$	$(6/0.55+38^*(0.55/2)/0.003)/1000$	=	3.827 MPa

Use formulations of Wang (1993) assuming full slip condition						
Flexibility ratio of tunnel lining	F	$(E^*(1-n^2)*r^3) / (6*E_i*I^*(1+n))$	$(145.5^*(1-0.3^2)*7.3^3) / (6*38729.834*1^*(1+0.3))$	=	66.875	
Full slip lining response coefficient	K _l	$12^*(1-n)/(2*F+5-6n)$	$12^*(1-0.3)/(2*67+5-6*0.3)$	=	0.06	
Maximum thrust in tunnel lining	T _{max}	$K_l^*E^*1000*r * g_{max}/(6^*(1+n))$	$0.062*145.5*1000*7.3*0.01/6^*(1+0.3)$	=	5	KN
Maximum bending moment in tunnel cross section due to S-waves	M _{max}	$K_l^*E^*1000*r^2 * g_{max}/(6^*(1+n))$	$0.062*145.5*1000*7.3^2*0.01/6^*(1+0.3)$	=	38	KNm
Combined stress from thrust and bending moment due to earthquake	s _e	$(T_{max}/A_i+M_{max}^*(t/2)/I)/1000$	$(5.2/0.55+37.91*(0.55/2)/1)/1000$	=	3.815	MPa
Required reinforcement			$(3.82 / 2) * 0.55 * 1000 / (2 * 0.87 * 500)$	=	1210	mm ²
Characteristic compressive strength of concrete, f _{ck}				=	60.0	MPa
Characteristic axial tensile strength of concrete, f _{ctk}				=	4.1	MPa
g _c (")				=	1.6	
g _n ("")				=	1.2	
g _{tot}				=	1.87	
Design value of concrete compressive strength, f _{cd} = α _{cc} * f _{ck} / γ _c				1 * 60/ 1.872	=	32.05 mpa
α _{cc} - coefficient taking account of long term effects on the compressive strength, the recommended value is 1.0						
f _{cd} > σ _e					safe	
Design value of the Concrete tensile strength, f _{ctd} = α _{ct} f _{ctk,0.05} / γ _c				1 * 4.1/ 1.872	=	2.19 mpa
α _{ct} , coefficient taking account of long term effects on the tensile strength, the recommended value is 1.0						
f _{ctd} > σ _e						
Exceeds, but ok in presence of reinforcement provided						

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature



PROJECT:

DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction

Job No

I40172

Section:

Segmental Lining - Seismic Check Calculation (O.D.E No Slip CASE)

Ultimate Limit State Design For Plain And Lightly Reinforced Concrete Structures

Circular Tunnel ODE Case- No Slip Condition

Assumed moment magnitude	(Mw)	Refer Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	6.5
Assumed ratio of ground motion at tunnel depth to motion at ground surface (tunnel depth 6-15m)	m	Refer Table 4 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	0.8
Assumed ratio of peak ground velocity (cm/s) to peak ground acceleration (g)	g	Refer Table 2 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	76
Seismic Zone	ϵ (*)		=	0.075

Axial and curvature deformation

Poisson's ratio of soil	n			0.30
Density of soil	g			19.10 KN/m ³
Apparent velocity of S-wave propagation	C _s	From Site specific study		147 m/s
Peak ground particle acceleration in soil	a _s [g]	0.8*0.075		0.0600
Earth's gravity	g			9.81 m/s ²
Peak ground particle velocity in soil	V _s	g * a _s /100	76*0.06/100	0.05 m/s
Dynamic Shear modulus of soil	G _m	$\rho_m C_m^2$	1 /10 x 146.709470175082 x 146.709470175082	56 MPa
Dynamic Young's Modulus of Soil	E _m	$\rho_m C_m^2$	2 x 56 x (1 + 0.3)	146 MPa
radius of circular tunnel (internal radius of the lining)	r			7.30 m
Angle of incidence	F			45 °,degree
Total axial strain	e ^{ab}	(Vs/Cs)*sinF *cosF +((as*g*r)/C _s ²)*cos ³ F	0.05/146.71*sin45*π/180*cos45*π/180+(0.06*9.81*7.3)/0.0456*2*cos*45*π/180	0.000226
Allowable compression strain of concrete	e _{allow}			0.003500 ok

Ovaling deformation

Lining thickness	t		=	0.550 m
No of Segments	n		=	9
Grade of Concrete	Fck		=	60.0 MPa
Concrete Young's modulus	E _c		=	38,730 MPa
Concrete Poisson's ratio	n _i		=	0.15
Area of the tunnel lining per unit width	A _i		=	0.550 m ² /m
Reduced Moment of inertia of the tunnel lining per unit width	I _r	I _r = I _j + (4/n) ² *I	(0) + ((4/9) ²) * 0.55* ³ *1/12	= 0.002739 m ⁴ /m
Young's modulus of soil	E		=	146 MPa

Use formulations of Penzien (2000) assuming no slip condition

Maximum free-field shear strain of soil or rock medium	g _{max}	V _s /C _s	0.05/146.71	=	0.00031
Coefficient to calculate R ⁿ	a	$(24^2 E_c^2 I^2 (3-4n)) / ((2r)^3 G^2 (1-n^2))$	$(24^2 * 38729.834^2 * 0.00274^2 * (3-4*0.3)) / ((2*7.3)^3 * 3^2 * 56^2 * (1-0.15^2))$	=	0.02692
Lining-soil racking ratio under normal loading only	R	$4^2 (1-v) / (a+1)$	$4^2 (1-0.3) / (0.027+1)$	=	2.73
Lining diametric deflection under normal loading only	Dd ⁿ _{lining}	$R^n * g_{max} * 2 * r / 2$	$2.73^2 * 0.01^2 * 2 * 7.3 / 2$	=	0.006
Maximum circumferential thrust in tunnel lining	T(p/4)	$(24^2 E_c^2 * 1000^2 * I^2 * Dd_{lining}^n * \cos 2(\theta+p/4)) / ((2r)^3 * (1-n^2))$	$(24^2 * 38730^2 * 1000^2 * 0.003^2 * 0.007^2 * \cos 2(\theta+\pi/4)) / (2^3 * 3^2 * (1-0.15^2))$	=	6.000 KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	$(6^2 E_c^2 * 1000^2 * I^2 * Dd_{lining}^n * \cos 2(\theta+p/4)) / ((2r)^3 * (1-n^2))$	$(6^2 * 38729.834^2 * 1000^2 * 0.003^2 * 0.007^2 * \cos 2(\theta+\pi/4)) / (2^3 * 3^2 * (1-0.15^2))$	=	19.000 KNm
Maximum Shear in tunnel lining	V(0)	$(24^2 E_c^2 * 1000^2 * I^2 * Dd_{lining}^n * \sin 2(\theta+p/4)) / ((2r)^3 * (1-n^2))$	$(24^2 * 38730^2 * 1000^2 * 0.003^2 * 0.007^2 * \sin 2(\theta+\pi/4)) / (2^3 * 3^2 * (1-0.15^2))$	=	6.000 KN
Combined stress from thrust and bending moment due to earthquake	s _e	$(T(p/4)/A_i + M(p/4)*(t/2)/I) / 1000$	$(6/0.55 + 19*(0.55/2)/0.003) / 1000$	=	1.919 MPa

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

Use formulations of Wang (1993) assuming no slip condition						
Flexibility ratio of tunnel lining	F	$(E^*(1-n^2)*r^3) / (6*E_t*(1+n))$	$(145.5*(1-0.15^2)*7.3^3)/(6*38729.834*1*(1+0.3))$	=	66.875	
Compressibility Ratio of tunnel Lining	C	$(E^*(1-n^2)*r) / (E_t*(1+n)(1-2n))$	$(145.5*(1-0.15^2)*7.3)/(66.875*(1+0.3)(1-2*0.3))$	=	0.094	
No slip lining response coefficient	K ₂	$1+((F[1-2n)-(1-2n)*C]-(1/2)*(1-2n)^2+2)/(F[(3-2n)*(1-2n)C]+C[(5/2)-8n+6n^2]+6-8n))$	$1+((66.875[(1-2*0.3*0.094)-(1/2)*(1-2*0.3)^2+2])/(66.875[(3-2*0.3)*(1-2*0.3)C]+0.094[(5/2)-8*0.3+6*0.3^2]+6-8*0.3))$	=	1.16	
Maximum thrust in tunnel lining	T _{max}	$K_2*E*1000*r * g_{max}/(2*(1+n))$	$1.157*145.5*1000*7.3*0.01/2*(1+0.3)$	=	147	KN
Maximum bending moment in tunnel cross section due to S-waves	M _{max}	Note that no solution is developed for calculating diametric strain and maximum moment under no-slip condition. It is recommended that the solutions for full-slip condition be used for no-slip condition. The more conservative estimates of the fullslip condition is considered		=	19	KNm
Combined stress from thrust and bending moment due to earthquake	s _e	$(T_{max}/A_t+M_{max}*(t/2)/I)/1000$	$(146.91/0.55+19*(0.55/2)/1)/1000$	=	2.175	MPa
Required reinforcement			$(2.18 / 2) * 0.55* 1000 / (2 * 0.87 * 500)$	=	687	mm ²
Characteristic compressive strength of concrete, f _{ck}				=	60.0	MPa
Characteristic axial tensile strength of concrete, f _{ctk}				=	4.1	MPa
g _c ^(*)				=	1.6	
g _n ^(**)				=	1.2	
g _{tot}				=	1.87	
Design value of concrete compressive strength, f _{cd} = α _{cc} * f _{ck} / γ _c			1 * 60/ 1.872	=	32.05	mpa
α _{cc} - coefficient taking account of long term effects on the compressive strength, the recommended value is 1.0						
f _{cd} > σ _e					safe	
Design value of the Concrete tensile strength, f _{ctd} = α _{ct} f _{ctk,0.05} / γ _c			1 * 4.1/ 1.872	=	2.19	mpa
α _{ct} , coefficient taking account of long term effects on the tensile strength, the recommended value is 1.0						
f _{ctd} > σ _e					safe	

Signature

Signature

Signature

Signature

Signature

Signature

**GEOCONSULT India Pvt Ltd**

A company of the GEOCONSULT group

Annexure -2

PROJECT:		DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Job No		I40172			
Section:		Segmental Lining - Seismic Check Calculation (M.C.E No Slip CASE)			
Ultimate Limit State Design For Plain And Lightly Reinforced Concrete Structures					
Circular Tunnel MCE Case- Full Slip Condition					
Assumed moment magnitude	(Mw)	Refer Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	6.5	
Assumed ratio of ground motion at tunnel depth to motion at ground surface (tunnel depth 6-15m)	m	Refer Table 4 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	0.8	
Assumed ratio of peak ground velocity (cm/s) to peak ground acceleration (g)	g	Refer Table 2 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	76	
Seismic Zone	ε (*)		=	0.15	
Axial and curvature deformation					
Poisson's ratio of soil	n			0.30	
Density of soil	g			19.10	KN/m³
Apparent velocity of S-wave propagation	C _s	From Site specific study		146.71	m/s
Peak ground particle acceleration in soil	a _s [g]	m * ε	0.8*0.15	0.1200	
Earth's gravity	g			9.81	m/s²
Peak ground particle velocity in soil	V _s	g * a _s /100	76*0.12/100	0.09	m/s
Dynamic Shear modulus of soil	G _m	ρ _m C _m ²	1 / 10 x 146.709470175082 x 146.709470175082	56	MPa
Dynamic Young's Modulus of Soil	E _m	2G _m (1+U)	2 x 56 x (1 + 0.3)	146	MPa
Radius of circular tunnel (internal radius of the lining)	r			7.30	m
Angle of incidence	F			45	°,degree
Total axial strain	e ^{ab}	(Vs/Cs)*sinF *cosF +((as*g*r)/C _s ²)*cos ³ F	0.1/146.71*sin45°π/180*cos45°π/180+(0.12*9.81*7.3)/0.0912 ² *cos ³ 45°π/180	0.000452	
Allowable compression strain of concrete	e _{allow}			0.003500	
Ovaling deformation					
Lining thickness	t		=	0.550	m
No of Segments	n		=	9	
Grade of Concrete	Fck		=	60.0	MPa
Concrete Young's modulus	E _c		=	38,730	MPa
Concrete Poisson's ratio	n _i		=	0.15	
Area of the tunnel lining per unit width	A _i		=	0.550	m²/m
Reduced Moment of inertia of the tunnel lining per unit width	I _r	I _r =I _j + (4/n) ² *I	(0) + ((4/9) ²) * 0.55³ *1/12	=	0.002739 m⁴/m
	z	I / (2*t)	0.002739/(2*0.55)	=	0.00996
Young's modulus of soil	E		=	146	MPa
Use formulations of Penzien (2000) assuming no slip condition					
Maximum free-field shear strain of soil or rock medium	g _{max}	V _s /C _s	0.1/146.71	=	0.00062
Coefficient to calculate R ⁿ	a	(24*E _c *I*(3-4*n))/((2r) ³ *G*(1-n _i ²))	(24*38729.834*0.00274*(3-4*0.3))/((2*7.3) ³ *56*(1-0.15 ²))	=	0.02692
Lining-soil racking ratio under normal loading only	R	4*(1-v)/(a+1)	4*(1-0.3)/(0.027+1)	=	2.73
Lining diametric deflection under normal loading only	Dd ⁿ _{lining}	R ⁿ * g _{max} * 2 * r/2	2.73*0.01²*2*7.3/2	=	0.012
Maximum circumferential thrust in tunnel lining	T(p/4)	(24*E _c *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4)) / ((2r) ³ *(1-n _i ²))	(24*38730*1000*0.003*0.013*cos2(θ+π/4))/(2*7.3) ³ *(1-0.15 ²)	=	11.000 KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	(6*E _c *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4)) / ((2r) ³ *(1-n _i ²))	(6*38729.834*1000*0.003*0.013*cos2(θ+π/4))/(2*7.3) ³ *(1-0.15 ²)	=	38.000 KNm
Maximum Shear in tunnel lining	V(0)	(24*E _c *1000*I*Dd ⁿ _{lining} *sin2(θ+p/4)) / ((2r) ³ *(1-n _i ²))	(24*38730*1000*0.003*0.013*sin2(θ+π/4))/(2*7.3) ³ *(1-0.15 ²)	=	11.000 KN
Combined stress from thrust and bending moment due to earthquake	s _e	(T(p/4)/A _i +M(p/4)*(t/2)/I)/1000	(11/0.55+38*(0.55/2)/0.003)/1000	=	3.836 MPa
Use formulations of Wang (1993) assuming no slip condition					
Flexibility ratio of tunnel lining	F	(E*(1-n _i ²)*r³) / (6*E _c *I*(1+n))	(145.5*(1-0.15 ²)*7.3³)/(6*38729.834*1*(1+0.3))	=	66.875
Compressibility Ratio of tunnel Lining	C	(E*(1-n _i ²)*r) / (E _c *I*(1+n)*(1-2n))	(145.5*(1-0.15 ²)*7.3)/(6.875[(3-2*0.3)+(1-2*0.3)*0.094]+0.094[(5/2)-8*0.3+6*0.3²]+6-80.3))	=	0.094
No slip lining response coefficient	K ₂	1+((F[(1-2n)-(1-2n)*C]-(1/2)*(1-2n)²+2)/((F[(3-2n)+(1-2n)*C]+C[(5/2)-8n+6n²]+6-8n))	1+((66.875[(1-2*0.3*0.094)-(1/2)*(1-2*0.3)²+2]/(6.875[(3-2*0.3)+(1-2*0.3)*0.094]+0.094[(5/2)-8*0.3+6*0.3²]+6-80.3))	=	1.16
Maximum thrust in tunnel lining	T _{max}	K ₂ *E*1000*r * g _{max} /(2*(1+n))	1.157*145.5*1000*7.3*0.01/2*(1+0.3)	=	294 KN

Maximum bending moment in tunnel cross section due to S-waves	$M_{\max}$	Note that no solution is developed for calculating diametric strain and maximum moment under no-slip condition. It is recommended that the solutions for full-slip condition be used for no-slip condition. The more conservative estimates of the fullslip condition is considered	=	38	KNm
Combined stress from thrust and bending moment due to earthquake	s_e	$(T_{\max}/A_t + M_{\max} * (t/2)/I)/1000$		$(293.82/0.55 + 38 * (0.55/2)/1)/1000$	= 4.350 MPa
Required reinforcement		$(4.35 / 2) * 0.55 * 1000 / (2 * 0.87 * 500)$	=	1375	mm ²
Characteristic compressive strength of concrete, f_{ck}			=	60.00	MPa
Characteristic axial tensile strength of concrete, f_{ctk}			=	4.10	MPa
g_c (*)			=	1.56	
g_n (**)			=	1.20	
g_{tot}			=	1.87	
Design value of concrete compressive strength, $f_{cd} = \alpha_{cc} * f_{ck} / \gamma_c$			1 * 60/ 1.872	=	32.05 mpa
α_{cc} - coefficient taking account of long term effects on the compressive strength, the recommended value is 1.0					
$f_{cd} > \sigma_e$					safe
Design value of the Concrete tensile strength, $f_{ctd} = \alpha_{ct} f_{ctk,0.05} / \gamma_c$			1 * 4.1/ 1.872	=	2.19 mpa
α_{ct} , coefficient taking account of long term effects on the tensile strength, the recommended value is 1.0					
$f_{ctd} > \sigma_e$					Exceeds, but ok in presence of reinforcement provided

Signature

Signature

Signature

Signature

Signature

CASE 2

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Amelia

Adri

Rob

Emma

James

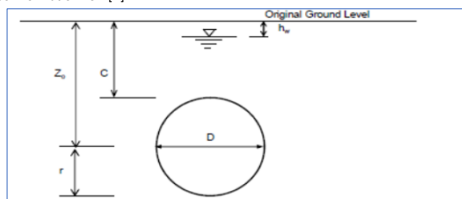
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction
-----------------	--

Calculation for	Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)
------------------------	---

TUNNEL LINING DESIGN

[Based on Muir Wood (1975) and Curtis (1976)]

Soil Formation : SM[A]



GL 879.533
RL 855.07
Centerline 857.63
Zo 21.90
Bottom Invert 851.14
Invert from GL 28.39
Cover 14.60

Load Combination Assumed

Load Combination	Dead load (DL)		Imposed load (IL)		Ground and Water loads		Seismic Loads (EQ)
	Adverse	Beneficial	Adverse	Beneficial	Adverse	Beneficial	
1.DL+IL	1.5	-	1.5	-	1.5	-	-
2.DL+EQ	1.5	0.9	-	-	-	-	1.5
3.DL+IL+EQ	1.2	-	1.2	-	1.2	-	1.2
4.Collision/Accidental	1.5	1.0	1.5	-	1.5	1.0	-

References:

- Ref 1 Muir Wood, A. M. (1975) The circular tunnel in elastic ground, Geotechnique 25, No. 1, 115 - 127
Ref 2 Curtis, D. J. (1976) Discussion on the reference above, Geotechnique 26, No. 1, 231 - 237
Ref 3 Duddeck, H., Erdmann, J. (1982) Structural design models for tunnels,
Ref 4 Tunnelling 82, International Symposium organised by Institution of Mining & Metallurgy

Notations

Symbol	Description
C	= Cover to tunnel crown
Z ₀	= Depth to tunnel axis
D	= Excavated tunnel diameter
r ₀	= Radius to extrados of tunnel lining
γ	= Average unit weight of overburden
k	= Constant
E	= Young's modulus for lining
E _{c,v}	= Young's modulus and Poisson's ratio of ground
I	= Second moment of inertia of lining per unit length of tunnel
I _e	= Effective value of I for a jointed lining
I _j	= Effective value of I at joint in a lining
M	= Bending moment in lining per unit length of tunnel
N	= Hoop (circumferential) thrust in lining per unit length of tunnel
η	= Ratio of radius of lining centroid to that of extrados
U _{max}	= Maximum radial movement of lining
h _w	= Water table from ground surface

Design Load Combination Assumed

Load Combination	Dead Load (DL*)	Hydrostatic pressure	Earth Pressure	Surcharge	Seismic Load
Case 1	1.5	1.5	1.5	1.5	-
Case 2	1.5	1.5	1.5	-	-
Case 3	1.5	-	1.5	1.5	-
Case 3 (With Seismic)	1.2	-	1.2	1.2	1.2
Case 4 (With Seismic)	1.5	-	1.5	-	1.5
Case 5	1.5	1.1	1.5	-	-
Case 6 (serviceability)	1.0	1.0	1.0	1.0	-
Case 7 (serviceability)	1.0	1.0	1.0	-	-
Case 8 (serviceability)	1.0	-	1.0	-	-
Case 9 (serviceability)	1.0	-	1.0	1.0	-

Load Combination	ULS					SLS			
	1	2	3	4	5	6	7	8	9
Load factor for Over Burden Load	1.50	1.50	1.50	1.50	1.50	1.00	1.00	1.00	1.00
Load Factor for Surcharge	1.50	1.50	1.50	1.50	1.50	1.00	1.00	1.00	1.00
Load Factor for Water	1.50	1.50	1.50	1.50	1.10	1.00	1.00	1.00	1.00
Surcharge (kN/mm2)	60.00	0.00	60.00	0.00	0.00	60.00	0.00	60.00	0.00
Water Table Below Ground Surface	-23.00	-23.00	21.90	21.90	-1.00	-23.00	-23.00	21.90	21.90
No of Segments	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
E _{concrete} (MN/m2)	38,730	38,730	38,730	38,730	38,730	38,730	38,730	38,730	38,730
Thickness of lining, T			0.55	m					
Where, Concrete f _{cu} (N/mm2)			60						
No of Segments			9	Ignoring Key Segment					
Unit weight of Water, γ _w			10	kN/m ²					
Lowest Credible Water Level			21.90	m (Assumed water table below the invert and it gives critical condition)					
ULS Load Factor			1.5						
SLS Load Factor			1						
Surcharge			60	kN/m ²					
Young's Modulus Ground			1600.00	N/mm ²					
Poisson's ratio of ground			0.26						
Stiffness Modulus of Soil			1957.67	N/mm ²					
Effective cohesion of the ground			1800	kN/m ²					
Effective friction angle of ground			30	degree					
Poisson's ratio of Concrete v			0.15						
Existing GL			879.53	m					
Road level			855.07	m					
Road Level to Invert of Tunnel			3.929	m					
K ₀			0.50						
Bulk Unit Weight of soil, γ			26	kN/m ³					
Depth of joint considered for reduced moment of inertia calculation			0.0	mm					

[Handwritten signatures and initials on the right margin]

SUMMARY OF RESULTS

Dynamic calculation has been done as per Hashash Paper. The summary of forces and moments obtained are given below:

RESULT OF SEISMIC FORCES		Adopted Values		
		F(kN)	M(kNm)	V(kN)
ODE	FULL SLIP	1.00	7.00	2.00
	NO SLIP	407.80	7.00	2.00
MCE	FULL SLIP	2.00	14.00	4.00
	NO SLIP	815.60	14.00	4.00

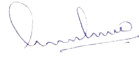
Summary of factored Forces, Moments and displacement from all 9 cases are listed below:

Load Combination		At Axis of Tunnel (per m run)			At Crown of Tunnel (per m run)			V (kN)
		N (kN)	U (mm)	M (kNm)	N (kN)	U (mm)	M (kNm)	
ULS	1	6221.93	0.49	2.99	5458.85	-0.49	-2.99	0.82
	2	5767.98	0.32	1.97	5264.65	-0.33	-1.97	0.54
	3	4711.13	1.73	10.58	2015.52	-1.73	-10.58	2.90
	4	4257.19	1.56	9.56	1821.31	-1.57	-9.56	2.62
	5	4362.30	0.93	5.71	2906.59	-0.94	-5.71	1.56
SLS	6	4147.95	0.33	2.00	3639.24	-0.33	-2.00	0.55
	7	3845.32	0.21	1.32	3509.76	-0.22	-1.32	0.36
	8	3140.76	1.15	7.05	1343.68	-1.15	-7.05	1.93
	9	2838.13	1.04	6.37	1214.21	-1.04	-6.37	1.75

Dynamic forces are now added with appropriate factors to obtain final set of forces

Load Combination			Dynamic Load Factor	At Axis of Tunnel (per m run)						Shear Force	
				SUMMARY OF FORCES		Factored Dynamic results		Final Results		Factored	Final
				N (kN)	M (kNm)	N (kN)	M (kNm)	N (kN)	M (kNm)	V (kN)	V (kN)
ULS CASE	Static	1	0	6221.9	3.0	0.0	0.0	6221.9	3.0	0.00	0.82
	Static	2	0	5768.0	2.0	0.0	0.0	5768.0	2.0	0.00	0.54
	Static	3	0	4711.1	10.6	0.0	0.0	4711.1	10.6	0.00	2.90
	Dynamic ODE FS	3A	1.2	3768.9	8.5	1.2	8.4	3770.1	16.9	2.40	5.30
	Dynamic ODE NS	3B	1.2	3768.9	8.5	489.4	8.4	4258.3	16.9	2.40	5.30
	Dynamic MCE FS	3C	1	3140.8	7.1	2.0	14.0	3142.8	21.1	4.00	6.90
	Dynamic MCE NS	3D	1	3140.8	7.1	815.6	14.0	3956.4	21.1	4.00	6.90
	Dynamic ODE FS	4A	1.5	4257.2	9.6	1.5	10.5	4258.7	20.1	3.00	5.90
	Dynamic ODE NS	4B	1.5	4257.2	9.6	611.7	10.5	4868.9	20.1	3.00	5.90
	Dynamic MCE FS	4C	1	2838.1	6.4	2.0	14.0	2840.1	20.4	4.00	6.90
	Dynamic MCE NS	4D	1	2838.1	6.4	815.6	14.0	3653.7	20.4	4.00	6.90
	Static	5	0	4362.3	5.7	0.0	0.0	4362.3	5.7	0.00	1.56
SLS	Static	6	0	4148.0	2.0	0.0	0.0	4148.0	2.0	0	0.55
	Static	7	0	3845.3	1.3	0.0	0.0	3845.3	1.3	0	0.36
	Static	8	0	3140.8	7.1	0.0	0.0	3140.8	7.1	0	1.93
	Static	9	0	2838.1	6.4	0.0	0.0	2838.1	6.4	0	1.75

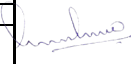
Load Combination			Dynamic Load Factor	At Crown of Tunnel (per m run)						Shear Force	
				SUMMARY OF FORCES		Factored Dynamic results		Final Results		Factored	Final
				N (kN)	M (kNm)	N (kN)	M (kNm)	N (kN)	M (kNm)	V (kN)	V (kN)
ULS CASE	Static	1	0	5458.9	-3.0	0.0	0.0	5458.9	3.0	0.00	0.82
	Static	2	0	5264.6	-2.0	0.0	0.0	5264.6	2.0	0.00	0.54
	Static	3	0	2015.5	-10.6	0.0	0.0	2015.5	10.6	0.00	2.90
	Dynamic ODE FS	3A	1.2	1612.4	-8.5	1.2	8.4	1613.6	16.9	2.40	5.30
	Dynamic ODE NS	3B	1.2	1612.4	-8.5	489.4	8.4	2101.8	16.9	2.40	5.30
	Dynamic MCE FS	3C	1	1343.7	-7.1	2.0	14.0	1345.7	21.1	4.00	6.90
	Dynamic MCE NS	3D	1	1343.7	-7.1	815.6	14.0	2159.3	21.1	4.00	6.90
	Dynamic ODE FS	4A	1.5	1821.3	-9.6	1.5	0.0	1822.8	9.6	3.00	5.90
	Dynamic ODE NS	4B	1.5	1821.3	-9.6	611.7	10.5	2433.0	20.1	3.00	5.90
	Dynamic MCE FS	4C	1	1214.2	-6.4	2.0	14.0	1216.2	20.4	4.00	6.90
	Dynamic MCE NS	4D	1	1214.2	-6.4	815.6	14.0	2029.8	20.4	4.00	6.90
	Static	5	0	2906.6	-5.7	0.0	0.0	2906.6	5.7	0.00	1.56
SLS	Static	6	0	3639.2	-2.0	0.0	0.0	3639.2	2.0	0	0.55
	Static	7	0	3509.8	-1.3	0.0	0.0	3509.8	1.3	0	0.36
	Static	8	0	1343.7	-7.1	0.0	0.0	1343.7	7.1	0	1.93
	Static	9	0	1214.2	-6.4	0.0	0.0	1214.2	6.4	0	1.75







 </	
--	--








	GEOCONSULT India Pvt Ltd		ANNEXURE -1	
	A company of the GEOCONSULT group		Job no:	140172
			Page No.:	-
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Calculation for	Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)			
LOAD COMBINATION 1 * ULS for Short Term * Flexible Lining * No Creep				
1. ALIGNMENT DATA				
Nominal Diameter of Tunnel	D_n	=	13.3	m
Construction Allowance	ΔD	=	100	mm
Thickness of Lining	t	=	0.55	m
Existing Ground Level:	GL	=	879.53	m
Road Level:	RL	=	855.070	m
Tunnel invert to Road Level	d	=	3.929	m
2. TUNNEL GEOMETRY				
Excavated Diameter of Tunnel	D	=	14.6	m
Internal radius of tunnel	r_i	=	6.750	m
Radius of lining centroid	r_e	=	7.025	m
Radius to extrados of lining	r_o	=	7.300	m
Distance between tunnel axis to road level		=	2.8210	m
Depth to Tunnel Axis	Z_o	=	21.642	m
$\sigma'_h = K\sigma'_v$ $p_o = \sigma'_v - \sigma'_h$				
3. LOADING				
Ave. unit weight of Water	γ_w	=	10	kN/m ³
Ave. unit weight of soil	γ_s	=	26.00	kN/m ³
Water table from ground surface	h_w	=	-23	m
Height of Water Table considered in design	h_w	=	44.64	m
Effective overburden pressure	q_1	=	116.3	kN/m ²
Surcharge	q_2	=	60	kN/m ²
Load factor for Overburden Load	FS1	=	1.5	
Load factor for Surcharge	FS2	=	1.5	
Factored vertical stress	σ_v'	=	264.41	kN/m ²
k value	K	=	0.500	
Factored horizontal stress, $\sigma_h' = k\sigma_v'$	σ_h'	=	132.2	kN/m ²
$P_o = \sigma_v' - \sigma_h'$	P_o	=	132.2	kN/m ²
Load factor for Water	Fsw	=	1.50	
Hydrostatic water pressure	psw	=	669.63	kN/m ²
			Unfactored load at tunnel crown	= 59.5 kN/m ²
			Unfactored load at tunnel axis	= 176.3 kN/m ²
$p_* = \frac{q_1 + Kq_1}{2}$ $\tau = c' + p_* \tan \phi'$				
4. SHEAR STRENGTH OF SOIL				
Uniform loading, $P_u = (q_1 + kq_1) / 2$	P_u	=	73.80	kN/m ²
Maximum shear strength of ground, $\tau = c' + P_u \tan \Phi$	τ	=	1842.61	kN/m ²
$I_e = I_f + \left(\frac{4}{n}\right)^2 I, \quad n > 4$ $\tau = c' + p_* \tan \phi'$				
5. PROPERTIES OF GROUND AND LINING				
Young's modulus of ground	E_c	=	1957671.958	kN/m ²
Poisson's ratio of ground	ν	=	0.26	
Effective cohesion of the ground	c'	=	1800	kN/m ²
Effective friction angle of ground	Φ	=	30	Degree
Maximum shear strength of ground, $(\tau = c' + P_u \tan \Phi)$	τ	=	1842.61	kN/m ²
Young's modulus of lining	E_l	=	38730	N/mm ²
Poisson's ratio of lining	ν_l	=	0.15	
E of lining in plane strain condition	E_1	=	39621	N/mm ²
Area of lining	A	=	0.55	m ²
Second moment of area of lining	I	=	0.01386	m ⁴
Total no. of segments	n=	=	9	
Reduced Lining, $I_e = I_l + (4/n)^2 I, (n > 4)$	I_e	=	0.002739	m ⁴

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu) \frac{P_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6} (2S_n + S_t) \cos 2\theta$$

$$M_d = -\frac{r_0^2}{6} (2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3} (S_n + 2S_t) \cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3} (S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI} (2S_n + S_t) \cos 2\theta + U_w + U_s$$

$$U_w = -\frac{P_w r_0^2}{EA}, U_s = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI} (2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0} (-2)(2S_n + S_t) \sin 2\theta = \frac{r_0}{3} (2S_n + S_t) \sin 2\theta$$

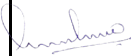
$$V_d = \frac{r_0}{3} (2S_n + S_t)$$

$Q2 = Ee \cdot r0^3 / 12EI(1+\nu)$
 $Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)]$ (if $S_t < \tau$)
 $Sn = (3*(3-4\nu)*(p0/2)-(2Q2+(4-6\nu))\tau)/4Q2+5-6\nu$, (if $S_t > \tau$)
 $St = (1+2Q2)Po/2[1+Q2(3-2\nu/3-4\nu)]$
 $M = -r0^2/6*(2Sn + St)*cos2\theta$
 $Md = -r0^2/6*(2Sn + St)$
 $N = -r0/3*(Sn + 2St)cos2\theta + Pw \cdot r0 + No$
 $Nd = -r0/3*(Sn + 2St)$
 $No = \sigma_v(1+k)*r0/2 + [2Ec*r0/Et*(1+\nu)]$
 $Uw = -pw*r0^2/E*A$
 $Us = -No*r0/E*A$
 $U = -r0^4/18EI*(2Sn+St)*cos2\theta + Uw + Us$
 $Ud = -r0^4/(18E*I)*(2*Sn+St)$
 $x=rq \quad dx/dq=r$
 $V = r0/3*(2Sn+St)*sin2q$
 $Vd = r0/3*(2Sn+St)$

Q2	=	464.180
Sn	=	-52.04
Sn	=	-921.8
St	=	104
M	=	-3
Md	=	-3
N	=	5459
Nd	=	-381.54
No	=	952.09
Uw	=	0.00
Us	=	0.00
U	=	0
Ud	=	0.00
V	=	0
Vd	=	0.820

Q2	τ	St ($\leq \tau$)	Sn	$P_w r_0$	N_0	Uw (mm)	Us (mm)	Nd (kN)	Ud (mm)	Md (kNm)
464.1796	1843	104	-52.0	4888	952.09	0.00	0.00	-382	0.00	-3.0
										Vd (kN)
										0.8

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	5458.854	-0.492	-2.994	0	CROWN
10	5481.863	-0.462	-2.813	0	
20	5548.117	-0.377	-2.293	1	
30	5649.623	-0.247	-1.497	1	
40	5774.138	-0.087	-0.520	1	
45	5840.392	-0.002	0.000	1	
50	5906.645	0.083	0.520	1	
60	6031.160	0.243	1.497	1	
70	6132.666	0.373	2.293	1	
80	6198.920	0.459	2.813	0	
90	6221.929	0.488	2.994	0	AXIS







	GEOCONSULT India Pvt Ltd		ANNEXURE -1	
	A company of the GEOCONSULT group		Job no:	140172
			Page No.:	-
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Calculation for	Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)			
LOAD COMBINATION 2 * ULS for Short Term * Flexible Lining * No Creep				
1. ALIGNMENT DATA				
Nominal Diameter of Tunnel	D_n	=	13.3	m
Construction Allowance	ΔD	=	100	mm
Thickness of Lining	t	=	0.55	m
Existing Ground Level:	GL	=	879.533	m
Road Level:	RL	=	855.07	m
Tunnel Axis to Road Level	d	=	3.929	m
2. TUNNEL GEOMETRY				
Excavated Diameter of Tunnel	D	=	14.6	m
Internal radius of tunnel	r_i	=	6.75	m
Radius of lining centroid	r_o	=	7.025	m
Radius to extrados of lining	r_e	=	7.3	m
Distance between tunnel axis to road level		=	2.821	m
Depth to Tunnel Axis	Z_o	=	21.642	m
$\sigma'_h = K\sigma'_v$ $p_o = \sigma'_v - \sigma'_h$				
3. LOADING				
Ave. unit weight of Water	γ_w	=	10	kN/m ³
Ave. unit weight of soil	γ_s	=	26.00	kN/m ³
Water table from ground surface	h_w	=	-23	m
Height of Water Table considered in design	h_w	=	44.642	m
Effective overburden pressure	q_1	=	116.3	kN/m ²
Surcharge	q_2	=	0	kN/m ²
Load factor for Overburden Load	FS_1	=	1.5	
Load factor for Surcharge	FS_2	=	1.5	
Factored vertical stress	σ'_v	=	174.41	kN/m ²
k value	K	=	0.5000	
Factored horizontal stress, $oh' = kov'$	oh'	=	87.2	kN/m ²
$P_o = \sigma'_v - oh'$	P_o	=	87.2	kN/m ²
Load factor for Water	F_{sw}	=	1.5	
Hydrostatic water pressure	psw	=	669.63	kN/m ²
$p_s = \frac{q_1 + Kq_2}{2}$ $\tau = c' + p_s \tan \phi'$ Unfactored load at tunnel crown = -0.528 kN/m² Unfactored load at tunnel axis = 116.272 kN/m²				
4. SHEAR STRENGTH OF SOIL				
Uniform loading, $P_u = (q_1+ kq_1) / 2$	P_u	=	28.80	kN/m ²
Maximum shear strength of ground, $\tau = c' + P_u \tan \Phi$	τ	=	1816.63	kN/m ²
$I_e = I_f + \left(\frac{4}{n}\right)^2 I_f, \quad n > 4$ $\tau = c' + p_s \tan \phi'$				
5. PROPERTIES OF GROUND AND LINING				
Young's modulus of ground	E_c	=	1957671.958	kN/m ²
Poisson's ratio of ground	ν	=	0.26	
Effective cohesion of the ground	c'	=	1800.000	kN/m ²
Effective friction angle of ground	Φ	=	30 Degree	
Maximum shear strength of ground, $(\tau = c' + P_u \tan \Phi)$	τ	=	1816.630	kN/m ²
Young's modulus of lining	E_l	=	38730	N/mm ²
Poisson's ratio of lining	ν_l	=	0.15	
E of lining in plane strain condition	E_l	=	39621	N/mm ²
Area of lining	A	=	0.55	m ²
Second moment of area of lining	I	=	0.013864583	m ⁴
Total no. of segments	n	=	9	
Reduced Lining, $I_e = I_f + (4/n)^2 I_f, (n>4)$	I_e	=	0.002738683	m ⁴








6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{P_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_t)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_t)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_n$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_n = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_t)\sin 2\theta = \frac{r_0}{3}(2S_n + S_t)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2v/3-4v)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4v)*(p0/2)-(2Q2+(4-6v))\tau)/4Q2+5-6v, \text{ (if } St > \tau)$$

$$St = (1+2Q2)Po/2/[1+Q2(3-2v/3-4v)]$$

$$M = -r0^2/6*(2Sn + St)*cos2\theta$$

$$Md = -r0^2/6*(2Sn + St)$$

$$N = -r0/3*(Sn + 2St)cos2\theta + Pw*r0 + No$$

$$Nd = -r0/3*(Sn + 2St)$$

$$No = \sigma_v(1+k)*r0/2 + [2Ec*r0/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Un = -No*r0/E*A$$

$$U = -r0^4/18EI*(2Sn + St)*cos2\theta + Uw + Un$$

$$Ud = -r0^4/(18E*I)*(2*Sn + St)$$

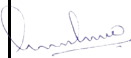
$$x=rq \quad dx/dq=r$$

$$V=0/3*(2Sn + St)*sin2q$$

$$Vd=r0/3*(2Sn + St)$$

Q2	=	464.180
Sn	=	-34.33
Sn	=	-908.88
St	=	69
M	=	-2
Md	=	-2
N	=	5265
Nd	=	-251.67
No	=	628.02
Uw	=	0.00
Un	=	0.0
U	=	0
Ud	=	0.32
V	=	0
Vd	=	0.541

Q2	τ	St (<= τ)	Sn	$p_w r_e$	N ₀	U _w (mm)	U _u (mm)	N _d (kN)	U _d (mm)	M _d (kNm)
464.1796	1817	69	-34.3	4888	628.02	0.00	0.00	-252	0.32	-2.0
										V _d (kN)
										0.5
θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)						
0	5264.647	-0.325	-1.975	0	CROWN					
10	5279.824	-0.306	-1.856	0						
20	5323.526	-0.249	-1.513	0						
30	5390.481	-0.163	-0.987	0						
40	5472.614	-0.058	-0.343	1						
45	5516.315	-0.002	0.000	1						
50	5560.017	0.054	0.343	1						
60	5642.150	0.160	0.987	0						
70	5709.105	0.246	1.513	0						
80	5752.807	0.302	1.856	0						
90	5767.984	0.321	1.975	0	AXIS					

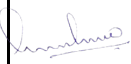




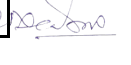




		GEOCONSULT India Pvt Ltd		ANNEXURE -1	
		A company of the GEOCONSULT group		Job no:	140172
				Page No.:	-
Project:		DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Calculation for		Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)			
LOAD COMBINATION 3 * ULS for Short Term * Flexible Lining * No Creep					
1. ALIGNMENT DATA					
Nominal Diameter of Tunnel		D_n	=	13.30	m
Construction Allowance		ΔD	=	100.00	mm
Thickness of Lining		t	=	0.550	m
Existing Ground Level:		GL	=	879.53	m
Road Level:		RL	=	855.07	m
Tunnel Axis to Road Level		d	=	3.9290	m
2. TUNNEL GEOMETRY					
Excavated Diameter of Tunnel		D	=	14.600	m
Internal radius of tunnel		r_i	=	6.750	m
Radius of lining centroid		r_o	=	7.025	m
Radius to extrados of lining		r_e	=	7.300	m
Distance between tunnel axis to road level			=	2.821	m
Depth to Tunnel Axis		Z_o	=	21.642	m
$\sigma'_h = K \sigma'_v$ $p_o = \sigma'_v - \sigma'_h$					
3. LOADING					
Ave. unit weight of Water		γ_w	=	10	kN/m ³
Ave. unit weight of soil		γ_s	=	26.00	kN/m ³
Water table from ground surface		h_w	=	21.902	m
Height of Water Table considered in design		h_w	=	21.642	m
Effective overburden pressure		q_1	=	562.7	kN/m ²
Surcharge		q_2	=	60	kN/m ²
Load factor for Overburden Load		FS_1	=	1.5	
Load factor for Surcharge		FS_2	=	1.5	
Factored vertical stress		σ_v'	=	934.04	kN/m ²
k value		K	=	0.5000	
Factored horizontal stress, $\sigma_h' = k \sigma_v'$		σ_h'	=	467.0	kN/m ²
$P_o = \sigma_v' - \sigma_h'$		P_o	=	467.0	kN/m ²
Load factor for Water		F_{sw}	=	1.5	
Hydrostatic water pressure		p_{sw}	=	0.00	kN/m ²
$p_s = \frac{q_1 + K q_2}{2}$ $\tau = c' + p_s \tan \phi'$					
		Unfactored load at tunnel crown	=	432.892	kN/m ²
		Unfactored load at tunnel axis	=	622.692	kN/m ²
4. SHEAR STRENGTH OF SOIL					
Uniform loading, $P_u = (q_1 + k q_1) / 2$		P_u	=	372.12	kN/m ²
		τ	=	2014.84	kN/m ²
$I_s = I_1 + \left(\frac{4}{n}\right)^2 I_1, \quad n > 4$ $\tau = c' + p_s \tan \phi'$					
5. PROPERTIES OF GROUND AND LINING					
Young's modulus of ground		E_c	=	1957671.958	kN/m ²
Poisson's ratio of ground		ν	=	0.26	
Effective cohesion of the ground		c'	=	1800.000	kN/m ²
Effective friction angle of ground		Φ	=	30	Degree
Maximum shear strength of ground, $(\tau = c' + P_u \tan \Phi)$		τ	=	2014.843	kN/m ²
Young's modulus of lining		E_l	=	38730	N/mm ²
Poisson's ratio of lining		ν_l	=	0.15	
E of lining in plane strain condition		E_l	=	39621	N/mm ²
Area of lining		A	=	0.55	m ²
Second moment of area of lining		I	=	0.01386	m ⁴
Total no. of segments		n	=	9	
Reduced Lining, $I_e = I_j + (4/n)^2, (n > 4)$		I_e	=	0.0027	m ⁴









6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_i < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{P_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_i > \tau$$

$$S_i = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_i)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_i), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_i)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_i)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_i)\cos 2\theta + U_w + U_u$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_i)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_i)\sin 2\theta = \frac{r_0}{3}(2S_n + S_i)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_i)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4\nu)*(p0/2)-(2Q2+(4-6\nu))\tau)/4Q2+5-6\nu, \text{ (if } St > \tau)$$

$$St = (1+2Q2)po/2[1+Q2(3-2\nu/3-4\nu)]$$

$$M = -r0^2/6*(2Sn + St)*\cos 2\theta$$

$$Md = -r0^2/6*(2Sn + St)$$

$$N = -r0/3*(Sn + 2St)\cos 2\theta + Pw*r0 + No$$

$$Nd = -r0/3*(Sn + 2St)$$

$$No = \sigma'_v(1+K)r0/2 + [2Ec*r0/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Uu = -No*r0/E*A$$

$$U = -r0^4/18EI*(2Sn+St)*\cos 2\theta + Uw + Uu$$

$$Ud = -r0^4/18EI*(2*Sn+St)$$

$$x=rq$$

$$dx/dq=r$$

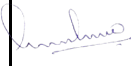
$$V=r0/3*(2Sn+St)*\sin 2q$$

$$Vd=r0/3*(2Sn+St)$$

Q2	=	464.180
Sn	=	-183.84
Sn	=	-1007.46
St	=	369
M	=	-11
Md	=	-11
N	=	2016
Nd	=	-1347.81
No	=	3363.33
Uw	=	0.00
Uu	=	0.0
U	=	0
Ud	=	0.00
V	=	0
Vd	=	2.897

Q2	τ	St ($\leq \tau$)	Sn	$p_w r_e$	N ₀	U _w (mm)	U _u (mm)	N _d (kN)	U _d (mm)	M _d (kNm)
464.1796	2015	369	-183.8	0	3363.33	0.00	0.00	-1348	0.00	-10.6
										V _d (kN)
										2.9

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	2015.520	-1.732	-10.575	0	CROWN
10	2096.803	-1.628	-9.938	1	
20	2330.847	-1.327	-8.101	2	
30	2689.424	-0.867	-5.288	3	
40	3129.283	-0.302	-1.836	3	
45	3363.327	-0.001	0.000	3	
50	3597.371	0.299	1.836	3	
60	4037.230	0.864	5.288	3	
70	4395.807	1.325	8.101	2	
80	4629.851	1.626	9.938	1	
90	4711.134	1.730	10.575	0	AXIS

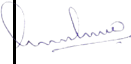








 </	
--	--






6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_c r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu) \frac{p_0}{2} - \{2Q_2 + (4-6\nu)\} \tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6} (2S_n + S_t) \cos 2\theta$$

$$M_d = -\frac{r_0^2}{6} (2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3} (S_n + 2S_t) \cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3} (S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_v (1+K) r_0}{2 + \frac{2E_c r_0}{Er(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI} (2S_n + S_t) \cos 2\theta + U_w + U_s$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_s = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI} (2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0} (-2)(2S_n + S_t) \sin 2\theta = \frac{r_0}{3} (2S_n + S_t) \sin 2\theta$$

$$V_d = \frac{r_0}{3} (2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2v/3-4v)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4v)*(p0/2) - (2Q2 + (4-6v))\tau) / (4Q2 + 5-6v), \text{ (if } St > \tau)$$

$$St = (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]$$

$$M = -r0^2/6*(2Sn + St)*cos2\theta$$

$$Md = -r0^2/6*(2Sn + St)$$

$$N = -r0/3*(Sn + 2St)cos2\theta + Pw * r0 + No$$

$$Nd = -r0/3*(Sn + 2St)$$

$$No = \sigma_v(1+k)*r0/2 + [2Ec*r0/Er*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Us = -No*r0/E*A$$

$$U = -r0^4/18EI*(2Sn + St)*cos2q + Uw + Us$$

$$Ud = -r0^4/(18EI)*(2*Sn + St)$$

$$x=rq \quad dx/dq=r$$

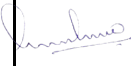
$$V=r0/3*(2Sn + St)*sin2q$$

$$Vd=r0/3*(2Sn + St)$$

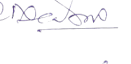
Q2	=	464.180
Sn	=	-166.12
Sn	=	-994.53
St	=	333
M	=	-10
Md	=	-10
N	=	1821
Nd	=	-1217.94
No	=	3039.25
Uw	=	0.00
Us	=	0.0
U	=	0
Ud	=	0.00
V	=	0
Vd	=	2.618

Q2	τ	St (<= τ)	Sn	$p_w r_e$	N ₀	Uw (mm)	Uu (mm)	Nd (kN)	Ud (mm)	Md (kNm)
464.1796	1989	333	-166.1	0	3039.25	0.00	0.00	-1218	0.00	-9.6
										Vd (kN)
										2.6

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	1821.313	-1.565	-9.556	0	CROWN
10	1894.764	-1.471	-8.980	1	
20	2106.257	-1.199	-7.321	2	
30	2430.282	-0.783	-4.778	2	
40	2827.758	-0.273	-1.659	3	
45	3039.251	-0.001	0.000	3	
50	3250.744	0.271	1.659	3	
60	3648.220	0.781	4.778	2	
70	3972.245	1.197	7.321	2	
80	4183.738	1.469	8.980	1	
90	4257.189	1.563	9.556	0	AXIS








	GEOCONSULT India Pvt Ltd		ANNEXURE -1																															
	A company of the GEOCONSULT group		Job no.:	I40172																														
		Page No.:		-																														
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction																																	
Calculation for	Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)																																	
LOAD COMBINATION S * ULS for Short Term * Flexible Lining * No Creep																																		
1. ALIGNMENT DATA <table> <tr> <td>Nominal Diameter of Tunnel</td> <td>D_n</td> <td>=</td> <td>13.3</td> <td>m</td> </tr> <tr> <td>Construction Allowance</td> <td>ΔD</td> <td>=</td> <td>100</td> <td>mm</td> </tr> <tr> <td>Thickness of Lining</td> <td>t</td> <td>=</td> <td>0.55</td> <td>m</td> </tr> <tr> <td>Existing Ground Level:</td> <td>GL</td> <td>=</td> <td>879.533</td> <td>m</td> </tr> <tr> <td>Road Level:</td> <td>RL</td> <td>=</td> <td>855.07</td> <td>m</td> </tr> <tr> <td>Tunnel Axis to Road Level</td> <td>d</td> <td>=</td> <td>3.93</td> <td>m</td> </tr> </table>					Nominal Diameter of Tunnel	D _n	=	13.3	m	Construction Allowance	ΔD	=	100	mm	Thickness of Lining	t	=	0.55	m	Existing Ground Level:	GL	=	879.533	m	Road Level:	RL	=	855.07	m	Tunnel Axis to Road Level	d	=	3.93	m
Nominal Diameter of Tunnel	D _n	=	13.3	m																														
Construction Allowance	ΔD	=	100	mm																														
Thickness of Lining	t	=	0.55	m																														
Existing Ground Level:	GL	=	879.533	m																														
Road Level:	RL	=	855.07	m																														
Tunnel Axis to Road Level	d	=	3.93	m																														








6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_i < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_i > \tau$$

$$S_i = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_i)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_i), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_i)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_i)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_i)\cos 2\theta + U_w + U_n$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_n = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_i)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_i)\sin 2\theta = \frac{r_0}{3}(2S_n + S_i)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_i)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2v/3-4v)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4v)*(p0/2) - (2Q2 + (4-6v))\tau) / (4Q2 + 5-6v), \text{ (if } St > \tau)$$

$$St = (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]$$

$$M = -ro^2/6*(2Sn + St)*cos2\theta$$

$$Md = -ro^2/6*(2Sn + St)$$

$$N = -ro/3*(Sn + 2St)cos2\theta + Pw * r0 + No$$

$$Nd = -ro/3*(Sn + 2St)$$

$$No = \sigma'_v(1+k)*ro/2 + [2Ec*ro/Et*(1+\nu)]$$

$$Uw = -pw * ro^2/E * A$$

$$Un = -No * ro/E * A$$

$$U = -ro^4/18EI*(2Sn + St)*cos2\theta + Uw + Un$$

$$Ud = -ro^4/18EI*(2*Sn + St)$$

$$x = r\theta \quad dx/d\theta = r$$

$$V = r0/3*(2Sn + St)*sin2\theta$$

$$Vd = ro/3*(2Sn + St)$$

Q2	=	464.180
Sn	=	-99.28
St	=	-956.29
St	=	199
M	=	-6
Md	=	-6
N	=	2907
Nd	=	-727.86
No	=	1816.30
Uw	=	0.00
Un	=	0.0
U	=	0
Ud	=	0.00
V	=	0
Vd	=	1.565

Q2	τ	St ($\leq \tau$)	Sn	$P_w r_0$	N_0	Uw (mm)	Un (mm)	Nd (kN)	Ud (mm)	Md (kNm)
464.1796	1912	199	-99.3	1818	1816.30	0.00	0.00	-728	0.00	-5.7

Vd (kN)

1.6

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	2906.593	-0.936	-5.711	0	CROWN
10	2950.488	-0.880	-5.367	1	
20	3076.879	-0.717	-4.375	1	
30	3270.521	-0.469	-2.856	1	
40	3508.057	-0.164	-0.992	2	
45	3634.448	-0.001	0.000	2	
50	3760.839	0.161	0.992	2	
60	3998.376	0.466	2.856	1	
70	4192.018	0.715	4.375	1	
80	4318.408	0.877	5.367	1	
90	4362.303	0.934	5.711	0	AXIS

Handwritten signatures and notes:

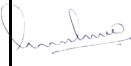
Rob

CSA

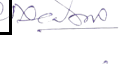
CSA

CSA

	GEOCONSULT India Pvt Ltd		ANNEXURE -1																																																																	
	A company of the GEOCONSULT group		Job no:	140172																																																																
		Page No.:		-																																																																
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction																																																																			
Calculation for	Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)																																																																			
LOAD COMBINATION 7 * SLS for Short Term * Flexible Lining * No Creep																																																																				
1. ALIGNMENT DATA <table> <tr> <td>Nominal Diameter of Tunnel</td> <td>D_n</td> <td>=</td> <td>13.3 m</td> </tr> <tr> <td>Construction Allowance</td> <td>ΔD</td> <td>=</td> <td>100 mm</td> </tr> <tr> <td>Thickness of Lining</td> <td>t</td> <td>=</td> <td>0.55 m</td> </tr> <tr> <td>Existing Ground Level:</td> <td>GL</td> <td>=</td> <td>879.533 m</td> </tr> <tr> <td>Road Level:</td> <td>RL</td> <td>=</td> <td>855.07 m</td> </tr> <tr> <td>Tunnel Axis to Road Level</td> <td>d</td> <td>=</td> <td>3.929 m</td> </tr> </table>					Nominal Diameter of Tunnel	D_n	=	13.3 m	Construction Allowance	ΔD	=	100 mm	Thickness of Lining	t	=	0.55 m	Existing Ground Level:	GL	=	879.533 m	Road Level:	RL	=	855.07 m	Tunnel Axis to Road Level	d	=	3.929 m																																								
Nominal Diameter of Tunnel	D_n	=	13.3 m																																																																	
Construction Allowance	ΔD	=	100 mm																																																																	
Thickness of Lining	t	=	0.55 m																																																																	
Existing Ground Level:	GL	=	879.533 m																																																																	
Road Level:	RL	=	855.07 m																																																																	
Tunnel Axis to Road Level	d	=	3.929 m																																																																	
2. TUNNEL GEOMETRY <table> <tr> <td>Excavated Diameter of Tunnel</td> <td>D</td> <td>=</td> <td>14.6 m</td> </tr> <tr> <td>Internal radius of tunnel</td> <td>r_i</td> <td>=</td> <td>6.750 m</td> </tr> <tr> <td>Radius of lining centroid</td> <td>r_o</td> <td>=</td> <td>7.025 m</td> </tr> <tr> <td>Radius to extrados of lining</td> <td>r_e</td> <td>=</td> <td>7.30 m</td> </tr> <tr> <td>Distance between tunnel axis to road level</td> <td></td> <td>=</td> <td>2.8210 m</td> </tr> <tr> <td>Depth to Tunnel Axis</td> <td>Z_o</td> <td>=</td> <td>21.642 m</td> </tr> </table> $\sigma'_h = K \sigma'_v$ $p_o = \sigma'_v - \sigma'_h$					Excavated Diameter of Tunnel	D	=	14.6 m	Internal radius of tunnel	r_i	=	6.750 m	Radius of lining centroid	r_o	=	7.025 m	Radius to extrados of lining	r_e	=	7.30 m	Distance between tunnel axis to road level		=	2.8210 m	Depth to Tunnel Axis	Z_o	=	21.642 m																																								
Excavated Diameter of Tunnel	D	=	14.6 m																																																																	
Internal radius of tunnel	r_i	=	6.750 m																																																																	
Radius of lining centroid	r_o	=	7.025 m																																																																	
Radius to extrados of lining	r_e	=	7.30 m																																																																	
Distance between tunnel axis to road level		=	2.8210 m																																																																	
Depth to Tunnel Axis	Z_o	=	21.642 m																																																																	
3. LOADING <table> <tr> <td>Ave. unit weight of Water</td> <td>γ_w</td> <td>=</td> <td>10 kN/m³</td> </tr> <tr> <td>Ave. unit weight of soil</td> <td>γ_s</td> <td>=</td> <td>26.00 kN/m³</td> </tr> <tr> <td>Water table from ground surface</td> <td>h_w</td> <td>=</td> <td>-23 m</td> </tr> <tr> <td>Height of Water Table considered in design</td> <td>h_w</td> <td>=</td> <td>44.642 m</td> </tr> <tr> <td>Effective overburden pressure</td> <td>q_1</td> <td>=</td> <td>116.3 kN/m²</td> </tr> <tr> <td>Surcharge</td> <td>q_2</td> <td>=</td> <td>60 kN/m²</td> </tr> <tr> <td>Load factor for Overburden Load</td> <td>FS1</td> <td>=</td> <td>1</td> </tr> <tr> <td>Load factor for Surcharge</td> <td>FS2</td> <td>=</td> <td>1</td> </tr> <tr> <td>Factored vertical stress</td> <td>σ_v'</td> <td>=</td> <td>176.27 kN/m²</td> </tr> <tr> <td>k value</td> <td>K</td> <td>=</td> <td>0.50</td> </tr> <tr> <td>Factored horizontal stress, $\sigma_h' = k \sigma_v'$</td> <td>σ_h'</td> <td>=</td> <td>88.1 kN/m²</td> </tr> <tr> <td>$P_o = \sigma_v' - \sigma_h'$</td> <td>$P_o$</td> <td>=</td> <td>88.1 kN/m²</td> </tr> <tr> <td>Load factor for Water</td> <td>Fsw</td> <td>=</td> <td>1</td> </tr> <tr> <td>Hydrostatic water pressure</td> <td>psw</td> <td>=</td> <td>446.42 kN/m²</td> </tr> </table> $p_s = \frac{q_1 + K q_2}{2}$ $\tau = c' + p_s \tan \phi'$ <table> <tr> <td>Unfactored load at tunnel crown</td> <td></td> <td>=</td> <td>59.472 kN/m²</td> </tr> <tr> <td>Unfactored load at tunnel axis</td> <td></td> <td>=</td> <td>176.272 kN/m²</td> </tr> </table>					Ave. unit weight of Water	γ_w	=	10 kN/m ³	Ave. unit weight of soil	γ_s	=	26.00 kN/m ³	Water table from ground surface	h_w	=	-23 m	Height of Water Table considered in design	h_w	=	44.642 m	Effective overburden pressure	q_1	=	116.3 kN/m ²	Surcharge	q_2	=	60 kN/m ²	Load factor for Overburden Load	FS1	=	1	Load factor for Surcharge	FS2	=	1	Factored vertical stress	σ_v'	=	176.27 kN/m ²	k value	K	=	0.50	Factored horizontal stress, $\sigma_h' = k \sigma_v'$	σ_h'	=	88.1 kN/m ²	$P_o = \sigma_v' - \sigma_h'$	P_o	=	88.1 kN/m ²	Load factor for Water	Fsw	=	1	Hydrostatic water pressure	psw	=	446.42 kN/m ²	Unfactored load at tunnel crown		=	59.472 kN/m ²	Unfactored load at tunnel axis		=	176.272 kN/m ²
Ave. unit weight of Water	γ_w	=	10 kN/m ³																																																																	
Ave. unit weight of soil	γ_s	=	26.00 kN/m ³																																																																	
Water table from ground surface	h_w	=	-23 m																																																																	
Height of Water Table considered in design	h_w	=	44.642 m																																																																	
Effective overburden pressure	q_1	=	116.3 kN/m ²																																																																	
Surcharge	q_2	=	60 kN/m ²																																																																	
Load factor for Overburden Load	FS1	=	1																																																																	
Load factor for Surcharge	FS2	=	1																																																																	
Factored vertical stress	σ_v'	=	176.27 kN/m ²																																																																	
k value	K	=	0.50																																																																	
Factored horizontal stress, $\sigma_h' = k \sigma_v'$	σ_h'	=	88.1 kN/m ²																																																																	
$P_o = \sigma_v' - \sigma_h'$	P_o	=	88.1 kN/m ²																																																																	
Load factor for Water	Fsw	=	1																																																																	
Hydrostatic water pressure	psw	=	446.42 kN/m ²																																																																	
Unfactored load at tunnel crown		=	59.472 kN/m ²																																																																	
Unfactored load at tunnel axis		=	176.272 kN/m ²																																																																	
4. SHEAR STRENGTH OF SOIL <table> <tr> <td>Uniform loading, $P_u = (q_1 + k q_2) / 2$</td> <td>P_u</td> <td>=</td> <td>73.80 kN/m²</td> </tr> <tr> <td>Maximum shear strength of ground, $\tau = c' + P_u \tan \phi'$</td> <td>$\tau$</td> <td>=</td> <td>1842.61 kN/m²</td> </tr> </table> $I_e = I_f + \left(\frac{4}{n}\right)^2 I_f, \quad n > 4$ $\tau = c' + p_s \tan \phi'$					Uniform loading, $P_u = (q_1 + k q_2) / 2$	P_u	=	73.80 kN/m ²	Maximum shear strength of ground, $\tau = c' + P_u \tan \phi'$	τ	=	1842.61 kN/m ²																																																								
Uniform loading, $P_u = (q_1 + k q_2) / 2$	P_u	=	73.80 kN/m ²																																																																	
Maximum shear strength of ground, $\tau = c' + P_u \tan \phi'$	τ	=	1842.61 kN/m ²																																																																	
5. PROPERTIES OF GROUND AND LINING <table> <tr> <td>Young's modulus of ground</td> <td>E_c</td> <td>=</td> <td>1957671.958 kN/m²</td> </tr> <tr> <td>Poisson's ratio of ground</td> <td>ν</td> <td>=</td> <td>0.26</td> </tr> <tr> <td>Effective cohesion of the ground</td> <td>c'</td> <td>=</td> <td>1800.000 kN/m²</td> </tr> <tr> <td>Effective friction angle of ground</td> <td>Φ</td> <td>=</td> <td>30 Degree</td> </tr> <tr> <td>Maximum shear strength of ground, $(\tau = c' + P_u \tan \Phi)$</td> <td>$\tau$</td> <td>=</td> <td>1842.611 kN/m²</td> </tr> <tr> <td>Young's modulus of lining</td> <td>E_l</td> <td>=</td> <td>38730 N/mm²</td> </tr> <tr> <td>Poisson's ratio of lining</td> <td>ν_l</td> <td>=</td> <td>0.15</td> </tr> <tr> <td>E of lining in plane strain condition</td> <td>E_l</td> <td>=</td> <td>39621 N/mm²</td> </tr> <tr> <td>Area of lining</td> <td>A</td> <td>=</td> <td>0.55 m²</td> </tr> <tr> <td>Second moment of area of lining</td> <td>I</td> <td>=</td> <td>0.0139 m⁴</td> </tr> <tr> <td>Total no. of segments</td> <td>n=</td> <td>=</td> <td>9</td> </tr> <tr> <td>Reduced Lining, $I_e = I_f + (4/n)^2 I_f, (n > 4)$</td> <td>$I_e$</td> <td>=</td> <td>0.002739 m⁴</td> </tr> </table>					Young's modulus of ground	E_c	=	1957671.958 kN/m ²	Poisson's ratio of ground	ν	=	0.26	Effective cohesion of the ground	c'	=	1800.000 kN/m ²	Effective friction angle of ground	Φ	=	30 Degree	Maximum shear strength of ground, $(\tau = c' + P_u \tan \Phi)$	τ	=	1842.611 kN/m ²	Young's modulus of lining	E_l	=	38730 N/mm ²	Poisson's ratio of lining	ν_l	=	0.15	E of lining in plane strain condition	E_l	=	39621 N/mm ²	Area of lining	A	=	0.55 m ²	Second moment of area of lining	I	=	0.0139 m ⁴	Total no. of segments	n=	=	9	Reduced Lining, $I_e = I_f + (4/n)^2 I_f, (n > 4)$	I_e	=	0.002739 m ⁴																
Young's modulus of ground	E_c	=	1957671.958 kN/m ²																																																																	
Poisson's ratio of ground	ν	=	0.26																																																																	
Effective cohesion of the ground	c'	=	1800.000 kN/m ²																																																																	
Effective friction angle of ground	Φ	=	30 Degree																																																																	
Maximum shear strength of ground, $(\tau = c' + P_u \tan \Phi)$	τ	=	1842.611 kN/m ²																																																																	
Young's modulus of lining	E_l	=	38730 N/mm ²																																																																	
Poisson's ratio of lining	ν_l	=	0.15																																																																	
E of lining in plane strain condition	E_l	=	39621 N/mm ²																																																																	
Area of lining	A	=	0.55 m ²																																																																	
Second moment of area of lining	I	=	0.0139 m ⁴																																																																	
Total no. of segments	n=	=	9																																																																	
Reduced Lining, $I_e = I_f + (4/n)^2 I_f, (n > 4)$	I_e	=	0.002739 m ⁴																																																																	









6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu) \frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6} (2S_n + S_t) \cos 2\theta$$

$$M_d = -\frac{r_0^2}{6} (2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3} (S_n + 2S_t) \cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3} (S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI} (2S_n + S_t) \cos 2\theta + U_w + U_u$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI} (2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0} (-2)(2S_n + S_t) \sin 2\theta = \frac{r_0}{3} (2S_n + S_t) \sin 2\theta$$

$$V_d = \frac{r_0}{3} (2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4\nu)*(po/2) - (2Q2 + (4-6\nu))\tau)/4Q2 + 5-6\nu, \text{ (if } St > \tau)$$

$$St = (1+2Q2)po/2[1+Q2(3-2\nu/3-4\nu)]$$

$$M = -ro^2/6*(2Sn + St)*\cos 2\theta$$

$$Md = -ro^2/6*(2Sn + St)$$

$$N = -ro/3*(Sn + 2St)\cos 2\theta + pw*r0 + No$$

$$Nd = -ro/3*(Sn + 2St)$$

$$No = \sigma_v(1+k)*ro/2 + 2Ec*ro/Et(1+\nu)$$

$$Uw = -pw*r0^2/E*A$$

$$Uu = -No*r0/E*A$$

$$U = -ro^4/18EI*(2Sn + St)*\cos 2\theta + Uw + Uu$$

$$Ud = -ro^4/18EI*(2Sn + St)$$

$$x = r\theta \quad dx/d\theta = r$$

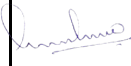
$$V = ro/3*(2Sn + St)*\sin 2\theta$$

$$Vd = ro/3*(2Sn + St)$$

Q2	=	464.180
Sn	=	-34.69
Sn	=	-921.88
St	=	70
M	=	-2
Md	=	-2
N	=	3639
Nd	=	-254.36
No	=	634.73
Uw	=	0.00
Uu	=	0.0
U	=	0
Ud	=	0.00
V	=	0
Vd	=	0.547

Q2	τ	St ($\leq \tau$)	Sn	$p_w r_e$	N_0	Uw (mm)	Uu (mm)	Nd (kN)	Ud (mm)	Md (kNm)
464.1796	1843	70	-34.7	3259	634.73	0.00	0.00	-254	0.00	-2.0
										Vd (kN)
										0.5

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	3639.236	-0.328	-1.996	0	CROWN
10	3654.575	-0.308	-1.875	0	
20	3698.744	-0.252	-1.529	0	
30	3766.415	-0.165	-0.998	0	
40	3849.425	-0.058	-0.347	1	
45	3893.594	-0.001	0.000	1	
50	3937.763	0.055	0.347	1	
60	4020.774	0.162	0.998	0	
70	4088.444	0.249	1.529	0	
80	4132.613	0.306	1.875	0	
90	4147.953	0.325	1.996	0	AXIS









	GEOCONSULT India Pvt Ltd A company of the GEOCONSULT group	ANNEXURE -1	
Project:		Job no:	140172
Calculation for		Page No.:	-
DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction		Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)	
LOAD COMBINATION 8 * SLS for Short Term * Flexible Lining * No Creep			
1. ALIGNMENT DATA			
Nominal Diameter of Tunnel	D _n =		13.3 m
Construction Allowance	ΔD =		100 mm
Thickness of Lining	t =		0.55 m
Existing Ground Level:	GL =		879.533 m
Road Level:	RL =		855.07 m
Tunnel Axis to Road Level	d =		3.929 m
2. TUNNEL GEOMETRY			
Excavated Diameter of Tunnel	D =		14.6 m
Internal radius of tunnel	r _i =		6.750 m
Radius of lining centroid	r _o =		7.025 m
Radius to extrados of lining	r _e =		7.30 m
Distance between tunnel axis to Road level			2.8210 m
Depth to Tunnel Axis	Z _o =		21.642 m
$\sigma'_h = K\sigma'_v \quad p_0 = \sigma'_v - \sigma'_h$			
3. LOADING			
Ave. unit weight of Water	γ _w =		10 kN/m ³
Ave. unit weight of soil	γ _s =		26.00 kN/m ³
Water table from ground surface	h _w =		-23.00 m
Height of Water Table considered in design	h _w =		44.642 m
Effective overburden pressure	q ₁ =		116.3 kN/m ²
Surcharge	q ₂ =		0.00 kN/m ²
Load factor for Overburden Load	FS ₁ =		1.00
Load factor for Surcharge	FS ₂ =		1.00
Factored vertical stress	σ _v ' =		116.27 kN/m ²
k value	K =		0.50
Factored horizontal stress, oh' = kov'	oh' =		58.1 kN/m ²
Po = σ _v ' - oh'	Po =		58.1 kN/m ²
Load factor for Water	F _{sw} =		1.00
Hydrostatic water pressure	psw =		446.42 kN/m ²
$p_s = \frac{q_1 + Kq_2}{2} \quad \tau = c' + p_s \tan \phi'$			
	Unfactored load at tunnel crown		-0.528 kN/m ²
	Unfactored load at tunnel axis		116.272 kN/m ²
4. SHEAR STRENGTH OF SOIL			
Uniform loading, Pu = (q ₁ + kq ₂) / 2	Pu =		28.80 kN/m ²
Maximum shear strength of ground, τ = c' + Pu tanΦ	τ =		1816.63 kN/m ²
$I_e = I_f + \left(\frac{4}{n}\right)^2 I_f, \quad n > 4 \quad \tau = c' + p_s \tan \phi'$			
5. PROPERTIES OF GROUND AND LINING			
Young's modulus of ground	E _c =		1957671.958 kN/m ²
Poisson's ratio of ground	ν =		0.26
Effective cohesion of the ground	c' =		1800.000 kN/m ²
Effective friction angle of ground	Φ =		30 Degree
Maximum shear strength of ground, (τ = c' + Pu tanΦ)	τ =		1816.630 kN/m ²
Young's modulus of lining	E _l =		38730 N/mm ²
Poisson's ratio of lining	ν _l =		0.15
E of lining in plane strain condition	E ₁ =		39621 N/mm ²
Area of lining	A =		0.55 m ²
Second moment of area of lining	I =		0.0139 m ⁴
Total no. of segments	n =		9
Reduced Lining, I _e = I _j + (4/n) ² I _j , (n>4)	I _e =		0.002739 m ⁴








6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_e r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu) \frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6} (2S_n + S_t) \cos 2\theta$$

$$M_d = -\frac{r_0^2}{6} (2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3} (S_n + 2S_t) \cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3} (S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_e r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI} (2S_n + S_t) \cos 2\theta + U_w + U_u$$

$$U_w = -\frac{P_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI} (2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0} (-2)(2S_n + S_t) \sin 2\theta = \frac{r_0}{3} (2S_n + S_t) \sin 2\theta$$

$$V_d = \frac{r_0}{3} (2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4\nu)*(po/2) - (2Q2 + (4-6\nu))\tau) / (4Q2 + 5-6\nu), \text{ (if } St > \tau)$$

$$St = (1+2Q2)po/2[1+Q2(3-2\nu/3-4\nu)]$$

$$M = -ro^2/6 * (2Sn + St) * \cos 2\theta$$

$$Md = -ro^2/6 * (2Sn + St)$$

$$N = -ro/3 * (Sn + 2St) \cos 2\theta + Pw * r0 + No$$

$$Nd = -ro/3 * (Sn + 2St)$$

$$No = \sigma_v(1+k)*ro/2 + 2Ec*ro/Et(1+\nu)$$

$$Uw = -pw*ro^2/E*A$$

$$Uu = -No*ro/E*A$$

$$U = -ro^4/18EI * (2Sn + St) * \cos 2\theta + Uw + Uu$$

$$Ud = -ro^4/18EI * (2Sn + St)$$

$$x = r\theta \quad dx/d\theta = r$$

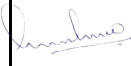
$$V = ro/3 * (2Sn + St) * \sin 2\theta$$

$$Vd = ro/3 * (2Sn + St)$$

Q2	=	464.180
Sn	=	-22.88
St	=	-908.93
M	=	46
Md	=	-1
N	=	3510
Nd	=	-167.78
No	=	418.68
Uw	=	0.00
Uu	=	0.0
U	=	0
Ud	=	0.00
V	=	0
Vd	=	0.361

Q2	τ	St (<= τ)	Sn	$P_w r_e$	N_0	Uw (mm)	Uu (mm)	Nd (kN)	Ud (mm)	Md (kNm)
464.1796	1817	46	-22.9	3259	418.68	0.00	0.00	-168	0.00	-1.3
										Vd (kN)
										0.4

θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)	
0	3509.764	-0.217	-1.316	0	CROWN
10	3519.883	-0.204	-1.237	0	
20	3549.017	-0.166	-1.008	0	
30	3593.654	-0.109	-0.658	0	
40	3648.409	-0.039	-0.229	0	
45	3677.544	-0.001	0.000	0	
50	3706.678	0.036	0.229	0	
60	3761.433	0.107	0.658	0	
70	3806.070	0.164	1.008	0	
80	3835.204	0.201	1.237	0	
90	3845.323	0.214	1.316	0	AXIS

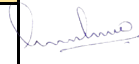








	GEOCONSULT India Pvt Ltd		ANNEXURE -1																									
	A company of the GEOCONSULT group		Job no:	140172																								
		Page No.:		-																								
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction																											
Calculation for	Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)																											
LOAD COMBINATION 9 * SLS for Short Term * Flexible Lining * No Creep																												
1. ALIGNMENT DATA <table> <tr> <td>Nominal Diameter of Tunnel</td> <td>D_n</td> <td>=</td> <td>13.3 m</td> </tr> <tr> <td>Construction Allowance</td> <td>ΔD</td> <td>=</td> <td>100 mm</td> </tr> <tr> <td>Thickness of Lining</td> <td>t</td> <td>=</td> <td>0.55 m</td> </tr> <tr> <td>Existing Ground Level:</td> <td>GL</td> <td>=</td> <td>879.533 m</td> </tr> <tr> <td>Road Level:</td> <td>RL</td> <td>=</td> <td>855.07 m</td> </tr> <tr> <td>Tunnel Axis to Road Level</td> <td>d</td> <td>=</td> <td>3.929 m</td> </tr> </table>					Nominal Diameter of Tunnel	D_n	=	13.3 m	Construction Allowance	ΔD	=	100 mm	Thickness of Lining	t	=	0.55 m	Existing Ground Level:	GL	=	879.533 m	Road Level:	RL	=	855.07 m	Tunnel Axis to Road Level	d	=	3.929 m
Nominal Diameter of Tunnel	D_n	=	13.3 m																									
Construction Allowance	ΔD	=	100 mm																									
Thickness of Lining	t	=	0.55 m																									
Existing Ground Level:	GL	=	879.533 m																									
Road Level:	RL	=	855.07 m																									
Tunnel Axis to Road Level	d	=	3.929 m																									








6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_c r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_t < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_t > \tau$$

$$S_t = \frac{(1+2Q_2)p_0}{2 \left[1+Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_t)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_t), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_t)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_t)$$

$$N_0 = \frac{\sigma'_c(1+K)r_0}{2 + \frac{2E_c r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_u$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_t)$$

$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_t)\sin 2\theta = \frac{r_0}{3}(2S_n + S_t)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_t)$$

$$Q2 = Ee * r0^3 / 12EI(1+\nu)$$

$$Sn = (1-Q2)po/2 * [1+Q2(3-2\nu/3-4\nu)] \text{ (if } St < \tau)$$

$$Sn = (3*(3-4\nu)*(po/2) - (2Q2 + (4-6\nu))\tau) / (4Q2 + 5-6\nu), \text{ (if } St > \tau)$$

$$St = (1+2Q2)po/2[1+Q2(3-2\nu/3-4\nu)]$$

$$M = -ro^2/6*(2Sn + St)*cos2\theta$$

$$Md = -ro^2/6*(2Sn + St)$$

$$N = -ro/3*(Sn + 2St)cos2\theta + pw*r0 + No$$

$$Nd = -ro/3*(Sn + 2St)$$

$$No = \sigma'_c(1+k)*ro/2 + [2Ec*ro/Et*(1+\nu)]$$

$$Uw = -pw*r0^2/E*A$$

$$Uu = -No*ro/E*A$$

$$U = -ro^4/18EI*(2Sn + St)*cos2q + Uw + Uu$$

$$Ud = -ro^4/18EI*(2*Sn + St)$$

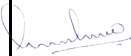
$$x = r\theta \quad dx/d\theta = r$$

$$V = ro/3*(2Sn + St)*sin2q$$

$$Vd = ro/3*(2Sn + St)$$

Q2	=	464.180
Sn	=	-122.56
St	=	-1007.71
St	=	246
M	=	-7
Md	=	-7
N	=	1344
Nd	=	-898.54
No	=	2242.22
Uw	=	0.00
Uu	=	0.0
U	=	0
Ud	=	0.00
V	=	0
Vd	=	1.932

Q2	τ	St (<= τ)	Sn	$p_w r_e$	N ₀	U _w (mm)	U _u (mm)	N _d (kN)	U _d (mm)	M _d (kNm)
464.1796	2015	246	-122.6	0	2242.22	0.00	0.00	-899	0.00	-7.1
										V _d (kN)
										1.9
θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)						
0	1343.680	-1.155	-7.050	0	CROWN					
10	1397.869	-1.085	-6.625	1						
20	1553.898	-0.885	-5.401	1						
30	1792.949	-0.578	-3.525	2						
40	2086.189	-0.201	-1.224	2						
45	2242.218	-0.001	0.000	2						
50	2398.248	0.200	1.224	2						
60	2691.487	0.576	3.525	2						
70	2930.538	0.883	5.401	1						
80	3086.567	1.084	6.625	1						
90	3140.756	1.153	7.050	0	AXIS					

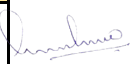








GC GROUP		GEOCONSULT India Pvt Ltd		ANNEXURE -1	
		A company of the GEOCONSULT group		Job no: 140172	
				Page No.:	-
Project:		DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Calculation for		Ground Force Calculation at Chainage by- Muir Wood (1975) and Curtis (1976)			
LOAD COMBINATION 10 * SLS for Short Term * Flexible Lining * No Creep					
1. ALIGNMENT DATA					
Nominal Diameter of Tunnel		D _n	=	13.3	m
Construction Allowance		ΔD	=	100	mm
Thickness of Lining		t	=	0.55	m
Existing Ground Level:		GL	=	879.533	m
Road Level:		RL	=	855.07	m
Tunnel Axis to Road Level		d	=	3.929	m
2. TUNNEL GEOMETRY					
Excavated Diameter of Tunnel		D	=	14.6	m
Internal radius of tunnel		r _i	=	6.750	m
Radius of lining centroid		r _o	=	7.025	m
Radius to extrados of lining		r _e	=	7.30	m
Distance between tunnel axis to Road level			=	2.8210	m
Depth to Tunnel Axis		Z _o	=	21.642	m
$\sigma'_h = K\sigma'_v$ $p_o = \sigma'_v - \sigma'_h$					
3. LOADING					
Ave. unit weight of Water		γ _w	=	10	kN/m ³
Ave. unit weight of soil		γ _s	=	26.00	kN/m ³
Water table from ground surface		h _w	=	21.90	m
Height of Water Table considered in design		h _w	=	21.642	m
Effective overburden pressure		q ₁	=	562.7	kN/m ²
Surcharge		q ₂	=	0.00	kN/m ²
Load factor for Overburden Load		FS1	=	1.00	
Load factor for Surcharge		FS2	=	1.00	
Factored vertical stress		σ _v '	=	562.69	kN/m ²
k value		K	=	0.50	
Factored horizontal stress, σ _h ' = kσ _v '		σ _h '	=	281.3	kN/m ²
P _o = σ _v ' - σ _h '		P _o	=	281.3	kN/m ²
Load factor for Water		F _{sw}	=	1.00	
Hydrostatic water pressure		p _{sw}	=	0.00	kN/m ²
$p_u = \frac{q_1 + Kq_2}{2}$ $\tau = c' + p_u \tan \phi'$ Unfactored load at tunnel crown = 372.892 kN/m² Unfactored load at tunnel axis = 562.692 kN/m²					
4. SHEAR STRENGTH OF SOIL					
Uniform loading, P _u = (q ₁ + kq ₁) / 2		P _u	=	327.12	kN/m ²
Maximum shear strength of ground, τ = c' + P _u tanφ		τ	=	1988.86	kN/m ²
$I_e = I_f + \left(\frac{4}{n}\right)^2 I_f, \quad n > 4$ $\tau = c' + p_u \tan \phi'$					
5. PROPERTIES OF GROUND AND LINING					
Young's modulus of ground		E _c	=	1957671.958	kN/m ²
Poisson's ratio of ground		v	=	0.26	
Effective cohesion of the ground		c'	=	1800.000	kN/m ²
Effective friction angle of ground		Φ	=	30	Degree
Maximum shear strength of ground,(τ = c' + P _u tanΦ)		τ	=	1988.862	kN/m ²
Young's modulus of lining		E _l	=	38730	N/mm ²
Poisson's ratio of lining		v _l	=	0.15	
E of lining in plane strain condition		E _l	=	39621	N/mm ²
Area of lining		A	=	0.55	m ²
Second moment of area of lining		I	=	0.0139	m ⁴
Total no. of segments		n=	=	9	
Reduced Lining, I _e = I _j +(4/n) ² , (n>4)		I _e =	=	0.002739	m ⁴








6. BENDING MOMENT, HOOP TRUST AND RADIAL MOVEMENT OF LINING

$$Q_2 = \frac{E_c r_0^3}{12EI(1+\nu)}$$

$$S_n = \frac{(1-Q_2)p_0}{2 \left[1 + Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}, \text{ if } S_i < \tau$$

$$S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5-6\nu}, \text{ if } S_i > \tau$$

$$S_i = \frac{(1+2Q_2)p_0}{2 \left[1 + Q_2 \left(\frac{3-2\nu}{3-4\nu} \right) \right]}$$

where S_n and S_t are normal and shear stresses respectively

$$M = -\frac{r_0^2}{6}(2S_n + S_i)\cos 2\theta$$

$$M_d = -\frac{r_0^2}{6}(2S_n + S_i), \text{ hogging moment positive}$$

$$N = -\frac{r_0}{3}(S_n + 2S_i)\cos 2\theta + p_w r_0 + N_0$$

$$N_d = -\frac{r_0}{3}(S_n + 2S_i)$$

$$N_0 = \frac{\sigma'_v(1+K)r_0}{2 + \frac{2E_c r_0}{Et(1+\nu)}}$$

$$U = -\frac{r_0^4}{18EI}(2S_n + S_i)\cos 2\theta + U_w + U_u$$

$$U_w = -\frac{p_w r_0^2}{EA}$$

$$U_u = -\frac{N_0 r_0}{EA}$$

$$U_d = -\frac{r_0^4}{18EI}(2S_n + S_i)$$

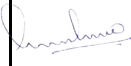
$$x = r\theta \Rightarrow \frac{\partial x}{\partial \theta} = r$$

$$V = \frac{\partial M}{\partial x} = \frac{\partial M}{\partial \theta} \frac{\partial \theta}{\partial x} = -\frac{r_0^2}{6r_0}(-2)(2S_n + S_i)\sin 2\theta = \frac{r_0}{3}(2S_n + S_i)\sin 2\theta$$

$$V_d = \frac{r_0}{3}(2S_n + S_i)$$

$Q_2 = Ee^* r_0^3 / 12EI(1+\nu)$	Q_2	=	464.180
$S_n = (1-Q_2)p_0/2 * [1+Q_2(3-2\nu/3-4\nu)]$ (if $S_t < \tau$)	S_n	=	-110.75
$S_n = (3*(3-4\nu)*(p_0/2) - (2Q_2 + (4-6\nu))\tau)/4Q_2 + 5-6\nu$, (if $S_t > \tau$)	S_n	=	-994.76
$S_t = (1+2Q_2)p_0/2[1+Q_2(3-2\nu/3-4\nu)]$	S_t	=	222
$M = -r_0^2/6*(2S_n + S_t)*\cos 2\theta$	M	=	-6
$M_d = -r_0^2/6*(2S_n + S_t)$	M_d	=	-6
$N = -r_0/3*(S_n + 2S_t)\cos 2\theta + p_w r_0 + N_0$	N	=	1214
$N_d = -r_0/3*(S_n + 2S_t)$	N_d	=	-811.96
$N_0 = \sigma'_v(1+K)r_0/2 + [2E_c r_0/Et(1+\nu)]$	N_0	=	2026.17
$U_w = -p_w r_0^2/E^*A$	U_w	=	0.00
$U_u = -N_0 r_0/E^*A$	U_u	=	0.0
$U = -r_0^4/18EI*(2S_n + S_t)*\cos 2\theta + U_w + U_u$	U	=	0
$U_d = -r_0^4/18EI*(2S_n + S_t)$	U_d	=	0.00
$x = r\theta$			
$dx/d\theta = r$			
$V = r_0/3*(2S_n + S_t)*\sin 2\theta$	V	=	0
$V_d = r_0/3*(2S_n + S_t)$	V_d	=	1.745

Q2	τ	St ($\leq \tau$)	S_n	$p_w r_e$	N_0	U_w (mm)	U_u (mm)	N_d (kN)	U_d (mm)	M_d (kNm)
464.1796	1989	222	-110.7	0	2026.17	0.00	0.00	-812	0.00	-6.4
										Vd (kN)
										1.7
θ (deg)	N (kN)	U (mm)	M (kNm)	V (kN)						
0	1214.209	-1.044	-6.371	0	CROWN					
10	1263.176	-0.981	-5.987	1						
20	1404.171	-0.800	-4.880	1						
30	1620.188	-0.522	-3.185	2						
40	1885.172	-0.182	-1.106	2						
45	2026.167	-0.001	0.000	2						
50	2167.162	0.180	1.106	2						
60	2432.147	0.521	3.185	2						
70	2648.164	0.798	4.880	1						
80	2789.159	0.979	5.987	1						
90	2838.126	1.042	6.371	0	AXIS					








SHEAR AT THE INTERFACE BETWEEN CONCRETE CAST AT DIFFERENT TIMES				
PROJECT:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
PID:	I40172			
Section:	Structural Design of Bored tunnel Segment			
Check for Shear Reinforcement -				
Characteristic Strength of steel			500 N/mm ²	
Design Yield strength of shear reinforcement f_{ywd} =			378 N/mm ²	
Depth of the section	D =		0.550 m	
Width of the section	b_w =		1.400 m	
Effective depth	d_t =		0.486 m	
Clear cover	=		50 mm	
Characteristic Strength of concrete	f_{ck} =		60 N/mm ²	
Reinforcement Provided	A_{st} =		1938 mm ²	
	$100A_{st}/bd$		0.28 %	
Design Shear Strength of Concrete	τ_c =		0.41 N/mm ²	Table 19, IS 456
For members subjected to axial compression, design shear strength is multiplied by δ				CI 40.2.2, IS 456
	$\delta = 1+3P_u/A_gf_{ck}$			
Maximum axial compressive force in N	P_u =		6222000 N	
	δ =		1.4	
Design Shear Strength of Concrete	τ_c =		0.573 N/mm ²	
Maximum Shear Strength of Concrete	τ_v =		5.20 N/mm ²	Table 20, IS 456
Shear Force (By MW sheet)	V_u =		20.00 kN	
Shear Stress generated	τ_u =		0.026 N/mm ²	
Shear stress	τ_u =	0.03	<	τ_c = 0.57
NO SHEAR REINFORCEMENT REQUIRED				







**Project Title :****DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction****Job No. :****I40172 Bored Tunnel Segment design -Strestch TS04-Type A - Crack Width Check at Crown (Intrados)****CALCULATION OF CRACK WIDTHS IN CONCRETE MEMBERS** E_c ... E-modulus of concrete f_{cu} ... characteristic strength of concrete f_{CT} ... tensile capacity of concrete at reinforcement level E_s ... E-modulus of steel f_y ... characteristic strength of steel c_{MIN} ... min. cover to steel h depth of member d' distance to steel A_{SC}, A_{ST} .. compression / tension reinforcement s spacing of steel bars N axial force due to service load M bending moment due to service load x depth of compression zone f_c compressive concrete stress f_s tensile steel stress ϵ_T strain at tension face w_{CR} crack width

$$N = [bx/2 f_{c-c} + ((x-d'))/x (\alpha-1) A_{sc} f_{c-c} - ((d-x))/x \alpha A_{st} f_{c-c}]$$

$$M = [bx/2 f_{c-c} \cdot (h/2 - x/3) + ((x-d'))/x (\alpha-1) A_{sc} f_{c-c} \cdot (h/2 - d') - ((d-x))/x \alpha A_{st} f_{c-c} \cdot (h/2 - d'')]$$

$$\epsilon \approx ((h-x))/((d-x)) \cdot f_s / E_s - (b(h-x)^2)/(3E_s A_s (d-x))$$

$$f_s = \frac{(d-x)}{x} \alpha f_c$$

$$w_{cr} = \frac{3a_{cr} \epsilon_m}{1 + 2 \left(\frac{a_{cr} - c_{min}}{h - x} \right)}$$

$$\text{where } a_{cr} = \sqrt{c_{min}^2 + \left(\frac{s}{2} \right)^2} - \frac{d_b}{2}$$

Concrete:		Steel:	
E_c	38,730 N/mm ²	E_s	205,000 N/mm ²
f_{cu}	60.0 N/mm ²	f_y	500.0 N/mm ²
b	1,000 mm	c_{MIN}	40.0 mm
f_{CT}	0.55 N/mm ²	d_b	12.0 mm
α	10.6	d_{link}	8.0 mm

Calculation performed for :
long - term case**Solve Crack**PRESS BUTTON
to solve crack equationsCrack width limit **0.3**

CASE	h [mm]	d [mm]	d' [mm]	$A_{s,c}$ [mm ²]	$A_{s,t}$ [mm ²]	s [mm]	$a_{c,r}$ [mm]	N [kN]	M [kNm]	x [mm]	f_c [N/mm ²]	f_s [N/mm ²]	ϵ [*1000]	w_{CR} [mm]		f_s' [N/mm ²]	N_i [kN]	M_i [kNm]	STATUS
1	550	496	54	647	647	200	108	3288.4	29.7	803	8.0	-32.5	-0.13	0.000	-	79	3288.4	29.7	OK
2	550	496	54	647	647	200	108	2880.4	23.1	806	7.0	-28.5	-0.11	0.000	-	69	2880.4	23.1	OK
3	550	496	54	647	647	200	108	3143.8	54.4	778	7.9	-30.4	-0.12	0.000	-	78	3143.8	54.4	OK
4	550	496	54	647	647	200	108	2749.4	47.6	778	6.9	-26.5	-0.10	0.000	-	68	2749.4	47.6	OK
5	550	496	54	647	647	200	108	0.0	0.0	387	0.0	0.0	-0.61	0.000	-	0	0.0	0.0	OK
6	550	496	54	647	647	200	108	0.0	0.0	394	0.0	0.0	-0.60	0.000	-	0	0.0	0.0	OK
7	550	496	54	647	647	200	108	0.0	0.0	323	0.0	0.0	-0.75	0.000	-	0	0.0	0.0	OK
8	550	496	54	647	647	200	108	0.0	0.0	330	0.0	0.0	-0.73	0.000	-	0	0.0	0.0	OK

OK

OK

OK

OK

OK

OK

OK

OK

OK

OK



Project Title :

DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction

Job No. :

I40172 Bored Tunnel Segment design -Strestch TS04-Type A - Crack Width Check at Crown (Extrados)

CALCULATION OF CRACK WIDTHS IN CONCRETE MEMBERS

 E_C .. E-modulus of concrete f_{CU} .. characteristic strength of concrete f_{CT} .. tensile capacity of concrete at reinforcement level E_S ... E-modulus of steel f_y characteristic strength of steel C_{MIN} . min. cover to steel

h..... depth of member

d'..... distance to steel

 A_{SC}, A_{ST} .. compression / tension reinforcement

s..... spacing of steel bars

N..... axial force due to service load

M..... bending moment due to service load

x..... depth of compression zone

 f_C compressive concrete stress f_S tensile steel stress ϵ_T strain at tension face w_{CR} crack width

$$N = [bx/2 f_c + ((x-d'))/x (\alpha-1) A_{sc} f_c - ((d-x))/x \alpha A_{st} f_c]$$

$$M = [bx/2 f_c \cdot (h/2 - x/3) + ((x-d'))/x (\alpha-1) A_{sc} f_c \cdot (h/2 - d') - ((d-x))/x \alpha A_{st} f_c \cdot (h/2 - d')]$$

$$f_s = \frac{(d-x)}{x} \alpha f_c$$

$$\epsilon \approx ((h-x))/((d-x)) \cdot f_s / E_s - (b(h-x)^2)/(3E_s A_s (d-x))$$

$$w_{cr} = \frac{3a_{cr}\epsilon_m}{1 + 2\left(\frac{a_{cr} - c_{min}}{h - x}\right)}$$

$$\text{where } a_{cr} = \sqrt{c_{min}^2 + \left(\frac{s}{2}\right)^2} - \frac{d_b}{2}$$

Concrete:			Steel:		
E_C	38,730	N/mm ²	E_S	205,000	N/mm ²
f_{CU}	60.0	N/mm ²	f_y	500.0	N/mm ²
b	1,000	mm	C_{MIN}	50.0	mm
f_{CT}	0.55	N/mm ²	d_b	12.0	mm
α	10.6		d_{link}	8.0	mm

Calculation performed for :
long - term case

Solve Crack

PRESS BUTTON

to solve crack equations

Crack width limit 0.2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CASE	h [mm]	d [mm]	d' [mm]	$A_{s,c}$ [mm ²]	$A_{s,t}$ [mm ²]	s [mm]	$a_{c,r}$ [mm]	N [kN]	M [kNm]	x [mm]	f_c [N/mm ²]	f_s [N/mm ²]	ϵ [*1000]	w_{CR} [mm]		f_s' [N/mm ²]	N_i [kN]	M_i [kNm]		STATUS
1	550	486	64	647	647	200	113	3288.4	29.7	802	8.0	-33.5	-0.13	0.000	-	78	3288.4	29.7		OK
2	550	486	64	647	647	200	113	2880.4	23.1	805	7.0	-29.4	-0.11	0.000	-	68	2880.4	23.1		OK
3	550	486	64	647	647	200	113	3143.8	54.4	777	7.9	-31.4	-0.12	0.000	-	77	3143.8	54.4		OK
4	550	486	64	647	647	200	113	2749.4	47.6	777	6.9	-27.5	-0.10	0.000	-	67	2749.4	47.6		OK
5	550	486	64	647	647	200	113	0.0	0.0	399	0.0	0.0	-0.66	0.000	-	0	0.0	0.0		OK
6	550	486	64	647	647	200	113	0.0	0.0	401	0.0	0.0	-0.66	0.000	-	0	0.0	0.0		OK
7	550	486	64	647	647	200	113	0.0	0.0	390	0.0	0.0	-0.67	0.000	-	0	0.0	0.0		OK
8	550	486	64	647	647	200	113	0.0	0.0	389	0.0	0.0	-0.67	0.000	-	0	0.0	0.0		OK

**PROJECT:****DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction****Job No****I40172****Section:****Segmental Lining - Seismic Check Calculation (O.D.E Full Slip CASE)**

Ultimate Limit State Design For Plain And Lightly Reinforced Concrete Structures

Circular Tunnel ODE Case- Full Slip Condition

Assumed moment magnitude	(Mw)	Refer Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	6.5
Assumed ratio of ground motion at tunnel depth to motion at ground surface (tunnel depth 15-30m)	m	Refer Table 4 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	0.8
Assumed ratio of peak ground velocity (cm/s) to peak ground acceleration (g)	g	Refer Table 2 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	76
Seismic Zone	ϵ (*)		=	0.075

Axial and curvature deformation

Poisson's ratio of soil	n		=	0.26
Density of soil	g		=	25.00 KN/m ³
Apparent velocity of S-wave propagation	C _s	From Site specific study	=	494 m/s
Peak ground particle acceleration in soil	a _s [g]	m * ϵ	0.8*0.075	= 0.0600
Earth's gravity	g		=	9.81 m/s ²
Peak ground particle velocity in soil	V _s	g * a _s /100	76*0.06/100	= 0.05 m/s
Dynamic Shear modulus of soil	G _m	Em/(2(1+U))	5 / 10 x 494.166211107401 x 494.166211107401	= 635 MPa
Dynamic Young's Modulus of Soil	E _m	2G _m (1+U)	2 x 635 x (1 + 0.26)	= 1,600 MPa
Radius of circular tunnel (internal radius of the lining)	r		=	6.75 m
Angle of incidence	F		=	45 °,degree
Total axial strain	e ^{ab}	(Vs/Cs)*sinF *cosF +((as*g*r)/C _s ²)*cos ³ F	0.05/494.17*sin45*PI/180*cos45*PI/180+(0.06*9.81*6.75)/0.0456*2*cos ³ 45*PI/180	= 0.000052
Allowable compression strain of concrete	e _{allow}		=	0.003500

Ovaling deformation

Lining thickness	t		=	0.550 m
No of Segments	n		=	9
Grade of Concrete	Fck		=	60 MPa
Concrete Young's modulus	E _i		=	38,730 MPa
Concrete Poisson's ratio	n _i		=	0.15
Area of the tunnel lining per unit width	A _i		=	0.550 m ² /m
Ij at a joint of lining	Ij		=	0.000000
Reduced Moment of inertia of the tunnel lining per unit width	I _r	I _r = Ij + (4/n)*t ² * I	(0) + ((4/9)*2) * 0.55*3 *1/12	= 0.002739 m ⁴ /m
Young's modulus of soil	E		=	0.00996
	Z	I / (2*t)	0.002739/(2*0.55)	= 1,600 MPa

Use formulations of Penzien (2000) assuming full slip condition

Maximum free-field shear strain of soil or rock medium	g _{max}	V _s /C _s	0.05/494.17	= 0.00009
Coefficient to calculate R ⁿ	a ⁿ	(12*E _i *I*(5-6*n))/((2*r) ³ *G*(1-n _i ²))	(12*38729.834*0.00274*(5-6*0.26))/((2*6.75) ³ *3*635*(1-0.15 ²))	= 0.00287
Lining-soil racking ratio under normal loading only	R ⁿ	4*(1-v)/(a ⁿ +1)	4*(1-0.26)/(0.003+1)	= 2.95
Lining diametric deflection under normal loading only	Dd ⁿ _{lining}	R ⁿ * g _{max} * 2 * r/2	2.96*0.01*2*6.75/2	= 0.002
Maximum circumferential thrust in tunnel lining	T(p/4)	(12*E _i *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4)) / ((2*r) ³ *(1-n _i ²))	(12*38730*1000*0.003*0.002*cos2(θ+PI/4))/(2*6.75) ³ *(1-0.15 ²)	= 1.000 KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	(6*E _i *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4)) / ((2*r) ³ *(1-n _i ²))	(6*38729.834*1000*0.003*0.002*cos2(θ+PI/4))/(2*6.75) ³ *(1-0.15 ²)	= 7.000 KNm
Maximum Shear in tunnel lining	V(0)	(24*E _i *1000*I*Dd ⁿ _{lining} *sin2(θ+p/4)) / ((2*r) ³ *(1-n _i ²))	(24*38730*1000*0.003*0.002*sin2(θ+PI/4))/(2*6.75) ³ *(1-0.15 ²)	= 2.000 KN
Combined stress from thrust and bending moment due to earthquake	s _e	(T(p/4)/A _i +M(p/4)*(t/2)/I)/1000	(1/0.55+7*(0.55/2)/0.003)/1000	= 0.705 MPa

[Handwritten signatures and initials]

Use formulations of Wang (1993) assuming full slip condition						
Flexibility ratio of tunnel lining	F	$(E^*(1-n^2)*r^3) / (6*E_i*I^*(1+n))$	$(1600*(1-0.15^2)*6.75^3) / (6*38729.834*1*(1+0.26))$	=	599.845	
Full slip lining response coefficient	K _l	$12*(1-n)/(2*F+5-6n)$	$12*(1-0.26)/(2*600+5-6*0.26)$	=	0.01	
Maximum thrust in tunnel lining	T _{max}	$K_l*E*1000*r * g_{max}/(6*(1+n))$	$0.008*1600*1000*6.75*0.01/6*(1+0.26)$	=	1	KN
Maximum bending moment in tunnel cross section due to S-waves	M _{max}	$K_l*E*1000*r^2 * g_{max}/(6*(1+n))$	$0.008*1600*1000*6.75^2*0.01/6*(1+0.26)$	=	7	KNm
Combined stress from thrust and bending moment due to earthquake	s _e	$(T_{max}/A_t+M_{max}*(t/2)/I)/1000$	$(0.98/0.55+6.57*(0.55/2)/1)/1000$	=	0.661	MPa
Required reinforcement			$(0.67 / 2) * 0.55* 1000 / (2 * 0.87 * 500)$	=	223	mm ²
Characteristic compressive strength of concrete, f _{ck}				=	60.00	MPa
Characteristic axial tensile strength of concrete, f _{ctk}				=	4.10	MPa
g _c (*)				=	1.56	
g _n (**)				=	1.20	
g _{tot}				=	1.87	
Design value of concrete compressive strength, f _{cd} = α _{cc} * f _{ck} / γ _c			1 * 60/ 1.872	=	32.05	mpa
α _{cc} - coefficient taking account of long term effects on the compressive strength, the recommended value is 1.0						
f _{cd} > σ _e					safe	
Design value of the Concrete tensile strength, f _{ctd} = α _{ct} f _{ctk,0.05} / γ _c			1 * 4.1/ 1.872	=	2.19	mpa
α _{ct} ,coefficient taking account of long term effects on the tensile strength, the recommended value is 1.0						
f _{ctd} > σ _e					safe	

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

**GEOCONSULT India Pvt Ltd**

A company of the GEOCONSULT group

Annexure -2**PROJECT:****DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction****Job No****I40172****Section:****Segmental Lining - Seismic Check Calculation (M.C.E Full Slip CASE)**

Ultimate Limit State Design For Plain And Lightly Reinforced Concrete Structures

Circular Tunnel MCE Case- Full Slip Condition

Assumed moment magnitude	(Mw)	Refer Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	6.5
Assumed ratio of ground motion at tunnel depth to motion at ground surface (tunnel depth 15-30m)	m	Refer Table 4 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	0.8
Assumed ratio of peak ground velocity (cm/s) to peak ground acceleration (g)	g	Refer Table 2 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	76
Seismic Zone	ϵ (*)		=	0.15

Axial and curvature deformation

Poisson's ratio of soil	n			0.26
Density of soil	g			25.00 KN/m ³
Apparent velocity of S-wave propagation	C _s	From Site specific study		494.17 m/s
Peak ground particle acceleration in soil	a _s [g]	m * ϵ	0.8*0.15	0.1200
Earth's gravity	g			9.81 m/s ²
Peak ground particle velocity in soil	V _s	g * a _s /100	76*0.12/100	0.09 m/s
Dynamic Shear modulus of soil	G _m	$\rho_m C_m^2$	5 / 10 x 494.166211107401 x 494.166211107401	635 MPa
Dynamic Young's Modulus of Soil	E _m	2G _m (1+U)	2 x 635 x (1 + 0.26)	1,600 MPa
Radius of circular tunnel (internal radius of the lining)	r			6.75 m
Angle of incidence	F			45 °,degree
Total axial strain	e ^{ab}	(Vs/Cs)*sinF *cosF +((as*g*r)/C _s ²)*cos ³ F	0.1/494.17*sin45* π /180*cos45* π /180+(0.12*9.81*6.75)/0.0912*2*cos ³ 45* π /180	0.000104
Allowable compression strain of concrete	e _{allow}			0.003500

ok

Ovaling deformation

Lining thickness	t		=	0.550 m
No of Segments	n		=	9.000
Grade of Concrete	Fck		=	60.0 MPa
Concrete Young's modulus	E _i		=	38,730 MPa
Concrete Poisson's ratio	n _i		=	0.15
Area of the tunnel lining per unit width	A _i		=	0.550 m ² /m
Reduced Moment of inertia of the tunnel lining per unit width	I _r	I _r = I _j + (4/n)*t ² I	(0) + ((4/9)^2) * 0.55^3 *1/12	0.002739 m ⁴ /m
	z	I / (2*t)	0.002739/(2*0.55)	0.00996
Young's modulus of soil	E		=	1,600 MPa

Use formulations of Penzien (2000) assuming full slip condition

Maximum free-field shear strain of soil or rock medium	g _{max}	V _g /C _s	0.1/494.17	=	0.00018
Coefficient to calculate R ⁿ	a ⁿ	(12*E _i *1*(5-6*n))/((2r)*G*(1-n _i ²))	(12*38729.834*0.00274*(5-6*0.26))/((2*6.75)*3*635*(1-0.15^2))	=	0.00287
Lining-soil racking ratio under normal loading only	R ⁿ	4*(1-v)/(a ⁿ +1)	4*(1-0.26)/(0.003+1)	=	2.95
Lining diametric deflection under normal loading only	Dd ⁿ lining	R ⁿ * g _{max} * 2 * r/2	2.96*0.01*2*6.75/2	=	0.004
Maximum circumferential thrust in tunnel lining	T(p/4)	(12*E _i *1000*I*Dd ⁿ lining*cos2(θ+p/4)) / ((2*r) ³ *(1-n _i ²))	(12*38730*1000*0.003*0.004*cos2(θ+ π /4))/((2*6.75)^3*(1-0.15^2))	=	2.000 KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	(6*E _i *1000*I*Dd ⁿ lining*cos2(θ+p/4)) / ((2*r) ² *(1-n _i ²))	(6*38729.834*1000*0.003*0.004*cos2(θ+ π /4))/((2*6.75)^2*(1-0.15^2))	=	14.000 KNm
Maximum Shear in tunnel lining	V(0)	(24*E _i *1000*I*Dd ⁿ lining*sin2(θ+p/4)) / ((2*r) ² *(1-n _i ²))	(24*38730*1000*0.003*0.004*sin2(θ+ π /4))/((2*6.75)^2*(1-0.15^2))	=	4.000 KN
Combined stress from thrust and bending moment due to earthquake	s _e	(T(p/4)/A _i +M(p/4)*(t/2)/I)/1000	(2/0.55+14*(0.55/2)/0.003)/1000	=	1.409 MPa

Use formulations of Wang (1993) assuming full slip condition						
Flexibility ratio of tunnel lining	F	$(E^*(1-n^2)*r^3) / (6*E_i*I^*(1+n))$	$(1600^*(1-0.15^2)*6.75^3)/(6*38729.834*1^*(1+0.26))$	=	599.845	
Full slip lining response coefficient	K _l	$12^*(1-n)/(2*F+5-6n)$	$12^*(1-0.26)/(2*600+5-6*0.26)$	=	0.01	
Maximum thrust in tunnel lining	T _{max}	$K_l*E*1000*r * g_{max}/(6*(1+n))$	$0.008*1600*1000*6.75*0.01/6*(1+0.26)$	=	2	KN
Maximum bending moment in tunnel cross section due to S-waves	M _{max}	$K_l*E*1000*r^2 * g_{max}/(6*(1+n))$	$0.008*1600*1000*6.75^2*0.01/6*(1+0.26)$	=	13	KNm
Combined stress from thrust and bending moment due to earthquake	s _e	$(T_{max}/A_i+M_{max}*(t/2)/I)/1000$	$(1.95/0.55+13.14*(0.55/2)/1)/1000$	=	1.322	MPa
Required reinforcement			$(1.33 / 2) * 0.55* 1000 / (2 * 0.87 * 500)$	=	446	mm ²
Characteristic compressive strength of concrete, f _{ck}				=	60.0	MPa
Characteristic axial tensile strength of concrete, f _{ctk}				=	4.1	MPa
g _c (*)				=	1.6	
g _n (**)				=	1.2	
g _{tot}				=	1.87	
Design value of concrete compressive strength, f _{cd} = α _{cc} * f _{ck} / γ _c			1 * 60/ 1.872	=	32.05	mpa
α _{cc} - coefficient taking account of long term effects on the compressive strength, the recommended value is 1.0						
f _{cd} > σ _e					safe	
Design value of the Concrete tensile strength, f _{ctd} = α _{ct} f _{ctk,0.05} / γ _c			1 * 4.1/ 1.872	=	2.19	mpa
α _{ct} , coefficient taking account of long term effects on the tensile strength, the recommended value is 1.0						
f _{ctd} > σ _e					safe	








**GEOCONSULT India Pvt Ltd**

A company of the GEOCONSULT group

Annexure -2

PROJECT:		DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Job No		I40172			
Section:		Segmental Lining - Seismic Check Calculation (O.D.E No Slip CASE)			
Ultimate Limit State Design For Plain And Lightly Reinforced Concrete Structures					
Circular Tunnel ODE Case- No Slip Condition					
Assumed moment magnitude	(Mw)	Refer Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	6.5	
Assumed ratio of ground motion at tunnel depth to motion at ground surface (tunnel depth 6-15m)	m	Refer Table 4 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	0.8	
Assumed ratio of peak ground velocity (cm/s) to peak ground acceleration (g)	g	Refer Table 2 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	76	
Seismic Zone	ε (*)		=	0.075	
Axial and curvature deformation					
Poisson's ratio of soil	n			0.26	
Density of soil	g			25.00	KN/m³
Apparent velocity of S-wave propagation	C _s	From Site specific study		494	m/s
Peak ground particle acceleration in soil	a _s [g]	m * ε	0.8*0.075	0.0600	
Earth's gravity	g			9.81	m/s²
Peak ground particle velocity in soil	V _s	g * a _s /100	76*0.06/100	0.05	m/s
Dynamic Shear modulus of soil	G _m	ρ ² C _m ²	5 / 10 x 494.166211107401 x 494.166211107401	635	MPa
Dynamic Young's Modulus of Soil	E _m	ρ _m C _m ²	2 x 635 x (1 + 0.26)	1,600	MPa
Radius of circular tunnel (internal radius of the lining)	r			6.75	m
Angle of incidence	F			45	°,degree
Total axial strain	e ^{ab}	(Vs/Cs)*sinF *cosF +((as*g*r)/C _s ²)*cos³F	0.05/494.17*sin45*Π/180*cos45*Π/180+(0.06*9.81*6.75)/0.0456²*cos³45*Π/180	0.000052	
Allowable compression strain of concrete	e _{allow}			0.003500	ok
Ovaling deformation					
Lining thickness	t		=	0.550	m
No of Segments	n		=	9	
Grade of Concrete	F _{ck}		=	60.0	MPa
Concrete Young's modulus	E _i		=	38,730	MPa
Concrete Poisson's ratio	n _i		=	0.15	
Area of the tunnel lining per unit width	A _i		=	0.550	m²/m
Reduced Moment of inertia of the tunnel lining per unit width	I _r	I _r = I _j + (4/n)*2*I	(0) + ((4/9)²) * 0.55³ *1/12	0.002739	m⁴/m
	z	I / (2*t)	0.002739/(2*0.55)	0.00996	
Young's modulus of soil	E		=	1,600	MPa
Use formulations of Penzien (2000) assuming no slip condition					
Maximum free-field shear strain of soil or rock medium	g _{max}	V _s /C _s	0.05/494.17	0.00009	
Coefficient to calculate R ⁿ	a	(24*E _i *I*(3-4*n))/((2r)³*G*(1-n _i ²))	(24*38729.834*0.00274*(3-4*0.26))/((2*6.75)³*635*(1-0.15²))	0.00327	
Lining-soil racking ratio under normal loading only	R	4*(1-v)/(a+1)	4*(1-0.26)/(0.004+1)	2.95	
Lining diametric deflection under normal loading only	Dd ⁿ _{lining}	R ⁿ * g _{max} * 2 * r/2	2.96*0.01²*6.75/2	0.002	
Maximum circumferential thrust in tunnel lining	T(p/4)	(24*E _i *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4))	(24*38730*1000*0.003*0.002*cos2(θ+Π/4))/(2*6.75)³*(1-0.15²)	2.000	KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	(6*E _i *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4))	(6*38729.834*1000*0.003*0.002*cos2(θ+Π/4))/((2*6.75)²*(1-n _i ²))	7.000	KNm
Maximum Shear in tunnel lining	V(0)	(24*E _i *1000*I*Dd ⁿ _{lining} *sin2(θ+p/4))	(24*38730*1000*0.003*0.002*sin2(θ+Π/4))/((2*6.75)³*(1-0.15²))	2.000	KN
Combined stress from thrust and bending moment due to earthquake	s _e	(T(p/4)/A _i +M(p/4)*(t/2)/I)/1000	(2/0.55+7*(0.55/2)/0.003)/1000	0.707	MPa

Use formulations of Wang (1993) assuming no slip condition						
Flexibility ratio of tunnel lining	F	$(E^*(1-n^2)*r^3) / (6*E_t*I^*(1+n))$	$(1600^*(1-0.15^2)*6.75^3)/(6*38729.834*1^*(1+0.26))$	=	599.845	
Compressibility Ratio of tunnel Lining	C	$(E^*(1-n^2)*r) / (E_t*I^*(1+n)(1-2n))$	$(1600^*(1-0.15^2)*6.75)/(6.7538729.834*0.55^*(1+0.26)(1-2*0.26))$	=	0.819	
No slip lining response coefficient	K ₂	$1+((F[1-2n]-(1-2n)*C]-(1/2)*(1-2n)^2+2)/(F[(3-2n)+(1-2n)C]+C[(5/2)-8n+6n^2]+6-8n))$	$1+((599.845[(1-2*0.26*0.819)-(1/2)*(1-2*0.26)^2+2]/(599.845[(3-2*0.26)+(1-2*0.26)*0.819]+0.819[(5/2)-8*0.26+6*0.26^2]+6-8*0.26))$	=	1.03	
Maximum thrust in tunnel lining	T _{max}	$K_2*E*1000*r * g_{max}/(2*(1+n))$	$1.032*1600*1000*6.75*0.01/2*(1+0.26)$	=	408	KN
Maximum bending moment in tunnel cross section due to S-waves	M _{max}	Note that no solution is developed for calculating diametric strain and maximum moment under no-slip condition. It is recommended that the solutions for full-slip condition be used for no-slip condition. The more conservative estimates of the fullslip condition is considered			=	7 KNm
Combined stress from thrust and bending moment due to earthquake	S _e	$(T_{max}/A_t+M_{max}*(t/2)/I)/1000$	$(407.8/0.55+7*(0.55/2)/1)/1000$	=	1.444	MPa
Required reinforcement			$(1.45 / 2) * 0.55 * 1000 / (2 * 0.87 * 500)$	=	457	mm ²
Characteristic compressive strength of concrete, f _{ck}				=	60.0	MPa
Characteristic axial tensile strength of concrete, f _{ctk}				=	4.1	MPa
g _c ^(*)				=	1.6	
g _n ^(**)				=	1.2	
g _{tot}				=	1.87	
Design value of concrete compressive strength, f _{cd} = α _{cc} * f _{ck} / γ _c			1 * 60/ 1.872	=	32.05	mpa
α _{cc} - coefficient taking account of long term effects on the compressive strength, the recommended value is 1.0						
f _{cd} > σ _e					safe	
Design value of the Concrete tensile strength, f _{ctd} = α _{ct} f _{ctk,0.05} / γ _c			1 * 4.1/ 1.872	=	2.19	mpa
α _{ct} , coefficient taking account of long term effects on the tensile strength, the recommended value is 1.0						
f _{ctd} > σ _e					safe	

Signature

Signature

Signature

Signature

Signature

Signature

**GEOCONSULT India Pvt Ltd**

A company of the GEOCONSULT group

Annexure -2**PROJECT:****DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction****Job No****I40172****Section:****Segmental Lining - Seismic Check Calculation (M.C.E No Slip CASE)**

Ultimate Limit State Design For Plain And Lightly Reinforced Concrete Structures

Circular Tunnel MCE Case- Full Slip Condition

Assumed moment magnitude	(Mw)	Refer Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	6.5
Assumed ratio of ground motion at tunnel depth to motion at ground surface (tunnel depth 6-15m)	m	Refer Table 4 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	0.8
Assumed ratio of peak ground velocity (cm/s) to peak ground acceleration (g)	g	Refer Table 2 of Y.M.A. Hashash et al. Tunnelling and Underground Space Technology 16 (2001) 247 293	=	76
Seismic Zone	ϵ (*)		=	0.15

Axial and curvature deformation

Poisson's ratio of soil	n			0.26	
Density of soil	g			25.00	KN/m ³
Apparent velocity of S-wave propagation	C _s	From Site specific study		494.17	m/s
Peak ground particle acceleration in soil	a _s [g]	m * ϵ	0.8*0.15	0.1200	
Earth's gravity	g			9.81	m/s ²
Peak ground particle velocity in soil	V _s	g * a _s /100	76*0.12/100	0.09	m/s
Dynamic Shear modulus of soil	G _m	$\rho_m C_m^2$	5 /10 x 494.166211107401 x 494.166211107401	635	MPa
Dynamic Young's Modulus of Soil	E _m	2G _m (1+U)	2 x 635 x (1 + 0.26)	1,600	MPa
Radius of circular tunnel (internal radius of the lining)	r			6.75	m
Angle of incidence	F			45	°,degree
Total axial strain	e ^{ab}	(Vs/Cs)*sinF *cosF +((as*g*r)/C _s ²)*cos ³ F	0.1/494.17*sin45* π /180*cos45* π /180+(0.12*9.81*6.75)/0.0912*2*cos ³ 45* π /180	0.000104	
Allowable compression strain of concrete	e _{allow}			0.003500	

Ovaling deformation

Lining thickness	t		=	0.550	m
No of Segments	n		=	9	
Grade of Concrete	Fck		=	60.0	MPa
Concrete Young's modulus	E _i		=	38,730	MPa
Concrete Poisson's ratio	n _i		=	0.15	
Area of the tunnel lining per unit width	A _i		=	0.550	m ² /m
Reduced Moment of inertia of the tunnel lining per unit width	I _r	I _r = I _j + (4/n)*2*I	(0) + ((4/9)*2) * 0.55 ³ *1/12	0.002739	m ⁴ /m
Young's modulus of soil	E		=	1,600	MPa

Use formulations of Penzien (2000) assuming no slip condition

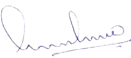
Maximum free-field shear strain of soil or rock medium	g _{max}	V _s /C _s	0.1/494.17	=	0.00018
Coefficient to calculate R ⁿ	a	(24*E _i *1*(3-4*n))/((2r) ³ *G*(1-n _i ²))	(24*38729.834*0.00274*(3-4*0.26))/((2*6.75) ³ *3*635*(1-0.15 ²))	=	0.00327
Lining-soil racking ratio under normal loading only	R	4*(1-v)/(a+1)	4*(1-0.26)/(0.004+1)	=	2.95
Lining diametric deflection under normal loading only	Dd ⁿ _{lining}	R ⁿ * g _{max} * 2 * r/2	2.96*0.01*2*6.75/2	=	0.004
Maximum circumferential thrust in tunnel lining	T(p/4)	(24*E _i *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4))	(24*38730*1000*0.003*0.004*cos2(θ+ π /4))/((2*r) ³ *(1-n _i ²))	=	4.000 KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	(6*E _i *1000*I*Dd ⁿ _{lining} *cos2(θ+p/4))	(6*38729.834*1000*0.003*0.004*cos2(θ+ π /4))/((2*r) ² *(1-n _i ²))	=	14.000 KNm
Maximum Shear in tunnel lining	V(0)	(24*E _i *1000*I*Dd ⁿ _{lining} *sin2(θ+p/4))	(24*38730*1000*0.003*0.004*sin2(θ+ π /4))/((2*r) ² *(1-n _i ²))	=	4.000 KN
Combined stress from thrust and bending moment due to earthquake	s _e	(T(p/4)/A _i +M(p/4)/(r/2))/1000	(4/0.55+14*(0.55/2)/0.003)/1000	=	1.413 MPa

Use formulations of Wang (1993) assuming no slip condition

Flexibility ratio of tunnel lining	F	(E*(1-n _i ²)*r)/(6*E _i *I*(1+n))	(1600*(1-0.15 ²)*6.75*3)/(6*38729.834*1*(1+0.26))	=	599.845
Compressibility Ratio of tunnel Lining	C	(E*(1-n _i ²)*r)/(E _i *I*(1+n)*(1-2n))	0.15*2*6.7538729.834*0.00273868312757202*(1+0.26)*(1-2*0.26)	=	0.819
No slip lining response coefficient	K ₂	1+((F*(1-2n)-(1-2n)*C)-(1/2)*(1-2n) ² +2)/(F*((3-2n)+(1-2n)*C)+C*((5/2)-8n+6n ² +6-8n))	1+((599.845*((1-2*0.26*0.819)-(1/2)*(1-2*0.26) ² +2)/(599.845*((3-2*0.26)+(1-2*0.26)*0.819)+0.819*((5/2)-8*0.26+6*0.26 ² +6-80.26))	=	1.03
Maximum thrust in tunnel lining	T _{max}	K ₂ *E*1000*r * g _{max} /(2*(1+n))	1.032*1600*1000*6.75*0.01/2*(1+0.26)	=	816 KN

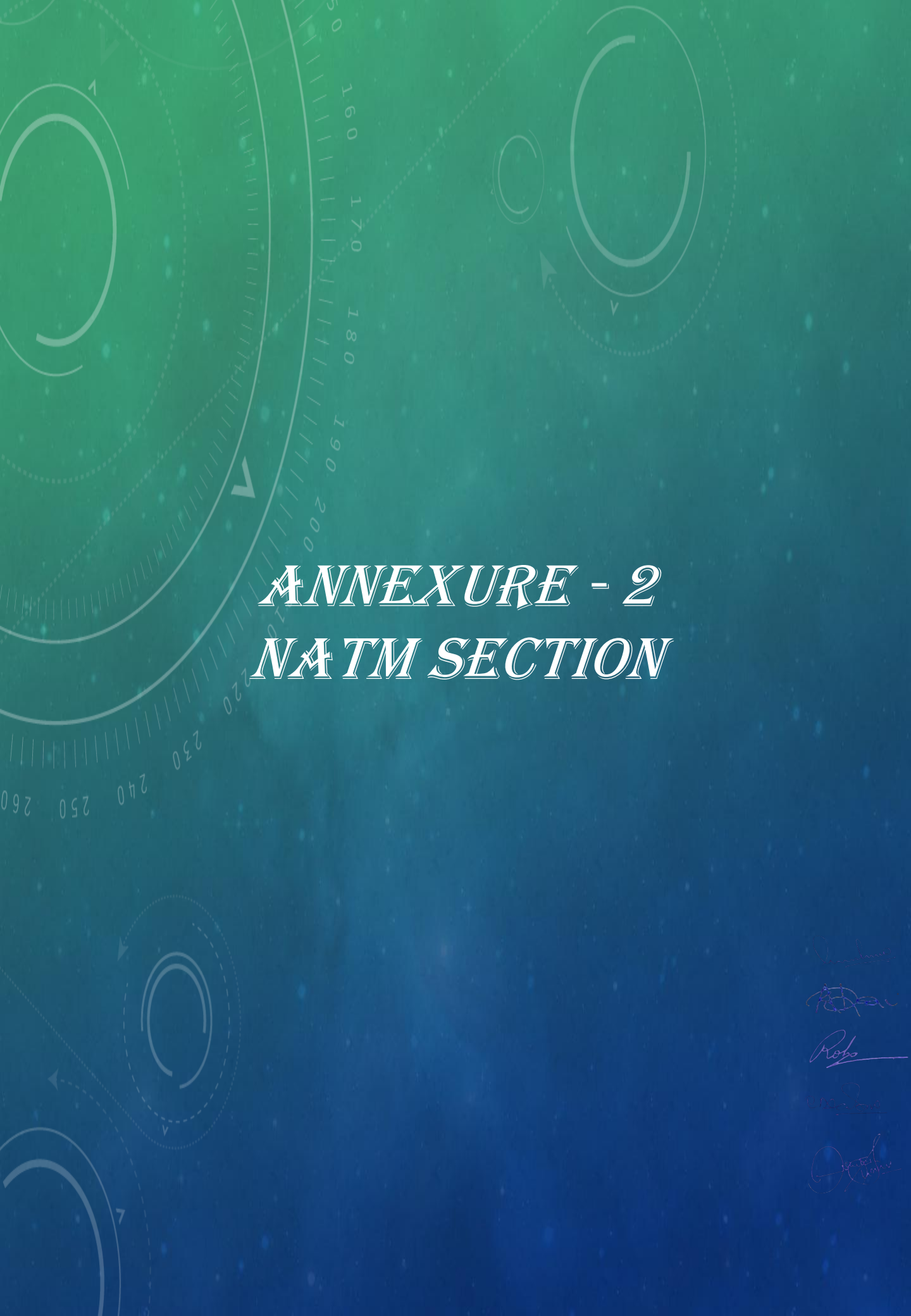
[Handwritten signatures and initials]

Maximum bending moment in tunnel cross section due to S-waves	M_{max}	Note that no solution is developed for calculating diametric strain and maximum moment under no-slip condition. It is recommended that the solutions for full-slip condition be used for no-slip condition. The more conservative estimates of the fullslip condition is considered	=	14	KNm
Combined stress from thrust and bending moment due to earthquake	S_e	$(T_{max}/A_t + M_{max} * (t/2)/I)/1000$		$(815.6/0.55 + 14 * (0.55/2)/1)/1000$	= 2.889 MPa
Required reinforcement		$(2.89 / 2) * 0.55 * 1000 / (2 * 0.87 * 500)$	=	913	mm ²
Characteristic compressive strength of concrete, f_{ck}			=	60.00	MPa
Characteristic axial tensile strength of concrete, f_{ctk}			=	4.10	MPa
$g_c^{(1)}$			=	1.56	
$g_n^{(1)}$			=	1.20	
g_{tot}			=	1.87	
Design value of concrete compressive strength, $f_{cd} = \alpha_{cc} * f_{ck} / \gamma_c$			$1 * 60 / 1.872$	=	32.05 mpa
α_{cc} - coefficient taking account of long term effects on the compressive strength, the recommended value is 1.0					
$f_{cd} > \sigma_e$					safe
Design value of the Concrete tensile strength, $f_{ctd} = \alpha_{ct} f_{ctk,0.05} / \gamma_c$			$1 * 4.1 / 1.872$	=	2.19 mpa
α_{ct} , coefficient taking account of long term effects on the tensile strength, the recommended value is 1.0					
$f_{ctd} > \sigma_e$					Exceeds, but ok in presence of reinforcement provided









ANNEXURE - 2

NATM SECTION

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

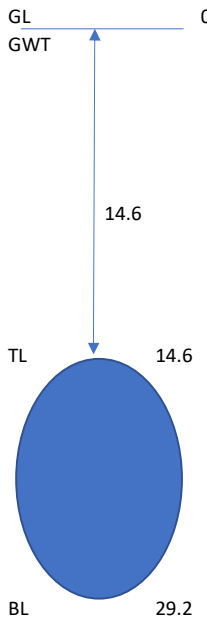
Amelia

Adri

Rob

Emma

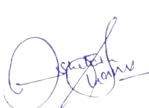
James

		GEOCONSULT India Pvt Ltd			
		A company of the GEOCONSULT group		Job no:	140172
				Page No.:	3
Project:		Project: DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction			
Calculation for		Calculation for STAAD loading			
Ground level at Ring beam location		0			
Top level at ring beam location		14.6			
Base level at ring beam location		29.2			
unit weight of compacted backfill		19.1 kn/m3			
height of overburden		14.6 m			
distance between crown and spring lvl		4.032 m			
height till springing level		18.632			
height of watertable		0 m			
height of water table above crown		14.6 m			
height of water table +1m above crown		15.6			
unit weight of water		10 kn/m3			
φ		31 deg			
K0		0.48			
poisson ratio		0.3		-0.383	
OVERBURDEN PRESSURE (SUBMERGED)					
				Wet Case Dry Case	
overburden pressure at crown		(unit weight of rock - unit weight of water) x overburden height		132.86 278.86	
overburden pressure at crown		AT MID HEIGHT (SPRINGING LEVEL)		169.5512 355.8712	
side earth pressure at top		k0 x overburden pressure at crown		64.432041 135.2365	
		k0 x overburden pressure at middle		96.648062 202.8547	
side earth pressure at bottom		k0 x overburden pressure at Invert		128.86408 270.473	
		(unit weight of rock - unit weight of water) x overburden height		265.72 557.72	
HYDROSTATIC PRESSURE					
Hydrostratic pressure at ring top		height of water table above crown x unit weight of water		146	
		height of water table at middle x unit weight of water		219	
bottom		height of water table at Invert x unit weight of water		292	
Hydrostratic pressure at wall					
top		k0(water) x Hydrostratic pressure at ring top		146	
		k0(water) x Hydrostratic pressure at ring mid sec		219	
bottom		k0(water) x Hydrostratic pressure at ring Invert		292	

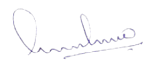
DRY OVERBURDEN		
At crown		278.86
side earth pressure at top		135.23648
		338.09121
side earth pressure at bottom		270.47296
overburden pressure at invert	(unit weight of rock - unit weight of water) x overburden height	557.72
EXTREME HYDROSTATIC PRESSURE		
Hydrostratic pressure at ring top	height of water table above crown x unit weight of water	156
	height of water table at middle x unit weight of water	229
	height of water table at Invert x unit weight of water	302
SURCHARGE LOAD		
Surcharge load for 1.2m height	1.2 x unit weight of rock x k0	11.115327







 GEOCONSULT India Pvt Ltd			
A company of the GEOCONSULT group		Job no:	I40172
OVERT		Page No.:	
SUPPORT			
Parameters	Unit	Top Tunnel Arc	Top Tunnel Arc
Modulus of Elasticity of Soil	E = Kpa	145500	
Stiffness Modulus of Soil	Es = Kpa	0	
Poisson's ratio of Soil	$\mu_r =$	0.3	
Tunnel Beam length (Avg arc Length)	l = m	0.5	
(node to node length of STAAD)			
Width of Element under consideration	b = m	1	
Lining radius of tunnel	R(max) = m	3.700	
Arc subtended by the beam element	$\Phi =$ Radian	0.13514	
Radial Spring Stiffness, $(E/(1 + \mu)R)$	Kr(max) kN/m	15125	
Tangential Spring $0.5 * K_s / (1 + \nu)$	Kt kN/m	5817	








 GEOCONSULT India Pvt Ltd			
A company of the GEOCONSULT group		Job no:	I40172
OVERT		Page No.:	

SUPPORT			Top Tunnel Arc	Top Tunnel Arc
Parameters		Unit		
Modulus of Elasticity of Soil	E =	Kpa	145500	
Stiffness Modulus of Soil	Es =	Kpa	0	
Poisson's ratio of Soil	μ_r =		0.3	
Tunnel Beam length (Avg arc Length)	l =	m	0.25	
(node to node length of STAAD)				
Width of Element under consideration	b =	m	1	
Lining radius of tunnel	R(max) =	m	3.700	
Arc subtended by the beam element	Φ =	Radian	0.06757	
Radial Spring Stiffness, $(E/(1+\mu)R)$	Kr(max)	kN/m	7562	
Tangential Spring $0.5*K_s/(1+\nu)$	Kt	kN/m	2909	








 GEOCONSULT India Pvt Ltd			
A company of the GEOCONSULT group		Job no:	I40172
SIDE WALLS		Page No.:	

SUPPORT				
Parameters		Unit	Top Tunnel Arc	Top Tunnel Arc
Modulus of Elasticity of Soil	E =	Kpa	145500	
Stiffness Modulus of Soil	Es =	Kpa	0	
Poisson's ratio of Soil	μ_r =		0.3	
Tunnel Beam length (Avg arc Length)	l =	m	0.5	
(node to node length of STAAD)				
Width of Element under consideration	b =	m	1	
Lining radius of tunnel	R(max) =	m	3.900	
Arc subtended by the beam element	Φ =	Radian	0.12821	
Radial Spring Stiffness, $(E/(1+\mu)R)$	Kr(max)	kN/m	14349	
Tangential Spring $0.5*K_s/(1+\nu)$	Kt	kN/m	5519	










Software licensed to

Job No

Sheet No

1

Rev

Part

Job Title

Ref

By

Date 04-Sep-24

Chd

Client

File Vehicular_CP_Final2.std

Date/Time 06-Sep-2024 17:30

Job Information

	Engineer	Checked	Approved
Name:			
Date:	04-Sep-24		

Project ID	
Project Name	

Structure Type	PLANE FRAME
----------------	-------------

Number of Nodes	35	Highest Node	35
Number of Elements	34	Highest Beam	35

Number of Basic Load Cases	-2
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure
-----	---------------------

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEAD LOAD
Primary	2	OVERBURDEN LOAD WET
Primary	3	HYDROSTATIC LOAD
Primary	4	SURCHARGE LOAD (SYM)
Primary	5	OVERBURDEN LOAD DRY
Primary	6	EXTREME HYDROSTATIC LOAD
Primary	7	SURCHARGE LOAD (ASYM)
Primary	8	SHRINKAGE
Primary	9	TEMPERATURE- SUMMER
Primary	10	TEMPERATURE-WINTER
Primary	1001	1.5 (DL + OB WET + HYD + SUR)
Primary	1002	1.5 (DL + OB WET + HYD + SUR)
Primary	1003	1.5 (DL + OB DRY + SUR)
Primary	1004	1.5 (DL + OB DRY)
Primary	1005	1.5 (DL + OB WET + HYD EXT)
Primary	10001	1.5 (DL + OB + HYD + SHRIN)
Primary	10002	1.5 (DL + OB + HYD + SHRIN)+ 1.25 SU
Primary	10003	1.5 (DL + OB + HYD + SHRIN) + 1.25 WI
Primary	2001	1.0 (DL + OB WET + HYD + SUR)
Primary	2002	1.0 (DL + OB WET + HYD + SUR)
Primary	2003	1.0 (DL + OB DRY + SUR)
Primary	2004	1.0 (DL + OB DRY)
Primary	20001	1.0 (DL + OB + HYD + SHRIN)
Primary	20002	1.0 (DL + OB + HYD + SHRIN)+ 1.0 SUM
Primary	20003	1.0 (DL + OB + HYD + SHRIN) + 1.0 WIN

Signature
Date
Rob
Date
Date



Software licensed to

Job No

Sheet No

2

Rev

Part

Job Title

Ref

By

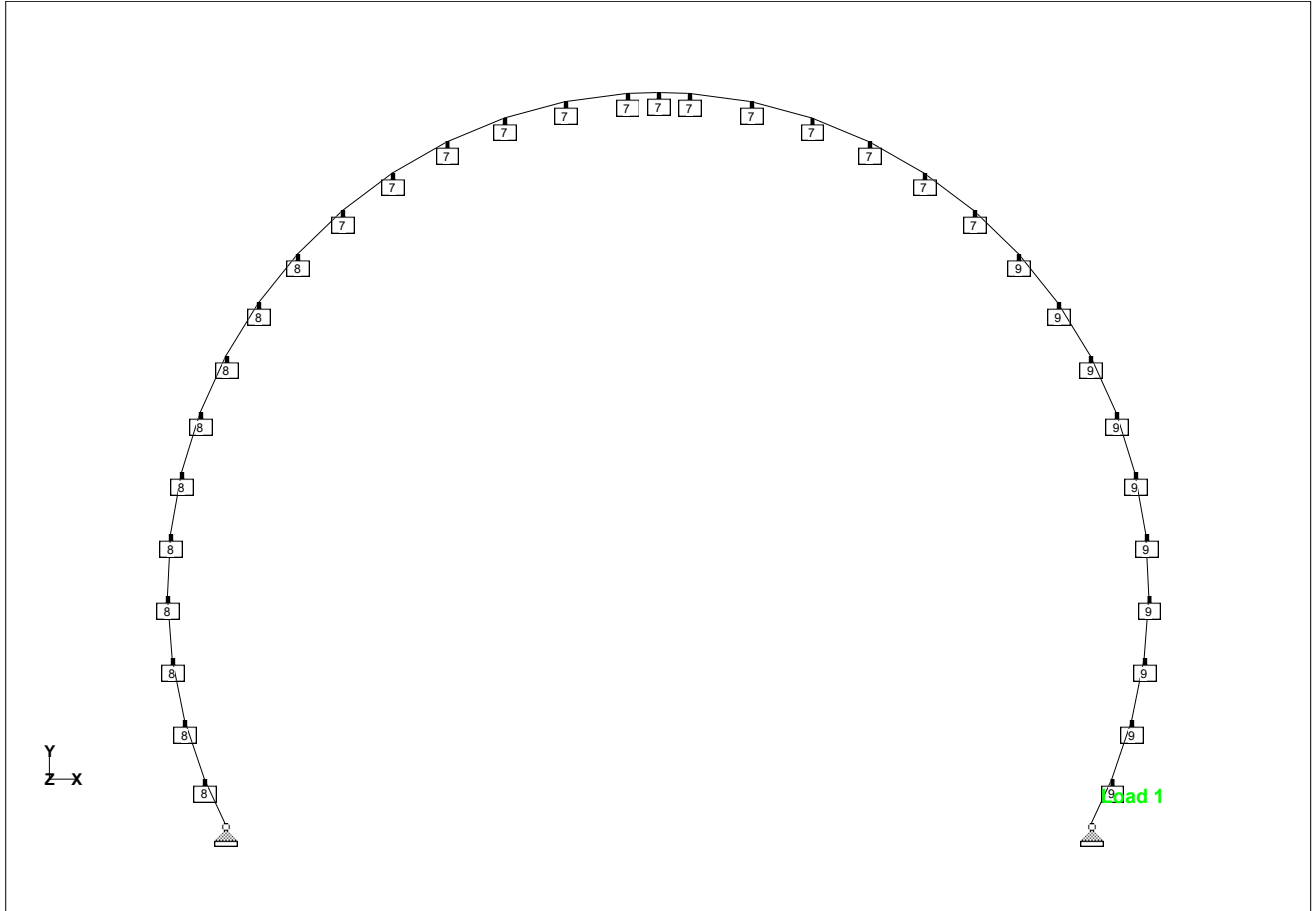
Date 04-Sep-24

Chd

Client

File Vehicular_CP_Final2.std

Date/Time 06-Sep-2024 17:30



Whole Structure

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

3

Rev

Part

Job Title

Ref

By

Date 04-Sep-24

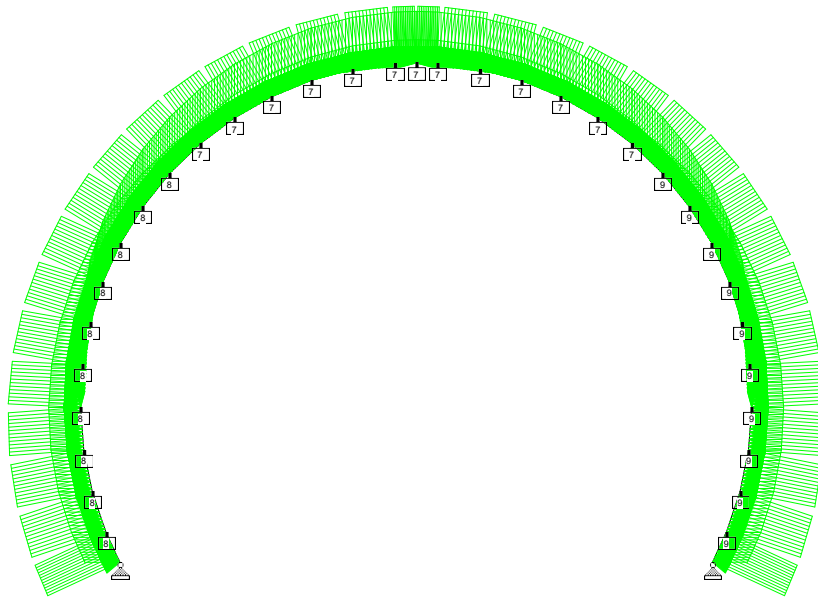
Chd

Client

File Vehicular_CP_Final2.std

Date/Time 06-Sep-2024 17:30

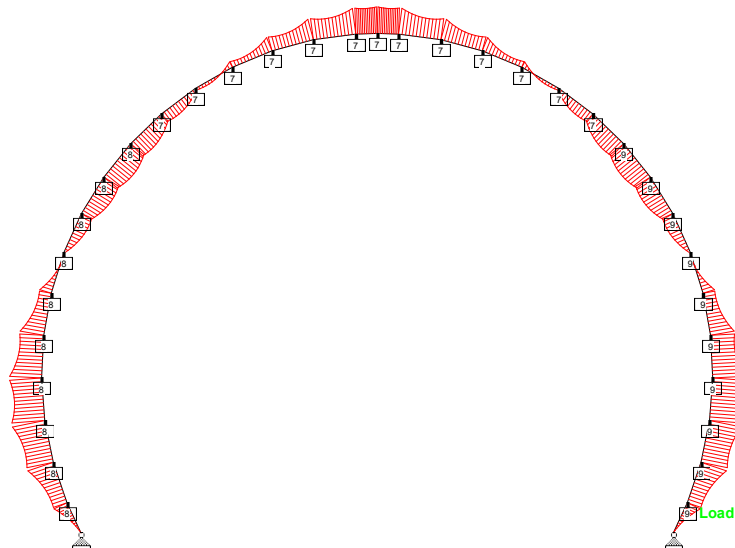
Y
Z-x



Load 1001

loading

Y
Z-x



Load 10003 : Bending Z

BM

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

4

Rev

Part

Job Title

Ref

By

Date 04-Sep-24

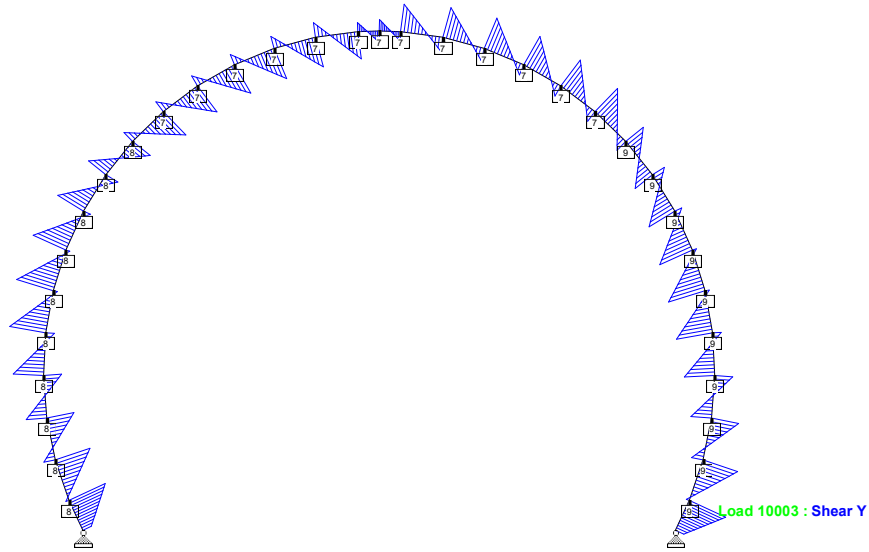
Chd

Client

File Vehicular_CP_Final2.std

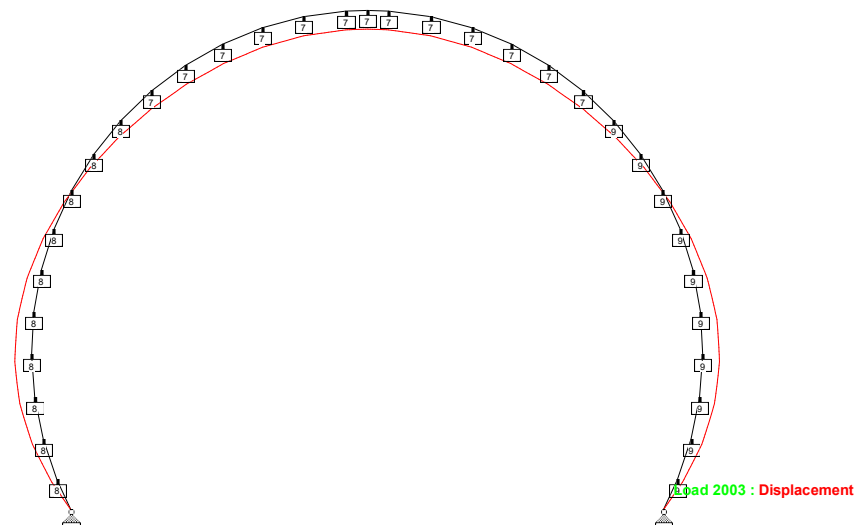
Date/Time 06-Sep-2024 17:30

Y
Z-X



SF

Y
Z-X



Deflection

Handwritten signatures and initials:
- Top right: *Amr*
- Middle right: *Adai*
- Below that: *Rob*
- Below that: *Chad*
- Bottom right: *Chad*



Software licensed to

Job No

Sheet No

5

Rev

Part

Job Title

Ref

By

Date 04-Sep-24

Chd

Client

File Vehicular_CP_Final2.std

Date/Time 06-Sep-2024 17:30

Beam Force Detail Summary

Sign convention as diagrams:- positive above line, negative below line except Fx where positive is compression. Distance d is given from beam end A.

	Beam	L/C	d (m)	Axial	Shear		Torsion	Bending	
				Fx (kN)	Fy (kN)	Fz (kN)	Mx (kN·m)	My (kN·m)	Mz (kN·m)
Max Fx	1	1003:1.5 (DL +	0.000	2971	-382	-0	0	-0	0
Min Fx	26	8:SHRINKAGE	0.000	-25	6	0	0	0	-17
Max Fy	33	1003:1.5 (DL +	0.000	2913	494	0	0	-0	169
Min Fy	1	1003:1.5 (DL +	0.385	2913	-494	-0	-0	-0	169
Max Fz	33	1003:1.5 (DL +	0.000	2913	494	0	0	-0	169
Min Fz	1	1003:1.5 (DL +	0.385	2913	-494	-0	-0	-0	169
Max Mx	1	1:DEAD LOAD	0.000	50	-13	-0	0	-0	0
Min Mx	1	1:DEAD LOAD	0.000	50	-13	-0	0	-0	0
Max My	30	6:EXTREME H	0.000	711	46	-0	0	0	-39
Min My	4	1003:1.5 (DL +	0.000	2895	90	0	0	-0	364
Max Mz	3	1003:1.5 (DL +	0.500	2883	-194	-0	-0	-0	364
Min Mz	23	10002:1.5 (DL	0.250	1561	10	0	0	0	-223

Signature
Date
Rob
C. S. S. S. S.
C. S. S. S. S.

Handwritten
~~Handwritten~~
Rob
MS. Jones
Handwritten

Handwritten
~~Adair~~
Rob
Edwards
Robert

SHEAR AT THE INTERFACE BETWEEN CONCRETE CAST AT DIFFERENT TIMES

Check for Shear Reinforcement

Characteristic Strength of steel			500 N/mm ²	
Design Yield strength of shear reinforcement f_{ywd}			415 N/mm ²	
Depth of the section	D	=	0.350 m	
Width of the section	b_w	=	1.000 m	
Effective depth	d_t	=	0.276 m	
Clear cover		=	60 mm	
Characteristic Strength of concrete	f_{ck}	=	35 N/mm ²	
Reinforcement Provided	A_{st}	=	754 mm ²	
	$100A_{st}/bd$	=	0.27 %	
Design Shear Strength of Concrete	τ_c	=	0.38 N/mm ²	Table 19, IS 456
For members subjected to axial compression, design shear strength is multiplied by δ				Cl 40.2.2, IS 456
	$\delta = 1 + 3P_u/A_g f_{ck}$			
Axial compressive force in N	P_u	=	2920000 N	
(corresponding to max shear force)	δ	=	1.5	
Design Shear Strength of Concrete	τ_c	=	0.57 N/mm ²	
Maximum Shear Strength of Concrete	τ_v	=	3.70 N/mm ²	Table 20, IS 456
Shear Force (By STAAD)	V_u	=	347.00 kN	
Shear Stress generated	τ_u	=	1.26 N/mm ²	
Shear stress	τ_u	=	1.26	> $\tau_c = 0.57$

SHEAR REINFORCED REQUIRED

Stirrups as transverse reinforcement is already provided

As per Clause 40.4, IS 456

$$\text{Shear to be resisted by stirrups} = V_u - \tau_c b d = 188829.81 \text{ N}$$

$$\text{Dia} = 8 \text{ mm}$$

$$\text{Spacing In Transverse Direction} = 150.00$$

$$\text{Area} = 50.27 \text{ mm}^2$$

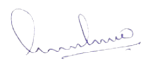
$$\text{Spacing provided} = 150.00 \text{ mm}$$

Shear resisted by vertical stirrups

$$V_{us} = 0.87 f_y A_{svd} / s_v$$

$$= 222619.8 \text{ N}$$

$$V_{us} \quad 222.6 \text{ kN} \quad > \quad 188.8 \text{ kN} \quad \text{Hence safe}$$








Amelia

Adri

Rob

Emma

James

ANNEXURE – 3
CUT & COVER BOX

Signature
Signature
Signature
Signature
Signature

Amelia

Adri

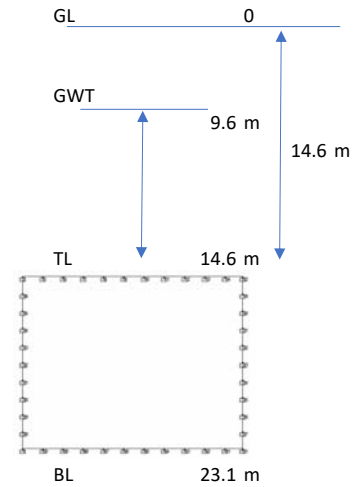
Rob

Emma

James

ANNEXURE 3 (Case 1 - Water level at 5m below ground level)

Ground level at C&C location	0 m	
Top level at C&C location	14.6 m	
Base level at C&C location	23.1 m	
unit weight of compacted backfill	19.1 kn/m ³	
height of overburden	14.6 m	
height of watertable	5 m	
height of water table above crown	9.6 m	(5m below GL)
height of water table +1m above crown	0	
unit weight of water	10 kn/m ³	
K0	0.43	
poisson ratio	0.3	



OVERBURDEN PRESSURE (SUBMERGED)

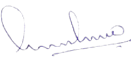
overburden pressure at top slab	(unit weight of rock - unit weight of water) x overburden height	182.86
side earth pressure at wall top	k0 x overburden pressure at wall top	78.6298
side earth pressure at wall bottom	k0 x overburden pressure at Invert	111.8903

HYDROSTATIC PRESSURE

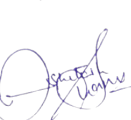
Hydrostratic pressure at top slab	height of water table above top slab x unit weight of water	96
bottom	height of water table at Invert x unit weight of water	181

DRY OVERBURDEN

overburden pressure at top slab	278.86
side earth pressure at wall top	119.9098
side earth pressure at wall bottom	189.7203

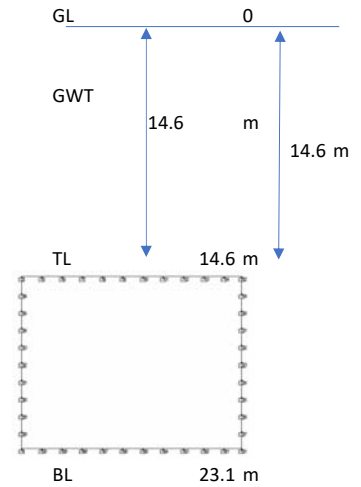






ANNEXURE 3 (Case 1 - Water level at 5m below ground level)

Ground level at C&C location	0 m	
Top level at C&C location	14.6 m	
Base level at C&C location	23.1 m	
unit weight of compacted backfill	19.1 kn/m3	
height of overburden	14.6 m	
height of watertable	0 m	
height of water table above crown	14.6 m	(5m below GL)
height of water table +1m above crown	0	
unit weight of water	10 kn/m3	
K0	0.43	
poisson ratio	0.3	



OVERBURDEN PRESSURE (SUBMERGED)

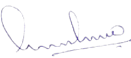
overburden pressure at top slab	(unit weight of rock - unit weight of water) x overburden height	132.86
side earth pressure at wall top	k0 x overburden pressure at wall top	57.1298
side earth pressure at wall bottom	k0 x overburden pressure at Invert	90.3903

HYDROSTATIC PRESSURE

Hydrostratic pressure at top slab	height of water table above top slab x unit weight of water	146
bottom	height of water table at Invert x unit weight of water	231

DRY OVERBURDEN

overburden pressure at top slab	278.86
side earth pressure at wall top	119.9098
side earth pressure at wall bottom	189.7203








Ks	=	E / [3(1-2v)]	
E	=	145.5	kn/m2 (weighted avg)
Overburden			
depth	=	14.6	m (1D)
v	=	0.3	
Ks	=	121250	
Kfx	=	Ks x A	(A = Area of each member)
	=	109125	
Kfy	=	10912.5	

Amir

Adi

Rob

Chris

David



Software licensed to

Job No

Sheet No

1

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

Job Information

	Engineer	Checked	Approved
Name:	KCh	CSa	SPa
Date:	03-Sep-24		

Project ID

Project Name

Structure Type

SPACE FRAME

Number of Nodes	42	Highest Node	52
Number of Elements	42	Highest Beam	51

Number of Basic Load Cases	7
Number of Combination Load Cases	10

Included in this printout are data for:

All

The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL (SELF WEIGHT)
Primary	2	EARTH PRESSURE (WT 5MBGL)
Primary	3	EARTH PRESSURE (WT AT GROUND)
Primary	4	HYDROSTRATIC (5MBGL)
Primary	5	HYDROSTRATIC (WT AT GROUND)
Primary	6	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYMM
Combination	101	1.5DL + 1.5EP(5M) + 1.5WL(5M)
Combination	102	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)
Combination	103	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE
Combination	104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SUF
Combination	105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SUF
Combination	201	1.0DL + 1.0EP(5M) + 1.0WL(5M)
Combination	202	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)
Combination	203	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE
Combination	204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SUF
Combination	205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SUF

Signature
Date
Rob
CSa
SPa



Software licensed to

Job No

Sheet No

2

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.000	8.500	0.000
5	0.897	8.500	0.000
6	1.793	8.500	0.000
7	2.690	8.500	0.000
8	3.587	8.500	0.000
9	4.483	8.500	0.000
10	5.380	8.500	0.000
11	6.277	8.500	0.000
12	7.173	8.500	0.000
13	8.070	8.500	0.000
14	8.967	8.500	0.000
19	9.750	7.650	0.000
20	9.750	6.800	0.000
21	9.750	5.950	0.000
22	9.750	5.100	0.000
23	9.750	4.250	0.000
24	9.750	3.400	0.000
25	9.750	2.550	0.000
26	9.750	1.700	0.000
27	9.750	0.850	0.000
28	0.000	0.850	0.000
29	0.000	1.700	0.000
30	0.000	2.550	0.000
31	0.000	3.400	0.000
32	0.000	4.250	0.000
33	0.000	5.100	0.000
34	0.000	5.950	0.000
35	0.000	6.800	0.000
36	0.000	7.650	0.000
41	8.967	0.000	0.000
42	8.070	0.000	0.000
43	7.173	0.000	0.000
44	6.277	0.000	0.000
45	5.380	0.000	0.000
46	4.483	0.000	0.000
47	3.587	0.000	0.000
48	2.690	0.000	0.000
49	1.793	0.000	0.000
50	0.897	0.000	0.000
51	9.750	0.000	0.000
52	9.750	8.500	0.000

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

3

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	2	5	0.897	1	0
2	52	19	0.850	1	0
4	1	28	0.850	1	0
5	5	6	0.897	1	0
6	6	7	0.897	1	0
7	7	8	0.897	1	0
8	8	9	0.897	1	0
9	9	10	0.897	1	0
10	10	11	0.897	1	0
11	11	12	0.897	1	0
12	12	13	0.897	1	0
13	13	14	0.897	1	0
14	14	52	0.783	1	0
19	19	20	0.850	1	0
20	20	21	0.850	1	0
21	21	22	0.850	1	0
22	22	23	0.850	1	0
23	23	24	0.850	1	0
24	24	25	0.850	1	0
25	25	26	0.850	1	0
26	26	27	0.850	1	0
27	27	51	0.850	1	0
28	28	29	0.850	1	0
29	29	30	0.850	1	0
30	30	31	0.850	1	0
31	31	32	0.850	1	0
32	32	33	0.850	1	0
33	33	34	0.850	1	0
34	34	35	0.850	1	0
35	35	36	0.850	1	0
36	36	2	0.850	1	0
41	41	42	0.897	1	0
42	42	43	0.897	1	0
43	43	44	0.897	1	0
44	44	45	0.897	1	0
45	45	46	0.897	1	0
46	46	47	0.897	1	0
47	47	48	0.897	1	0
48	48	49	0.897	1	0
49	49	50	0.897	1	0
50	50	1	0.897	1	0
51	51	41	0.783	1	0

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

4

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

Section Properties

Prop	Section	Area (cm ²)	I _{yy} (cm ⁴)	I _{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 1.00x1.00	10E+3	8.33E+6	8.33E+6	14.1E+6	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	v	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN`m/deg)	rY (kN`m/deg)	rZ (kN`m/deg)
1	-	-	-	-	-	-
2	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
11	-	-	-	-	-	-
12	-	-	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
32	-	-	-	-	-	-
33	-	-	-	-	-	-
34	-	-	-	-	-	-
35	-	-	-	-	-	-
36	-	-	-	-	-	-

Handwritten signatures and initials:
- Top signature: [unclear]
- Middle signature: [unclear]
- Below middle: Rob
- Below Rob: [unclear]
- Bottom signature: [unclear]



Software licensed to

Job No

Sheet No

5

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

Supports Cont...

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN`m/deg)	rY (kN`m/deg)	rZ (kN`m/deg)
41	-	-	-	-	-	-
42	-	-	-	-	-	-
43	-	-	-	-	-	-
44	-	-	-	-	-	-
45	-	-	-	-	-	-
46	-	-	-	-	-	-
47	-	-	-	-	-	-
48	-	-	-	-	-	-
49	-	-	-	-	-	-
50	-	-	-	-	-	-
51	-	-	-	-	-	-
52	-	-	-	-	-	-

Releases

There is no data of this type.

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT 5MBGL)	Live
3	EARTH PRESSURE (WT AT GROUND)	Live
4	HYDROSTRATIC (5MBGL)	Live
5	HYDROSTRATIC (WT AT GROUND)	Live
6	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYM	Live

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
101	1.5DL + 1.5EP(5M) + 1.5WL(5M)	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT 5MBGL)	1.50
		4	HYDROSTRATIC (5MBGL)	1.50
102	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)	1	DL (SELF WEIGHT)	1.50
		3	EARTH PRESSURE (WT AT GROUND)	1.50
		5	HYDROSTRATIC (WT AT GROUND)	1.50
103	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE	1	DL (SELF WEIGHT)	1.50
		6	EARTH PRESSURE (DRY)	1.50
		7	SURCHARGE SYM	1.50
104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SUf	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT 5MBGL)	1.50
		4	HYDROSTRATIC (5MBGL)	1.50

Handwritten signatures and initials:
1. *Amr*
2. *Adi*
3. *Rob*
4. *CSA*
5. *CSA*
6. *CSA*



Software licensed to

Job No

Sheet No

6

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

Combination Load Cases Cont...

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
		7	SURCHARGE SYMM	1.50
105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5	1	DL (SELF WEIGHT)	1.50
		3	EARTH PRESSURE (WT AT GROUND)	1.50
		5	HYDROSTRATIC (WT AT GROUND)	1.50
		7	SURCHARGE SYMM	1.50
201	1.0DL + 1.0EP(5M) + 1.0WL(5M)	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT 5MBGL)	1.00
		4	HYDROSTRATIC (5MBGL)	1.00
202	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)	1	DL (SELF WEIGHT)	1.00
		3	EARTH PRESSURE (WT AT GROUND)	1.00
		5	HYDROSTRATIC (WT AT GROUND)	1.00
203	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	1	DL (SELF WEIGHT)	1.00
		6	EARTH PRESSURE (DRY)	1.00
		7	SURCHARGE SYMM	1.00
204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SU	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT 5MBGL)	1.00
		4	HYDROSTRATIC (5MBGL)	1.00
		7	SURCHARGE SYMM	1.00
205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0	1	DL (SELF WEIGHT)	1.00
		3	EARTH PRESSURE (WT AT GROUND)	1.00
		5	HYDROSTRATIC (WT AT GROUND)	1.00
		7	SURCHARGE SYMM	1.00

Load Generators

There is no data of this type.

1 DL (SELF WEIGHT) : Selfweight

Direction	Factor	Assigned Geometry
Y	-1.000	ALL

Handwritten signatures and initials:
1. [Signature]
2. [Signature]
3. [Signature]
4. [Signature]
5. [Signature]



Software licensed to

Job No

Sheet No

7

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

2 EARTH PRESSURE (WT 5MBGL) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-182.860	-	-	-	-
2	TRAP kN/m	GX	-78.600	-	-81.920	-	-
4	TRAP kN/m	GX	111.800	-	108.480	-	-
5	UNI kN/m	GY	-182.860	-	-	-	-
6	UNI kN/m	GY	-182.860	-	-	-	-
7	UNI kN/m	GY	-182.860	-	-	-	-
8	UNI kN/m	GY	-182.860	-	-	-	-
9	UNI kN/m	GY	-182.860	-	-	-	-
10	UNI kN/m	GY	-182.860	-	-	-	-
11	UNI kN/m	GY	-182.860	-	-	-	-
12	UNI kN/m	GY	-182.860	-	-	-	-
13	UNI kN/m	GY	-182.860	-	-	-	-
14	UNI kN/m	GY	-182.860	-	-	-	-
19	TRAP kN/m	GX	-81.920	-	-85.240	-	-
20	TRAP kN/m	GX	-85.240	-	-88.560	-	-
21	TRAP kN/m	GX	-88.560	-	-91.880	-	-
22	TRAP kN/m	GX	-91.880	-	-95.200	-	-
23	TRAP kN/m	GX	-95.200	-	-98.520	-	-
24	TRAP kN/m	GX	-98.520	-	-101.840	-	-
25	TRAP kN/m	GX	-101.840	-	-105.160	-	-
26	TRAP kN/m	GX	-105.160	-	-108.480	-	-
27	TRAP kN/m	GX	-108.480	-	-111.800	-	-
28	TRAP kN/m	GX	108.480	-	105.160	-	-
29	TRAP kN/m	GX	105.160	-	101.840	-	-
30	TRAP kN/m	GX	101.840	-	98.520	-	-
31	TRAP kN/m	GX	98.520	-	95.200	-	-
32	TRAP kN/m	GX	95.200	-	91.880	-	-
33	TRAP kN/m	GX	91.880	-	88.560	-	-
34	TRAP kN/m	GX	88.560	-	85.240	-	-
35	TRAP kN/m	GX	85.240	-	81.920	-	-
36	TRAP kN/m	GX	81.920	-	78.600	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

8

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

3 EARTH PRESSURE (WT AT GROUND) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-132.860	-	-	-	-
2	TRAP kN/m	GX	-57.100	-	-60.430	-	-
4	TRAP kN/m	GX	90.400	-	87.070	-	-
5	UNI kN/m	GY	-132.860	-	-	-	-
6	UNI kN/m	GY	-132.860	-	-	-	-
7	UNI kN/m	GY	-132.860	-	-	-	-
8	UNI kN/m	GY	-132.860	-	-	-	-
9	UNI kN/m	GY	-132.860	-	-	-	-
10	UNI kN/m	GY	-132.860	-	-	-	-
11	UNI kN/m	GY	-132.860	-	-	-	-
12	UNI kN/m	GY	-132.860	-	-	-	-
13	UNI kN/m	GY	-132.860	-	-	-	-
14	UNI kN/m	GY	-132.860	-	-	-	-
19	TRAP kN/m	GX	-60.430	-	-63.760	-	-
20	TRAP kN/m	GX	-63.760	-	-67.090	-	-
21	TRAP kN/m	GX	-67.090	-	-70.420	-	-
22	TRAP kN/m	GX	-70.420	-	-73.750	-	-
23	TRAP kN/m	GX	-73.750	-	-77.080	-	-
24	TRAP kN/m	GX	-77.080	-	-80.410	-	-
25	TRAP kN/m	GX	-80.410	-	-83.740	-	-
26	TRAP kN/m	GX	-83.740	-	-87.070	-	-
27	TRAP kN/m	GX	-87.070	-	-90.400	-	-
28	TRAP kN/m	GX	87.070	-	83.740	-	-
29	TRAP kN/m	GX	83.740	-	80.410	-	-
30	TRAP kN/m	GX	80.410	-	77.080	-	-
31	TRAP kN/m	GX	77.080	-	73.750	-	-
32	TRAP kN/m	GX	73.750	-	70.420	-	-
33	TRAP kN/m	GX	70.420	-	67.090	-	-
34	TRAP kN/m	GX	67.090	-	63.760	-	-
35	TRAP kN/m	GX	63.760	-	60.430	-	-
36	TRAP kN/m	GX	60.430	-	57.100	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

9

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

4 HYDROSTRATIC (5MBGL) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-96.000	-	-	-	-
2	TRAP kN/m	GX	-96.000	-	-104.500	-	-
4	TRAP kN/m	GX	181.000	-	172.500	-	-
5	UNI kN/m	GY	-96.000	-	-	-	-
6	UNI kN/m	GY	-96.000	-	-	-	-
7	UNI kN/m	GY	-96.000	-	-	-	-
8	UNI kN/m	GY	-96.000	-	-	-	-
9	UNI kN/m	GY	-96.000	-	-	-	-
10	UNI kN/m	GY	-96.000	-	-	-	-
11	UNI kN/m	GY	-96.000	-	-	-	-
12	UNI kN/m	GY	-96.000	-	-	-	-
13	UNI kN/m	GY	-96.000	-	-	-	-
14	UNI kN/m	GY	-96.000	-	-	-	-
19	TRAP kN/m	GX	-104.500	-	-113.000	-	-
20	TRAP kN/m	GX	-113.000	-	-121.500	-	-
21	TRAP kN/m	GX	-121.500	-	-130.000	-	-
22	TRAP kN/m	GX	-130.000	-	-138.500	-	-
23	TRAP kN/m	GX	-138.500	-	-147.000	-	-
24	TRAP kN/m	GX	-147.000	-	-155.500	-	-
25	TRAP kN/m	GX	-155.500	-	-164.000	-	-
26	TRAP kN/m	GX	-164.000	-	-172.500	-	-
27	TRAP kN/m	GX	-172.500	-	-181.000	-	-
28	TRAP kN/m	GX	172.500	-	164.000	-	-
29	TRAP kN/m	GX	164.000	-	155.500	-	-
30	TRAP kN/m	GX	155.500	-	147.000	-	-
31	TRAP kN/m	GX	147.000	-	138.500	-	-
32	TRAP kN/m	GX	138.500	-	130.000	-	-
33	TRAP kN/m	GX	130.000	-	121.500	-	-
34	TRAP kN/m	GX	121.500	-	113.000	-	-
35	TRAP kN/m	GX	113.000	-	104.500	-	-
36	TRAP kN/m	GX	104.500	-	96.000	-	-
41	UNI kN/m	GY	181.000	-	-	-	-
42	UNI kN/m	GY	181.000	-	-	-	-
43	UNI kN/m	GY	181.000	-	-	-	-
44	UNI kN/m	GY	181.000	-	-	-	-
45	UNI kN/m	GY	181.000	-	-	-	-
46	UNI kN/m	GY	181.000	-	-	-	-
47	UNI kN/m	GY	181.000	-	-	-	-
48	UNI kN/m	GY	181.000	-	-	-	-
49	UNI kN/m	GY	181.000	-	-	-	-
50	UNI kN/m	GY	181.000	-	-	-	-
51	UNI kN/m	GY	181.000	-	-	-	-



Software licensed to

Job No

Sheet No

10

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

5 HYDROSTATIC (WT AT GROUND) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-146.000	-	-	-	-
2	TRAP kN/m	GX	-146.000	-	-154.500	-	-
4	TRAP kN/m	GX	231.000	-	222.500	-	-
5	UNI kN/m	GY	-146.000	-	-	-	-
6	UNI kN/m	GY	-146.000	-	-	-	-
7	UNI kN/m	GY	-146.000	-	-	-	-
8	UNI kN/m	GY	-146.000	-	-	-	-
9	UNI kN/m	GY	-146.000	-	-	-	-
10	UNI kN/m	GY	-146.000	-	-	-	-
11	UNI kN/m	GY	-146.000	-	-	-	-
12	UNI kN/m	GY	-146.000	-	-	-	-
13	UNI kN/m	GY	-146.000	-	-	-	-
14	UNI kN/m	GY	-146.000	-	-	-	-
19	TRAP kN/m	GX	-154.500	-	-163.000	-	-
20	TRAP kN/m	GX	-163.000	-	-171.500	-	-
21	TRAP kN/m	GX	-171.500	-	-180.000	-	-
22	TRAP kN/m	GX	-180.000	-	-188.500	-	-
23	TRAP kN/m	GX	-188.500	-	-197.000	-	-
24	TRAP kN/m	GX	-197.000	-	-205.500	-	-
25	TRAP kN/m	GX	-205.500	-	-214.000	-	-
26	TRAP kN/m	GX	-214.000	-	-222.500	-	-
27	TRAP kN/m	GX	-222.500	-	-231.000	-	-
28	TRAP kN/m	GX	222.500	-	214.000	-	-
29	TRAP kN/m	GX	214.000	-	205.500	-	-
30	TRAP kN/m	GX	205.500	-	197.000	-	-
31	TRAP kN/m	GX	197.000	-	188.500	-	-
32	TRAP kN/m	GX	188.500	-	180.000	-	-
33	TRAP kN/m	GX	180.000	-	171.500	-	-
34	TRAP kN/m	GX	171.500	-	163.000	-	-
35	TRAP kN/m	GX	163.000	-	154.500	-	-
36	TRAP kN/m	GX	154.500	-	146.000	-	-
41	UNI kN/m	GY	231.000	-	-	-	-
42	UNI kN/m	GY	231.000	-	-	-	-
43	UNI kN/m	GY	231.000	-	-	-	-
44	UNI kN/m	GY	231.000	-	-	-	-
45	UNI kN/m	GY	231.000	-	-	-	-
46	UNI kN/m	GY	231.000	-	-	-	-
47	UNI kN/m	GY	231.000	-	-	-	-
48	UNI kN/m	GY	231.000	-	-	-	-
49	UNI kN/m	GY	231.000	-	-	-	-
50	UNI kN/m	GY	231.000	-	-	-	-
51	UNI kN/m	GY	231.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

11

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

6 EARTH PRESSURE (DRY) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-278.860	-	-	-	-
2	TRAP kN/m	GX	-119.900	-	-126.880	-	-
4	TRAP kN/m	GX	189.700	-	182.720	-	-
5	UNI kN/m	GY	-278.860	-	-	-	-
6	UNI kN/m	GY	-278.860	-	-	-	-
7	UNI kN/m	GY	-278.860	-	-	-	-
8	UNI kN/m	GY	-278.860	-	-	-	-
9	UNI kN/m	GY	-278.860	-	-	-	-
10	UNI kN/m	GY	-278.860	-	-	-	-
11	UNI kN/m	GY	-278.860	-	-	-	-
12	UNI kN/m	GY	-278.860	-	-	-	-
13	UNI kN/m	GY	-278.860	-	-	-	-
14	UNI kN/m	GY	-278.860	-	-	-	-
19	TRAP kN/m	GX	-126.880	-	-133.860	-	-
20	TRAP kN/m	GX	-133.860	-	-140.840	-	-
21	TRAP kN/m	GX	-140.840	-	-147.820	-	-
22	TRAP kN/m	GX	-147.820	-	-154.800	-	-
23	TRAP kN/m	GX	-154.800	-	-161.780	-	-
24	TRAP kN/m	GX	-161.780	-	-168.760	-	-
25	TRAP kN/m	GX	-168.760	-	-175.740	-	-
26	TRAP kN/m	GX	-175.740	-	-182.720	-	-
27	TRAP kN/m	GX	-182.720	-	-189.700	-	-
28	TRAP kN/m	GX	182.720	-	175.740	-	-
29	TRAP kN/m	GX	175.740	-	168.760	-	-
30	TRAP kN/m	GX	168.760	-	161.780	-	-
31	TRAP kN/m	GX	161.780	-	154.800	-	-
32	TRAP kN/m	GX	154.800	-	147.820	-	-
33	TRAP kN/m	GX	147.820	-	140.840	-	-
34	TRAP kN/m	GX	140.840	-	133.860	-	-
35	TRAP kN/m	GX	133.860	-	126.880	-	-
36	TRAP kN/m	GX	126.880	-	119.900	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

12

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

7 SURCHARGE SYMM : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-60.000	-	-	-	-
2	UNI kN/m	GX	-30.000	-	-	-	-
4	UNI kN/m	GX	30.000	-	-	-	-
5	UNI kN/m	GY	-60.000	-	-	-	-
6	UNI kN/m	GY	-60.000	-	-	-	-
7	UNI kN/m	GY	-60.000	-	-	-	-
8	UNI kN/m	GY	-60.000	-	-	-	-
9	UNI kN/m	GY	-60.000	-	-	-	-
10	UNI kN/m	GY	-60.000	-	-	-	-
11	UNI kN/m	GY	-60.000	-	-	-	-
12	UNI kN/m	GY	-60.000	-	-	-	-
13	UNI kN/m	GY	-60.000	-	-	-	-
14	UNI kN/m	GY	-60.000	-	-	-	-
19	UNI kN/m	GX	-30.000	-	-	-	-
20	UNI kN/m	GX	-30.000	-	-	-	-
21	UNI kN/m	GX	-30.000	-	-	-	-
22	UNI kN/m	GX	-30.000	-	-	-	-
23	UNI kN/m	GX	-30.000	-	-	-	-
24	UNI kN/m	GX	-30.000	-	-	-	-
25	UNI kN/m	GX	-30.000	-	-	-	-
26	UNI kN/m	GX	-30.000	-	-	-	-
27	UNI kN/m	GX	-30.000	-	-	-	-
28	UNI kN/m	GX	30.000	-	-	-	-
29	UNI kN/m	GX	30.000	-	-	-	-
30	UNI kN/m	GX	30.000	-	-	-	-
31	UNI kN/m	GX	30.000	-	-	-	-
32	UNI kN/m	GX	30.000	-	-	-	-
33	UNI kN/m	GX	30.000	-	-	-	-
34	UNI kN/m	GX	30.000	-	-	-	-
35	UNI kN/m	GX	30.000	-	-	-	-
36	UNI kN/m	GX	30.000	-	-	-	-

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

13

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

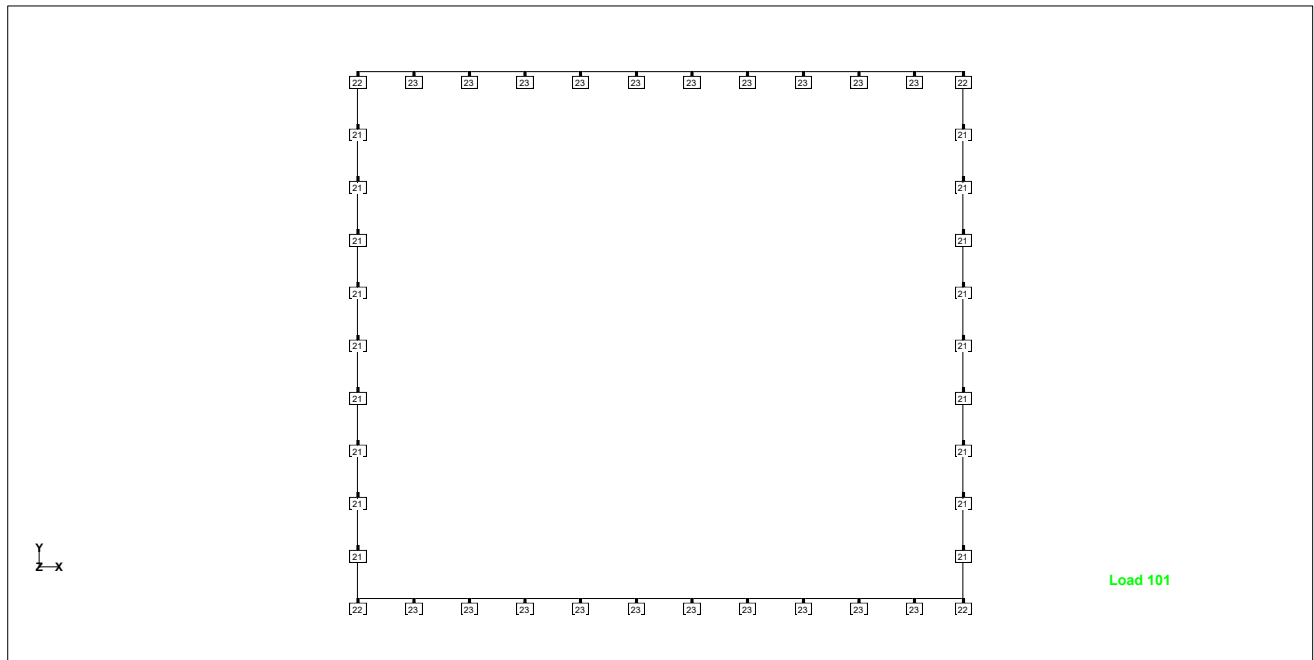
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



Whole Structure

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

14

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

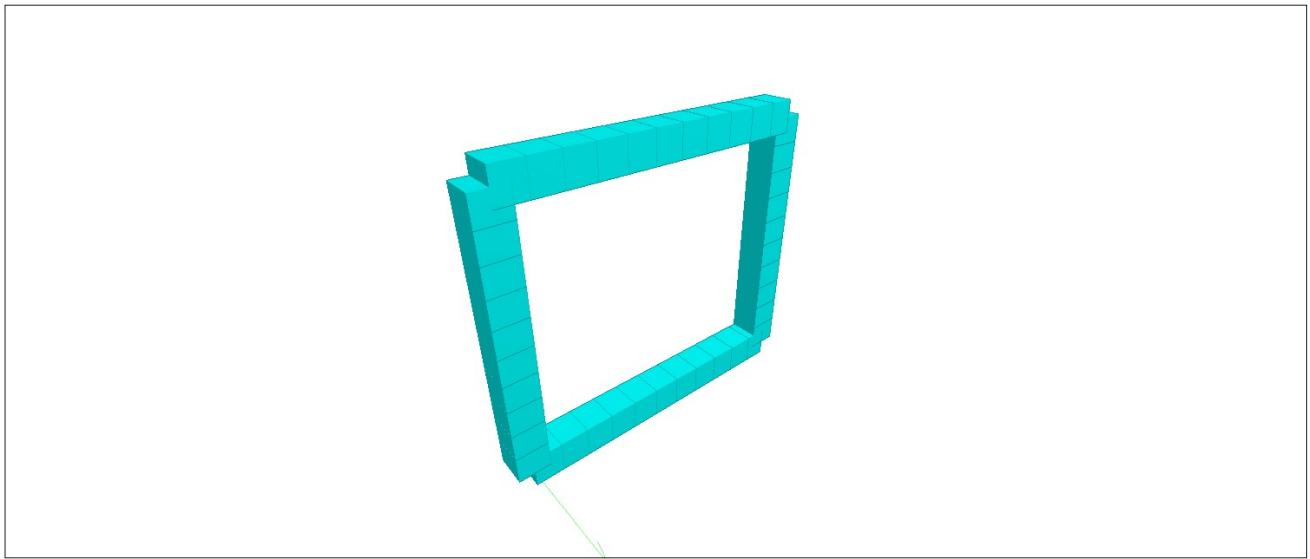
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



3D Rendered View

Signature
Signature
Rob
CSA
Signature



Software licensed to

Job No

Sheet No

15

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

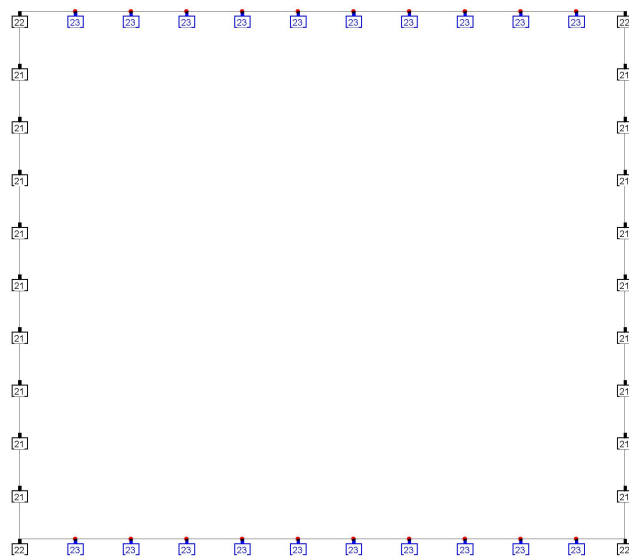
Chd CSa

Client

File I40172_C&C section (2 l

Date/Time 11-Sep-2024 12:17

Y
Z-x



Load 101

SUPPORTS

Handwritten signatures and initials:
1. *Amir*
2. *Rob*
3. *CSa*
4. *John*



Software licensed to

Job No

Sheet No

16

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

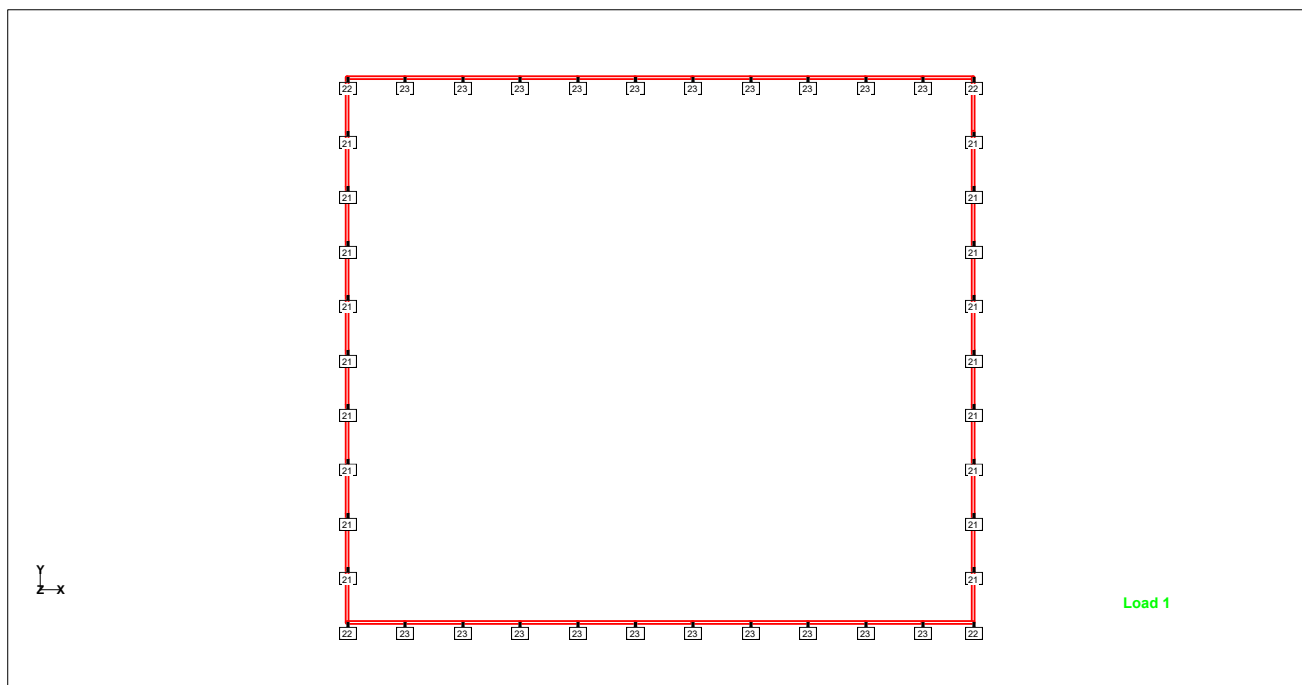
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



DL

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

17

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

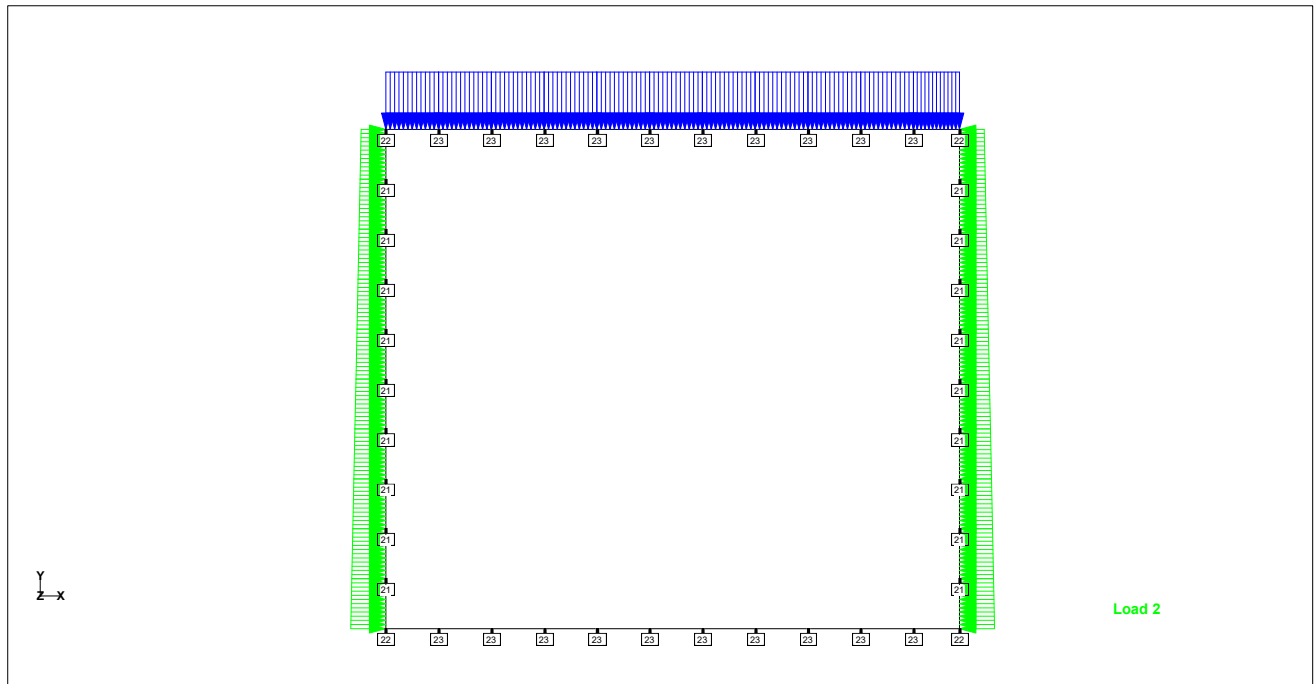
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



EP(5MBGL)

Handwritten signatures and initials:
1. *Longhand*
2. *ADai*
3. *Rob*
4. *CSa*
5. *Handwritten signature*



Software licensed to

Job No

Sheet No

18

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

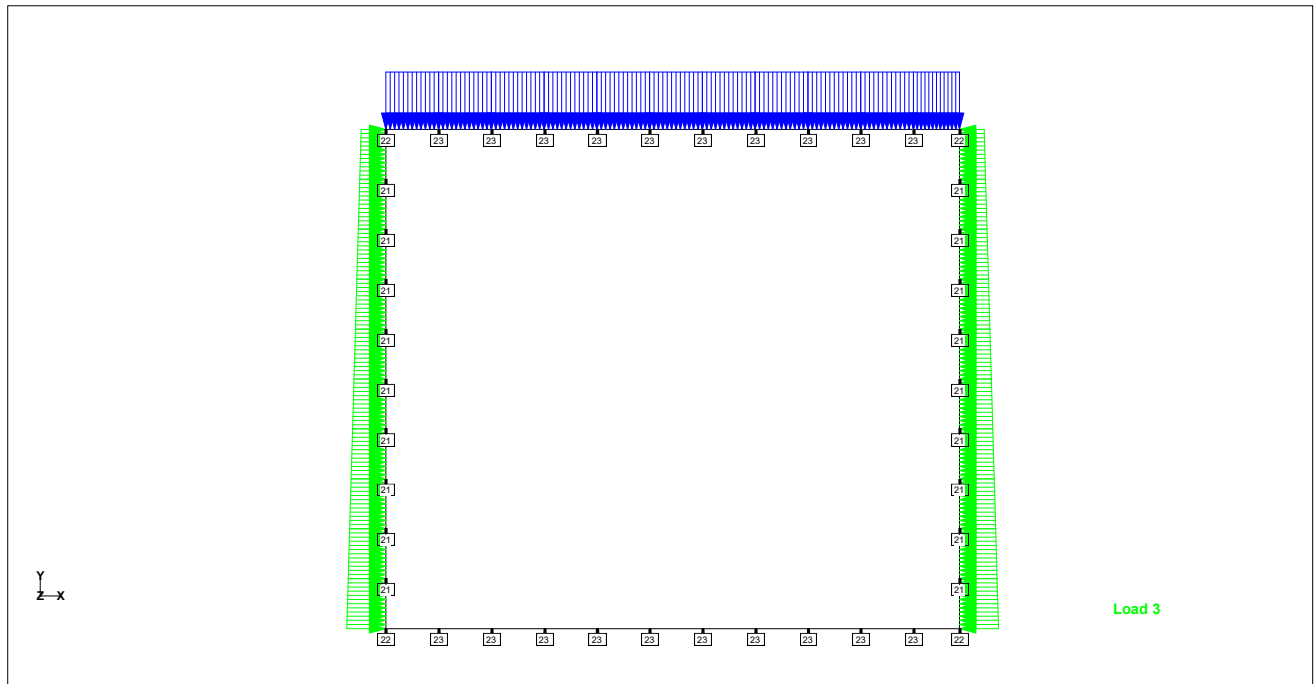
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



EP(WT AT GROUND)

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

19

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

Date 03-Sep-24

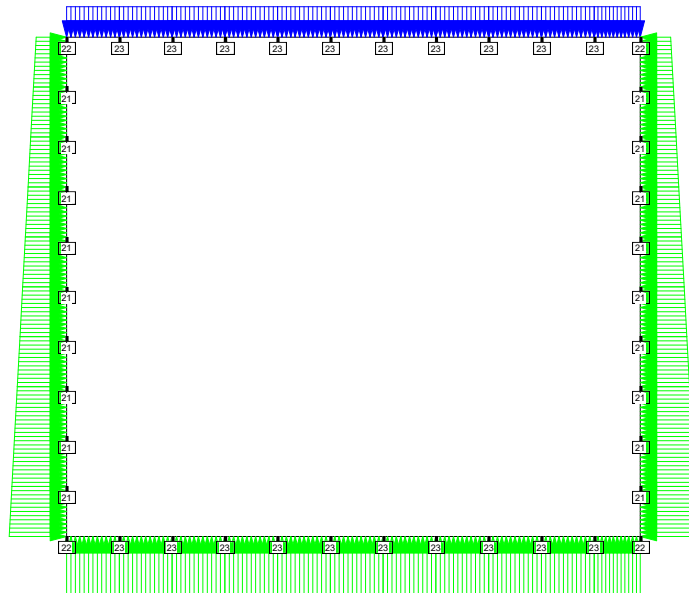
Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17

Y
Z-X



Load 4

WATER(5MBGL)

Handwritten signatures and initials:
1. *Amir*
2. *Rob*
3. *CSA*
4. *CSA*



Software licensed to

Job No

Sheet No

20

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

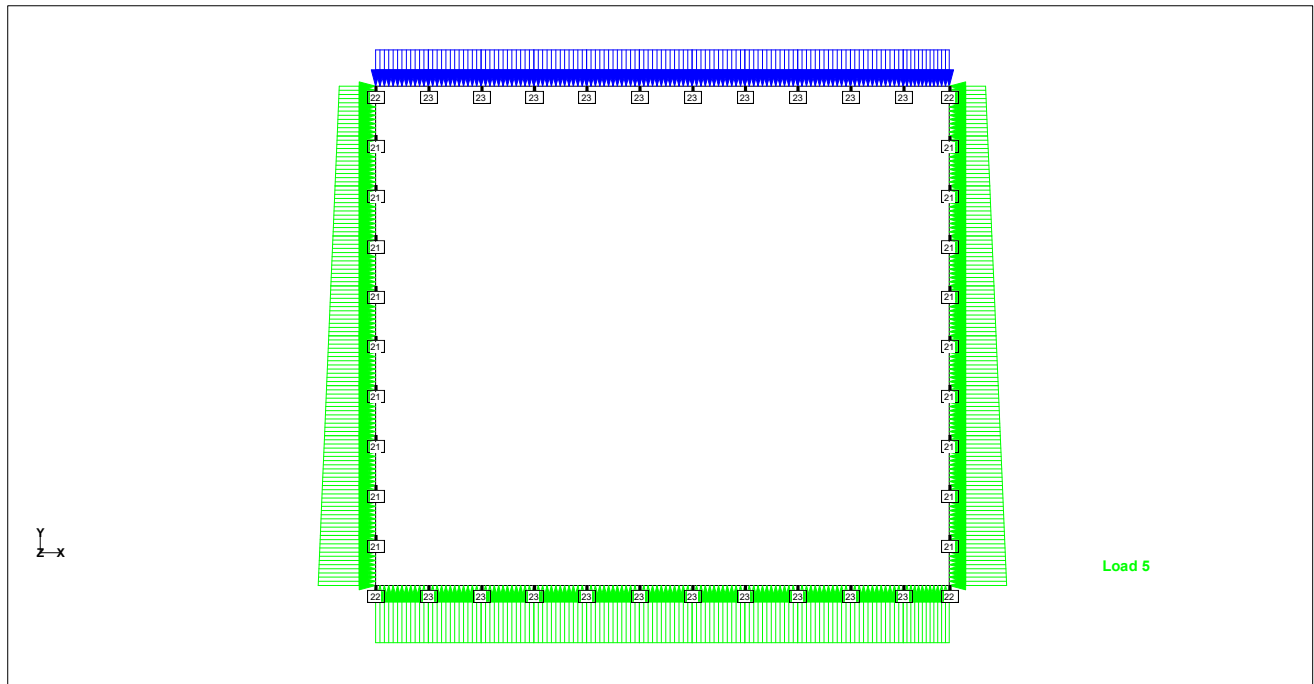
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



WATER(WT AT GROUND)

Handwritten signatures and initials:
1. *Longhand*
2. *ADai*
3. *Rob*
4. *CSA*
5. *CSA*



Software licensed to

Job No

Sheet No

21

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

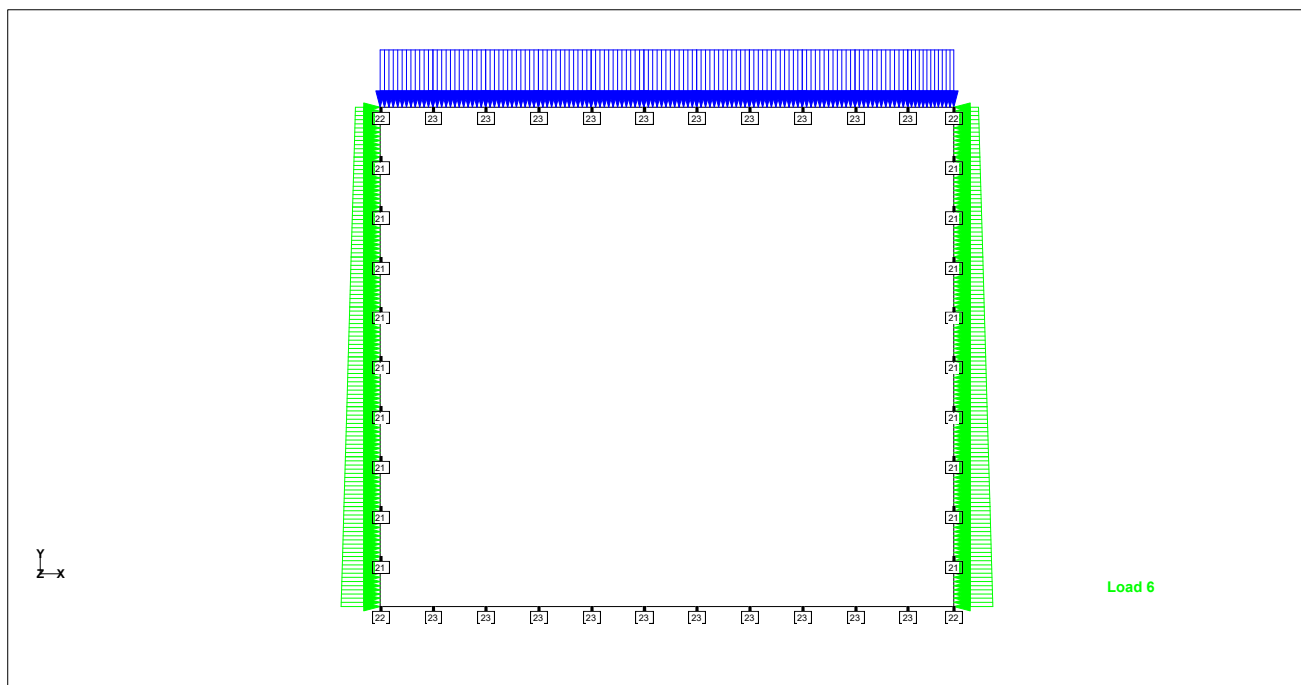
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



EP(DRY)

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

22

Rev
A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

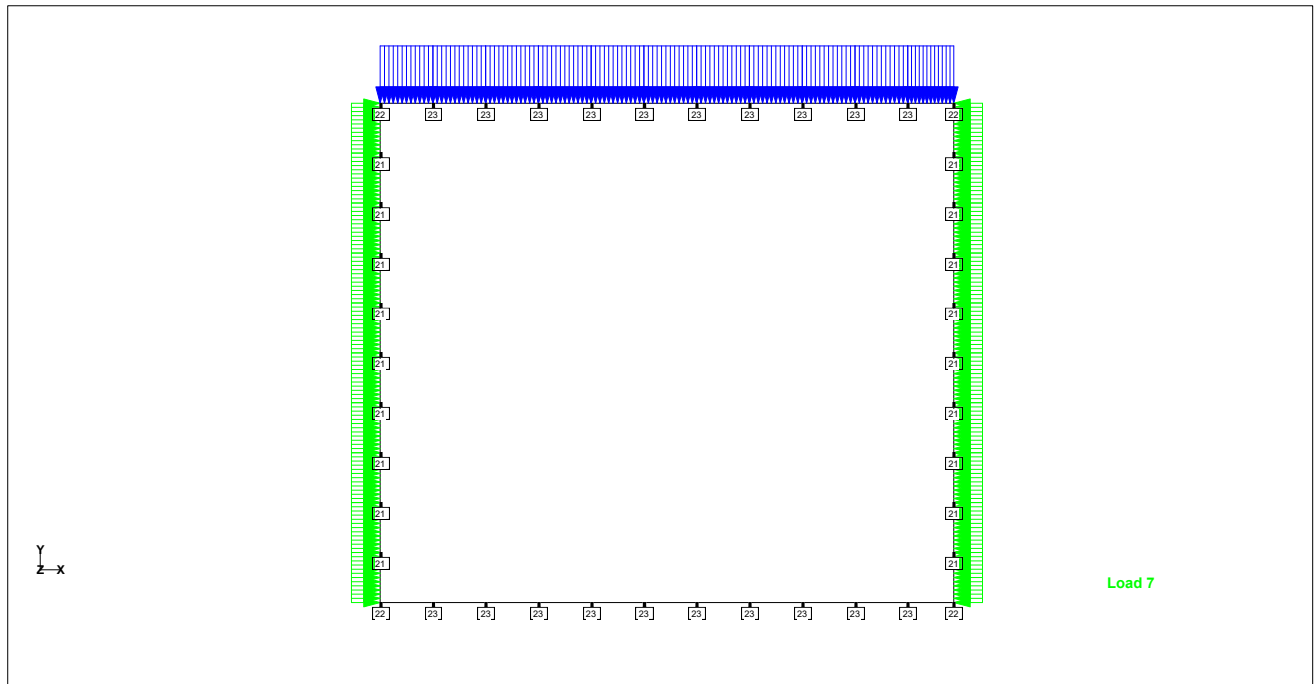
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



SURCHARGE

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

23

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

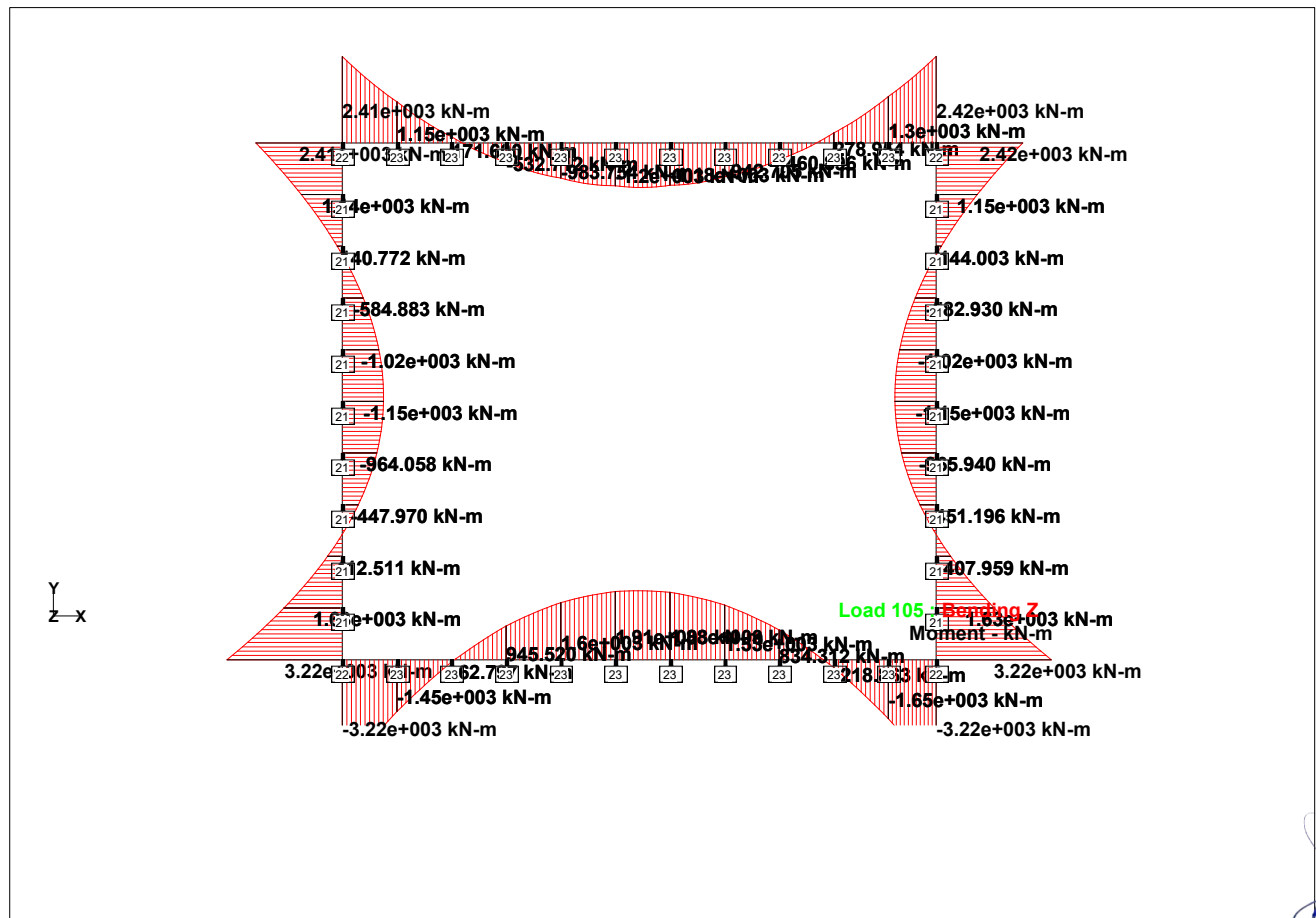
Date 03-Sep-24

Chd CSa

Client

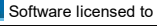
File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



Mz

[Handwritten signatures and initials]



Sheet No

Rev

Chd CSa

Date/Time 11-Sep-2024 12:17



[Signature]
 [Signature]
 Rob
 [Signature]
 [Signature]



Software licensed to

Job No

Sheet No

25

Rev

A

Part

Job Title I40172_C&C (2 lane)

Ref

By KCh

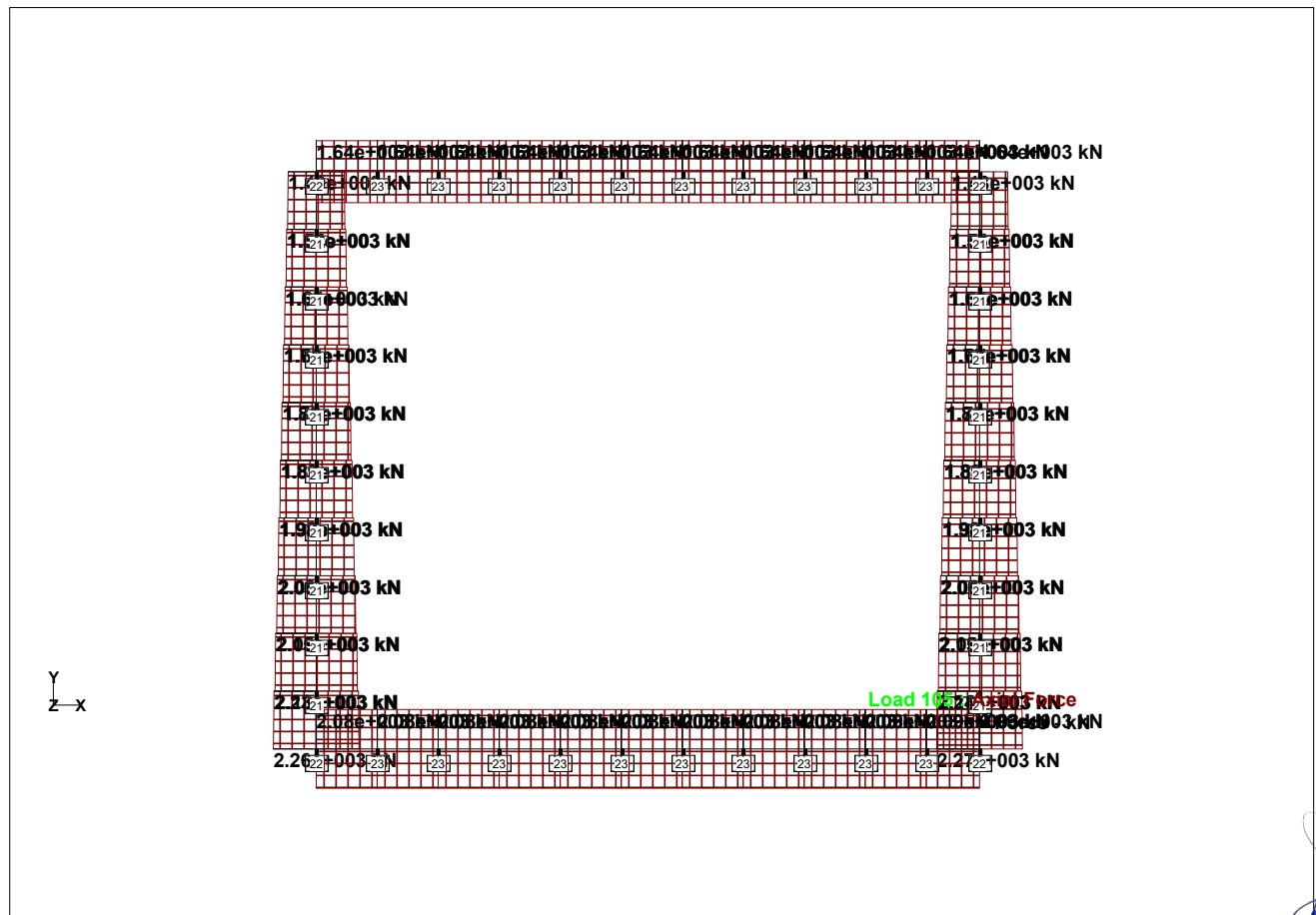
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (2 la

Date/Time 11-Sep-2024 12:17



AXIAL

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

1

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

Job Information

	Engineer	Checked	Approved
Name:	KCh	CSa	SPa
Date:	03-Sep-24		

Project ID

Project Name

Structure Type

SPACE FRAME

Number of Nodes	50	Highest Node	60
Number of Elements	50	Highest Beam	59

Number of Basic Load Cases	7
Number of Combination Load Cases	10

Included in this printout are data for:

All

The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL (SELF WEIGHT)
Primary	2	EARTH PRESSURE (WT 5MBGL)
Primary	3	EARTH PRESSURE (WT AT GROUND)
Primary	4	HYDROSTATIC (5MBGL)
Primary	5	HYDROSTATIC (WT AT GROUND)
Primary	6	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYMM
Combination	101	1.5DL + 1.5EP(5M) + 1.5WL(5M)
Combination	102	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)
Combination	103	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE
Combination	104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SURCHARGE
Combination	105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE
Combination	201	1.0DL + 1.0EP(5M) + 1.0WL(5M)
Combination	202	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)
Combination	203	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE
Combination	204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SURCHARGE
Combination	205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

2

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.000	8.500	0.000
5	0.897	8.500	0.000
6	1.793	8.500	0.000
7	2.690	8.500	0.000
8	3.587	8.500	0.000
9	4.483	8.500	0.000
10	5.380	8.500	0.000
11	6.277	8.500	0.000
12	7.173	8.500	0.000
13	8.070	8.500	0.000
14	8.967	8.500	0.000
19	13.450	7.650	0.000
20	13.450	6.800	0.000
21	13.450	5.950	0.000
22	13.450	5.100	0.000
23	13.450	4.250	0.000
24	13.450	3.400	0.000
25	13.450	2.550	0.000
26	13.450	1.700	0.000
27	13.450	0.850	0.000
28	0.000	0.850	0.000
29	0.000	1.700	0.000
30	0.000	2.550	0.000
31	0.000	3.400	0.000
32	0.000	4.250	0.000
33	0.000	5.100	0.000
34	0.000	5.950	0.000
35	0.000	6.800	0.000
36	0.000	7.650	0.000
41	8.967	0.000	0.000
42	8.070	0.000	0.000
43	7.173	0.000	0.000
44	6.277	0.000	0.000
45	5.380	0.000	0.000
46	4.483	0.000	0.000
47	3.587	0.000	0.000
48	2.690	0.000	0.000
49	1.793	0.000	0.000
50	0.897	0.000	0.000
51	9.750	0.000	0.000
52	9.750	8.500	0.000
53	13.450	0.000	0.000
54	13.450	8.500	0.000
55	10.675	8.500	0.000
56	11.600	8.500	0.000

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

3

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
57	12.525	8.500	0.000
58	10.675	0.000	0.000
59	11.600	0.000	0.000
60	12.525	0.000	0.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	2	5	0.897	1	0
2	54	19	0.850	1	0
4	1	28	0.850	1	0
5	5	6	0.897	1	0
6	6	7	0.897	1	0
7	7	8	0.897	1	0
8	8	9	0.897	1	0
9	9	10	0.897	1	0
10	10	11	0.897	1	0
11	11	12	0.897	1	0
12	12	13	0.897	1	0
13	13	14	0.897	1	0
14	14	52	0.783	1	0
19	19	20	0.850	1	0
20	20	21	0.850	1	0
21	21	22	0.850	1	0
22	22	23	0.850	1	0
23	23	24	0.850	1	0
24	24	25	0.850	1	0
25	25	26	0.850	1	0
26	26	27	0.850	1	0
27	27	53	0.850	1	0
28	28	29	0.850	1	0
29	29	30	0.850	1	0
30	30	31	0.850	1	0
31	31	32	0.850	1	0
32	32	33	0.850	1	0
33	33	34	0.850	1	0
34	34	35	0.850	1	0
35	35	36	0.850	1	0
36	36	2	0.850	1	0
41	41	42	0.897	1	0
42	42	43	0.897	1	0
43	43	44	0.897	1	0
44	44	45	0.897	1	0
45	45	46	0.897	1	0
46	46	47	0.897	1	0

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

4

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
47	47	48	0.897	1	0
48	48	49	0.897	1	0
49	49	50	0.897	1	0
50	50	1	0.897	1	0
51	51	41	0.783	1	0
52	52	55	0.925	1	0
53	55	56	0.925	1	0
54	56	57	0.925	1	0
55	57	54	0.925	1	0
56	51	58	0.925	1	0
57	58	59	0.925	1	0
58	59	60	0.925	1	0
59	60	53	0.925	1	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 1.20x1.00	12E+3	10E+6	14.4E+6	19.8E+6	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN·m/deg)	rY (kN·m/deg)	rZ (kN·m/deg)
1	-	-	-	-	-	-
2	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
11	-	-	-	-	-	-
12	-	-	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	-	-	-

Handwritten signatures and initials:
- Top right: *Handwritten signature*
- Middle right: *Handwritten signature*
- Bottom right: *Handwritten signature*
- Far right: *Handwritten signature*



Software licensed to

Job No

Sheet No

5

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

Supports Cont...

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN`m/deg)	rY (kN`m/deg)	rZ (kN`m/deg)
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
32	-	-	-	-	-	-
33	-	-	-	-	-	-
34	-	-	-	-	-	-
35	-	-	-	-	-	-
36	-	-	-	-	-	-
41	-	-	-	-	-	-
42	-	-	-	-	-	-
43	-	-	-	-	-	-
44	-	-	-	-	-	-
45	-	-	-	-	-	-
46	-	-	-	-	-	-
47	-	-	-	-	-	-
48	-	-	-	-	-	-
49	-	-	-	-	-	-
50	-	-	-	-	-	-
51	-	-	-	-	-	-
52	-	-	-	-	-	-
53	-	-	-	-	-	-
54	-	-	-	-	-	-
55	-	-	-	-	-	-
56	-	-	-	-	-	-
57	-	-	-	-	-	-
58	-	-	-	-	-	-
59	-	-	-	-	-	-
60	-	-	-	-	-	-

Releases

There is no data of this type.

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

6

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT 5MBGL)	Live
3	EARTH PRESSURE (WT AT GROUND)	Live
4	HYDROSTRATIC (5MBGL)	Live
5	HYDROSTRATIC (WT AT GROUND)	Live
6	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYMM	Live

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
101	1.5DL + 1.5EP(5M) + 1.5WL(5M)	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT 5MBGL)	1.50
		4	HYDROSTRATIC (5MBGL)	1.50
102	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)	1	DL (SELF WEIGHT)	1.50
		3	EARTH PRESSURE (WT AT GROUND)	1.50
		5	HYDROSTRATIC (WT AT GROUND)	1.50
103	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE	1	DL (SELF WEIGHT)	1.50
		6	EARTH PRESSURE (DRY)	1.50
		7	SURCHARGE SYMM	1.50
104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SUf	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT 5MBGL)	1.50
		4	HYDROSTRATIC (5MBGL)	1.50
		7	SURCHARGE SYMM	1.50
105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SUf	1	DL (SELF WEIGHT)	1.50
		3	EARTH PRESSURE (WT AT GROUND)	1.50
		5	HYDROSTRATIC (WT AT GROUND)	1.50
		7	SURCHARGE SYMM	1.50
201	1.0DL + 1.0EP(5M) + 1.0WL(5M)	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT 5MBGL)	1.00
		4	HYDROSTRATIC (5MBGL)	1.00
202	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)	1	DL (SELF WEIGHT)	1.00
		3	EARTH PRESSURE (WT AT GROUND)	1.00
		5	HYDROSTRATIC (WT AT GROUND)	1.00
203	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	1	DL (SELF WEIGHT)	1.00
		6	EARTH PRESSURE (DRY)	1.00
		7	SURCHARGE SYMM	1.00
204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SUf	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT 5MBGL)	1.00
		4	HYDROSTRATIC (5MBGL)	1.00
		7	SURCHARGE SYMM	1.00
205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SUf	1	DL (SELF WEIGHT)	1.00
		3	EARTH PRESSURE (WT AT GROUND)	1.00
		5	HYDROSTRATIC (WT AT GROUND)	1.00
		7	SURCHARGE SYMM	1.00

Handwritten signatures and initials:
- Top signature: [unclear]
- Middle signature: [unclear]
- Bottom signature: [unclear]
- Bottom signature: [unclear]
- Bottom signature: [unclear]

Load Generators



Software licensed to

Job No

Sheet No

7

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

2 EARTH PRESSURE (WT 5MBGL) : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
36	TRAP kN/m	GX	81.920	-	78.600	-	-
52	UNI kN/m	GY	-182.860	-	-	-	-
53	UNI kN/m	GY	-182.860	-	-	-	-
54	UNI kN/m	GY	-182.860	-	-	-	-
55	UNI kN/m	GY	-182.860	-	-	-	-

3 EARTH PRESSURE (WT AT GROUND) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-132.860	-	-	-	-
2	TRAP kN/m	GX	-57.100	-	-60.430	-	-
4	TRAP kN/m	GX	90.400	-	87.070	-	-
5	UNI kN/m	GY	-132.860	-	-	-	-
6	UNI kN/m	GY	-132.860	-	-	-	-
7	UNI kN/m	GY	-132.860	-	-	-	-
8	UNI kN/m	GY	-132.860	-	-	-	-
9	UNI kN/m	GY	-132.860	-	-	-	-
10	UNI kN/m	GY	-132.860	-	-	-	-
11	UNI kN/m	GY	-132.860	-	-	-	-
12	UNI kN/m	GY	-132.860	-	-	-	-
13	UNI kN/m	GY	-132.860	-	-	-	-
14	UNI kN/m	GY	-132.860	-	-	-	-
19	TRAP kN/m	GX	-60.430	-	-63.760	-	-
20	TRAP kN/m	GX	-63.760	-	-67.090	-	-
21	TRAP kN/m	GX	-67.090	-	-70.420	-	-
22	TRAP kN/m	GX	-70.420	-	-73.750	-	-
23	TRAP kN/m	GX	-73.750	-	-77.080	-	-
24	TRAP kN/m	GX	-77.080	-	-80.410	-	-
25	TRAP kN/m	GX	-80.410	-	-83.740	-	-
26	TRAP kN/m	GX	-83.740	-	-87.070	-	-
27	TRAP kN/m	GX	-87.070	-	-90.400	-	-
28	TRAP kN/m	GX	87.070	-	83.740	-	-
29	TRAP kN/m	GX	83.740	-	80.410	-	-
30	TRAP kN/m	GX	80.410	-	77.080	-	-
31	TRAP kN/m	GX	77.080	-	73.750	-	-
32	TRAP kN/m	GX	73.750	-	70.420	-	-
33	TRAP kN/m	GX	70.420	-	67.090	-	-
34	TRAP kN/m	GX	67.090	-	63.760	-	-
35	TRAP kN/m	GX	63.760	-	60.430	-	-
36	TRAP kN/m	GX	60.430	-	57.100	-	-
52	UNI kN/m	GY	-132.860	-	-	-	-
53	UNI kN/m	GY	-132.860	-	-	-	-
54	UNI kN/m	GY	-132.860	-	-	-	-
55	UNI kN/m	GY	-132.860	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

8

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

4 HYDROSTATIC (5MBGL) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI	kN/m	GY	-96.000	-	-	-
2	TRAP	kN/m	GX	-96.000	-	-104.500	-
4	TRAP	kN/m	GX	181.000	-	172.500	-
5	UNI	kN/m	GY	-96.000	-	-	-
6	UNI	kN/m	GY	-96.000	-	-	-
7	UNI	kN/m	GY	-96.000	-	-	-
8	UNI	kN/m	GY	-96.000	-	-	-
9	UNI	kN/m	GY	-96.000	-	-	-
10	UNI	kN/m	GY	-96.000	-	-	-
11	UNI	kN/m	GY	-96.000	-	-	-
12	UNI	kN/m	GY	-96.000	-	-	-
13	UNI	kN/m	GY	-96.000	-	-	-
14	UNI	kN/m	GY	-96.000	-	-	-
19	TRAP	kN/m	GX	-104.500	-	-113.000	-
20	TRAP	kN/m	GX	-113.000	-	-121.500	-
21	TRAP	kN/m	GX	-121.500	-	-130.000	-
22	TRAP	kN/m	GX	-130.000	-	-138.500	-
23	TRAP	kN/m	GX	-138.500	-	-147.000	-
24	TRAP	kN/m	GX	-147.000	-	-155.500	-
25	TRAP	kN/m	GX	-155.500	-	-164.000	-
26	TRAP	kN/m	GX	-164.000	-	-172.500	-
27	TRAP	kN/m	GX	-172.500	-	-181.000	-
28	TRAP	kN/m	GX	172.500	-	164.000	-
29	TRAP	kN/m	GX	164.000	-	155.500	-
30	TRAP	kN/m	GX	155.500	-	147.000	-
31	TRAP	kN/m	GX	147.000	-	138.500	-
32	TRAP	kN/m	GX	138.500	-	130.000	-
33	TRAP	kN/m	GX	130.000	-	121.500	-
34	TRAP	kN/m	GX	121.500	-	113.000	-
35	TRAP	kN/m	GX	113.000	-	104.500	-
36	TRAP	kN/m	GX	104.500	-	96.000	-
41	UNI	kN/m	GY	181.000	-	-	-
42	UNI	kN/m	GY	181.000	-	-	-
43	UNI	kN/m	GY	181.000	-	-	-
44	UNI	kN/m	GY	181.000	-	-	-
45	UNI	kN/m	GY	181.000	-	-	-
46	UNI	kN/m	GY	181.000	-	-	-
47	UNI	kN/m	GY	181.000	-	-	-
48	UNI	kN/m	GY	181.000	-	-	-
49	UNI	kN/m	GY	181.000	-	-	-
50	UNI	kN/m	GY	181.000	-	-	-
51	UNI	kN/m	GY	181.000	-	-	-
52	UNI	kN/m	GY	-96.000	-	-	-
53	UNI	kN/m	GY	-96.000	-	-	-
54	UNI	kN/m	GY	-96.000	-	-	-
55	UNI	kN/m	GY	-96.000	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

9

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

4 HYDROSTRATIC (5MBGL) : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
56	UNI kN/m	GY	181.000	-	-	-	-
57	UNI kN/m	GY	181.000	-	-	-	-
58	UNI kN/m	GY	181.000	-	-	-	-
59	UNI kN/m	GY	181.000	-	-	-	-

5 HYDROSTRATIC (WT AT GROUND) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-146.000	-	-	-	-
2	TRAP kN/m	GX	-146.000	-	-154.500	-	-
4	TRAP kN/m	GX	231.000	-	222.500	-	-
5	UNI kN/m	GY	-146.000	-	-	-	-
6	UNI kN/m	GY	-146.000	-	-	-	-
7	UNI kN/m	GY	-146.000	-	-	-	-
8	UNI kN/m	GY	-146.000	-	-	-	-
9	UNI kN/m	GY	-146.000	-	-	-	-
10	UNI kN/m	GY	-146.000	-	-	-	-
11	UNI kN/m	GY	-146.000	-	-	-	-
12	UNI kN/m	GY	-146.000	-	-	-	-
13	UNI kN/m	GY	-146.000	-	-	-	-
14	UNI kN/m	GY	-146.000	-	-	-	-
19	TRAP kN/m	GX	-154.500	-	-163.000	-	-
20	TRAP kN/m	GX	-163.000	-	-171.500	-	-
21	TRAP kN/m	GX	-171.500	-	-180.000	-	-
22	TRAP kN/m	GX	-180.000	-	-188.500	-	-
23	TRAP kN/m	GX	-188.500	-	-197.000	-	-
24	TRAP kN/m	GX	-197.000	-	-205.500	-	-
25	TRAP kN/m	GX	-205.500	-	-214.000	-	-
26	TRAP kN/m	GX	-214.000	-	-222.500	-	-
27	TRAP kN/m	GX	-222.500	-	-231.000	-	-
28	TRAP kN/m	GX	222.500	-	214.000	-	-
29	TRAP kN/m	GX	214.000	-	205.500	-	-
30	TRAP kN/m	GX	205.500	-	197.000	-	-
31	TRAP kN/m	GX	197.000	-	188.500	-	-
32	TRAP kN/m	GX	188.500	-	180.000	-	-
33	TRAP kN/m	GX	180.000	-	171.500	-	-
34	TRAP kN/m	GX	171.500	-	163.000	-	-
35	TRAP kN/m	GX	163.000	-	154.500	-	-
36	TRAP kN/m	GX	154.500	-	146.000	-	-
41	UNI kN/m	GY	231.000	-	-	-	-
42	UNI kN/m	GY	231.000	-	-	-	-
43	UNI kN/m	GY	231.000	-	-	-	-
44	UNI kN/m	GY	231.000	-	-	-	-
45	UNI kN/m	GY	231.000	-	-	-	-
46	UNI kN/m	GY	231.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

10

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

5 HYDROSTATIC (WT AT GROUND) : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
47	UNI kN/m	GY	231.000	-	-	-	-
48	UNI kN/m	GY	231.000	-	-	-	-
49	UNI kN/m	GY	231.000	-	-	-	-
50	UNI kN/m	GY	231.000	-	-	-	-
51	UNI kN/m	GY	231.000	-	-	-	-
52	UNI kN/m	GY	-146.000	-	-	-	-
53	UNI kN/m	GY	-146.000	-	-	-	-
54	UNI kN/m	GY	-146.000	-	-	-	-
55	UNI kN/m	GY	-146.000	-	-	-	-
56	UNI kN/m	GY	231.000	-	-	-	-
57	UNI kN/m	GY	231.000	-	-	-	-
58	UNI kN/m	GY	231.000	-	-	-	-
59	UNI kN/m	GY	231.000	-	-	-	-

6 EARTH PRESSURE (DRY) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-278.860	-	-	-	-
2	TRAP kN/m	GX	-119.900	-	-126.880	-	-
4	TRAP kN/m	GX	189.700	-	182.720	-	-
5	UNI kN/m	GY	-278.860	-	-	-	-
6	UNI kN/m	GY	-278.860	-	-	-	-
7	UNI kN/m	GY	-278.860	-	-	-	-
8	UNI kN/m	GY	-278.860	-	-	-	-
9	UNI kN/m	GY	-278.860	-	-	-	-
10	UNI kN/m	GY	-278.860	-	-	-	-
11	UNI kN/m	GY	-278.860	-	-	-	-
12	UNI kN/m	GY	-278.860	-	-	-	-
13	UNI kN/m	GY	-278.860	-	-	-	-
14	UNI kN/m	GY	-278.860	-	-	-	-
19	TRAP kN/m	GX	-126.880	-	-133.860	-	-
20	TRAP kN/m	GX	-133.860	-	-140.840	-	-
21	TRAP kN/m	GX	-140.840	-	-147.820	-	-
22	TRAP kN/m	GX	-147.820	-	-154.800	-	-
23	TRAP kN/m	GX	-154.800	-	-161.780	-	-
24	TRAP kN/m	GX	-161.780	-	-168.760	-	-
25	TRAP kN/m	GX	-168.760	-	-175.740	-	-
26	TRAP kN/m	GX	-175.740	-	-182.720	-	-
27	TRAP kN/m	GX	-182.720	-	-189.700	-	-
28	TRAP kN/m	GX	182.720	-	175.740	-	-
29	TRAP kN/m	GX	175.740	-	168.760	-	-
30	TRAP kN/m	GX	168.760	-	161.780	-	-
31	TRAP kN/m	GX	161.780	-	154.800	-	-
32	TRAP kN/m	GX	154.800	-	147.820	-	-
33	TRAP kN/m	GX	147.820	-	140.840	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

11

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

6 EARTH PRESSURE (DRY) : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
34	TRAP kN/m	GX	140.840	-	133.860	-	-
35	TRAP kN/m	GX	133.860	-	126.880	-	-
36	TRAP kN/m	GX	126.880	-	119.900	-	-
52	UNI kN/m	GY	-278.860	-	-	-	-
53	UNI kN/m	GY	-278.860	-	-	-	-
54	UNI kN/m	GY	-278.860	-	-	-	-
55	UNI kN/m	GY	-278.860	-	-	-	-

7 SURCHARGE SYM : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-60.000	-	-	-	-
2	UNI kN/m	GX	-30.000	-	-	-	-
4	UNI kN/m	GX	30.000	-	-	-	-
5	UNI kN/m	GY	-60.000	-	-	-	-
6	UNI kN/m	GY	-60.000	-	-	-	-
7	UNI kN/m	GY	-60.000	-	-	-	-
8	UNI kN/m	GY	-60.000	-	-	-	-
9	UNI kN/m	GY	-60.000	-	-	-	-
10	UNI kN/m	GY	-60.000	-	-	-	-
11	UNI kN/m	GY	-60.000	-	-	-	-
12	UNI kN/m	GY	-60.000	-	-	-	-
13	UNI kN/m	GY	-60.000	-	-	-	-
14	UNI kN/m	GY	-60.000	-	-	-	-
19	UNI kN/m	GX	-30.000	-	-	-	-
20	UNI kN/m	GX	-30.000	-	-	-	-
21	UNI kN/m	GX	-30.000	-	-	-	-
22	UNI kN/m	GX	-30.000	-	-	-	-
23	UNI kN/m	GX	-30.000	-	-	-	-
24	UNI kN/m	GX	-30.000	-	-	-	-
25	UNI kN/m	GX	-30.000	-	-	-	-
26	UNI kN/m	GX	-30.000	-	-	-	-
27	UNI kN/m	GX	-30.000	-	-	-	-
28	UNI kN/m	GX	30.000	-	-	-	-
29	UNI kN/m	GX	30.000	-	-	-	-
30	UNI kN/m	GX	30.000	-	-	-	-
31	UNI kN/m	GX	30.000	-	-	-	-
32	UNI kN/m	GX	30.000	-	-	-	-
33	UNI kN/m	GX	30.000	-	-	-	-
34	UNI kN/m	GX	30.000	-	-	-	-
35	UNI kN/m	GX	30.000	-	-	-	-
36	UNI kN/m	GX	30.000	-	-	-	-
52	UNI kN/m	GY	-60.000	-	-	-	-
53	UNI kN/m	GY	-60.000	-	-	-	-
54	UNI kN/m	GY	-60.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

12

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

7 SURCHARGE SYMM : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
55	UNI kN/m	GY	-60.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

13

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

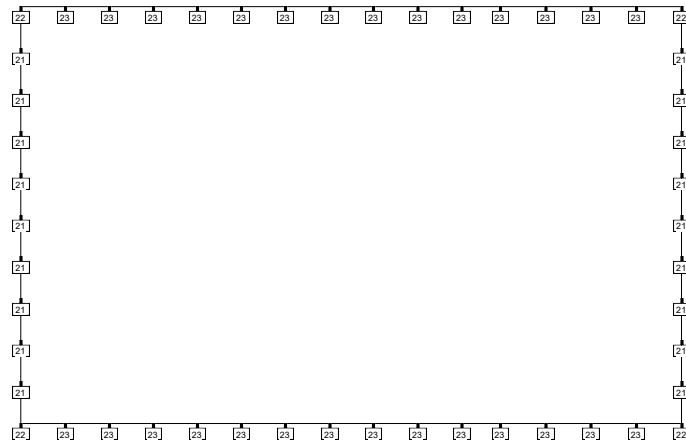
Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

Y
Z-X



Load 1

Whole Structure

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

14

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

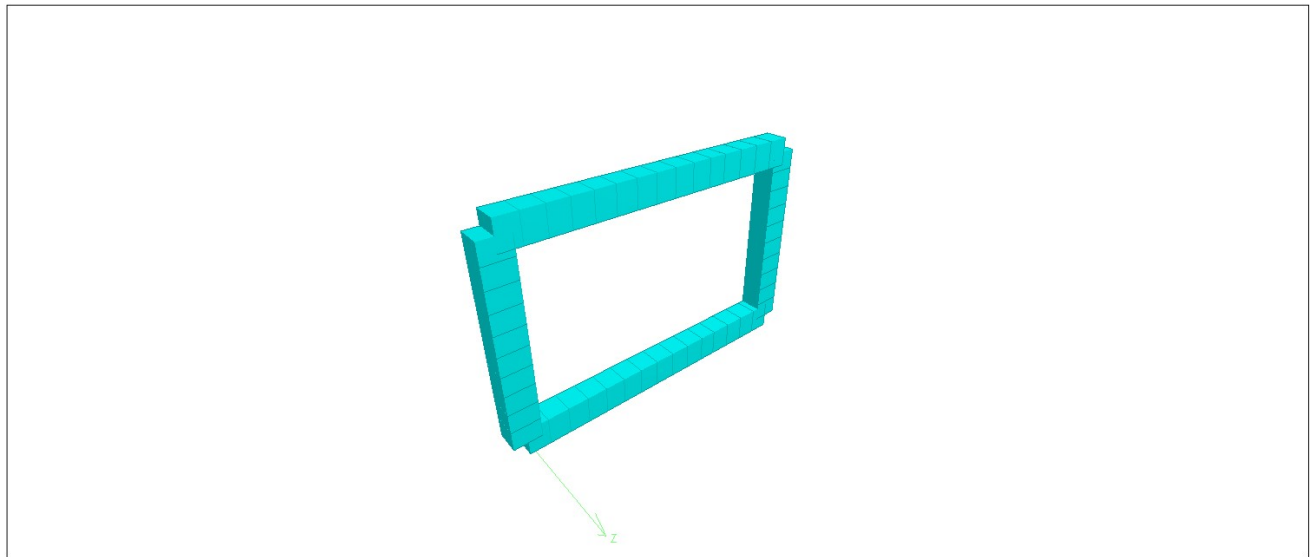
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



3D Rendered View

Signature
Signature
Rob
CSA
Signature



Software licensed to

Job No

Sheet No

15

Rev

A

Part

Job Title **I40172_C&C (3 lane)**

Ref

By **KCh**

Date **03-Sep-24**

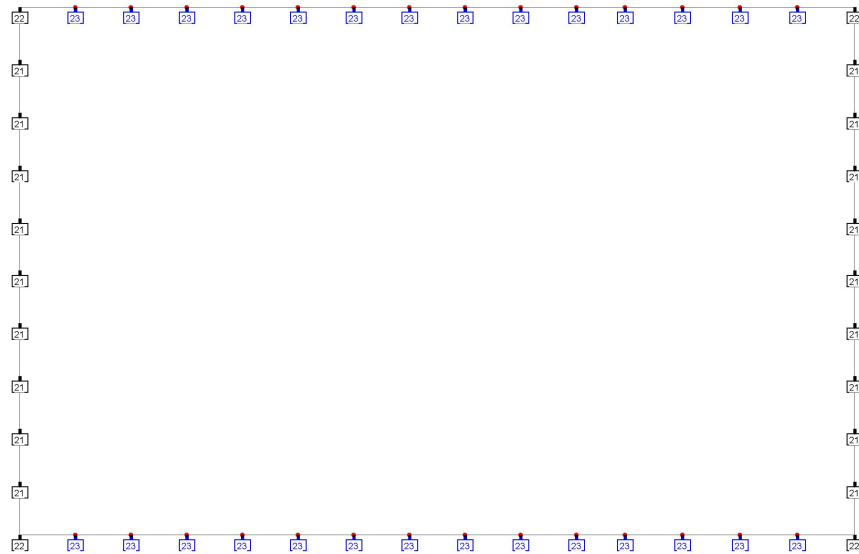
Chd **CSa**

Client

File **I40172_C&C section (3 l**

Date/Time **05-Sep-2024 19:38**

Y
Z-x



Load 1

SUPPORTS

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

16

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

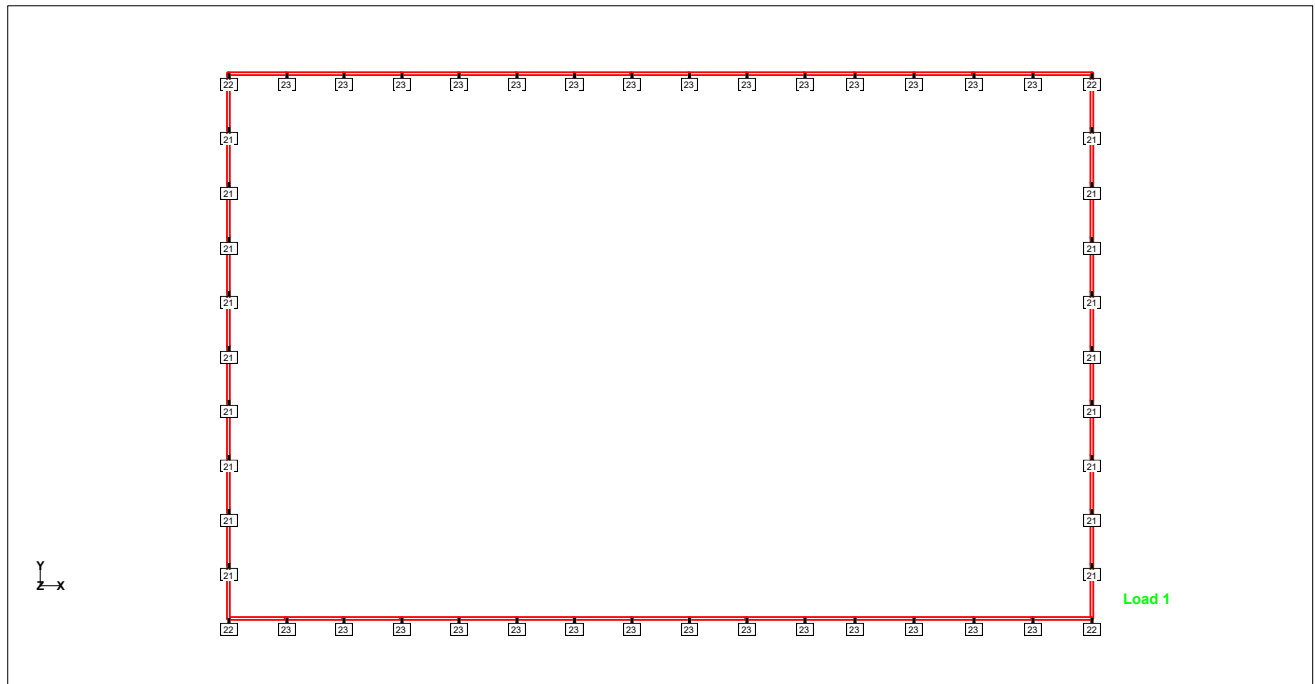
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



DL

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

17

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

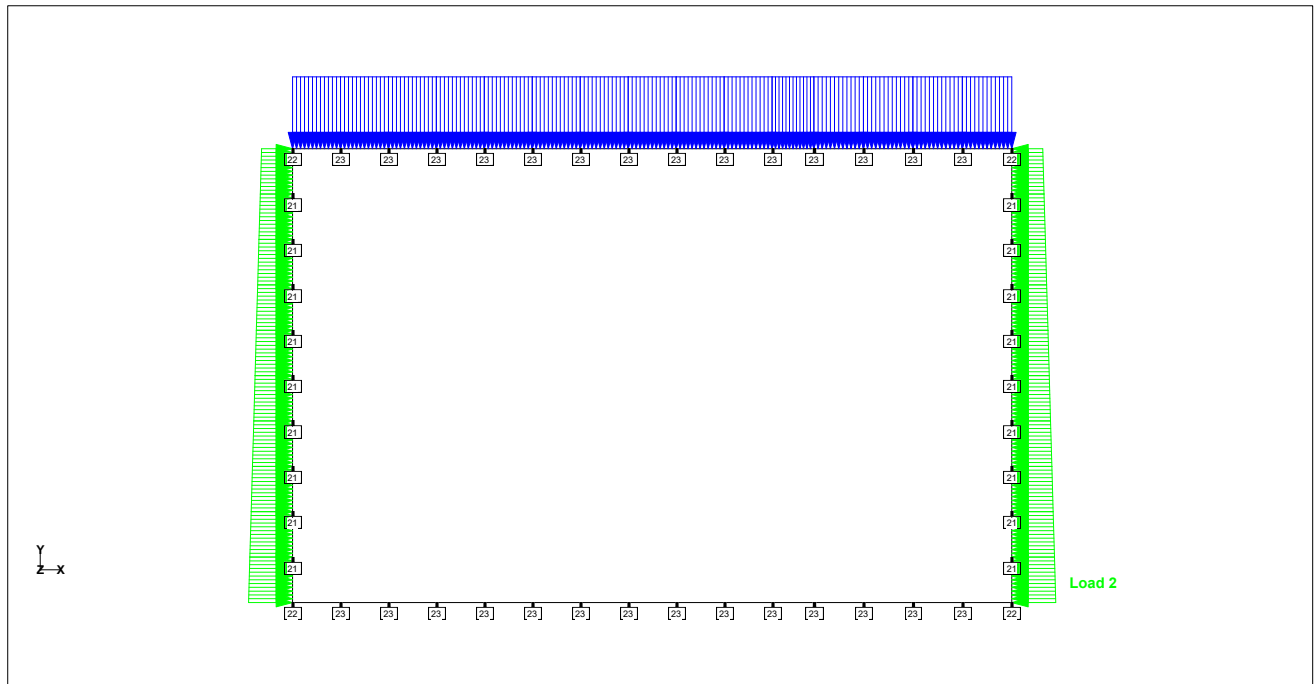
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



EP(WT 5MBGL)

Handwritten signatures and initials:
1. *Handwritten signature*
2. *Handwritten signature*
3. *Handwritten signature*
4. *Handwritten signature*
5. *Handwritten signature*



Software licensed to

Job No

Sheet No

18

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

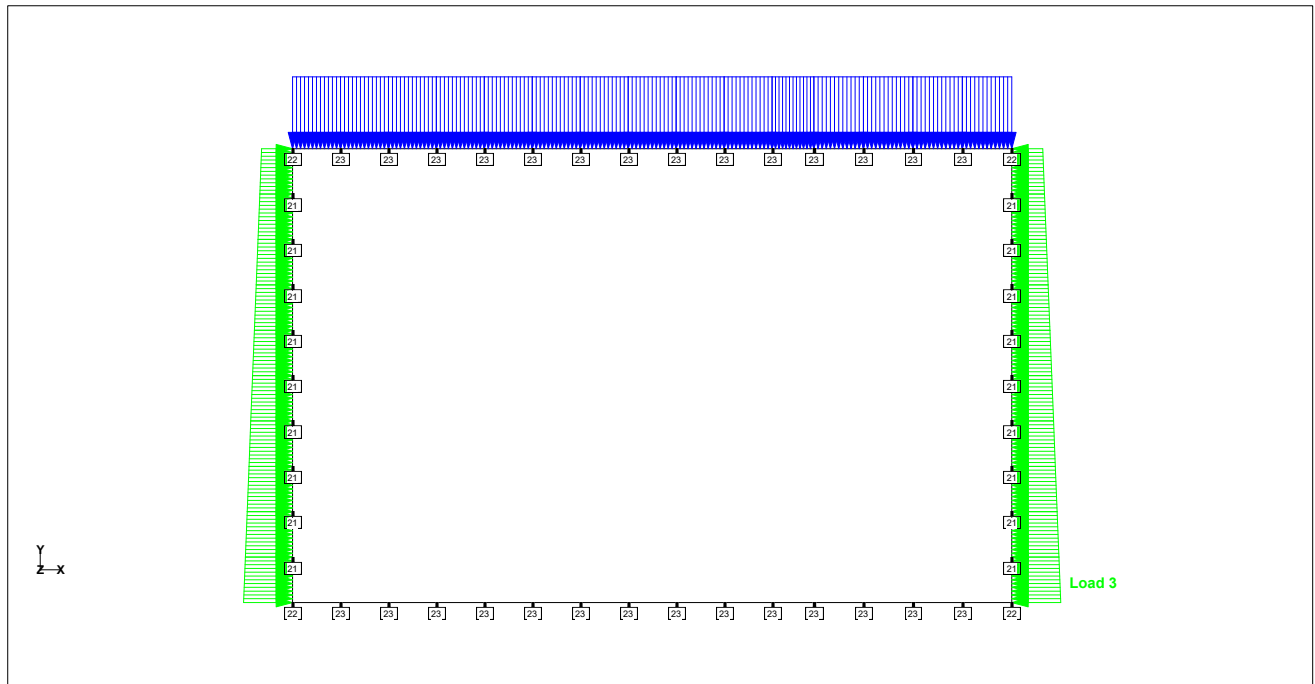
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



EP(WT AT GROUND)

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

19

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

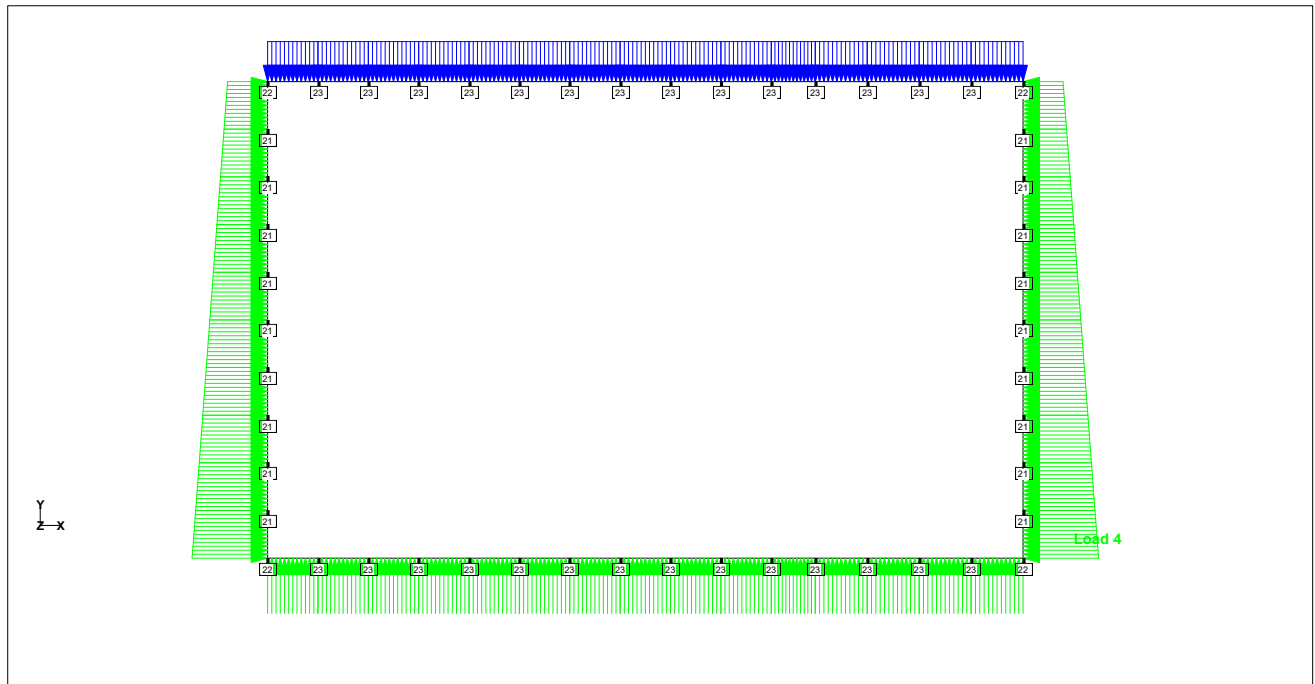
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



WATER(5MBGL)

Handwritten signatures and initials:
[Signature]
[Signature]
[Signature]
[Signature]
[Signature]



Software licensed to

Job No

Sheet No

20

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

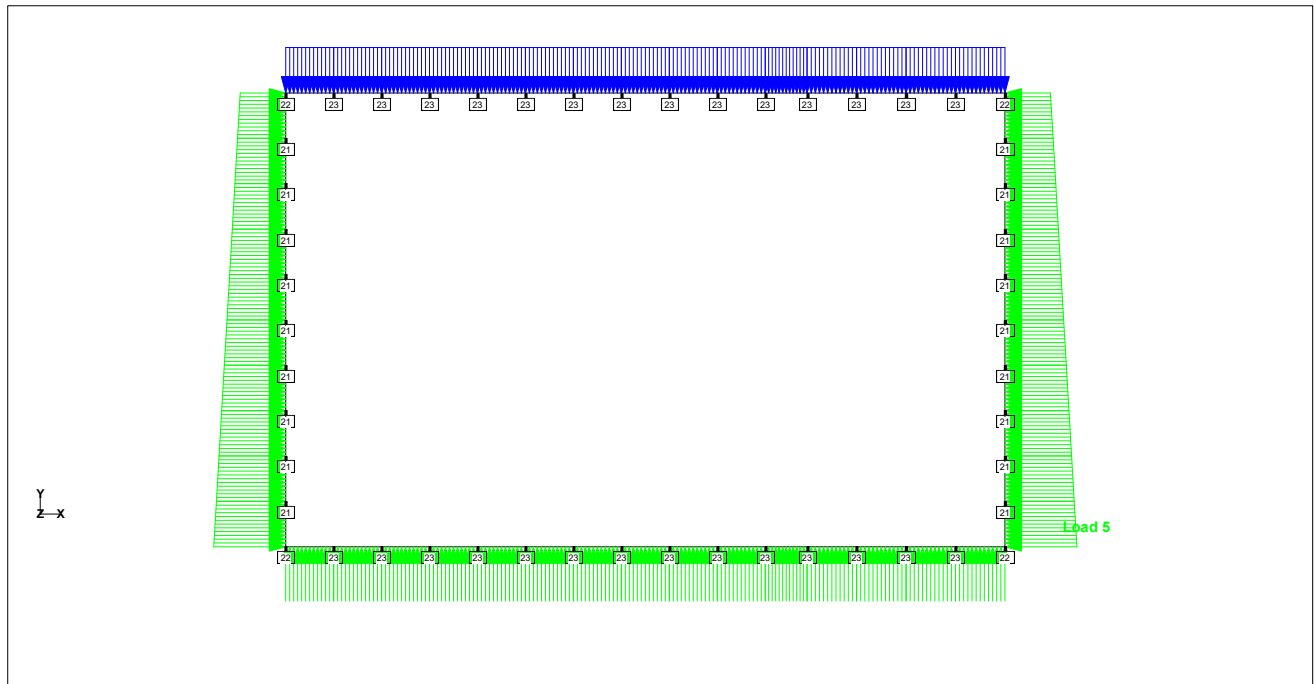
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



WATER(WT AT GROUND)

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

21

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

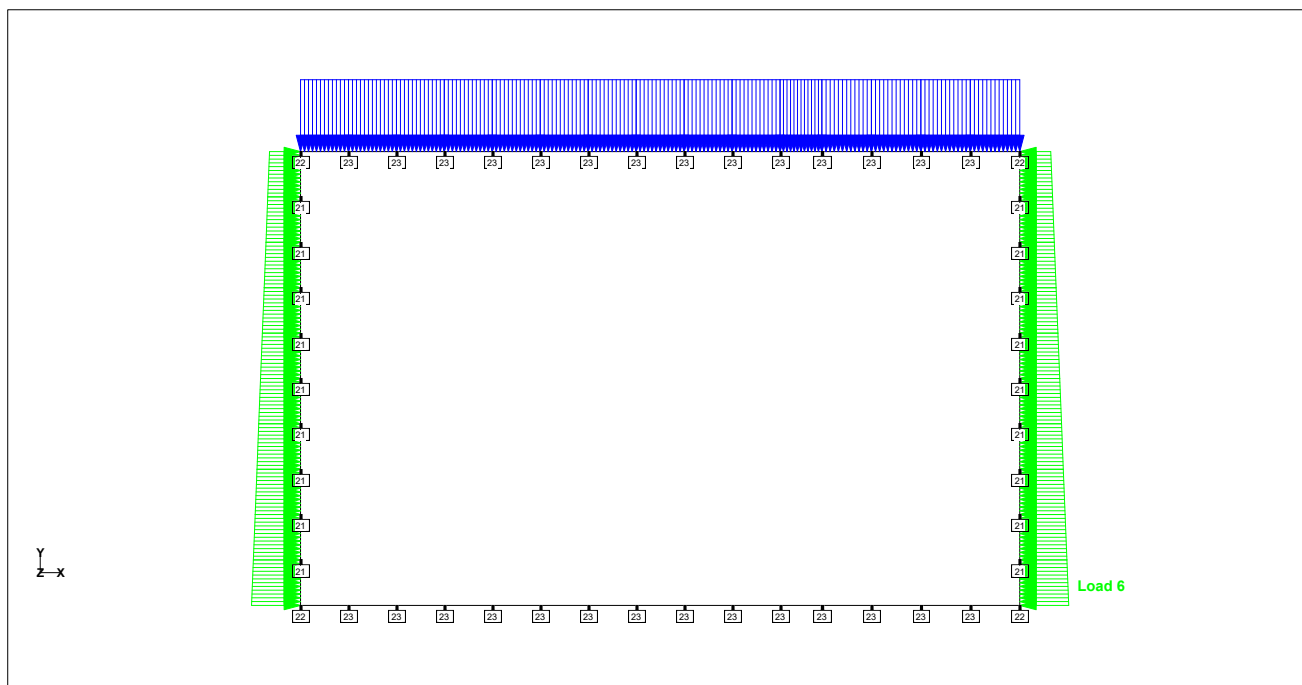
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



EP(DRY)

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

22

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

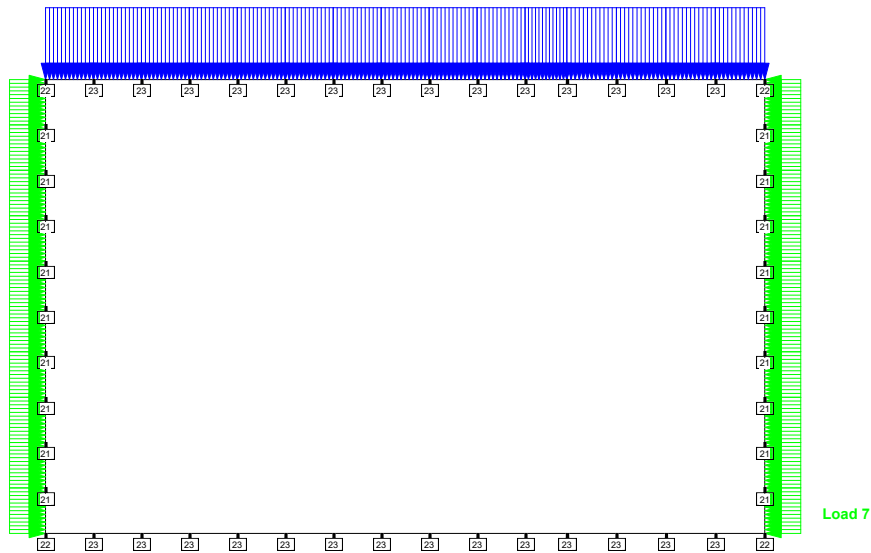
Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38

Y
Z-x



SURCHARGE

Handwritten signatures and initials:
[Signature]
[Signature]
[Signature]
[Signature]
[Signature]



Software licensed to

Job No

Sheet No

23

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

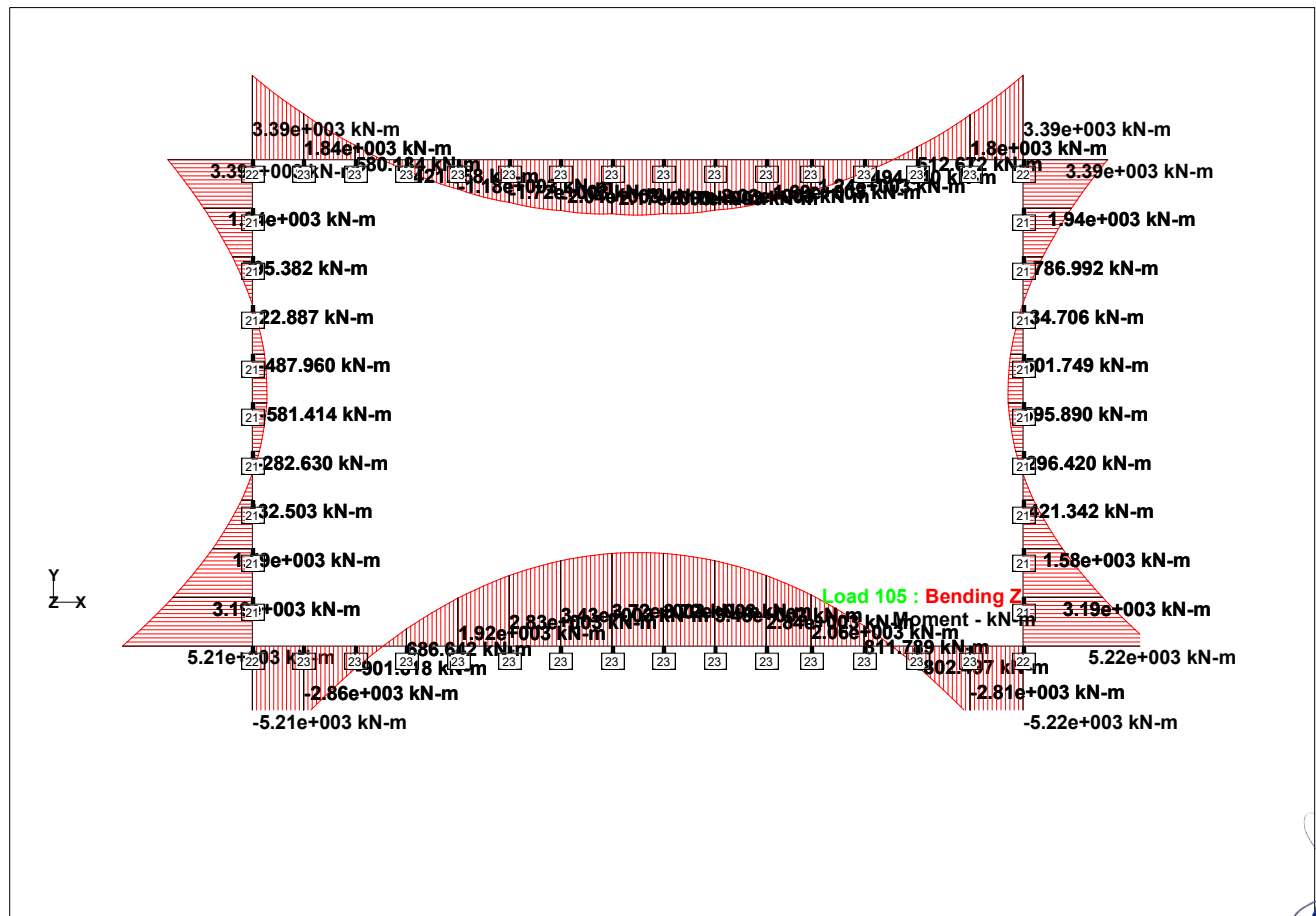
Date 03-Sep-24

Chd CSa

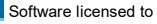
Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



[Handwritten signatures and initials]



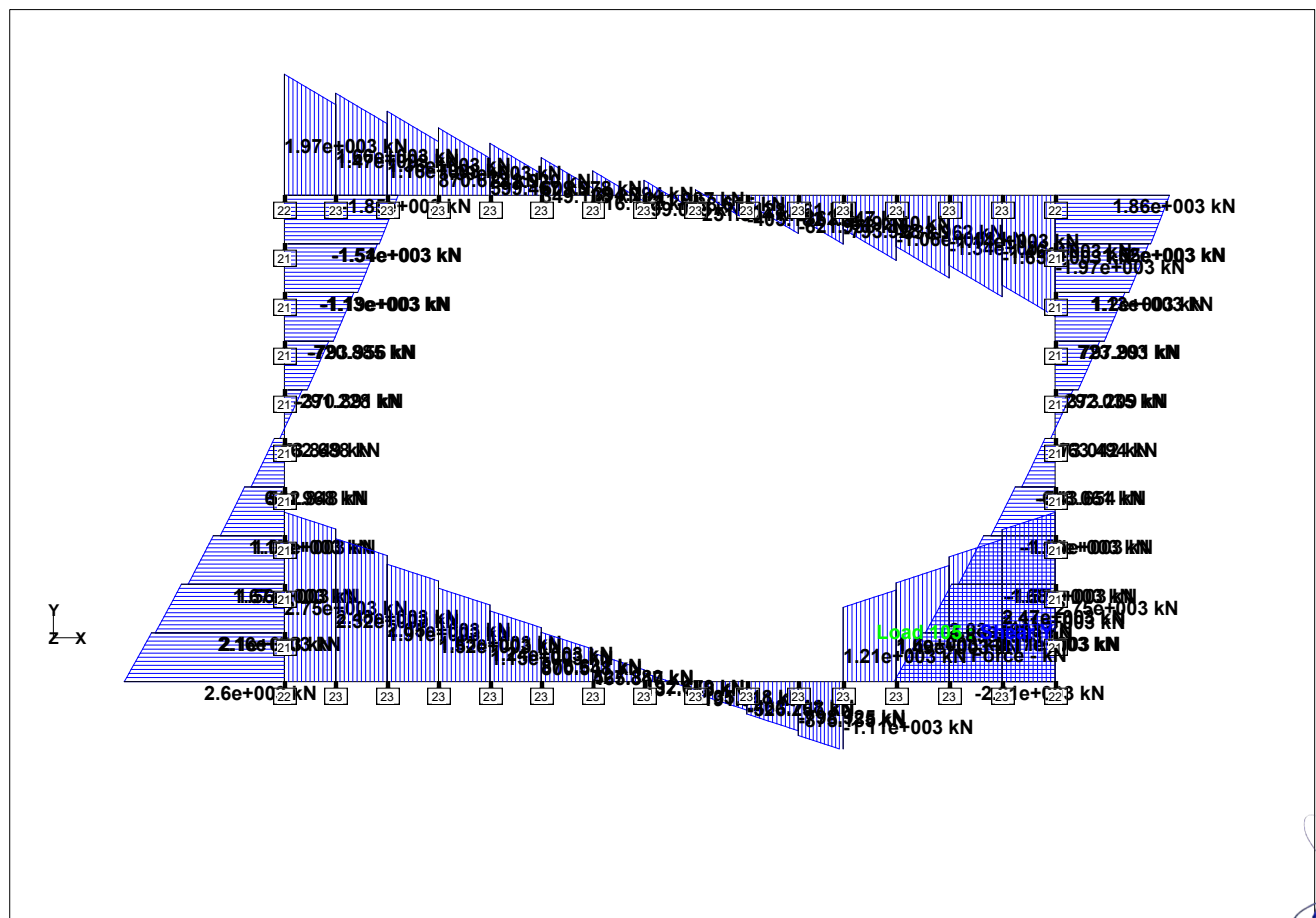
Sheet No

Rev

Ref

Chd CSa

Date/Time 05-Sep-2024 19:38



shear

Lachner
~~Adair~~
 Rob
 P. S. Low
 J. S. Low



Software licensed to

Job No

Sheet No

25

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

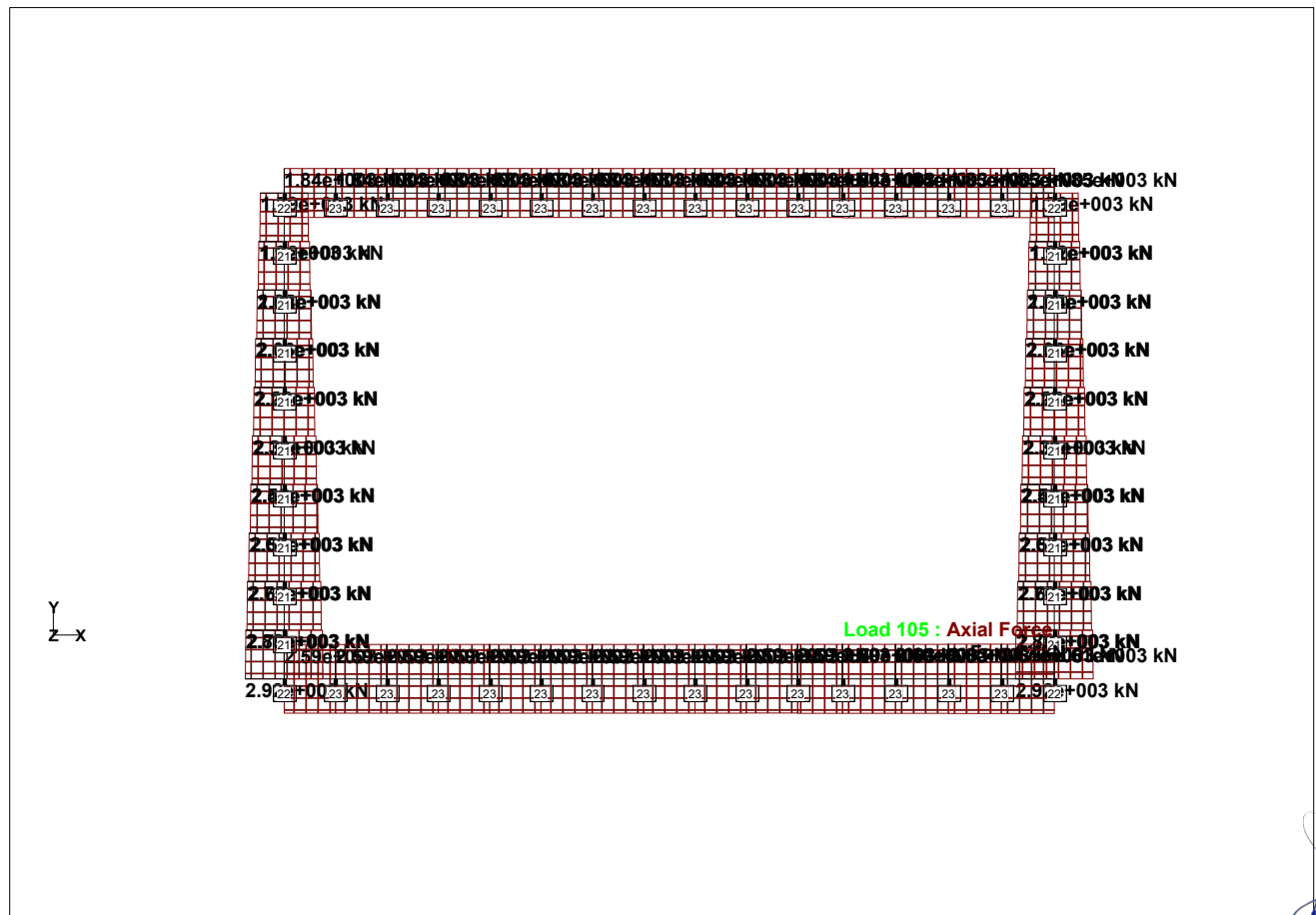
Date 03-Sep-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 05-Sep-2024 19:38



AXIAL

[Handwritten signatures]

	GEOCONSULT India Pvt Ltd		APPENDIX-3	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	2	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Base Slab(1000mm thk) - C&C box (2 lane)			

DESIGN OF BASE SLAB- C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1000 mm
Unit width of slab	b	=	1000 mm

3)Design for Support Moment (Earth Face)

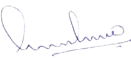
Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	2240 kNm
Effective Thickness		=	899 mm
d'		=	101 mm
Mu/bd ²		=	2.772
Mulim		=	3762.18 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	11870.76
Mu2	$=Mu - Mulim$	=	-1522.18
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-4385.03
Ast	$=Astlim + Ast2$	=	7485.73
d'/d	0.11	=	0.15
fsc	Refer Table F SP 16 pg 13	=	395.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-5027.78







Minimum area of steel required (0.12% on each face in one direction)	=	1078.80 mm ²
Required area of steel	Ast =	0.83% = 7485.73 mm ²
Refer Table 2 SP 16 pg 48	Asc =	-0.56% = -5027.78 mm ²

Side Face bars are required

Tension Reinforcement (Ast)

Required spacing of bars	=	107.4 mm
Provided spacing	=	100 mm
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	8042.5 mm ²

OK

Compression Reinforcement (Asc)

Required spacing of bars	=	-62.5 mm
Provided spacing	=	100 mm
Provide 1 layer	20mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	3141.6 mm ²

OK

2m from sidewall

Design Moments

Minimum thickness of the slab	D =	1000 mm
Max factored bending moment (From STAAD)	=	0 kNm

2m+0.5m away from the support

Effective Thickness	=	909 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$

Minimum area of steel required (0.12% on each face in one direction)	=	1090.80 mm ²
--	---	-------------------------

Required area of steel	=	1090.80 mm ²
Required spacing of bars	=	737.3 mm
Provided spacing	=	100 mm
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	8042.5 mm ²

OK

4) Design for Span Moment (Inside)

Gross area	Ag =	1000000 mm ²
------------	------	-------------------------

Design Moments

Minimum thickness of the slab	D =	1000 mm
Max factored bending moment (from STAAD)	=	1906 kNm

Effective Thickness	=	909 mm
---------------------	---	--------

Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$
------------------------	---	---

Minimum area of steel required (0.12% on each face in one direction)	=	5256.98 mm ²
--	---	-------------------------

Required area of steel	=	1090.80 mm ²
Required spacing of bars	=	150 mm
Provided spacing	=	100 mm
Provide	32mm dia bars @ 100 mm c/c on both faces	
Area of steel provided	=	8042.5 mm ²

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.12 % of Cross Sectional Area	=	1078.8 mm ²
0.2 Times of Main Bar	=	1608 mm ²
Longitudinal Bar Required at Each Face	=	1608 mm ²

Steel Provided	16 Dia Bar at 150 mm c/c	
Area of Steel Provided	=	1340 mm ²

[Signature]

[Signature]

[Signature]

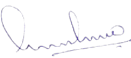
[Signature]

[Signature]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	2116.0	kN	
Effective Shear Area	=	1000000	mm ²	
Shear Stress in Base Slab	=	2.12	N/mm ²	
Allowable Shear Stress	=	0.40	N/mm ²	
Shear force against which stirrups required	=	1348	KN	
Considering 10mm Dia shear link at 100 mm c/c				
Spacing of stirrups	=	210	mm	449.3752695
Provide shear reinforcement at	=	100	mm c/c	
Provide this Shear Reinforcement up to 2m from sidewall .				235.619449







	GEOCONSULT India Pvt Ltd		APPENDIX-3	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1000mm thk) - C&C box (2 lane)			

Check for crack width For Base Slab (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

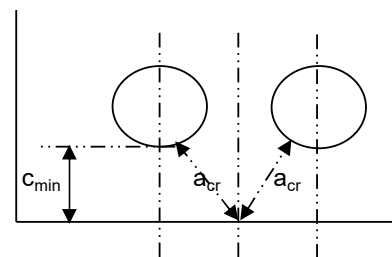
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	149333333	
Axial Force (P) (N) =	2089000	
Tension R/F=	32T	100c/c
	T	85c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	883
A_{st} (mm ² /m) =	8042.477193
p_t (ratio)=	0.009108128
x (mm) =	260.24
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	8333333333
I_{cr} (mm ⁴) =	26963965868

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 960$$

Strain in concrete at the level of steel

$$e_s = 0.001165968$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00131$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00015$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00116$$

$$\text{Average strain } e_m = 0.000989572$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.178 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1336 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*

	GEOCONSULT India Pvt Ltd	APPENDIX-3	
	A company of the GEOCONSULT group	Job no:	I40172
		Page No.:	2
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for	Design of Top Slab(1000mm thk) - C&C box (2 lane)		

DESIGN OF BASE SLAB- Ramp

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1000 mm
Unit width of slab	b	=	1000 mm

3)Design for Support Moment (Earth Face)

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	1800 kNm
Effective Thickness		=	899 mm
d'		=	101 mm
Mu/bd ²		=	2.227
Mulim		=	3762.18 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{b^2 - 4ac})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	11870.76
Mu2	$=Mu - Mulim$	=	-1962.18
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-5652.57
Ast	$=Astlim + Ast2$	=	6218.20
d'/d	0.11	=	0.15
fsc	Refer Table F SP 16 pg 13	=	395.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-6481.11








Minimum area of steel required (0.12% on each face in one direction)	=	1078.80 mm ²	
Required area of steel	Ast =	0.69%	6218.20 mm ²
Refer Table 2 SP 16 pg 48	Asc =	-0.72%	-6481.11 mm ²
Side Face bars are required			
Tension Reinforcement (Ast)			
Required spacing of bars	=	129.3 mm	
Provided spacing	=	100 mm	
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	8042.5 mm ²	OK
Compression Reinforcement (Asc)			
Required spacing of bars	=	-48.5 mm	
Provided spacing	=	100 mm	
Provide 1 layer	20mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	3141.6 mm ²	OK

2m from sidewall

Design Moments

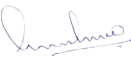
Minimum thickness of the slab	D =	1000 mm	
Max factored bending moment (From STAAD)	=	0 kNm	
Effective Thickness	2m+0.5m away from the support	909 mm	
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
Minimum area of steel required (0.12% on each face in one direction)	=	0.00 mm ²	
Required area of steel	=	1090.80 mm ²	
Required spacing of bars	=	737.3 mm	
Provided spacing	=	100 mm	
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	8042.5 mm ²	OK

4) Design for Span Moment (Inside)

Gross area	Ag =	1000000 mm ²	
Design Moments			
Minimum thickness of the slab	D =	1000 mm	
Max factored bending moment (from STAAD)	=	1246 kNm	
Effective Thickness	=	913 mm	
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
Minimum area of steel required (0.12% on each face in one direction)	=	3312.37 mm ²	
Required area of steel	=	1095.00 mm ²	
Required spacing of bars	=	3312.37 mm ²	
Provided spacing	=	125 mm	
Provide	25mm dia bars @ 100 mm c/c on both faces	100 mm	
Area of steel provided	=	4908.7 mm ²	OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of			
0.12 % of Cross Sectional Area	=	1078.8 mm ²	
0.2 Times of Main Bar	=	982 mm ²	
Longitudinal Bar Required at Each Face	=	1079 mm ²	
Steel Provided			
16 Dia Bar at 150 mm c/c			
Area of Steel Provided	=	1340 mm ²	



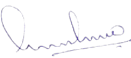




6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	1654.0	kN	
Effective Shear Area	=	1000000	mm ²	
Shear Stress in Base Slab	=	1.65	N/mm ²	
Allowable Shear Stress	=	0.40	N/mm ²	
Shear force against which stirrups required	=	985	KN	
Considering 10mm Dia shear link at 100 mm c/c				
Spacing of stirrups	=	288	mm	328.38962
Provide shear reinforcement at	=	100	mm c/c	
Provide this Shear Reinforcement up to 2m from sidewall .				235.619449







	GEOCONSULT India Pvt Ltd		APPENDIX-3	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1000mm thk) - C&C box (2 lane)			

Check for crack width For Base Slab (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

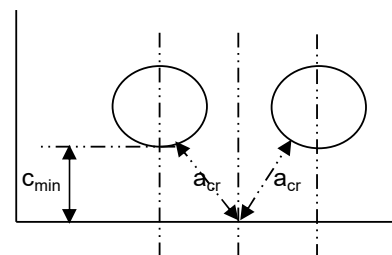
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1200000000	
Axial Force (P) (N) =	1643000	
Tension R/F=	32T	100c/c
	T	85c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	883
A_{st} (mm ² /m) =	8042.477193
p_t (ratio)=	0.009108128
x (mm) =	260.24
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	26963965868

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 960$$

Strain in concrete at the level of steel

$$e_s = 0.000936938$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00105$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00012$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00094$$

$$\text{Average strain } e_m = 0.000763887$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.137 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1031 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*

	GEOCONSULT India Pvt Ltd		APPENDIX-3	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1000mm thk) - C&C box (2 lane)			

Check for crack width For Base Slab (At Mid)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

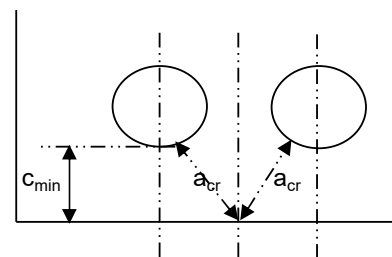
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	830666666.7	
Axial Force (P) (N) =	1266000	
Tension R/F=	25T	100c/c
	T	85c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	890
A_{st} (mm ² /m) =	4908.738521
p_t (ratio)=	0.005515437
x (mm) =	212.12
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	18432550962

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 960$$

Strain in concrete at the level of steel

$$e_s = 0.001032733$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00114$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00009$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00105$$

$$\text{Average strain } e_m = 0.000754368$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 63.70 \text{ mm}$$

$$\text{crack width (mm) } w = 0.138 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1018 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*

	GEOCONSULT India Pvt Ltd	APPENDIX-3	
	A company of the GEOCONSULT group	Job no:	I40172
		Page No.:	2
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for	Design of Side Wall(1000mm thk) - C&C box (2 lane)		

DESIGN OF SIDE WALL (1000 mm THK)-C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Side Wall

Minimum thickness of the Wall	D	=	1000 mm
Unit width of Wall	b	=	1000 mm

3)Design for Reinforcement Earth Side

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	2384 kNm
Effective Thickness		=	899 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_u / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	6843.42 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1078.80 mm ²
Required area of steel		=	6843.42 mm ²
Required spacing of bars		=	117.5 mm
Provided spacing		=	100 mm
Provide 1 layers 32mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	8042.5 mm ²

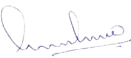
OK

Above 2m from base slab

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	0 kNm
Effective Thickness		=	909 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_u / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	0.00 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1090.80 mm ²
Required area of steel		=	1090.80 mm ²
Required spacing of bars		=	737.3 mm
Provided spacing		=	100 mm
Provide 1 layers 32mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	8042.5 mm ²

OK







4) Design for Reinforcement Open Side

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (from STAAD)		=	1150 kNm
Effective Thickness		=	915 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_e / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	3034.47 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1098.00 mm ²
Required area of steel		=	3034.47 mm ²
Required spacing of bars		=	100 mm
Provided spacing		=	100 mm
Provide 20mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	3141.6 mm ²

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of			
0.12 % of Cross Sectional Area		=	1078.8 mm ²
0.2 Times of Main Bar		=	628 mm ²
Longitudinal Bar Required at Each Face		=	1079 mm ²
Steel Provided			
16 Dia Bar at 150 mm c/c			
Area of Steel Provided	=	1340 mm ²	OK

6) Check For Shear

Upto 2m from base slab

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	2092.0 kN	
Effective Shear Area	=	1000000 mm ²	
Shear Stress in Side Wall	=	2.09 N/mm ²	443.0903007
Allowable Shear Stress	=	0.40 N/mm ²	
Shear force against which stirrups required	=	1329 KN	
Considering 10mm Dia shear link at 100 mm c/c			
Spacing of stirrups	=	213 mm	314.1592654
Provide shear reinforcement at	=	100 mm c/c	

Provide this Shear Reinforcement up to 2m of height from baseslab .

[Handwritten signatures and initials]

	GEOCONSULT India Pvt Ltd		APPENDIX-3	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Side wall (1000mm thk)			

Check for crack width For Side Wall (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

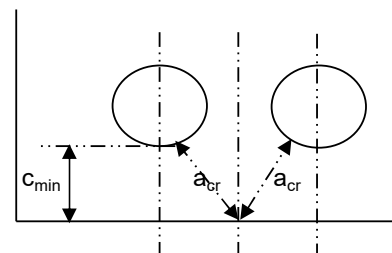
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1589333333	
Axial Force (P) (N) =	2266000	
Tension R/F=	32T	100c/c
	T	85c/c
	T	85c/c
	T	mm
Diameter of Spacer Bar=	T	
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	883
A_{st} (mm ² /m) =	8042.477193
p_t (ratio)=	0.009108128
x (mm) =	260.24
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	26963965868

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 960$$

Strain in concrete at the level of steel

$$e_s = 0.001240923$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00139$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00016$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00123$$

$$\text{Average strain } e_m = 0.001061229$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.191 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1433 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*

	GEOCONSULT India Pvt Ltd		APPENDIX-3	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Side wall (1000mm thk)			

Check for crack width For Side Wall (At Mid)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

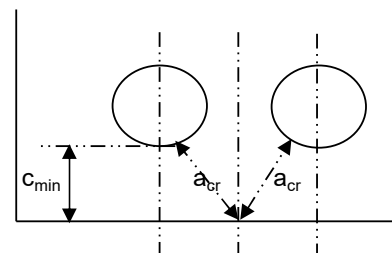
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	76666666.7	
Axial Force (P) (N) =	1839000	
Tension R/F=	20T	100c/c
	T	85c/c
	T	85c/c
	T	mm
Diameter of Spacer Bar=	T	
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	895
A_{st} (mm ² /m) =	3141.592654
p_t (ratio)=	0.003510159
x (mm) =	174.90
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	12797813289

safe



(fig 1)

[Handwritten signatures and initials]

$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.001458336$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00159$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00013$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00146$$

$$\text{Average strain } e_m = 0.000982178$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min}(mm) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(mm) = 64.33 \text{ mm}$$

$$\text{crack width (mm) } w = 0.181 < 0.2 \text{ mm}$$

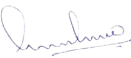
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1326 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX-3	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	2	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Base Slab(1200mm thk) - C&C box (3 lane)			

DESIGN OF BASE SLAB- C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1200 mm
Unit width of slab	b	=	1000 mm

3)Design for Support Moment (Earth Face)

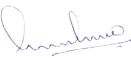
Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	4000 kNm
Effective Thickness		=	1099 mm
d'		=	101 mm
Mu/bd ²		=	3.312
Mulim		=	5622.31 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=(Mulim/bd^2)$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	14511.65
Mu2	$=(Mu - Mulim)$	=	-1622.31
Ast2	$=(Mu2/((0.87*fy)*(d-d')))$	=	-3736.93
Ast	$=(Astlim + Ast2)$	=	10774.72
d'/d	0.09	=	0.10
fsc	Refer Table F SP 16 pg 13	=	412.00
fcc	$=0.446*fck$	=	15.61
Asc	$=(Mu2/((fsc-fcc)*(d-d')))$	=	-4100.92








Minimum area of steel required (0.12% on each face in one direction)	=	1318.80 mm ²	
Required area of steel	Ast =	0.98%	10774.72 mm ²
Refer Table 2 SP 16 pg 48	Asc =	-0.37%	-4100.92 mm ²
Side Face bars are required			
Tension Reinforcement (Ast)			
Required spacing of bars	=	74.6 mm	
Provided spacing	=	100 mm	
Provide 2 layers	32mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	16085.0 mm ²	OK
Compression Reinforcement (Asc)			
Required spacing of bars	=	-119.7 mm	
Provided spacing	=	100 mm	
Provide 1 layer	25mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	4908.7 mm ²	OK

2m from sidewall

Design Moments

Minimum thickness of the slab	D =	1200 mm	
Max factored bending moment (From STAAD)	=	0 kNm	
Effective Thickness	2m+0.5m away from the support		
Area of steel required	=	1109 mm	
	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
	=	0.00 mm ²	
Minimum area of steel required (0.12% on each face in one direction)	=	1330.80 mm ²	
Required area of steel	=	1330.80 mm ²	
Required spacing of bars	=	604.3 mm	
Provided spacing	=	100 mm	
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	8042.5 mm ²	OK

4) Design for Span Moment (Inside)

Gross area	Ag =	1200000 mm ²	
Design Moments			
Minimum thickness of the slab	D =	1200 mm	
Max factored bending moment (from STAAD)	=	3754 kNm	
Effective Thickness	=	1109 mm	
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
	=	8778.19 mm ²	
Minimum area of steel required (0.12% on each face in one direction)	=	1330.80 mm ²	
Required area of steel	=	8778.19 mm ²	
Required spacing of bars	=	75 mm	
Provided spacing	=	100 mm	
Provide 2 layers	32mm dia bars @ 100 mm c/c on both faces		
Area of steel provided	=	16085.0 mm ²	OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of			
0.12 % of Cross Sectional Area	=	1318.8 mm ²	
0.2 Times of Main Bar	=	3217 mm ²	
Longitudinal Bar Required at Each Face	=	3217 mm ²	
Steel Provided			
20 Dia Bar	at	150 mm c/c	
Area of Steel Provided	=	2094 mm ²	

Handwritten signatures and initials:
 [Signature]
 [Signature]
 [Signature]
 [Signature]
 [Signature]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	2752.0	kN	
Effective Shear Area	=	1200000	mm ²	
Shear Stress in Base Slab	=	2.29	N/mm ²	
Allowable Shear Stress	=	0.40	N/mm ²	
Shear force against which stirrups required	=	1487	KN	
Considering 10mm Dia shear link at 100 mm c/c				
Spacing of stirrups	=	191	mm	405.5841409
Provide shear reinforcement at	=	100	mm c/c	
Provide this Shear Reinforcement up to 2m from sidewall .				235.619449

Signature

Signature

Signature

Signature

Signature

	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1200mm thk) - C&C box (2 lane)			

Check for crack width For Base Slab (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

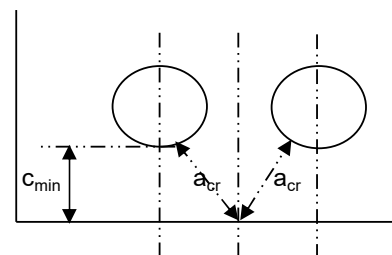
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	2666666667	
Axial Force (P) (N) =	2431000	
Tension R/F=	32T	100c/c
	32T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	1051
A_{st} (mm ² /m) =	16084.95439
p_t (ratio)=	0.015304429
x (mm) =	381.58
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	67255015416

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 1160$$

Strain in concrete at the level of steel

$$e_s = 0.000897301$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00104$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00014$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00090$$

$$\text{Average strain } e_m = 0.000800976$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.145 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1081 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*

	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1000mm thk) - C&C box (2 lane)			

Check for crack width For Base Slab (At mid)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

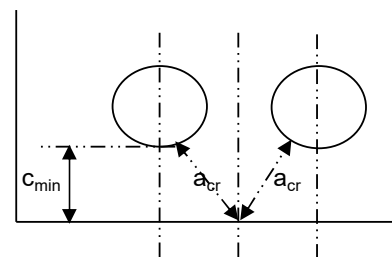
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	2502666667	
Axial Force (P) (N) =	2429000	
Tension R/F=	32T	100c/c
	32T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	1051
A_{st} (mm ² /m) =	16084.95439
p_t (ratio)=	0.015304429
x (mm) =	381.58
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	67255015416

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 1160$$

Strain in concrete at the level of steel

$$e_s = 0.000842117$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00098$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00014$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00084$$

$$\text{Average strain } e_m = 0.000736925$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.133 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0995 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 [Signature]
 [Signature]
 [Signature]
 [Signature]
 [Signature]

	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	2	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Top Slab(1000mm thk) - C&C box (3 lane)			

DESIGN OF BASE SLAB- Ramp

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1200 mm
Unit width of slab	b	=	1000 mm

3)Design for Support Moment (Earth Face)

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	2576 kNm
Effective Thickness		=	1099 mm
d'		=	101 mm
Mu/bd ²		=	2.133
Mulim		=	5622.31 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	14511.65
Mu2	$=Mu - Mulim$	=	-3046.31
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-7017.05
Ast	$=Astlim + Ast2$	=	7494.59
d'/d	0.09	=	0.10
fsc	Refer Table F SP 16 pg 13	=	412.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-7700.54







Minimum area of steel required (0.12% on each face in one direction)	=	1318.80 mm ²
Required area of steel	Ast =	0.68% = 7494.59 mm ²
Refer Table 2 SP 16 pg 48	Asc =	-0.70% = -7700.54 mm ²

Side Face bars are required

Tension Reinforcement (Ast)

Required spacing of bars	=	107.3 mm
Provided spacing	=	100 mm
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	8042.5 mm ²

OK

Compression Reinforcement (Asc)

Required spacing of bars	=	-63.7 mm
Provided spacing	=	100 mm
Provide 1 layer	25mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	4908.7 mm ²

OK

2m from sidewall

Design Moments

Minimum thickness of the slab	D =	1200 mm
Max factored bending moment (From STAAD)	=	0 kNm

2m+0.5m away from the support

Effective Thickness	=	1109 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$

Minimum area of steel required (0.12% on each face in one direction)	=	1330.80 mm ²
--	---	-------------------------

Required area of steel	=	1330.80 mm ²
Required spacing of bars	=	604.3 mm
Provided spacing	=	100 mm
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	8042.5 mm ²

OK

4) Design for Span Moment (Inside)

Gross area	Ag =	1200000 mm ²
------------	------	-------------------------

Design Moments

Minimum thickness of the slab	D =	1200 mm
Max factored bending moment (from STAAD)	=	2226 kNm

Effective Thickness	=	1109 mm
---------------------	---	---------

Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$
------------------------	---	---

Minimum area of steel required (0.12% on each face in one direction)	=	4929.63 mm ²
--	---	-------------------------

Required area of steel	=	1330.80 mm ²
Required spacing of bars	=	4929.63 mm ²
Provided spacing	=	150 mm
Provide 1 layers	32mm dia bars @ 100 mm c/c on both faces	
Area of steel provided	=	100 mm
	=	8042.5 mm ²

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.12 % of Cross Sectional Area	=	1318.8 mm ²
--------------------------------	---	------------------------

0.2 Times of Main Bar	=	1608 mm ²
-----------------------	---	----------------------

Longitudinal Bar Required at Each Face	=	1608 mm ²
--	---	----------------------

Steel Provided	20 Dia Bar at 150 mm c/c	
Area of Steel Provided	=	2094 mm ²

[Signature]

[Signature]

[Signature]

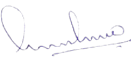
[Signature]

[Signature]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	1965.0	kN	
Effective Shear Area	=	1200000	mm ²	
Shear Stress in Base Slab	=	1.64	N/mm ²	
Allowable Shear Stress	=	0.40	N/mm ²	
Shear force against which stirrups required	=	972	KN	
Considering 10mm Dia shear link at 100 mm c/c				
Spacing of stirrups	=	292	mm	265.0935076
Provide shear reinforcement at	=	100	mm c/c	
Provide this Shear Reinforcement up to 2m from sidewall .				235.619449







	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1000mm thk) - C&C box (2 lane)			

Check for crack width For Base Slab (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

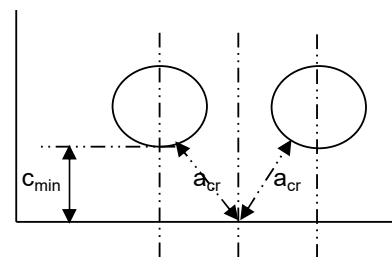
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1717333333	
Axial Force (P) (N) =	1813000	
Tension R/F=	32T	100c/c
	T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	1083
A_{st} (mm ² /m) =	8042.477193
p_t (ratio)=	0.00742611
x (mm) =	293.10
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	42321312187

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 1160$$

Strain in concrete at the level of steel

$$e_s = 0.001083592$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00119$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00011$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00108$$

$$\text{Average strain } e_m = 0.000875701$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.159 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1182 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*

	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
Project:		I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Base Slab(1000mm thk) - C&C box (2 lane)		

Check for crack width For Base Slab (At Mid)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

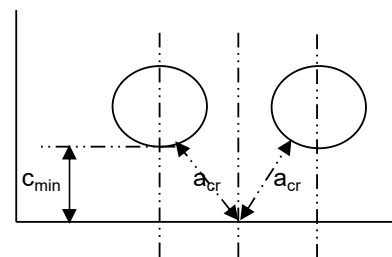
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1484000000	
Axial Force (P) (N) =	1812000	
Tension R/F=	32T	100c/c
	T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	1083
A_{st} (mm ² /m) =	8042.477193
p_t (ratio)=	0.00742611
x (mm) =	293.10
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	42321312187

safe



(fig 1)

[Handwritten signatures and initials]

$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $e_s = 0.000936365$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00103$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00011$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00092$$

$$\text{Average strain } e_m = 0.000714181$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min}(mm) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.130 < 0.2 \text{ mm}$$

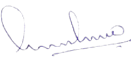
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0964 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd	APPENDIX-2	
	A company of the GEOCONSULT group	Job no:	I40172
		Page No.:	2
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for	Design of Side Wall(1000mm thk) - C&C box (2 lane)		

DESIGN OF SIDE WALL (1000 mm THK)-C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Side Wall

Minimum thickness of the Wall	D	=	1200 mm
Unit width of Wall	b	=	1000 mm

3)Design for Reinforcement Earth Side

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	4200 kNm
Effective Thickness		=	1099 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_u / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	10121.46 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1318.80 mm ²
Required area of steel		=	10121.46 mm ²
Required spacing of bars		=	79.5 mm
Provided spacing		=	100 mm
Provide 2 layers 32mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	16085.0 mm ²

OK

Above 2m from base slab

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	0 kNm
Effective Thickness		=	1109 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_u / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	0.00 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1330.80 mm ²
Required area of steel		=	1330.80 mm ²
Required spacing of bars		=	604.3 mm
Provided spacing		=	100 mm
Provide 1 layers 32mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	8042.5 mm ²

OK








4) Design for Reinforcement Open Side

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (from STAAD)		=	977 kNm
Effective Thickness		=	1115 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	2070.25 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1338.00 mm ²
Required area of steel		=	2070.25 mm ²
Required spacing of bars		=	150 mm
Provided spacing		=	100 mm
Provide 20mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	3141.6 mm ²

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of			
0.12 % of Cross Sectional Area		=	1318.8 mm ²
0.2 Times of Main Bar		=	628 mm ²
Longitudinal Bar Required at Each Face		=	1319 mm ²
Steel Provided			
20 Dia Bar at 150 mm c/c			
Area of Steel Provided	=	2094 mm ²	OK

6) Check For Shear

Upto 2m from base slab

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	2597.0 kN	
Effective Shear Area	=	1200000 mm ²	
Shear Stress in Side Wall	=	2.16 N/mm ²	377.9144482
Allowable Shear Stress	=	0.40 N/mm ²	
Shear force against which stirrups required	=	1386 KN	
Considering 10mm Dia shear link at 100 mm c/c			
Spacing of stirrups	=	205 mm	314.1592654
Provide shear reinforcement at	=	100 mm c/c	

Provide this Shear Reinforcement up to 2m of height from baseslab .

[Handwritten signatures]

	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Side wall (1000mm thk)			

Check for crack width For Side Wall (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

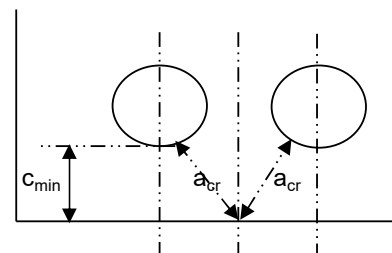
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	2800000000	
Axial Force (P) (N) =	2988000	
Tension R/F=	32T	100c/c
	32T	85c/c
	T	85c/c
	T	mm
Diameter of Spacer Bar=	10	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	1051
A_{st} (mm ² /m) =	17504.21507
p_t (ratio)=	0.016654819
x (mm) =	394.27
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	71473324199

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 1160$$

Strain in concrete at the level of steel

$$e_s = 0.000869756$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00101$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00018$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00084$$

$$\text{Average strain } e_m = 0.000747889$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.135 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1010 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*

	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Side wall (1000mm thk)			

Check for crack width For Side Wall (At Mid)

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

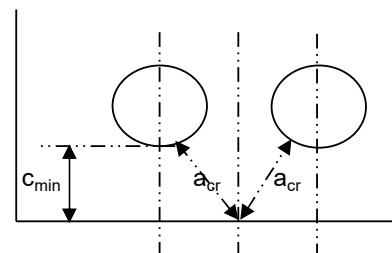
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	65133333.3	
Axial Force (P) (N) =	925000	
Tension R/F=	20T	100c/c
	T	85c/c
	T	85c/c
	T	mm
Diameter of Spacer Bar=	T	
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	1095
A_{st} (mm ² /m) =	3141.592654
p_t (ratio)=	0.002869034
x (mm) =	195.48
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	19676819574

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 1160$$

Strain in concrete at the level of steel

$$e_s = 0.001006593$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00108$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00005$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00102$$

$$\text{Average strain } e_m = 0.000453185$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 64.33 \text{ mm}$$

$$\text{crack width (mm) } w = 0.084 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0612 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*



Software licensed to

Job No

Sheet No

1

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49

Job Information

	Engineer	Checked	Approved
Name:	RSh	CSa	SPa
Date:	23-Dec-24		

Project ID	
Project Name	

Structure Type	PLANE FRAME
----------------	-------------

Number of Nodes	80	Highest Node	90
Number of Elements	81	Highest Beam	90

Number of Basic Load Cases	17
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure
-----	---------------------

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL (SELF WEIGHT)
Primary	2	EARTH PRESSURE (WT 5MBGL)
Primary	3	EARTH PRESSURE (WT AT GROUND)
Primary	4	HYDROSTATIC (5MBGL)
Primary	5	HYDROSTATIC (WT AT GROUND)
Primary	6	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYMM
Primary	101	1.5DL + 1.5EP(5M) + 1.5WL(5M)
Primary	102	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)
Primary	103	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE
Primary	104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SURCHARGE
Primary	105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE
Primary	201	1.0DL + 1.0EP(5M) + 1.0WL(5M)
Primary	202	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)
Primary	203	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE
Primary	204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SURCHARGE
Primary	205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE

Handwritten signatures and initials:
1. [Signature]
2. [Signature]
3. [Signature]
4. [Signature]
5. [Signature]



Software licensed to

Job No

Sheet No

2

Rev

A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.000	8.500	0.000
5	0.897	8.500	0.000
6	1.793	8.500	0.000
7	2.690	8.500	0.000
8	3.587	8.500	0.000
9	4.483	8.500	0.000
10	5.380	8.500	0.000
11	6.277	8.500	0.000
12	7.173	8.500	0.000
13	8.070	8.500	0.000
14	8.967	8.500	0.000
19	26.500	7.650	0.000
20	26.500	6.800	0.000
21	26.500	5.950	0.000
22	26.500	5.100	0.000
23	26.500	4.250	0.000
24	26.500	3.400	0.000
25	26.500	2.550	0.000
26	26.500	1.700	0.000
27	26.500	0.850	0.000
28	0.000	0.850	0.000
29	0.000	1.700	0.000
30	0.000	2.550	0.000
31	0.000	3.400	0.000
32	0.000	4.250	0.000
33	0.000	5.100	0.000
34	0.000	5.950	0.000
35	0.000	6.800	0.000
36	0.000	7.650	0.000
41	8.967	0.000	0.000
42	8.070	0.000	0.000
43	7.173	0.000	0.000
44	6.277	0.000	0.000
45	5.380	0.000	0.000
46	4.483	0.000	0.000
47	3.587	0.000	0.000
48	2.690	0.000	0.000
49	1.793	0.000	0.000
50	0.897	0.000	0.000
51	9.750	0.000	0.000
52	9.750	8.500	0.000
53	26.500	0.000	0.000
54	26.500	8.500	0.000
55	10.675	8.500	0.000
56	11.600	8.500	0.000



Software licensed to

Job No

Sheet No

3

Rev

A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
57	25.575	8.500	0.000
58	10.675	0.000	0.000
59	11.600	0.000	0.000
60	25.575	0.000	0.000
61	12.425	8.500	0.000
62	13.250	8.500	0.000
63	12.425	0.000	0.000
64	13.250	0.000	0.000
65	14.130	8.500	0.000
66	15.011	8.500	0.000
67	15.891	8.500	0.000
68	16.771	8.500	0.000
69	17.652	8.500	0.000
70	18.532	8.500	0.000
71	19.413	8.500	0.000
72	20.293	8.500	0.000
73	21.173	8.500	0.000
74	22.054	8.500	0.000
75	22.934	8.500	0.000
76	23.814	8.500	0.000
77	24.695	8.500	0.000
78	14.130	0.000	0.000
79	15.011	0.000	0.000
80	15.891	0.000	0.000
81	16.771	0.000	0.000
82	17.652	0.000	0.000
83	18.532	0.000	0.000
84	19.413	0.000	0.000
85	20.293	0.000	0.000
86	21.173	0.000	0.000
87	22.054	0.000	0.000
88	22.934	0.000	0.000
89	23.814	0.000	0.000
90	24.695	0.000	0.000

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

4

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	2	5	0.897	1	0
2	54	19	0.850	1	0
4	1	28	0.850	1	0
5	5	6	0.897	1	0
6	6	7	0.897	1	0
7	7	8	0.897	1	0
8	8	9	0.897	1	0
9	9	10	0.897	1	0
10	10	11	0.897	1	0
11	11	12	0.897	1	0
12	12	13	0.897	1	0
13	13	14	0.897	1	0
14	14	52	0.783	1	0
19	19	20	0.850	1	0
20	20	21	0.850	1	0
21	21	22	0.850	1	0
22	22	23	0.850	1	0
23	23	24	0.850	1	0
24	24	25	0.850	1	0
25	25	26	0.850	1	0
26	26	27	0.850	1	0
27	27	53	0.850	1	0
28	28	29	0.850	1	0
29	29	30	0.850	1	0
30	30	31	0.850	1	0
31	31	32	0.850	1	0
32	32	33	0.850	1	0
33	33	34	0.850	1	0
34	34	35	0.850	1	0
35	35	36	0.850	1	0
36	36	2	0.850	1	0
41	41	42	0.897	1	0
42	42	43	0.897	1	0
43	43	44	0.897	1	0
44	44	45	0.897	1	0
45	45	46	0.897	1	0
46	46	47	0.897	1	0
47	47	48	0.897	1	0
48	48	49	0.897	1	0
49	49	50	0.897	1	0
50	50	1	0.897	1	0
51	51	41	0.783	1	0
52	52	55	0.925	1	0
53	55	56	0.925	1	0
54	56	61	0.825	1	0
55	57	54	0.925	1	0



Software licensed to

Job No

Sheet No

5Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
56	51	58	0.925	1	0
57	58	59	0.925	1	0
58	59	63	0.825	1	0
59	60	53	0.925	1	0
60	61	62	0.825	1	0
61	62	65	0.880	1	0
62	63	64	0.825	1	0
63	64	78	0.880	1	0
64	65	66	0.880	1	0
65	66	67	0.880	1	0
66	67	68	0.880	1	0
67	68	69	0.880	1	0
68	69	70	0.880	1	0
69	70	71	0.880	1	0
70	71	72	0.880	1	0
71	72	73	0.880	1	0
72	73	74	0.880	1	0
73	74	75	0.880	1	0
74	75	76	0.880	1	0
75	76	77	0.880	1	0
76	77	57	0.880	1	0
77	78	79	0.880	1	0
78	79	80	0.880	1	0
79	80	81	0.880	1	0
80	81	82	0.880	1	0
81	82	83	0.880	1	0
82	83	84	0.880	1	0
83	84	85	0.880	1	0
84	85	86	0.880	1	0
85	86	87	0.880	1	0
86	87	88	0.880	1	0
87	88	89	0.880	1	0
88	89	90	0.880	1	0
89	90	60	0.880	1	0
90	62	64	8.500	1	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 1.20x1.00	12E+3	10E+6	14.4E+6	19.8E+6	CONCRETE



Software licensed to

Job No

Sheet No

6

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT 5MBGL)	Live
3	EARTH PRESSURE (WT AT GROUND)	Live
4	HYDROSTATIC (5MBGL)	Live
5	HYDROSTATIC (WT AT GROUND)	Live
6	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYMM	Live
101	1.5DL + 1.5EP(5M) + 1.5WL(5M)	None
102	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)	None
103	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE	None
104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SURCHARGE	None
105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE	None
201	1.0DL + 1.0EP(5M) + 1.0WL(5M)	None
202	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)	None
203	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	None
204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SURCHARGE	None
205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE	None

Combination Load Cases

There is no data of this type.

Handwritten signatures and initials:
1. [Signature]
2. [Signature]
3. [Signature]
4. [Signature]
5. [Signature]



Software licensed to

Job No

Sheet No

7

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

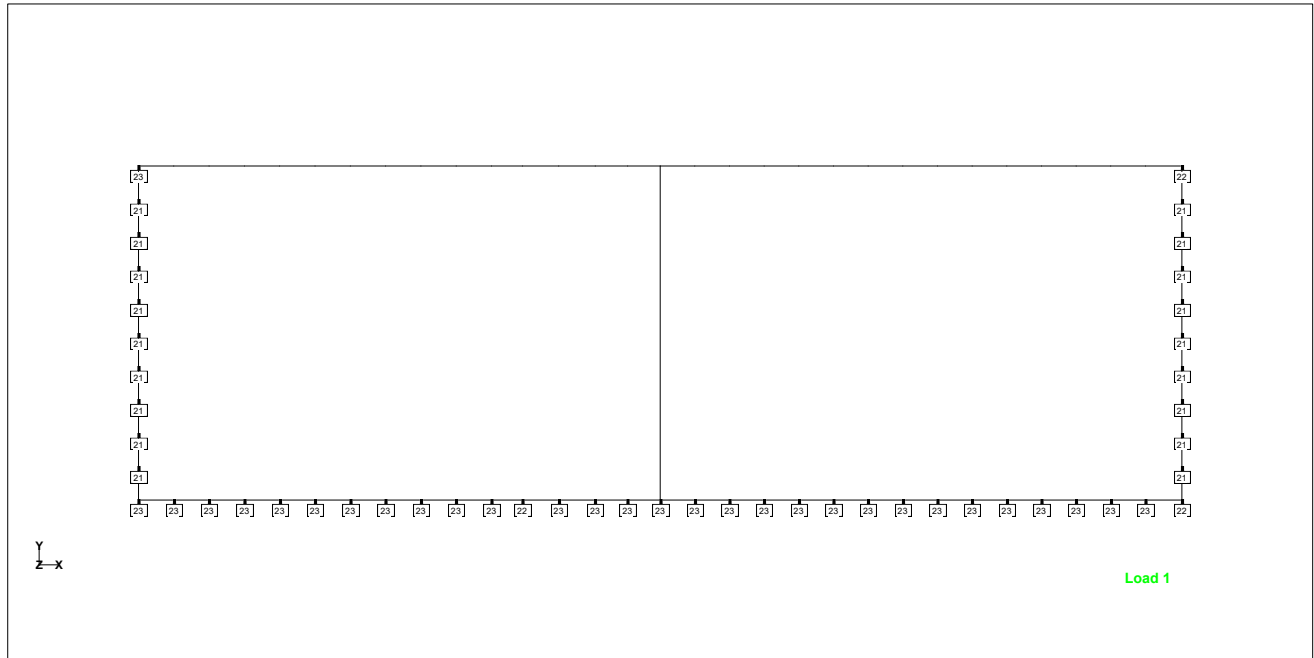
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Whole Structure

[Handwritten signatures]



Software licensed to

Job No

Sheet No

8

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

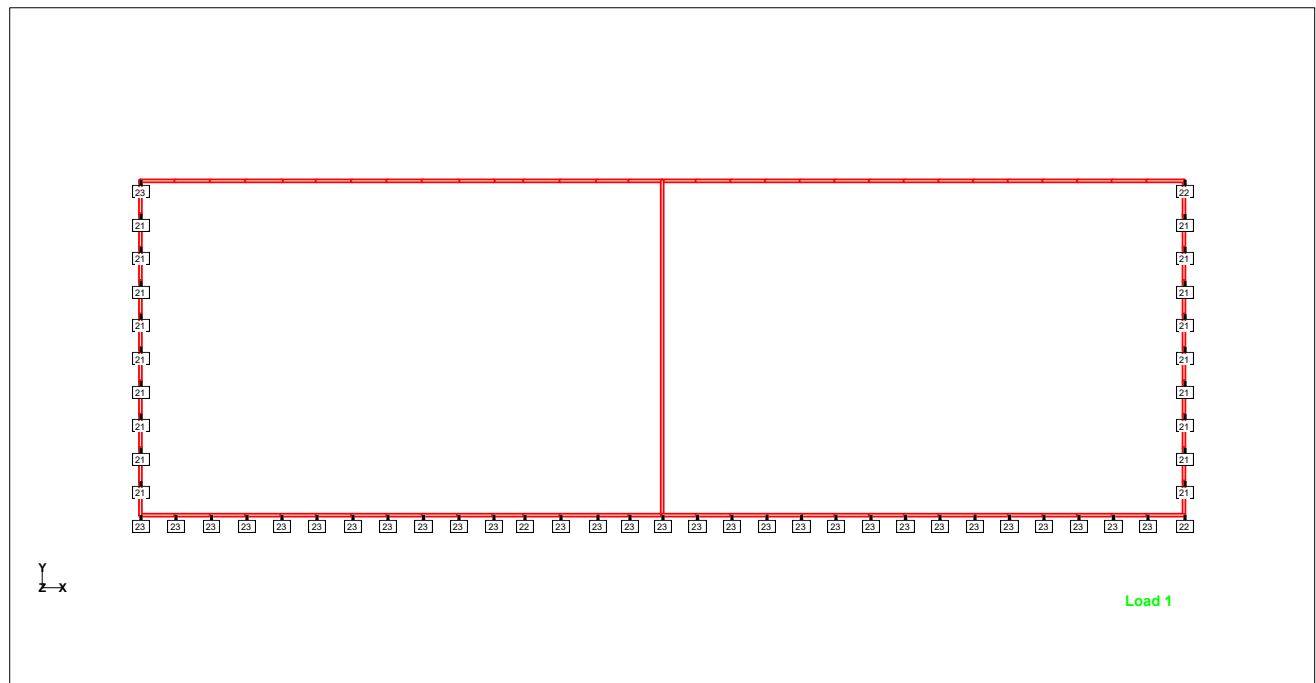
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Self Weight

Handwritten signatures and initials:
1. *Handwritten signature*
2. *Handwritten signature*
3. *Handwritten signature*
4. *Handwritten signature*
5. *Handwritten signature*



Software licensed to

Job No

Sheet No

9

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

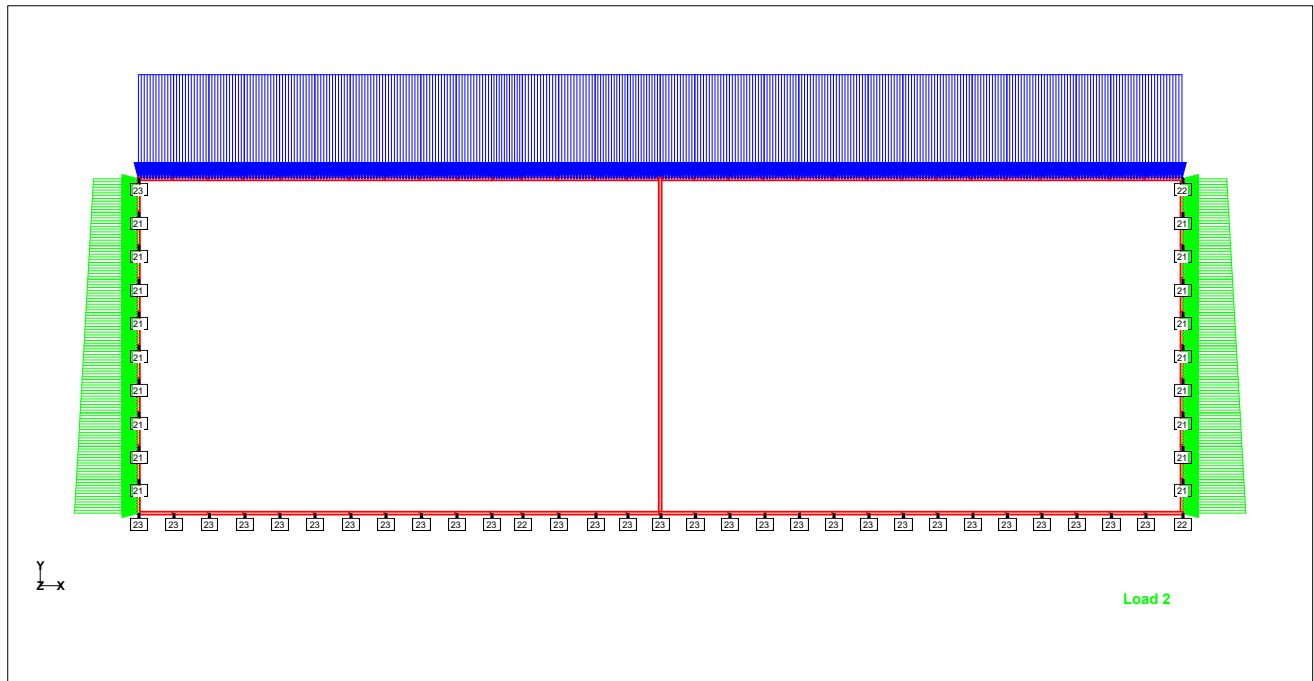
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Earth Pressure

Handwritten signatures and initials:
L. J. J.
A. J.
R. J.
C. J.
D. J.



Software licensed to

Job No

Sheet No

10

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

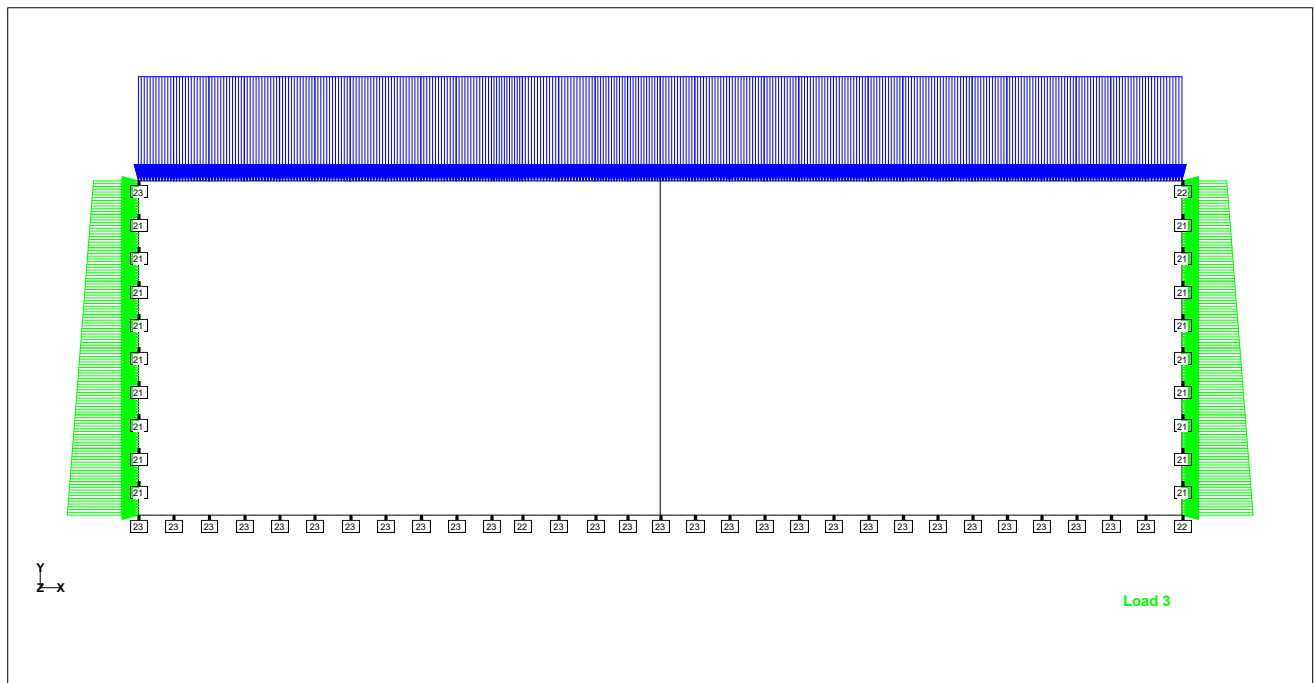
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Earth Pressure at Ground

Handwritten signatures and initials:
L. J. J.
A. J.
R. J.
C. J.
D. J.



Software licensed to

Job No

Sheet No

11

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

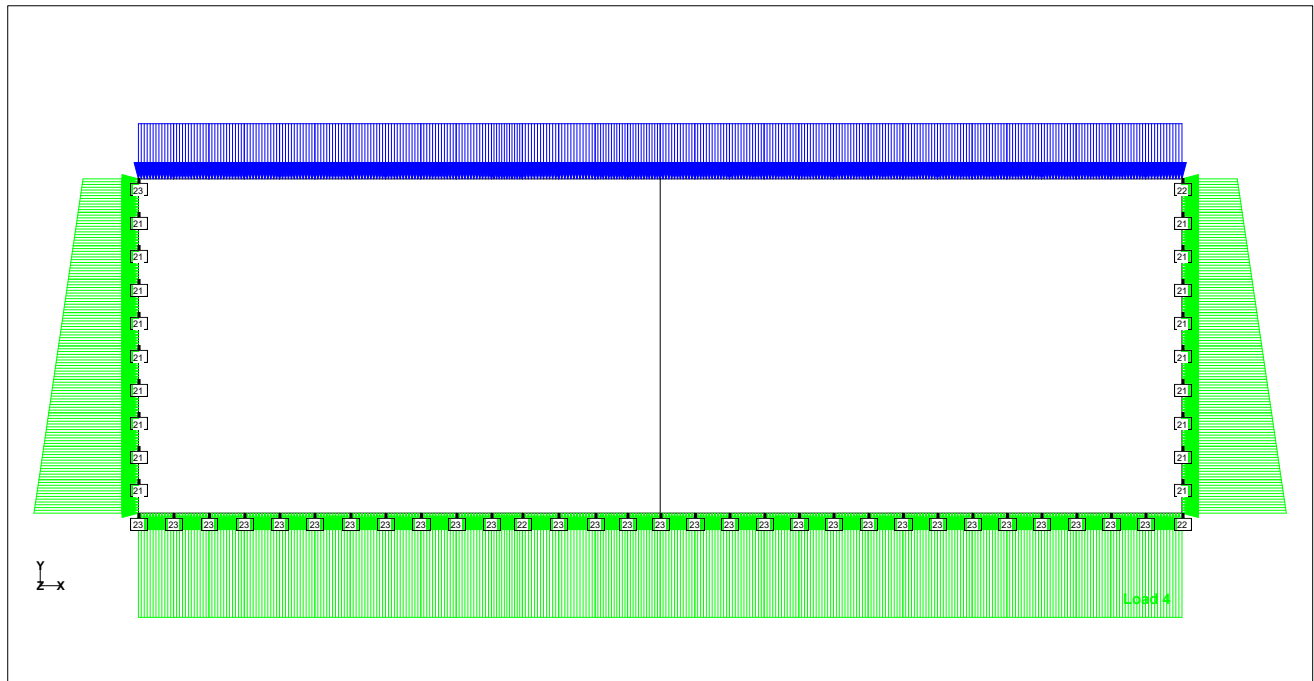
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Hydrostatic

Handwritten signatures and initials:
L. L. L.
A. A.
R. R.
C. S. S.
D. D.



Software licensed to

Job No

Sheet No

12

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

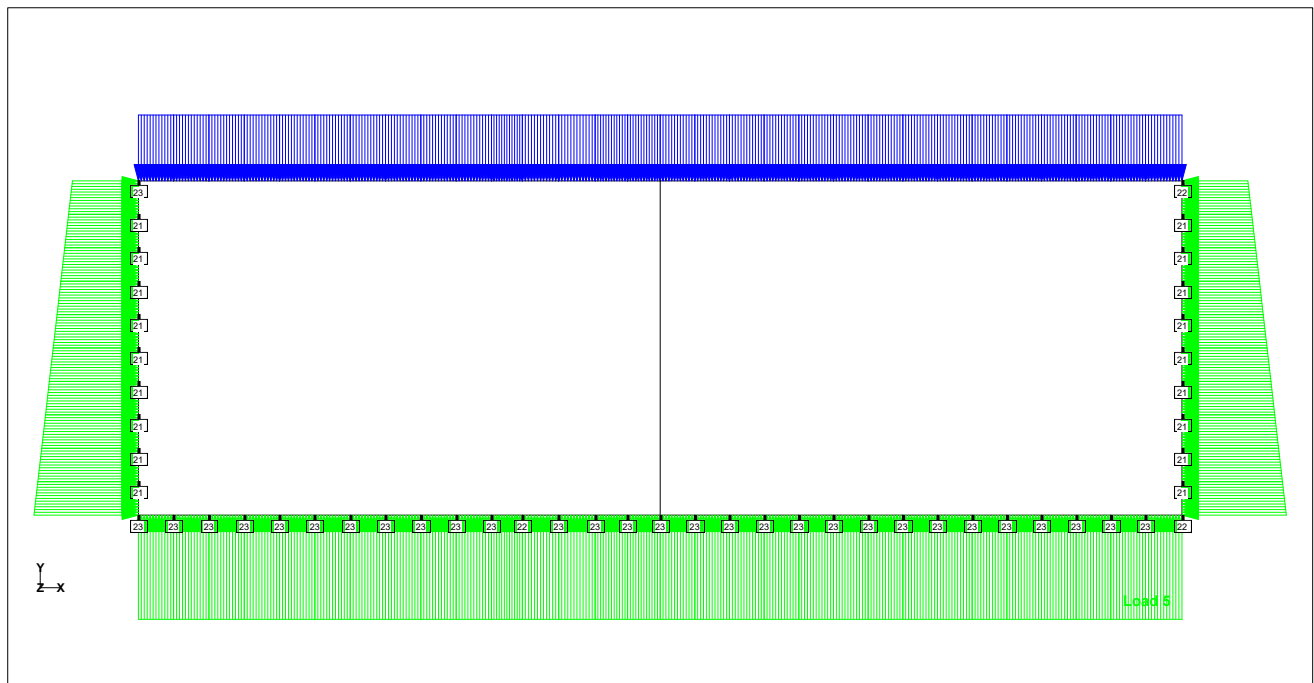
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Hydrostatic at Ground

Handwritten signatures and initials:
L. L. L.
A. A.
R. R.
C. C.
D. D.



Software licensed to

Job No

Sheet No

13

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

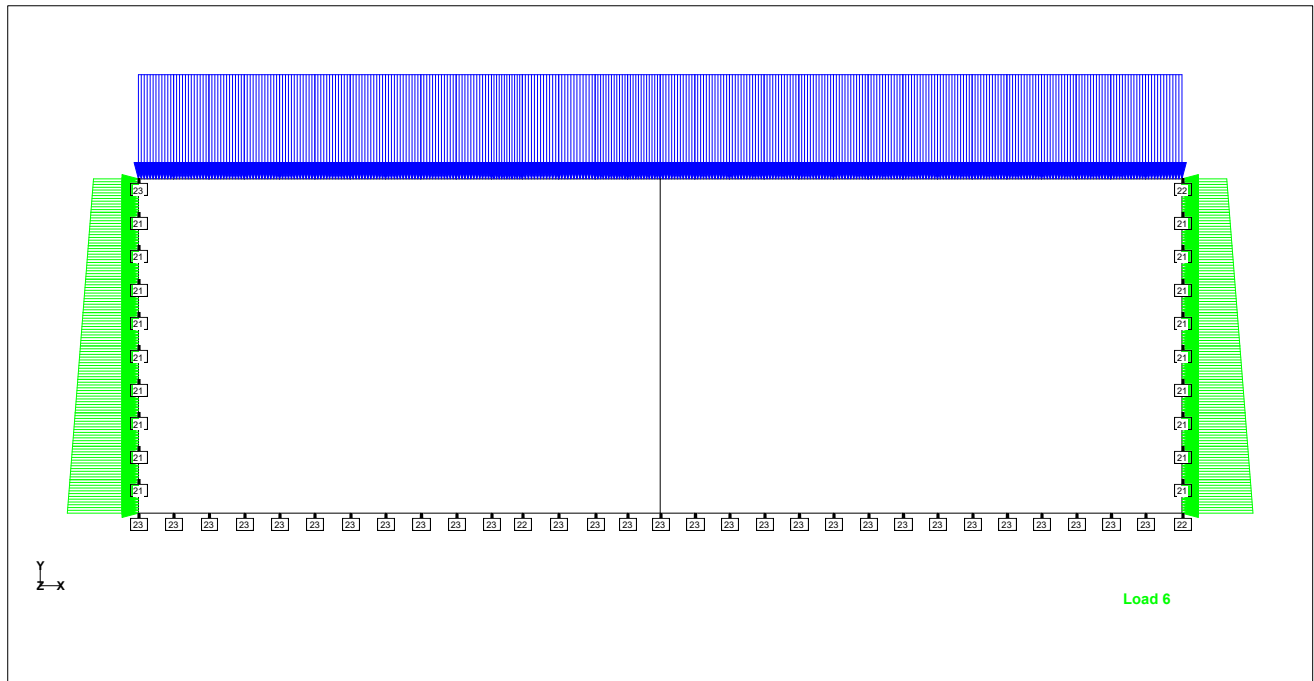
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Earth Pressure Dry

Handwritten signatures and initials:
L. J. J.
A. J.
R. J.
C. J.
D. J.



Software licensed to

Job No

Sheet No

14

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

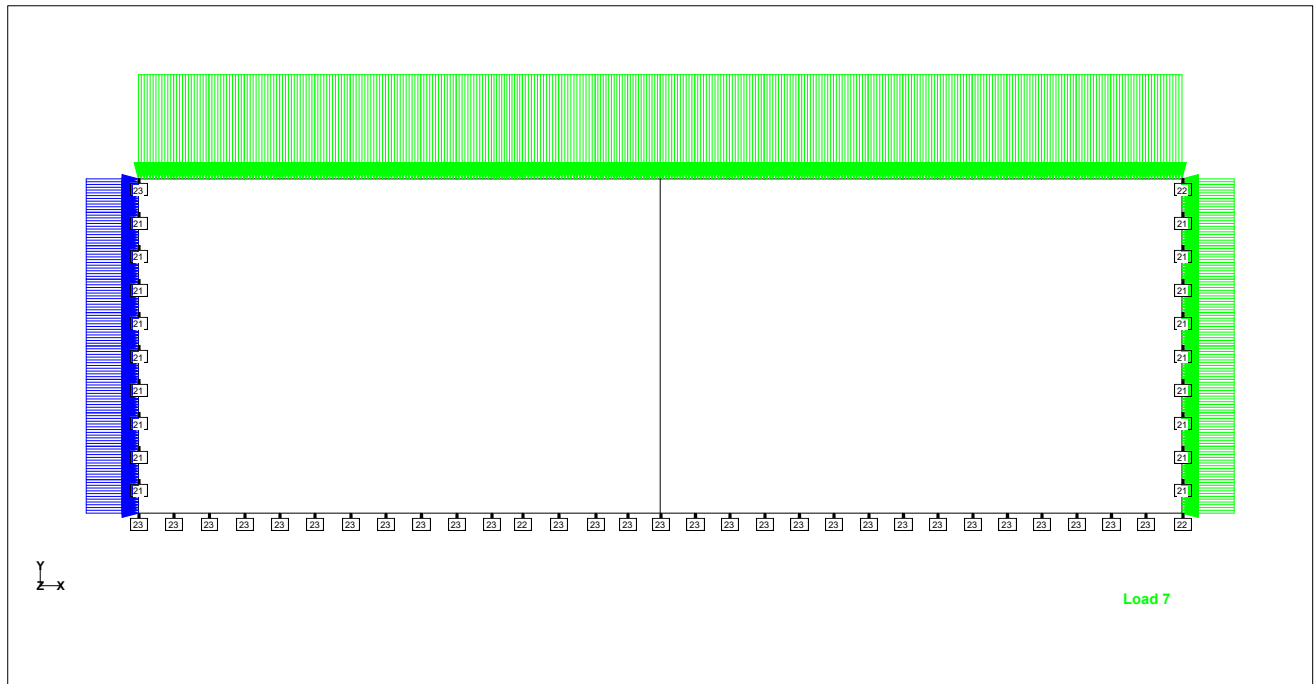
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Surcharge Sym

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

15

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

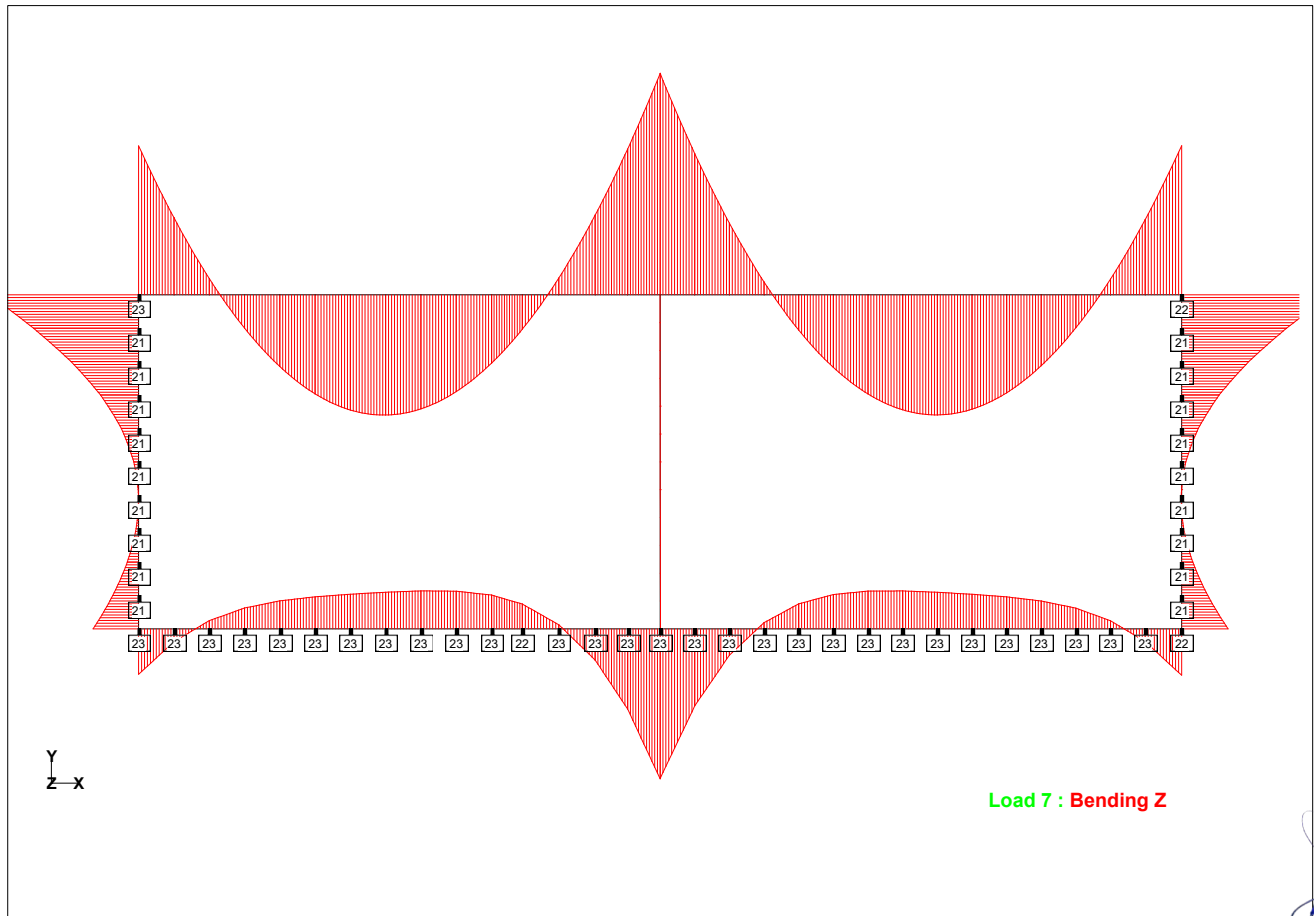
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Bending Moment

Load 7 : Bending Z

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

16

Rev
A

Part

Job Title I40172_C&C (3 lane + median wall + 3 lane))

Ref

By RSh

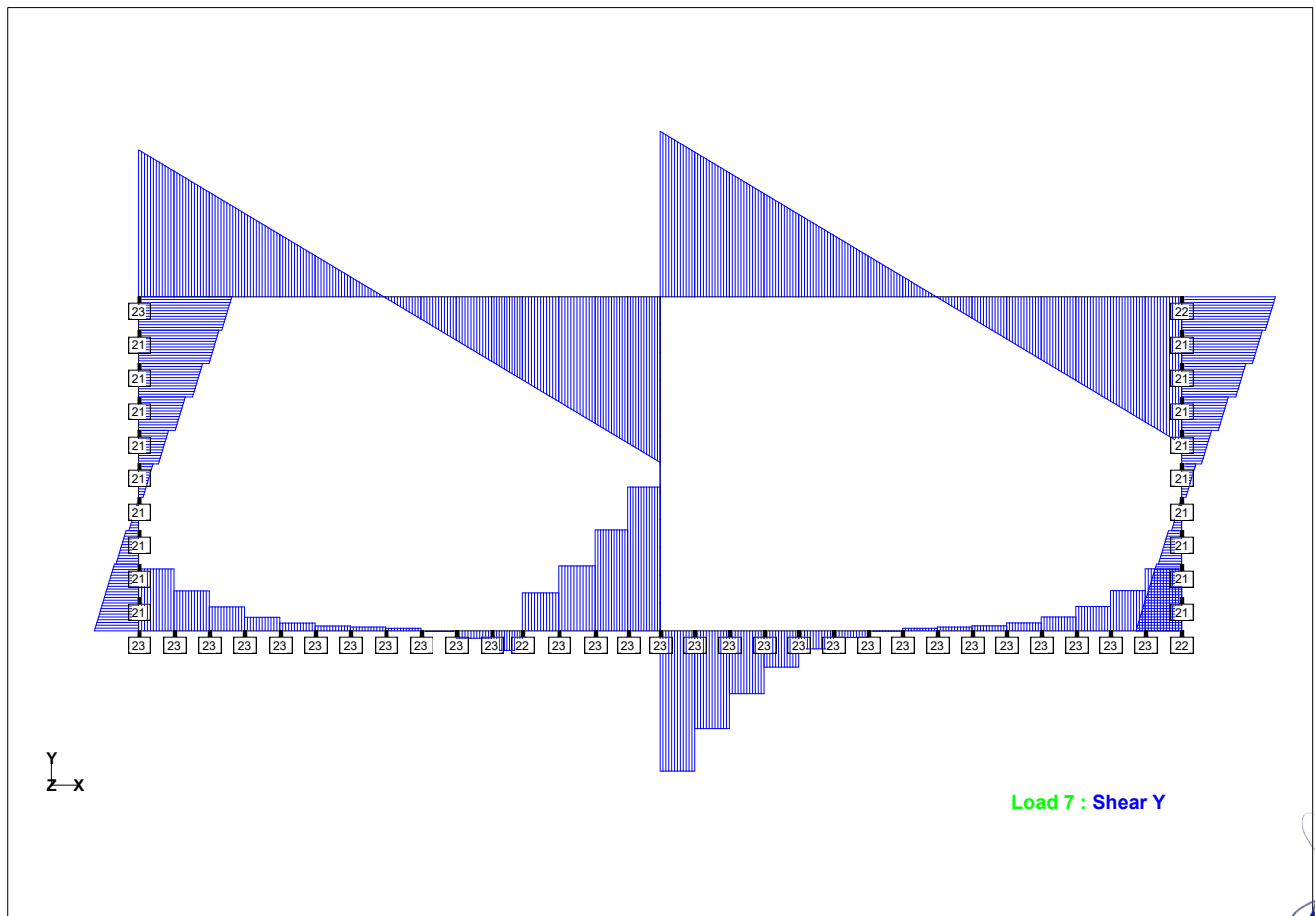
Date 23-Dec-24

Chd CSa

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 20:49



Shear Force

Load 7 : Shear Y

[Handwritten signatures and initials]

	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	-	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Base Slab (1200mm thk.) - C&C box (3 lane + median wall + 3 lane)			

Design of Base Slab C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1200 mm
Unit width of slab	b	=	1000 mm

3) Design for Support Moment (Earth Face)

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	5000 kNm
Effective Thickness		=	1055 mm
d'		=	145 mm
Mu/bd ²		=	4.492
Mulim		=	5181.13 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	13930.65
Mu2	$=Mu - Mulim$	=	-181.13
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-457.58
Ast	$=Astlim + Ast2$	=	13473.08
d'/d	0.14	=	0.15
fsc	Refer Table F SP 16 pg 13	=	395.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-524.65







Minimum area of steel required (0.12% on each face in one direction)	=	1266.00 mm ²
Required area of steel	Asc =	1.28% = 13473.08 mm ²
Refer Table 2 SP 16 pg 48	Asc =	-0.05% = -524.65 mm ²

Side Face bars are required

Tension Reinforcement (Ast)		
Required spacing of bars	=	93.3 mm
Provided spacing	=	100 mm
Provide 2 layers	40mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	25132.7 mm ²
(2 Layers of T40 + T32 has been provided as per Crack Width Calculation)		

OK

Compression Reinforcement (Asc)		
Required spacing of bars	=	-935.6 mm
Provided spacing	=	100 mm
Provide 1 layer	25mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	4908.7 mm ²

OK

4) Design for Span Moment (Inside)

Gross area	Ag =	1200000 mm ²
------------	------	-------------------------

Design Moments

Minimum thickness of the slab	D =	1200 mm
Max factored bending moment (from STAAD)	=	2758 kNm

Effective Thickness	=	1113 mm
---------------------	---	---------

Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$
------------------------	---	---

	=	6194.70 mm ²
--	---	-------------------------

Minimum area of steel required (0.12% on each face in one direction)	=	1335.00 mm ²
--	---	-------------------------

Required area of steel	=	6194.70 mm ²
------------------------	---	-------------------------

Required spacing of bars	=	75 mm
--------------------------	---	-------

Provided spacing	=	100 mm
------------------	---	--------

Provide 2 layers	25mm dia bars @ 100 mm c/c on both faces	
------------------	--	--

Area of steel provided	=	9817.5 mm ²
------------------------	---	------------------------

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of		
0.12 % of Cross Sectional Area	=	1266 mm ²
0.2 Times of Main Bar	=	1963 mm ²
Longitudinal Bar Required at Each Face	=	1963 mm ²
Steel Provided		
20 Dia Bar at 150 mm c/c		
Area of Steel Provided	=	2094 mm ²

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_o)

Factored Shear Force V_u	=	2441	kN
Effective Shear Area	=	1200000	mm ²
Pt%	=	2.4	%
Shear Stress in Base Slab	=	2.03	N/mm ²
Allowable Shear Stress	=	0.4	N/mm ²
Shear force against which shear force is required	=	1283.5	kN
Provide Diameter	=	10.0	mm
Spacing of the Stirrups	=	147.3	mm
Provide Stirrups	=	100.0	mm C/C











	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Base slab C&C Box		

Crack width For Base Slab (3 lane + median wall + 3 lane) (1200mm Thick C&C)_At Support

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

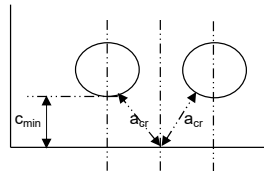
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

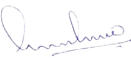
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	3333333333	
Axial Force (P) (N) =	0	
Tension R/F=	40T	100c/c (1st Layer)
	32T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1043
Ast (mm ² /m) =	20608.84781
p_t (ratio)=	0.019759202
x (mm) =	417.51
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	78774916017

safe



(fig 1)







$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $\epsilon_s = 0.000894763$
 Strain in concrete at the outer most tension face
 $\epsilon_1 = 0.00106$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $\epsilon_2 = ((P/b \cdot h) / E_{eff})$

$$\epsilon_2 = 0.00000$$

Net effective Strain $\epsilon'_1 = \epsilon_1 - \epsilon_2$

$$\epsilon'_1 = 0.00106$$

$$\text{Average strain } \epsilon_m = 0.000987013$$

$$\epsilon_m = \epsilon_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 \quad -30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.01 \text{ mm}$$

$$\text{crack width (mm) } w = 0.176 < 0.2 \text{ mm}$$

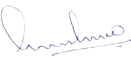
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1332 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Base slab C&C Box		

Crack width For Base Slab (3 lane + median wall + 3 lane) (1200mm Thick C&C)_At Mid

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

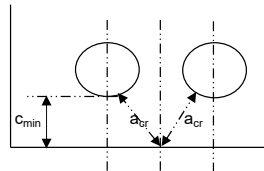
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

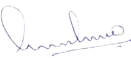
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1838666667	
Axial Force (P) (N) =	0	
Tension R/F=	25T	100c/c (1st Layer)
	25T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1065
A_{st} (mm ² /m) =	9817.477042
p_t (ratio)=	0.009218288
x (mm) =	315.45
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	47756319402

safe



(fig 1)








$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $e_s = 0.000975595$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00110$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00110$$

$$\text{Average strain } e_m = 0.000930046$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 \quad -30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 63.70 \text{ mm}$$

$$\text{crack width (mm) } w = 0.171 < 0.3 \text{ mm}$$

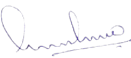
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1256 < 0.3 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	-	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Top Slab (1200mm thk.) - C&C box (3 lane + median wall + 3 lane)			

Design of Base Slab C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1200 mm
Unit width of slab	b	=	1000 mm

3) Design for Support Moment (Earth Face)

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	4010 kNm
Effective Thickness		=	1099 mm
d'		=	101 mm
Mu/bd ²		=	3.320
Mulim		=	5622.31 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	14511.65
Mu2	$=Mu - Mulim$	=	-1612.31
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-3713.90
Ast	$=Astlim + Ast2$	=	10797.75
d'/d	0.09	=	0.10
fsc	Refer Table F SP 16 pg 13	=	412.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-4075.64







Minimum area of steel required (0.12% on each face in one direction)	=	1318.80 mm ²
Required area of steel	Asc	= 0.98% = 10797.75 mm ²
Refer Table 2 SP 16 pg 48	Asc	= -0.37% = -4075.64 mm ²

Side Face bars are required

Tension Reinforcement (Ast)					
Required spacing of bars					= 74.5 mm
Provided spacing					= 100 mm
Provide 2 layers	32mm	dia bars	@ 100 mm c/c on bottom face		
Area of steel provided					= 16085.0 mm ²

OK

Compression Reinforcement (Asc)					
Required spacing of bars					= -120.4 mm
Provided spacing					= 100 mm
Provide 1 layer	25mm	dia bars	@ 100 mm c/c on bottom face		
Area of steel provided					= 4908.7 mm ²

OK

4) Design for Span Moment (Inside)

Gross area	Ag	=	1200000 mm ²
------------	----	---	-------------------------

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (from STAAD)		=	4730 kNm

Effective Thickness		=	1109 mm
---------------------	--	---	---------

Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$
------------------------	---	---

		=	11518.95 mm ²
--	--	---	--------------------------

Minimum area of steel required (0.12% on each face in one direction)		=	1330.80 mm ²
--	--	---	-------------------------

Required area of steel		=	11518.95 mm ²
------------------------	--	---	--------------------------

Required spacing of bars		=	50 mm
--------------------------	--	---	-------

Provided spacing		=	100 mm
------------------	--	---	--------

Provide 2 layers	32mm	dia bars	@ 100 mm c/c on both faces		
------------------	------	----------	----------------------------	--	--

Area of steel provided		=	16085.0 mm ²
------------------------	--	---	-------------------------

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.12 % of Cross Sectional Area		=	1318.8 mm ²
--------------------------------	--	---	------------------------

0.2 Times of Main Bar		=	3217 mm ²
-----------------------	--	---	----------------------

Longitudinal Bar Required at Each Face		=	3217 mm ²
--	--	---	----------------------

Steel Provided

	20	Dia Bar	at	150	mm c/c
Area of Steel Provided			=	2094	mm ²

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_o)

Factored Shear Force V_u	=	2445	kN
Effective Shear Area	=	1200000	mm ²
Pt%	=	1.5	%
Shear Stress in Base Slab	=	2.04	N/mm ²
Allowable Shear Stress	=	0.4	N/mm ²
Shear force against which shear force is required	=	1286.1	kN
Provide Diameter	=	10.0	mm
Spacing of the Stirrups	=	147.0	mm
Provide Stirrups	=	100.0	mm C/C











	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Top slab C&C Box		

Crack width For Base Slab (3 lane + median wall + 3 lane) (1200mm Thick C&C)_At Support

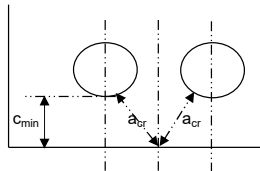
$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

C_{min} = minimum cover to bar.

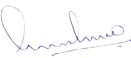
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	267333333	
Axial Force (P) (N) =	0	
Tension R/F=	32T	100c/c
	32T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm



(fig 1)

d (mm) =	1051
Ast (mm ² /m) =	16084.95439
p_t (ratio)=	0.015304429
x (mm) =	381.58
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	67255015416

safe







$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $\epsilon_s = 0.000899544$
 Strain in concrete at the outer most tension face
 $\epsilon_1 = 0.00105$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $\epsilon_2 = ((P/b \cdot h) / E_{eff})$

$$\epsilon_2 = 0.00000$$

Net effective Strain $\epsilon'_1 = \epsilon_1 - \epsilon_2$

$$\epsilon'_1 = 0.00105$$

$$\text{Average strain } \epsilon_m = 0.000947405$$

$$\epsilon_m = \epsilon_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 \quad -30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.171 < 0.2 \text{ mm}$$

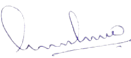
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1279 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Top slab C&C Box		

Crack width For Base Slab (3 lane + median wall + 3 lane) (1200mm Thick C&C)_At Mid

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr}-C_{min}}{D-x} \right]}$$

Crack width= w

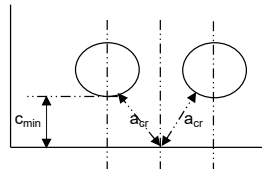
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

C_{min} = minimum cover to bar.

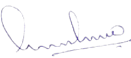
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	315333333	
Axial Force (P) (N) =	0	
Tension R/F=	32T	100c/c (1st Layer)
	32T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1051
A_{st} (mm ² /m) =	16084.95439
p_t (ratio)=	0.015304429
x (mm) =	381.58
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	67255015416

safe



(fig 1)








$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $\epsilon_s = 0.001061058$
 Strain in concrete at the outer most tension face
 $\epsilon_1 = 0.00123$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $\epsilon_2 = ((P/b \cdot h) / E_{eff})$

$$\epsilon_2 = 0.00000$$

Net effective Strain $\epsilon'_1 = \epsilon_1 - \epsilon_2$

$$\epsilon'_1 = 0.00123$$

$$\text{Average strain } \epsilon_m = 0.001135218$$

$$\epsilon_m = \epsilon_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 \quad -30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.205 < 0.3 \text{ mm}$$

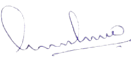
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1533 < 0.3 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:		
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Side Wall - 1000mm Thk. for C&C (3 lane + median wall + 3 lane)			

Design of Side Wall - 1000mm Thk. for C&C (3 lane + median wall + 3 lane)

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Side Wall

Minimum thickness of the slab	D	=	1200 mm
Unit width of slab	b	=	1000 mm

3) Design for Earth Face (Support)

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	4681 kNm
Effective Thickness		=	1065 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	12060.23 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1278.00 mm ²
Required area of steel		=	12060.23 mm ²
Required spacing of bars		=	104 mm
Provided spacing		=	100 mm
Provide 2 Layer 40mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	25132.7 mm ²

(2 Layers of T40 + T32 has been provided as per Crack Width Calculation)

OK

4) Design for Inner Side Reinforcement

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (from STAAD)		=	800 kNm
Maximum factored axial force		=	1044 kN
Effective Thickness		=	1115 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	1686.67 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1338.00 mm ²
Required area of steel		=	1686.67 mm ²
Required spacing of bars		=	186 mm
Provided spacing		=	100 mm
Provide 20mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	3141.6 mm ²

OK

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.2% of Cross Sectional Area

0.2 Times of Main Bar

Longitudinal Bar Required at Each Face

Steel Provided

$$\begin{aligned} &= 1065 \text{ mm}^2 \\ &= 628 \text{ mm}^2 \\ &= 1065 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} &20 \text{ Dia Bar at } 150 \text{ mm c/c} \\ &\text{Area of Steel Provided} = 2094 \text{ mm}^2 \end{aligned}$$

OK

6) Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

$$\text{Factored Shear Force } V_u = 1640 \text{ kN}$$

$$\text{Effective Shear Area} = 1000000 \text{ mm}^2$$

$$\text{Shear Stress in Side Wall} = 1.64 \text{ N/mm}^2$$

$$\text{Allowable Shear Stress} = 0.40 \text{ N/mm}^2$$

$$\text{Shear force against which stirrups required} = 974 \text{ KN}$$

$$\text{Provided Diameter} = 10$$

$$\text{Spacing of Stirrups} = 194$$

$$\text{Stirrups provided } 10 \text{ mm Dia. } 100 \text{ mm Spacing}$$

Ok

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Side wall (1200mm Thk.)		

Check for crack width For Side Wall - 1200mm Thk._At Support

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

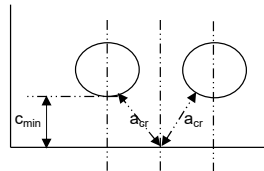
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

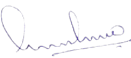
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	3120666667	
Axial Force (P) (N) =	0	
Tension R/F=	40T	100c/c (1st Layer)
	32T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1043
A_{st} (mm ² /m) =	20608.84781
p_t (ratio)=	0.019759202
x (mm) =	417.51
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	78774916017

safe



(fig 1)







$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $e_s = 0.000837677$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00099$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00099$$

$$\text{Average strain } e_m = 0.000919249$$

$$c_{min} (mm) = 45$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.01 \text{ mm}$$

$$\text{crack width (mm) } w = 0.164 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1241 < 0.2 \text{ mm}$$

OK

Signature

Signature

Signature

Signature

Signature

	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Side wall (1200mm Thk.)		

Check for crack width For Side Wall - 1200mm Thk._At Mid

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

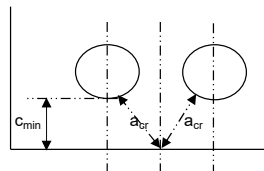
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	53333333.3	
Axial Force (P) (N) =	0	
Tension R/F=	20T	100c/c (1st Layer)
	T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1095
A_{st} (mm ² /m) =	3141.592654
p_t (ratio)=	0.002869034
x (mm) =	195.48
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	19676819574

safe



(fig 1)

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $e_s = 0.000824232$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00088$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00088$$

$$\text{Average strain } e_m = 0.00031237$$

$$c_{min} (mm) = 45$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 64.33 \text{ mm}$$

$$\text{crack width (mm) } w = 0.058 < 0.3 \text{ mm}$$

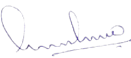
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0422 < 0.3 \text{ mm}$$

OK









Software licensed to

Job No

Sheet No

1

Rev
A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03

Job Information

	Engineer	Checked	Approved
Name:	RSh	CSa/KMp	SPa
Date:	23-Dec-24		

Project ID

Project Name

Structure Type

PLANE FRAME

Number of Nodes	72	Highest Node	90
Number of Elements	73	Highest Beam	91

Number of Basic Load Cases	17
Number of Combination Load Cases	0

Included in this printout are data for:

All

The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL (SELF WEIGHT)
Primary	2	EARTH PRESSURE (WT 5MBGL)
Primary	3	EARTH PRESSURE (WT AT GROUND)
Primary	4	HYDROSTATIC (5MBGL)
Primary	5	HYDROSTATIC (WT AT GROUND)
Primary	6	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYMM
Primary	101	1.5DL + 1.5EP(5M) + 1.5WL(5M)
Primary	102	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)
Primary	103	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE
Primary	104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SURCHARGE
Primary	105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE
Primary	201	1.0DL + 1.0EP(5M) + 1.0WL(5M)
Primary	202	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)
Primary	203	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE
Primary	204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SURCHARGE
Primary	205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

2Rev
A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.000	8.500	0.000
5	0.897	8.500	0.000
6	1.793	8.500	0.000
7	2.690	8.500	0.000
8	3.587	8.500	0.000
9	4.483	8.500	0.000
10	5.380	8.500	0.000
11	6.277	8.500	0.000
12	7.173	8.500	0.000
13	8.070	8.500	0.000
14	8.967	8.500	0.000
19	23.000	7.650	0.000
20	23.000	6.800	0.000
21	23.000	5.950	0.000
22	23.000	5.100	0.000
23	23.000	4.250	0.000
24	23.000	3.400	0.000
25	23.000	2.550	0.000
26	23.000	1.700	0.000
27	23.000	0.850	0.000
28	0.000	0.850	0.000
29	0.000	1.700	0.000
30	0.000	2.550	0.000
31	0.000	3.400	0.000
32	0.000	4.250	0.000
33	0.000	5.100	0.000
34	0.000	5.950	0.000
35	0.000	6.800	0.000
36	0.000	7.650	0.000
41	8.967	0.000	0.000
42	8.070	0.000	0.000
43	7.173	0.000	0.000
44	6.277	0.000	0.000
45	5.380	0.000	0.000
46	4.483	0.000	0.000
47	3.587	0.000	0.000
48	2.690	0.000	0.000
49	1.793	0.000	0.000
50	0.897	0.000	0.000
51	9.750	0.000	0.000
52	9.750	8.500	0.000
53	23.000	0.000	0.000
54	23.000	8.500	0.000
57	22.075	8.500	0.000
60	22.075	0.000	0.000



Software licensed to

Job No

Sheet No

3

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
65	10.630	8.500	0.000
66	11.511	8.500	0.000
67	12.391	8.500	0.000
68	13.271	8.500	0.000
69	14.152	8.500	0.000
70	15.032	8.500	0.000
71	15.913	8.500	0.000
72	16.793	8.500	0.000
73	17.673	8.500	0.000
74	18.554	8.500	0.000
75	19.434	8.500	0.000
76	20.314	8.500	0.000
77	21.195	8.500	0.000
78	10.630	0.000	0.000
79	11.511	0.000	0.000
80	12.391	0.000	0.000
81	13.271	0.000	0.000
82	14.152	0.000	0.000
83	15.032	0.000	0.000
84	15.913	0.000	0.000
85	16.793	0.000	0.000
86	17.673	0.000	0.000
87	18.554	0.000	0.000
88	19.434	0.000	0.000
89	20.314	0.000	0.000
90	21.195	0.000	0.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	2	5	0.897	1	0
2	54	19	0.850	1	0
4	1	28	0.850	1	0
5	5	6	0.897	1	0
6	6	7	0.897	1	0
7	7	8	0.897	1	0
8	8	9	0.897	1	0
9	9	10	0.897	1	0
10	10	11	0.897	1	0
11	11	12	0.897	1	0
12	12	13	0.897	1	0
13	13	14	0.897	1	0
14	14	52	0.783	1	0
19	19	20	0.850	1	0
20	20	21	0.850	1	0



Software licensed to

Job No

Sheet No

4

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
21	21	22	0.850	1	0
22	22	23	0.850	1	0
23	23	24	0.850	1	0
24	24	25	0.850	1	0
25	25	26	0.850	1	0
26	26	27	0.850	1	0
27	27	53	0.850	1	0
28	28	29	0.850	1	0
29	29	30	0.850	1	0
30	30	31	0.850	1	0
31	31	32	0.850	1	0
32	32	33	0.850	1	0
33	33	34	0.850	1	0
34	34	35	0.850	1	0
35	35	36	0.850	1	0
36	36	2	0.850	1	0
41	41	42	0.897	1	0
42	42	43	0.897	1	0
43	43	44	0.897	1	0
44	44	45	0.897	1	0
45	45	46	0.897	1	0
46	46	47	0.897	1	0
47	47	48	0.897	1	0
48	48	49	0.897	1	0
49	49	50	0.897	1	0
50	50	1	0.897	1	0
51	51	41	0.783	1	0
55	57	54	0.925	1	0
59	60	53	0.925	1	0
61	52	65	0.880	1	0
63	51	78	0.880	1	0
64	65	66	0.880	1	0
65	66	67	0.880	1	0
66	67	68	0.880	1	0
67	68	69	0.880	1	0
68	69	70	0.880	1	0
69	70	71	0.880	1	0
70	71	72	0.880	1	0
71	72	73	0.880	1	0
72	73	74	0.880	1	0
73	74	75	0.880	1	0
74	75	76	0.880	1	0
75	76	77	0.880	1	0
76	77	57	0.880	1	0
77	78	79	0.880	1	0
78	79	80	0.880	1	0

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

5

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
79	80	81	0.880	1	0
80	81	82	0.880	1	0
81	82	83	0.880	1	0
82	83	84	0.880	1	0
83	84	85	0.880	1	0
84	85	86	0.880	1	0
85	86	87	0.880	1	0
86	87	88	0.880	1	0
87	88	89	0.880	1	0
88	89	90	0.880	1	0
89	90	60	0.880	1	0
91	52	51	8.500	1	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 1.20x1.00	12E+3	10E+6	14.4E+6	19.8E+6	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT 5MBGL)	Live
3	EARTH PRESSURE (WT AT GROUND)	Live
4	HYDROSTATIC (5MBGL)	Live
5	HYDROSTATIC (WT AT GROUND)	Live
6	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYMM	Live
101	1.5DL + 1.5EP(5M) + 1.5WL(5M)	None
102	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)	None
103	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE	None
104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SURCHARGE	None
105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE	None
201	1.0DL + 1.0EP(5M) + 1.0WL(5M)	None

Handwritten signatures and initials:
- Top right: *Handwritten signature*
- Middle right: *Handwritten signature*
- Bottom right: *Handwritten signature*
- Far right: *Handwritten signature*



Software licensed to

Job No

Sheet No

6

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03

Primary Load Cases Cont...

Number	Name	Type
202	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)	None
203	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	None
204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SUf	None
205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0	None

Combination Load Cases

There is no data of this type.

Handwritten signatures:
1. [Signature]
2. [Signature]
3. [Signature]
4. [Signature]
5. [Signature]



Software licensed to

Job No

Sheet No

7

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

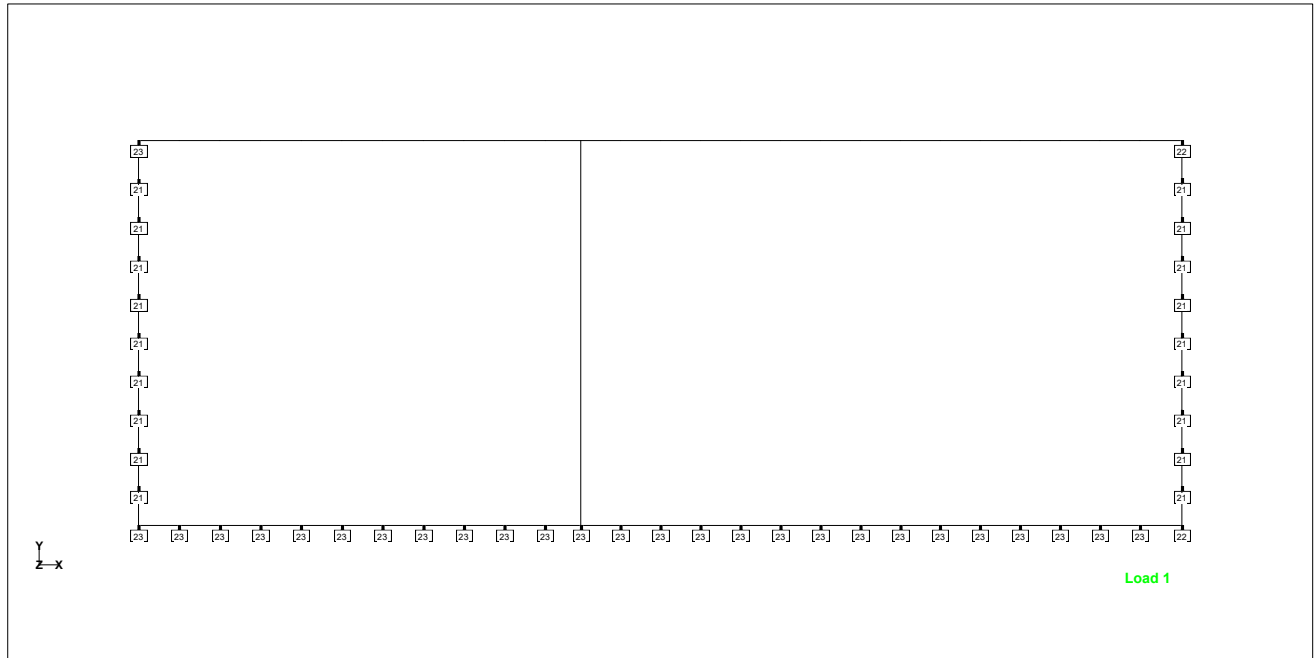
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Whole Structure

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

8

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

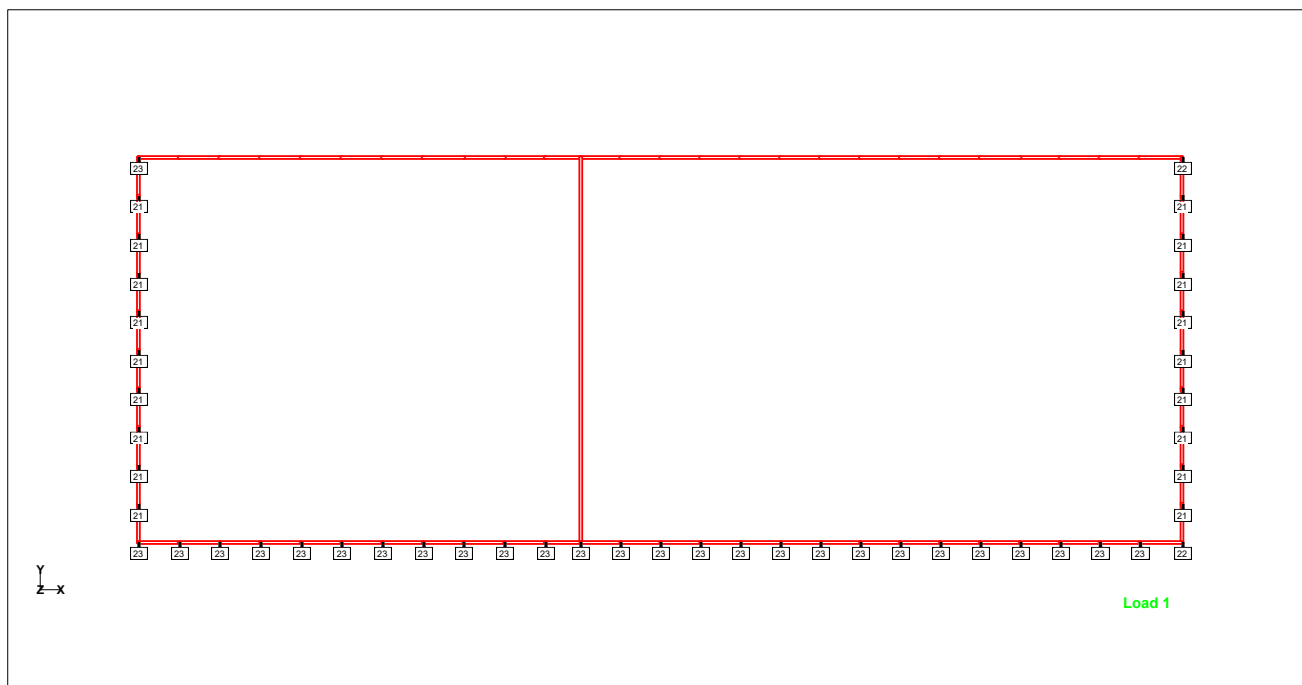
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Self Weight

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

9

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

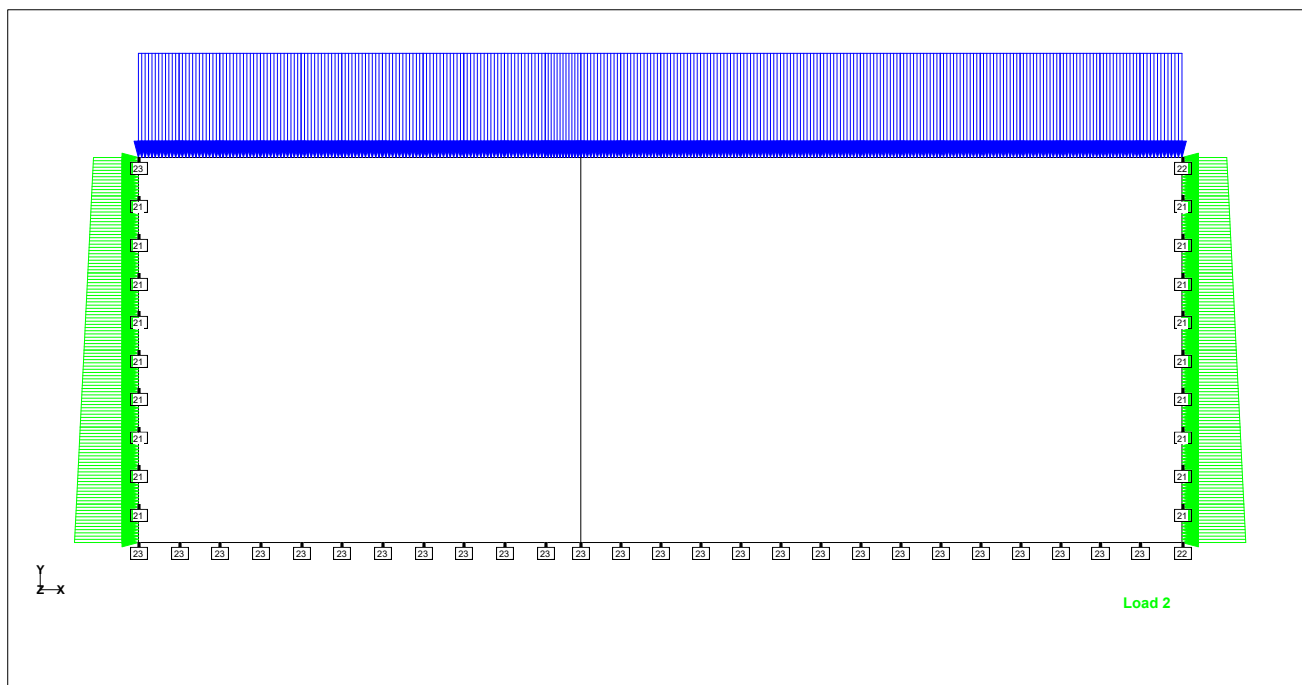
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Earth Pressure

Handwritten signatures and initials:
1. *Amir*
2. *Rob*
3. *CSa/KMp*
4. *Amir*



Software licensed to

Job No

Sheet No

10

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

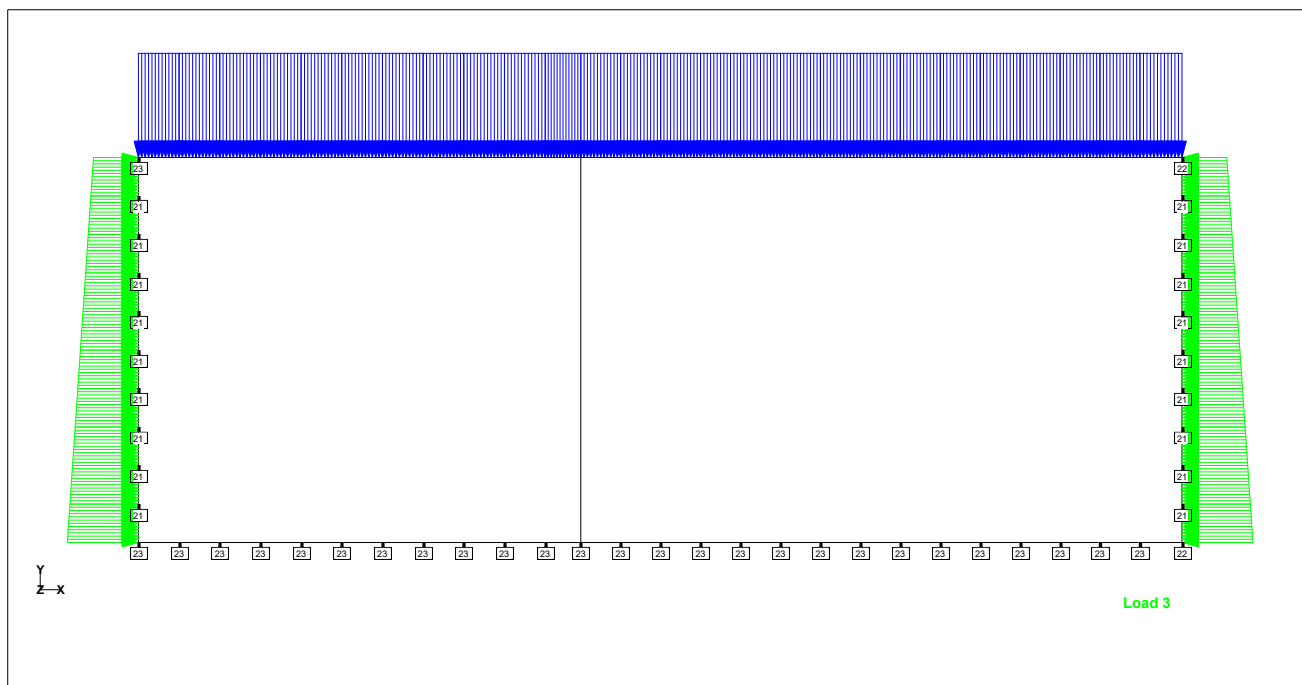
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Earth Pressure at Ground

Handwritten signatures and initials:
1. *Amir*
2. *Adi*
3. *Rob*
4. *CSa/KMp*
5. *CSa/KMp*



Software licensed to

Job No

Sheet No

11

Rev

A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

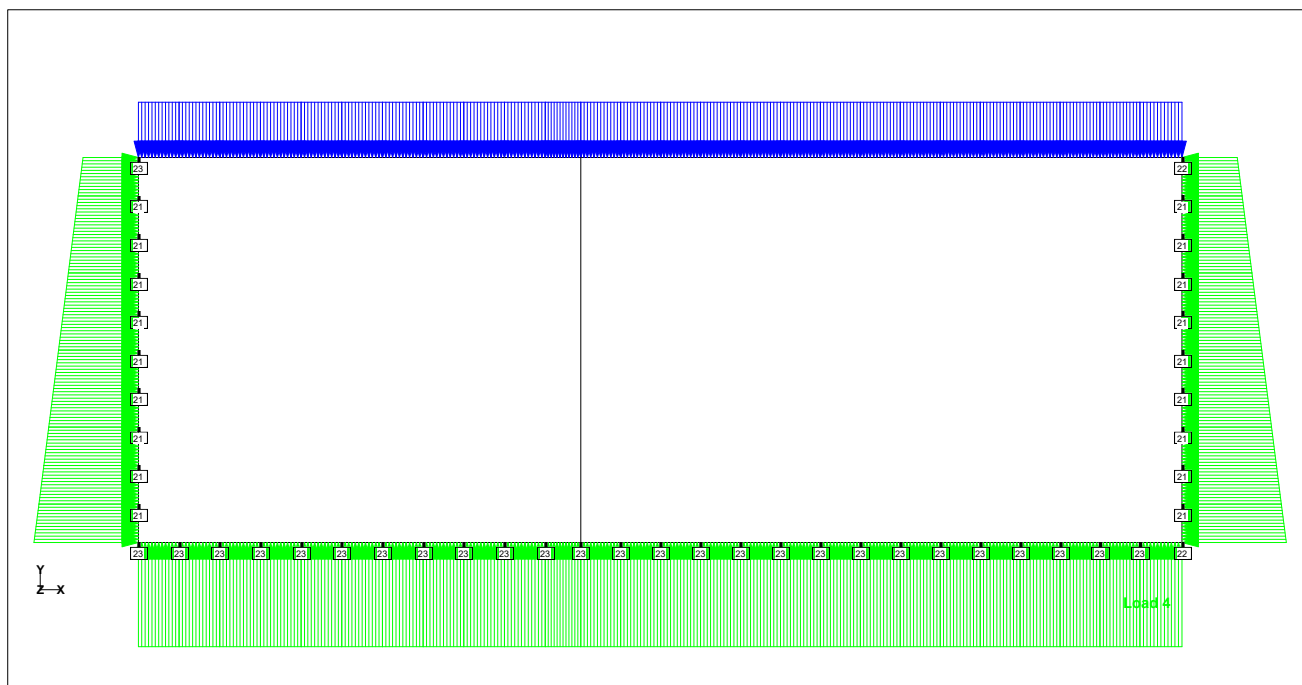
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Hydrostatic

Handwritten signatures and initials:
1. *Handwritten signature*
2. *Handwritten signature*
3. *Handwritten signature*
4. *Handwritten signature*
5. *Handwritten signature*



Software licensed to

Job No

Sheet No

12

Rev
A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

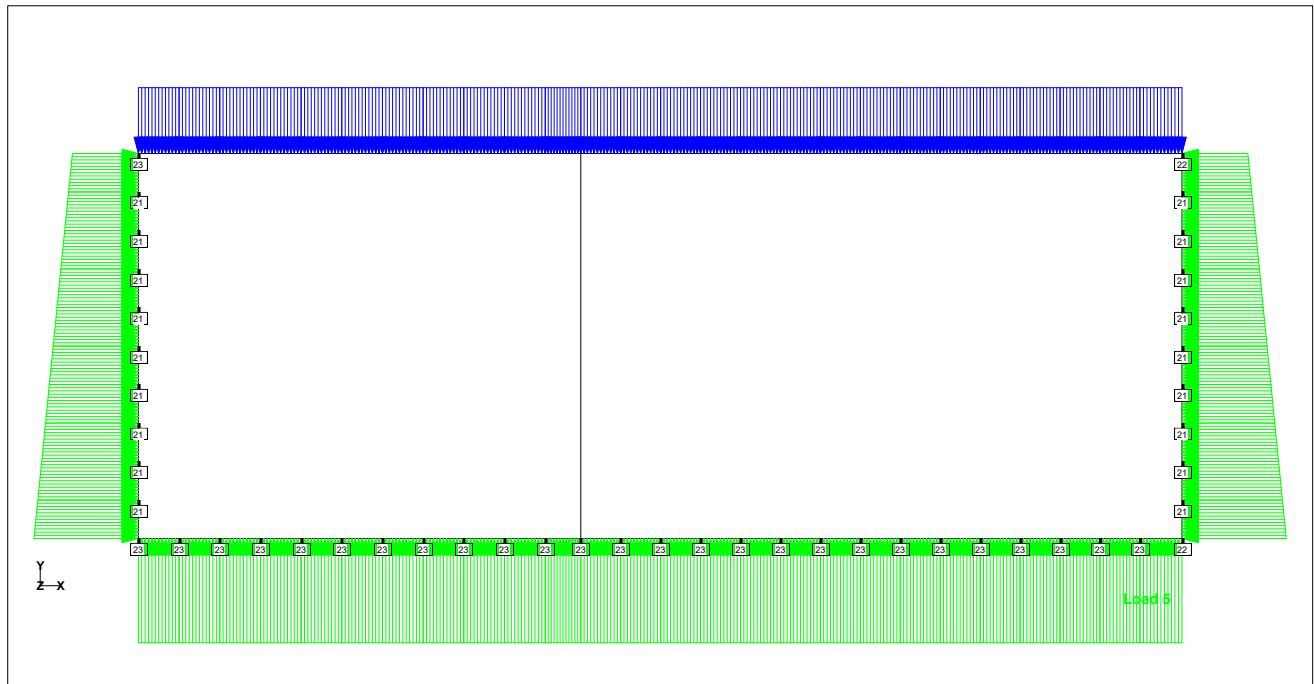
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Hydrostatic at Ground

Handwritten signatures and initials:
1. *Amir*
2. *Rob*
3. *CSa/KMp*
4. *CSa/KMp*



Software licensed to

Job No

Sheet No

13

Rev
A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

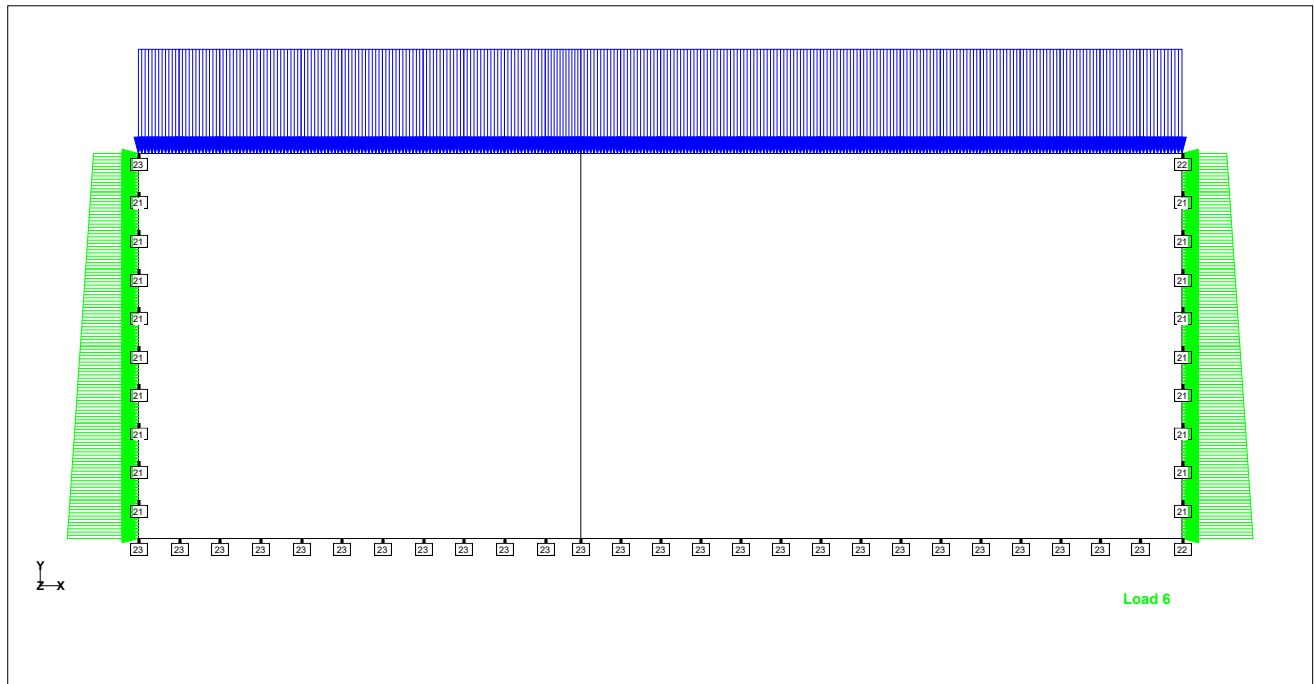
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Earth Pressure Dry

Handwritten signatures and initials:
L. J. J.
A. J.
R. J.
C. J.
D. J.



Software licensed to

Job No

Sheet No

14

Rev
A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

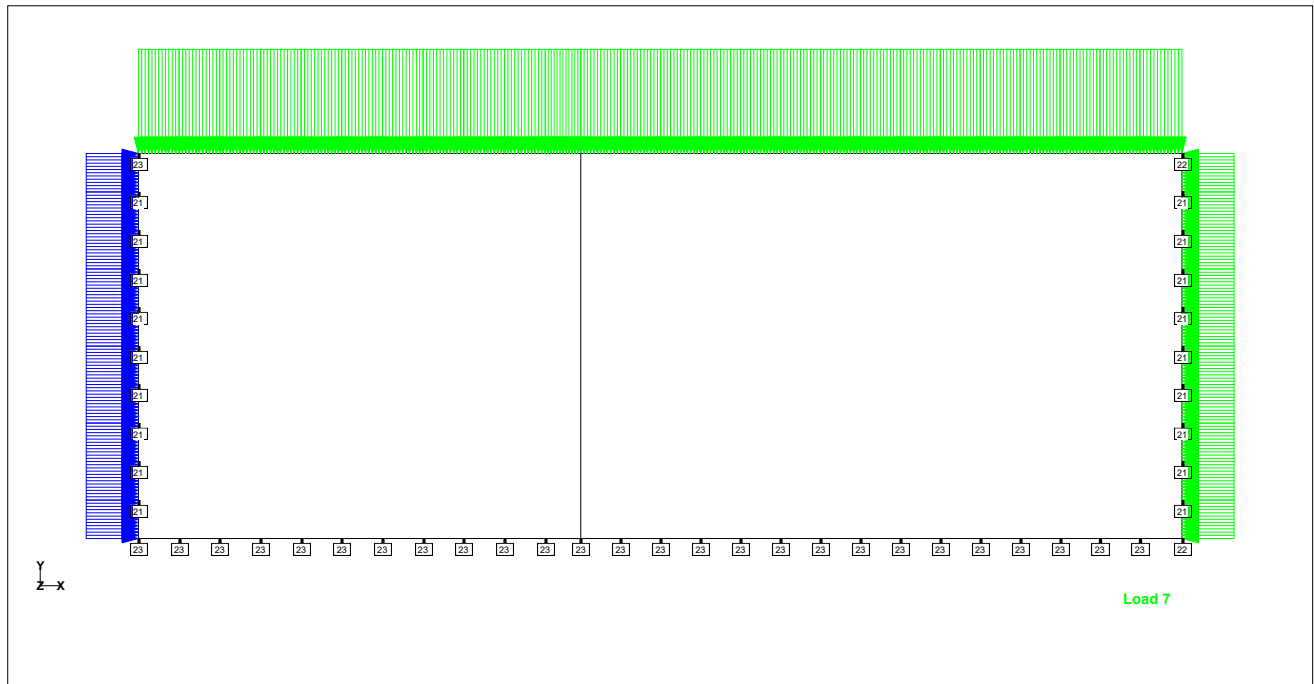
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Surcharge

Handwritten signatures and initials:
1. *Handwritten signature*
2. *Handwritten signature*
3. *Handwritten signature*
4. *Handwritten signature*
5. *Handwritten signature*



Software licensed to

Job No

Sheet No

15

Rev
A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

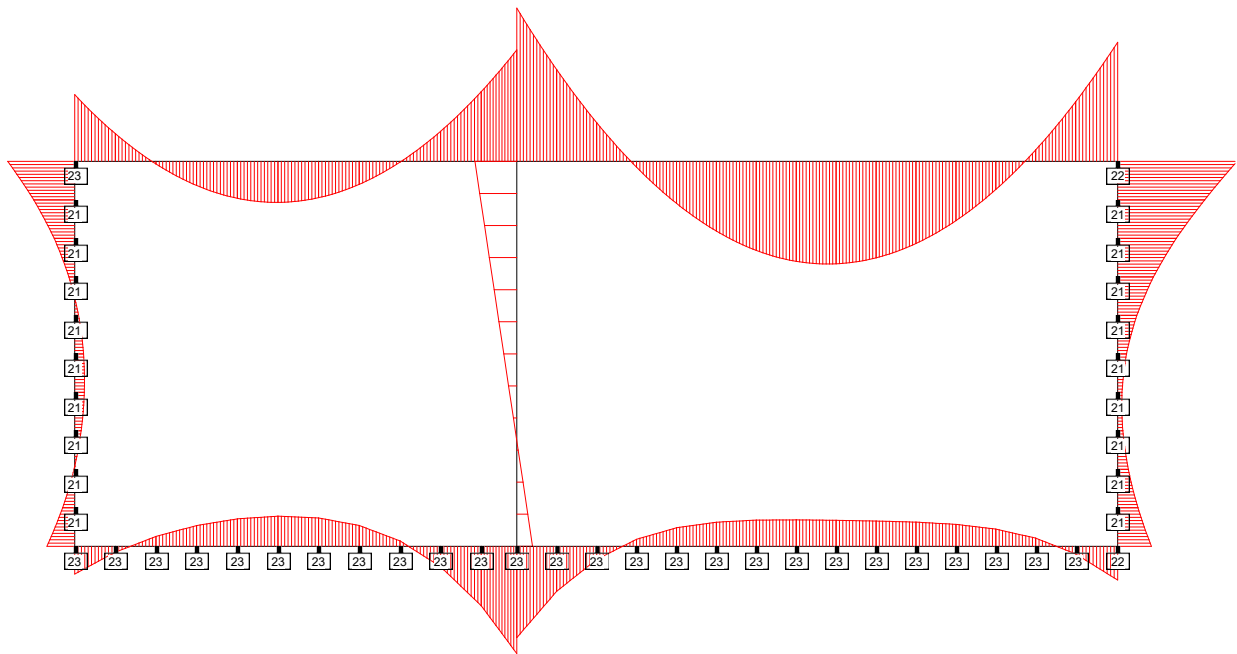
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Y
Z-X

Load 7 : Bending Z

Bending Moment

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

16

Rev
A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

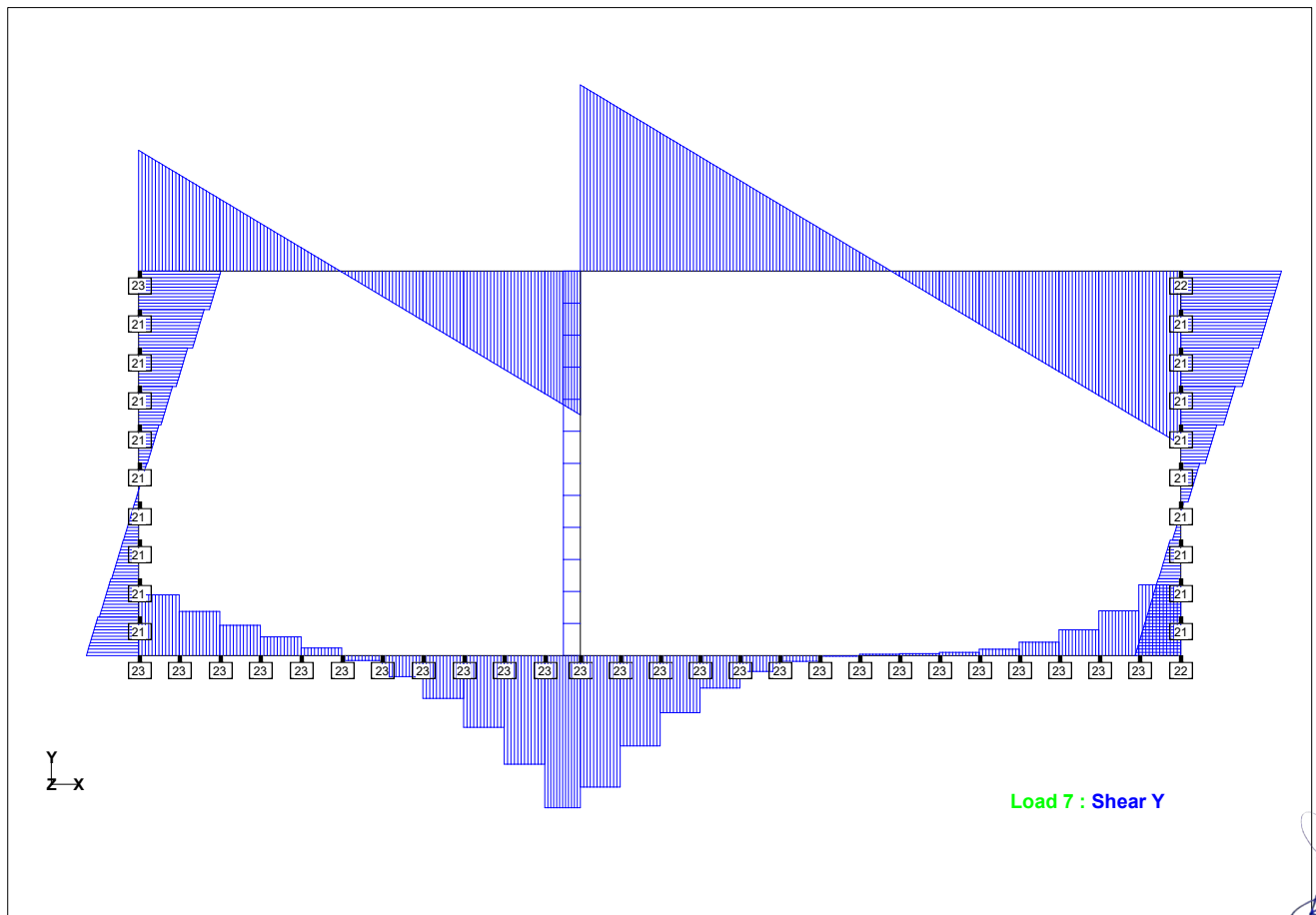
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Shear Force

Load 7 : Shear Y

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

17

Rev
A

Part

Job Title I40172_C&C (2 lane + median wall + 3 lane)

Ref

By RSh

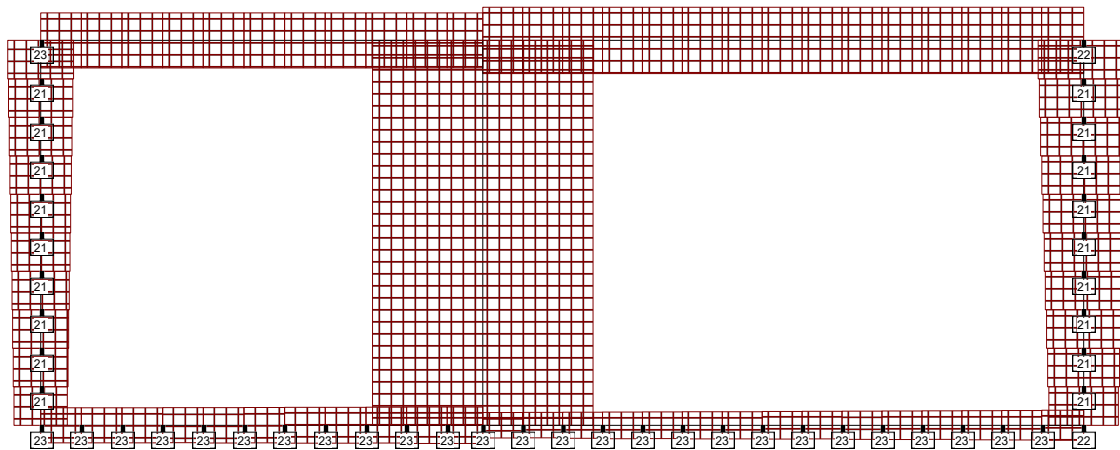
Date 23-Dec-24

Chd CSa/KMp

Client

File I40172_C&C section (3 la

Date/Time 03-Jan-2025 22:03



Y
Z-X

Load 7 : Axial Force

Axial Force

[Handwritten signatures and initials]

	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	-	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Base Slab (1200mm thk.) - C&C box (2 lane + Median Wall + 3 Lane))			

Design of Base Slab C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1200 mm
Unit width of slab	b	=	1000 mm

3) Design for Support Moment (Earth Face)

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	4029 kNm
Effective Thickness		=	1067 mm
d'		=	133 mm
Mu/bd ²		=	3.539
Mulim		=	5299.67 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	14089.11
Mu2	$=Mu - Mulim$	=	-1270.67
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-3127.49
Ast	$=Astlim + Ast2$	=	10961.62
d'/d	0.12	=	0.15
fsc	Refer Table F SP 16 pg 13	=	395.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-3585.90







Minimum area of steel required (0.12% on each face in one direction)		=		1280.40 mm ²
Required area of steel	Ast	=	1.03%	10961.62 mm ²
Refer Table 2 SP 16 pg 48	Asc	=	-0.34%	-3585.90 mm ²

Side Face bars are required

Tension Reinforcement (Ast)				
Required spacing of bars		=		73.4 mm
Provided spacing		=		100 mm
Provide 2 layers	32mm	dia bars	@ 100 mm c/c on bottom face	
Area of steel provided		=		16085.0 mm ²

OK

Compression Reinforcement (Asc)				
Required spacing of bars		=		-136.9 mm
Provided spacing		=		100 mm
Provide 1 layer	25mm	dia bars	@ 100 mm c/c on bottom face	
Area of steel provided		=		4908.7 mm ²

OK

4) Design for Span Moment (Inside)

Gross area	Ag	=		1200000 mm ²
------------	----	---	--	-------------------------

Design Moments

Minimum thickness of the slab	D	=		1200 mm
Max factored bending moment (from STAAD)		=		2758 kNm

Effective Thickness		=		1113 mm
---------------------	--	---	--	---------

Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$		
------------------------	---	---	--	--

		=		6194.70 mm ²
--	--	---	--	-------------------------

Minimum area of steel required (0.12% on each face in one direction)		=		1335.00 mm ²
--	--	---	--	-------------------------

Required area of steel		=		6194.70 mm ²
------------------------	--	---	--	-------------------------

Required spacing of bars		=		75 mm
--------------------------	--	---	--	-------

Provided spacing		=		100 mm
------------------	--	---	--	--------

Provide 2 layers	25mm	dia bars	@ 100 mm c/c on both faces	
------------------	------	----------	----------------------------	--

Area of steel provided		=		9817.5 mm ²
------------------------	--	---	--	------------------------

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.12 % of Cross Sectional Area		=		1280.4 mm ²
--------------------------------	--	---	--	------------------------

0.2 Times of Main Bar		=		1963 mm ²
-----------------------	--	---	--	----------------------

Longitudinal Bar Required at Each Face		=		1963 mm ²
--	--	---	--	----------------------

Steel Provided

	20	Dia Bar	at	150	mm c/c
Area of Steel Provided			=	2094	mm ²

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_o)

Factored Shear Force V_u	=	2441	kN
Effective Shear Area	=	1200000	mm ²
Pt%	=	1.5	%
Shear Stress in Base Slab	=	2.03	N/mm ²
Allowable Shear Stress	=	0.4	N/mm ²
Shear force against which shear force is required	=	1283.5	kN
Provide Diameter	=	10.0	mm
Spacing of the Stirrups	=	147.3	mm
Provide Stirrups	=	100.0	mm C/C











	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Base slab C&C Box		

Crack width For Base Slab (2 lane + median wall + 3 lane) (1200mm Thick C&C)_At Support

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

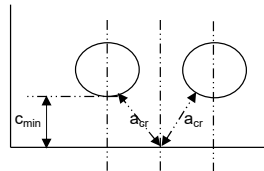
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

C_{min} = minimum cover to bar.

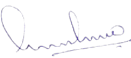
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	2686000000	
Axial Force (P) (N) =	0	
Tension R/F=	32T	100c/c (1st Layer)
	32T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1051
Ast (mm ² /m) =	16084.95439
p_t (ratio)=	0.015304429
x (mm) =	381.58
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	67255015416

safe



(fig 1)







$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $e_s = 0.000903806$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00105$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00105$$

$$\text{Average strain } e_m = 0.000952361$$

$$c_{min} (mm) = 45$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.172 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1286 < 0.2 \text{ mm}$$

OK

Signature

Signature

Signature

Signature

Signature

	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Base slab C&C Box		

Crack width For Base Slab (2 lane + median wall + 3 lane) (1200mm Thick C&C)_At Mid

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

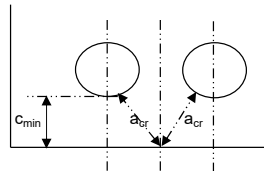
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1838666667	
Axial Force (P) (N) =	0	
Tension R/F=	25T	100c/c (1st Layer)
	25T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1065
A_{st} (mm ² /m) =	9817.477042
p_t (ratio)=	0.009218288
x (mm) =	315.45
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	47756319402

safe



(fig 1)







$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $e_s = 0.000975595$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00110$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00110$$

$$\text{Average strain } e_m = 0.000930046$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 \quad -30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 63.70 \text{ mm}$$

$$\text{crack width (mm) } w = 0.171 < 0.3 \text{ mm}$$

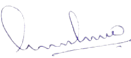
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1256 < 0.3 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	-	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Top Slab (1200mm thk.) - C&C box (2 lane + Median Wall + 3 lane)			

Design of Base Slab C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1200 mm
Unit width of slab	b	=	1000 mm

3) Design for Support Moment (Earth Face)

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	5603 kNm
Effective Thickness		=	1095 mm
d'		=	105 mm
Mu/bd ²		=	4.673
Mulim		=	5581.46 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Doubly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	14458.83
Mu2	$=Mu - Mulim$	=	21.54
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	50.01
Ast	$=Astlim + Ast2$	=	14508.84
d'/d	0.10	=	0.10
fsc	Refer Table F SP 16 pg 13	=	412.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	54.89







Minimum area of steel required (0.12% on each face in one direction)	=	1314.00 mm ²
Required area of steel	Asc = 1.33%	14508.84 mm ²
Refer Table 45-56 SP 16 pg 81-92	Asc = 0.01%	54.89 mm ²

Side Face bars are required

Tension Reinforcement (Ast)		
Required spacing of bars	=	86.6 mm
Provided spacing	=	100 mm
Provide 2 layers	40mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	25132.7 mm ²
(2 Layers of T40 + T32 has been provided as per Crack Width Calculation)		

OK

Compression Reinforcement (Asc)		
Required spacing of bars	=	5723.9 mm
Provided spacing	=	100 mm
Provide 1 layer	20mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	3141.6 mm ²

OK

4) Design for Span Moment (Inside)

Gross area	Ag =	1200000 mm ²
------------	------	-------------------------

Design Moments

Minimum thickness of the slab	D =	1200 mm
Max factored bending moment (from STAAD)	=	5200 kNm

Effective Thickness	=	1109 mm
---------------------	---	---------

Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$
------------------------	---	---

	=	12942.15 mm ²
--	---	--------------------------

Minimum area of steel required (0.12% on each face in one direction)	=	1330.80 mm ²
--	---	-------------------------

Required area of steel	=	12942.15 mm ²
------------------------	---	--------------------------

Required spacing of bars	=	50 mm
--------------------------	---	-------

Provided spacing	=	100 mm
------------------	---	--------

Provide 2 layers	32mm dia bars @ 100 mm c/c on both faces	
------------------	--	--

Area of steel provided	=	16085.0 mm ²
------------------------	---	-------------------------

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.12 % of Cross Sectional Area	=	1314 mm ²
--------------------------------	---	----------------------

0.2 Times of Main Bar	=	3217 mm ²
-----------------------	---	----------------------

Longitudinal Bar Required at Each Face	=	3217 mm ²
--	---	----------------------

Steel Provided

20	Dia Bar	at	150	mm c/c
Area of Steel Provided	=	2094	mm ²	

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_o)

Factored Shear Force V_u	=	2445	kN
Effective Shear Area	=	1200000	mm ²
Pt%	=	2.3	%
Shear Stress in Base Slab	=	2.04	N/mm ²
Allowable Shear Stress	=	0.4	N/mm ²
Shear force against which shear force is required	=	1286.1	kN
Provide Diameter	=	10.0	mm
Spacing of the Stirrups	=	147.0	mm
Provide Stirrups	=	100.0	mm C/C











	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For top slab C&C Box		

Crack width For Base Slab (2 lane + median wall + 3 lane) (1200mm Thick C&C)_At Support

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

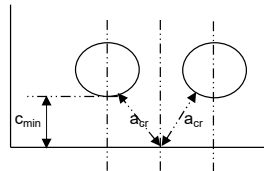
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

C_{min} = minimum cover to bar.

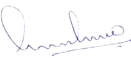
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	373533333	
Axial Force (P) (N) =	0	
Tension R/F=	40T	100c/c (1st Layer)
	32T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1043
Ast (mm ² /m) =	20608.84781
p_t (ratio)=	0.019759202
x (mm) =	417.51
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	78774916017

safe



(fig 1)







$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $\epsilon_s = 0.001002672$
 Strain in concrete at the outer most tension face
 $\epsilon_1 = 0.00119$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $\epsilon_2 = ((P/b \cdot h) / E_{eff})$

$$\epsilon_2 = 0.00000$$

Net effective Strain $\epsilon'_1 = \epsilon_1 - \epsilon_2$

$$\epsilon'_1 = 0.00119$$

$$\text{Average strain } \epsilon_m = 0.001115106$$

$$c_{min} (mm) = 45$$

$$\epsilon_m = \epsilon_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.01 \text{ mm}$$

$$\text{crack width (mm) } w = 0.199 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1505 < 0.2 \text{ mm}$$

OK

Signature

Signature

Signature

Signature

Signature

	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For top slab C&C Box		

Crack width For Base Slab (2 lane + median wall + 3 lane) (1200mm Thick C&C)_At Mid

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

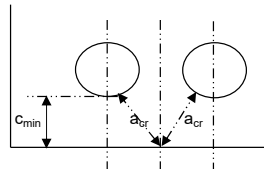
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

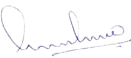
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	3466666667	
Axial Force (P) (N) =	0	
Tension R/F=	32T	100c/c (1st Layer)
	32T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1051
Ast (mm ² /m) =	16084.95439
p_t (ratio)=	0.015304429
x (mm) =	381.58
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	67255015416

safe



(fig 1)








$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $\epsilon_s = 0.001166491$
 Strain in concrete at the outer most tension face
 $\epsilon_1 = 0.00136$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $\epsilon_2 = ((P/b \cdot h) / E_{eff})$

$$\epsilon_2 = 0.00000$$

Net effective Strain $\epsilon'_1 = \epsilon_1 - \epsilon_2$

$$\epsilon'_1 = 0.00136$$

$$\text{Average strain } \epsilon_m = 0.001257818$$

$$c_{min} (mm) = 45$$

$$\epsilon_m = \epsilon_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.227 < 0.3 \text{ mm}$$

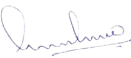
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1698 < 0.3 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd	APPENDIX	
	A company of the GEOCONSULT group	Job no.: I40172	
		Page No.: -	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for	Design of Side Wall - 1000mm Thk. for for C&C (2 lane + median wall + 3 lane)		

Design of Side Wall - 1000mm Thk. for for C&C

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Side Wall

Minimum thickness of the slab	D	=	1200 mm
Unit width of slab	b	=	1000 mm

3) Design for Earth Face (Support)

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	4681 kNm
Effective Thickness		=	1065 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	12060.23 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1278.00 mm ²
Required area of steel		=	12060.23 mm ²
Required spacing of bars		=	104 mm
Provided spacing		=	100 mm
Provide 2 Layer 40mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	25132.7 mm ²

(2 Layers of T40 + T32 has been provided as per Crack Width Calculation)

OK

4) Design for Inner Side Reinforcement

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (from STAAD)		=	800 kNm
Maximum factored axial force		=	1044 kN
Effective Thickness		=	1115 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	1686.67 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1338.00 mm ²
Required area of steel		=	1686.67 mm ²
Required spacing of bars		=	186 mm
Provided spacing		=	100 mm
Provide 20mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	3141.6 mm ²

OK

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.2% of Cross Sectional Area

= 1065 mm²

0.2 Times of Main Bar

= 628 mm²

Longitudinal Bar Required at Each Face

= 1065 mm²

Steel Provided

20

Dia Bar

at

150

mm c/c

Area of Steel Provided

=

2094

mm²

OK

6) Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u

=

1640

kN

Effective Shear Area

=

1000000

mm²

Shear Stress in Side Wall

=

1.64

N/mm²

Allowable Shear Stress

=

0.40

N/mm²

Shear force against which stirrups required

=

974

kN

Provided Diameter

=

10

Spacing of Stirrups

=

194

Stirrups provided

10

mm Dia.

100

mm Spacing

Ok











	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no.:	I6066
Project:		Detailed Design, 3D Monitoring, Geotechnical in-ventilation and construction supervision of Sin-gle Line BG Tunnel No. 12 at Km 8.656/106.63 to Km 19.39/117.371 in between Tupul – Imphal		
Calculation for		Crack Width Check For Side wall (1200mm Thk.)		

Check for crack width For Side Wall - 1200mm Thk._At Support

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

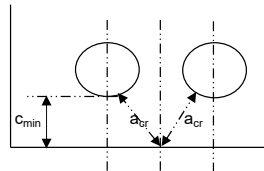
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

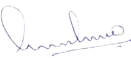
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	3120666667	
Axial Force (P) (N) =	0	
Tension R/F=	40T	100c/c (1st Layer)
	32T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1043
A_{st} (mm ² /m) =	20608.84781
p_t (ratio)=	0.019759202
x (mm) =	417.51
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	78774916017

safe



(fig 1)







$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $e_s = 0.000837677$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00099$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00099$$

$$\text{Average strain } e_m = 0.000919249$$

$$c_{min} (mm) = 45$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.01 \text{ mm}$$

$$\text{crack width (mm) } w = 0.164 < 0.2 \text{ mm}$$

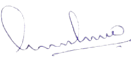
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1241 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no.:	I6066
Project:		Detailed Design, 3D Monitoring, Geotechnical in-ventilation and construction supervision of Sin-gle Line BG Tunnel No. 12 at Km 8.656/106.63 to Km 19.39/117.371 in between Tupul – Imphal		
Calculation for		Crack Width Check For Side wall (1200mm Thk.)		

Check for crack width For Side Wall - 1200mm Thk._At Mid

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

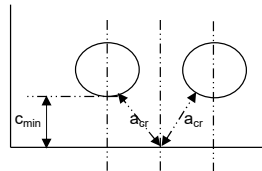
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

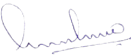
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1200	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	53333333.3	
Axial Force (P) (N) =	0	
Tension R/F=	20T	100c/c (1st Layer)
	T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	1095
A_{st} (mm ² /m) =	3141.592654
p_t (ratio)=	0.002869034
x (mm) =	195.48
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	1.44E+11
I_{cr} (mm ⁴) =	19676819574

safe



(fig 1)







$a'(mm) = 1160$
 Strain in concrete at the level of steel
 $\epsilon_s = 0.000824232$
 Strain in concrete at the outer most tension face
 $\epsilon_1 = 0.00088$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $\epsilon_2 = ((P/b \cdot h) / E_{eff})$

$$\epsilon_2 = 0.00000$$

Net effective Strain $\epsilon'_1 = \epsilon_1 - \epsilon_2$

$$\epsilon'_1 = 0.00088$$

$$\text{Average strain } \epsilon_m = 0.00031237$$

$$c_{min} (mm) = 45$$

$$\epsilon_m = \epsilon_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 64.33 \text{ mm}$$

$$\text{crack width (mm) } w = 0.058 < 0.3 \text{ mm}$$

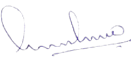
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0422 < 0.3 \text{ mm}$$

OK







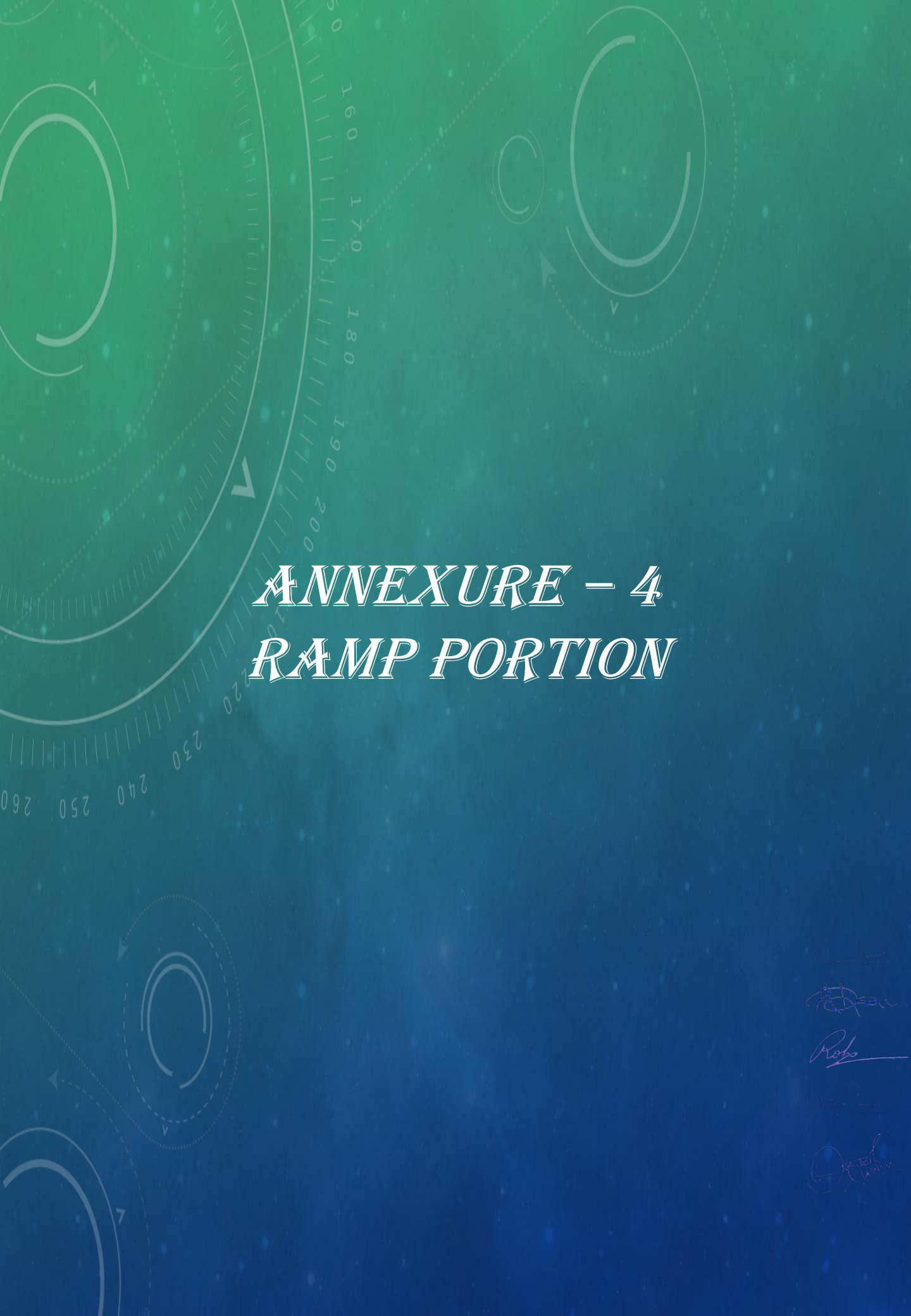
Amelia

Adri

Rob

Emma

James



ANNEXURE – 4

RAMP PORTION

Signature

Signature

Signature

Signature

Signature

Amelia

Adri

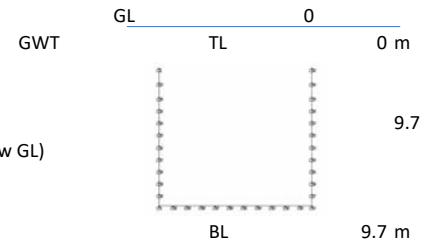
Rob

Emma

James

ANNEXURE 4

Ground level at C&C location	0 m
Top level at C&C location	0 m
Base level at C&C location	9.7 m
unit weight of compacted backfill	19.1 kn/m3
height of overburden	0 m
height of watertable	0 m
height of water table above crown	0 m (5m below GL)
height of water table +1m above crown	0
unit weight of water	10 kn/m3
K0	0.43
poisson ratio	0.3



OVERBURDEN PRESSURE (SUBMERGED)

side earth pressure at wall top	$k_0 \times \text{overburden pressure at wall top}$	0
side earth pressure at wall bottom	$k_0 \times \text{overburden pressure at Invert}$	37.9561

88.27

HYDROSTATIC PRESSURE

Hydrostratic pressure at top slab	height of water table above top slab x unit weight of water	0
bottom	height of water table at Invert x unit weight of water	97

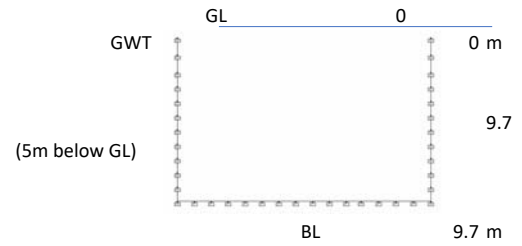
DRY OVERBURDEN

side earth pressure at wall top	0
side earth pressure at wall bottom	79.6661

185.27

ANNEXURE 4

Ground level at C&C location	0 m
Top level at C&C location	0 m
Base level at C&C location	9.7 m
unit weight of compacted backfill	19.1 kn/m3
height of overburden	0 m
height of watertable	0 m
height of water table above crown	0 m
height of water table +1m above crown	0
unit weight of water	10 kn/m3
K0	0.43
poisson ratio	0.3



OVERBURDEN PRESSURE (SUBMERGED)

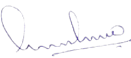
side earth pressure at wall top	$k_0 \times$ overburden pressure at wall top	0
side earth pressure at wall bottom	$k_0 \times$ overburden pressure at Invert	37.9561

HYDROSTATIC PRESSURE

Hydrostratic pressure at top slab	height of water table above top slab x unit weight of water	0
bottom	height of water table at Invert x unit weight of water	97

DRY OVERBURDEN

side earth pressure at wall top	0
side earth pressure at wall bottom	79.6661








Ks	=	E / [3(1-2v)]	
E	=	145.5	kn/m2 (weighted avg)
Overburden			
depth	=	14.6	m (1D)
v	=	0.3	
Ks	=	121250	
Kfx	=	Ks x A	(A = Area of each member)
	=	109125	
Kfy	=	10912.5	

As per depth 0 to 7.5m

E	=	6	kn/m2 (weighted avg)
Overburden			
depth	=	14.6	m (1D)
v	=	0.3	
Ks	=	5000	
Kfx	=	Ks x A	(A = Area of each member)
	=	4500	
Kfy	=	450	

As per depth 7.5 to 12m

E	=	25	kn/m2 (weighted avg)
Overburden			
depth	=	14.6	m (1D)
v	=	0.3	
Ks	=	20833.3333	
Kfx	=	Ks x A	(A = Area of each member)
	=	18750	
Kfy	=	1875	

As per depth 12 to 22m

E	=	305	kn/m2 (weighted avg)
Overburden			
depth	=	14.6	m (1D)
v	=	0.3	
Ks	=	254166.667	
Kfx	=	Ks x A	(A = Area of each member)
	=	228750	
Kfy	=	22875	

Signature

Signature

Signature

Signature

Signature

Signature



Software licensed to

Job No

Sheet No

1

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

Job Information

	Engineer	Checked	Approved
Name:	KCh	CSa	SPa
Date:	03-Sep-24		

Project ID

Project Name

Structure Type

SPACE FRAME

Number of Nodes	36	Highest Node	56
Number of Elements	36	Highest Beam	56

Number of Basic Load Cases	5
Number of Combination Load Cases	6

Included in this printout are data for:

All

The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL (SELF WEIGHT)
Primary	2	EARTH PRESSURE (WT AT GROUND)
Primary	3	HYDROSTATIC (WT AT GROUND)
Primary	4	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYMM
Combination	101	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)
Combination	102	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE
Combination	103	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE
Combination	201	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)
Combination	202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE
Combination	203	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.000	9.700	0.000
19	9.750	7.650	0.000
20	9.750	6.800	0.000
21	9.750	5.950	0.000
22	9.750	5.100	0.000
23	9.750	4.250	0.000
24	9.750	3.400	0.000
25	9.750	2.550	0.000
26	9.750	1.700	0.000

Signature
Date
Rob
CSa
SPa



Software licensed to

Job No

Sheet No

2

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
30	0.000	2.550	0.000
31	0.000	3.400	0.000
32	0.000	4.250	0.000
33	0.000	5.100	0.000
34	0.000	5.950	0.000
35	0.000	6.800	0.000
36	0.000	7.650	0.000
41	8.967	0.000	0.000
42	8.070	0.000	0.000
43	7.173	0.000	0.000
44	6.277	0.000	0.000
45	5.380	0.000	0.000
46	4.483	0.000	0.000
47	3.587	0.000	0.000
48	2.690	0.000	0.000
49	1.793	0.000	0.000
50	0.897	0.000	0.000
51	9.750	0.000	0.000
52	9.750	9.700	0.000
53	0.000	8.675	0.000
54	9.750	8.675	0.000
55	-1.500	0.000	0.000
56	11.250	0.000	0.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
2	52	54	1.025	1	0
4	1	28	0.850	1	0
19	19	20	0.850	1	0
20	20	21	0.850	1	0
21	21	22	0.850	1	0
22	22	23	0.850	1	0
23	23	24	0.850	1	0
24	24	25	0.850	1	0
25	25	26	0.850	1	0
26	26	27	0.850	1	0
27	27	51	0.850	1	0
28	28	29	0.850	1	0
29	29	30	0.850	1	0
30	30	31	0.850	1	0
31	31	32	0.850	1	0
32	32	33	0.850	1	0
33	33	34	0.850	1	0
34	34	35	0.850	1	0

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

3

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
35	35	36	0.850	1	0
36	36	53	1.025	1	0
41	41	42	0.897	1	0
42	42	43	0.897	1	0
43	43	44	0.897	1	0
44	44	45	0.897	1	0
45	45	46	0.897	1	0
46	46	47	0.897	1	0
47	47	48	0.897	1	0
48	48	49	0.897	1	0
49	49	50	0.897	1	0
50	50	1	0.897	1	0
51	51	41	0.783	1	0
52	53	2	1.025	1	0
53	54	19	1.025	1	0
54	1	55	1.500	1	0
55	51	56	1.500	1	0
56	35	20	9.750	2	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 1.20x1.00	12E+3	10E+6	14.4E+6	19.8E+6	CONCRETE
2	Prismatic General	600.000	180E+3	360E+3	180E+3	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Handwritten signatures and initials:
1. *Amal*
2. *Adar*
3. *Rob*
4. *CSA*
5. *CSA*



Software licensed to

Job No

Sheet No

4

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN`m/deg)	rY (kN`m/deg)	rZ (kN`m/deg)
1	Fixed	Fixed	Fixed	-	-	-
2	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
32	-	-	-	-	-	-
33	-	-	-	-	-	-
34	-	-	-	-	-	-
35	-	-	-	-	-	-
36	-	-	-	-	-	-
41	-	-	-	-	-	-
42	-	-	-	-	-	-
43	-	-	-	-	-	-
44	-	-	-	-	-	-
45	-	-	-	-	-	-
46	-	-	-	-	-	-
47	-	-	-	-	-	-
48	-	-	-	-	-	-
49	-	-	-	-	-	-
50	-	-	-	-	-	-
51	Fixed	Fixed	Fixed	-	-	-
52	-	-	-	-	-	-
53	-	-	-	-	-	-
54	-	-	-	-	-	-
55	-	-	-	-	-	-
56	-	-	-	-	-	-

Releases

There is no data of this type.

[Handwritten signatures and initials in blue ink, including "L. J. J.", "R. J.", "R. J.", and "R. J."]



Software licensed to

Job No

Sheet No

5

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT AT GROUND)	Live
3	HYDROSTATIC (WT AT GROUND)	Live
4	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYMM	Live

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
101	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT AT GROUND)	1.50
		3	HYDROSTATIC (WT AT GROUND)	1.50
102	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE	1	DL (SELF WEIGHT)	1.50
		4	EARTH PRESSURE (DRY)	1.50
		7	SURCHARGE SYMM	1.50
103	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT AT GROUND)	1.50
		3	HYDROSTATIC (WT AT GROUND)	1.50
		7	SURCHARGE SYMM	1.50
201	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT AT GROUND)	1.00
		3	HYDROSTATIC (WT AT GROUND)	1.00
202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	1	DL (SELF WEIGHT)	1.00
		7	SURCHARGE SYMM	1.00
		4	EARTH PRESSURE (DRY)	1.00
203	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT AT GROUND)	1.00
		7	SURCHARGE SYMM	1.00
		3	HYDROSTATIC (WT AT GROUND)	1.00

Load Generators

There is no data of this type.

1 DL (SELF WEIGHT) : Selfweight

Direction	Factor	Assigned Geometry
Y	-1.000	ALL

Handwritten signatures and initials:
1. *Amrutha*
2. *Adar*
3. *Rob*
4. *CSA*
5. *Shah*



Software licensed to

Job No

Sheet No

6

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

2 EARTH PRESSURE (WT AT GROUND) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	TRAP kN/m	GX	0.000	-	-4.015	-	-
4	TRAP kN/m	GX	38.000	-	34.670	-	-
19	TRAP kN/m	GX	-8.031	-	-11.361	-	-
20	TRAP kN/m	GX	-11.361	-	-14.691	-	-
21	TRAP kN/m	GX	-14.691	-	-18.021	-	-
22	TRAP kN/m	GX	-18.021	-	-21.351	-	-
23	TRAP kN/m	GX	-21.351	-	-24.680	-	-
24	TRAP kN/m	GX	-24.680	-	-28.010	-	-
25	TRAP kN/m	GX	-28.010	-	-31.340	-	-
26	TRAP kN/m	GX	-31.340	-	-34.670	-	-
27	TRAP kN/m	GX	-34.670	-	-38.000	-	-
28	TRAP kN/m	GX	34.670	-	31.340	-	-
29	TRAP kN/m	GX	31.340	-	28.010	-	-
30	TRAP kN/m	GX	28.010	-	24.680	-	-
31	TRAP kN/m	GX	24.680	-	21.351	-	-
32	TRAP kN/m	GX	21.351	-	18.021	-	-
33	TRAP kN/m	GX	18.021	-	14.691	-	-
34	TRAP kN/m	GX	14.691	-	11.361	-	-
35	TRAP kN/m	GX	11.361	-	8.031	-	-
36	TRAP kN/m	GX	8.031	-	4.015	-	-
52	TRAP kN/m	GX	4.015	-	0.000	-	-
53	TRAP kN/m	GX	-4.015	-	-8.031	-	-
54	UNI kN/m	GY	-88.000	-	-	-	-
55	UNI kN/m	GY	-88.000	-	-	-	-

3 HYDROSTRATIC (WT AT GROUND) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	TRAP kN/m	GX	0.000	-	-10.250	-	-
4	TRAP kN/m	GX	97.000	-	88.500	-	-
19	TRAP kN/m	GX	-20.500	-	-29.000	-	-
20	TRAP kN/m	GX	-29.000	-	-37.500	-	-
21	TRAP kN/m	GX	-37.500	-	-46.000	-	-
22	TRAP kN/m	GX	-46.000	-	-54.500	-	-
23	TRAP kN/m	GX	-54.500	-	-63.000	-	-
24	TRAP kN/m	GX	-63.000	-	-71.500	-	-
25	TRAP kN/m	GX	-71.500	-	-80.000	-	-
26	TRAP kN/m	GX	-80.000	-	-88.500	-	-
27	TRAP kN/m	GX	-88.500	-	-97.000	-	-
28	TRAP kN/m	GX	88.500	-	80.000	-	-
29	TRAP kN/m	GX	80.000	-	71.500	-	-
30	TRAP kN/m	GX	71.500	-	63.000	-	-
31	TRAP kN/m	GX	63.000	-	54.500	-	-
32	TRAP kN/m	GX	54.500	-	46.000	-	-
33	TRAP kN/m	GX	46.000	-	37.500	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

7

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

3 HYDROSTATIC (WT AT GROUND) : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
34	TRAP kN/m	GX	37.500	-	29.000	-	-
35	TRAP kN/m	GX	29.000	-	20.500	-	-
36	TRAP kN/m	GX	20.500	-	10.250	-	-
41	UNI kN/m	GY	97.000	-	-	-	-
42	UNI kN/m	GY	97.000	-	-	-	-
43	UNI kN/m	GY	97.000	-	-	-	-
44	UNI kN/m	GY	97.000	-	-	-	-
45	UNI kN/m	GY	97.000	-	-	-	-
46	UNI kN/m	GY	97.000	-	-	-	-
47	UNI kN/m	GY	97.000	-	-	-	-
48	UNI kN/m	GY	97.000	-	-	-	-
49	UNI kN/m	GY	97.000	-	-	-	-
50	UNI kN/m	GY	97.000	-	-	-	-
51	UNI kN/m	GY	97.000	-	-	-	-
52	TRAP kN/m	GX	10.250	-	0.000	-	-
53	TRAP kN/m	GX	-10.250	-	-20.500	-	-
54	UNI kN/m	GY	97.000	-	-	-	-
55	UNI kN/m	GY	97.000	-	-	-	-

4 EARTH PRESSURE (DRY) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	TRAP kN/m	GX	0.000	-	-8.454	-	-
4	TRAP kN/m	GX	80.000	-	72.990	-	-
19	TRAP kN/m	GX	-16.907	-	-23.917	-	-
20	TRAP kN/m	GX	-23.917	-	-30.928	-	-
21	TRAP kN/m	GX	-30.928	-	-37.938	-	-
22	TRAP kN/m	GX	-37.938	-	-44.949	-	-
23	TRAP kN/m	GX	-44.949	-	-51.959	-	-
24	TRAP kN/m	GX	-51.959	-	-58.969	-	-
25	TRAP kN/m	GX	-58.969	-	-65.979	-	-
26	TRAP kN/m	GX	-65.979	-	-72.990	-	-
27	TRAP kN/m	GX	-72.990	-	-80.000	-	-
28	TRAP kN/m	GX	72.990	-	65.979	-	-
29	TRAP kN/m	GX	65.979	-	58.969	-	-
30	TRAP kN/m	GX	58.969	-	51.959	-	-
31	TRAP kN/m	GX	51.959	-	44.949	-	-
32	TRAP kN/m	GX	44.949	-	37.938	-	-
33	TRAP kN/m	GX	37.938	-	30.928	-	-
34	TRAP kN/m	GX	30.928	-	23.917	-	-
35	TRAP kN/m	GX	23.917	-	16.907	-	-
36	TRAP kN/m	GX	16.907	-	8.454	-	-
52	TRAP kN/m	GX	8.454	-	0.000	-	-
53	TRAP kN/m	GX	-8.454	-	-16.907	-	-
54	UNI kN/m	GY	-185.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

8

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

4 EARTH PRESSURE (DRY) : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
55	UNI kN/m	GY	-185.000	-	-	-	-

7 SURCHARGE SYM : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	UNI kN/m	GX	-30.000	-	-	-	-
4	UNI kN/m	GX	30.000	-	-	-	-
19	UNI kN/m	GX	-30.000	-	-	-	-
20	UNI kN/m	GX	-30.000	-	-	-	-
21	UNI kN/m	GX	-30.000	-	-	-	-
22	UNI kN/m	GX	-30.000	-	-	-	-
23	UNI kN/m	GX	-30.000	-	-	-	-
24	UNI kN/m	GX	-30.000	-	-	-	-
25	UNI kN/m	GX	-30.000	-	-	-	-
26	UNI kN/m	GX	-30.000	-	-	-	-
27	UNI kN/m	GX	-30.000	-	-	-	-
28	UNI kN/m	GX	30.000	-	-	-	-
29	UNI kN/m	GX	30.000	-	-	-	-
30	UNI kN/m	GX	30.000	-	-	-	-
31	UNI kN/m	GX	30.000	-	-	-	-
32	UNI kN/m	GX	30.000	-	-	-	-
33	UNI kN/m	GX	30.000	-	-	-	-
34	UNI kN/m	GX	30.000	-	-	-	-
35	UNI kN/m	GX	30.000	-	-	-	-
36	UNI kN/m	GX	30.000	-	-	-	-
52	UNI kN/m	GX	30.000	-	-	-	-
53	UNI kN/m	GX	-30.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

9

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

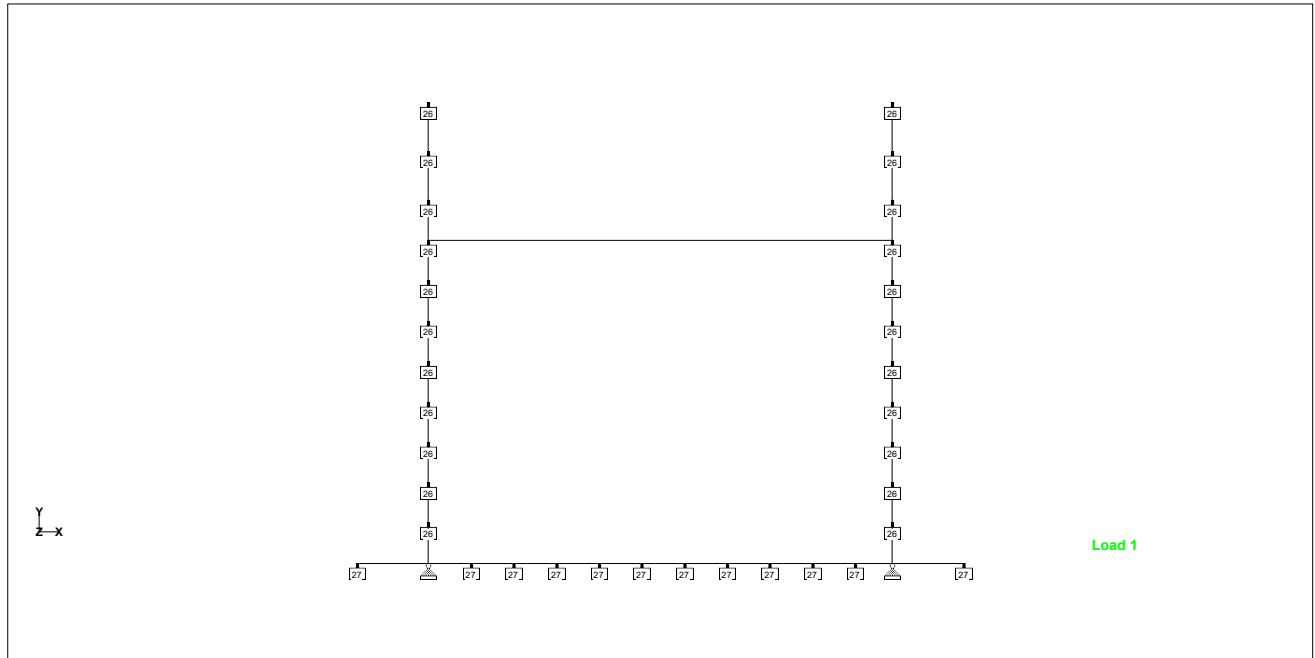
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53



Whole Structure

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

10

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

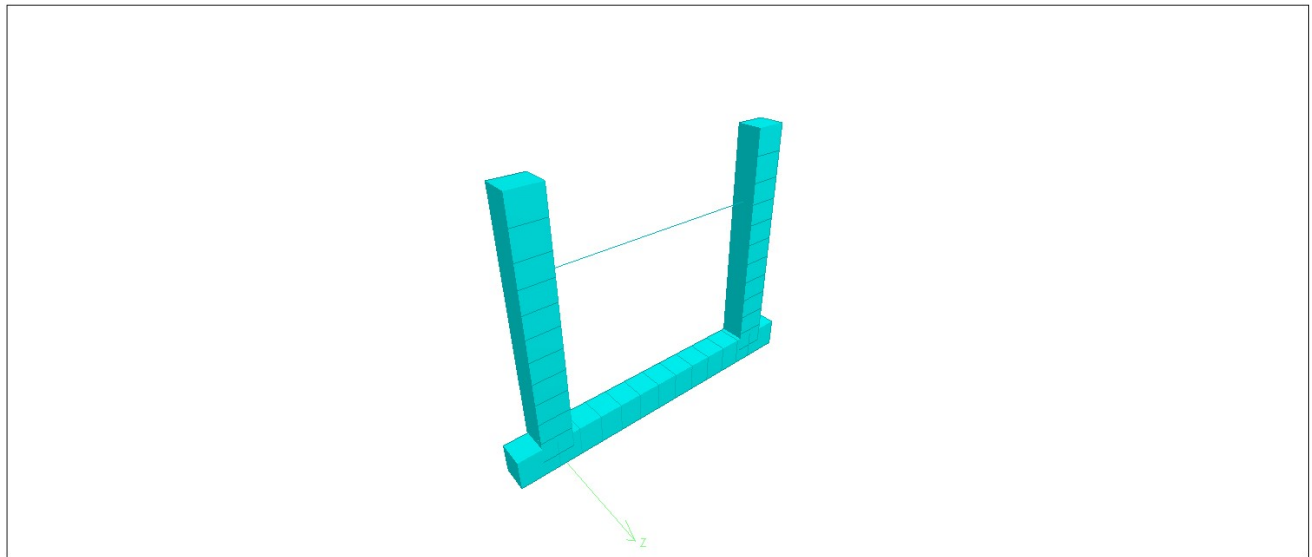
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53



3D Rendered View

Signature
Signature
Rob
CSA
Signature



Software licensed to

Job No

Sheet No

11

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

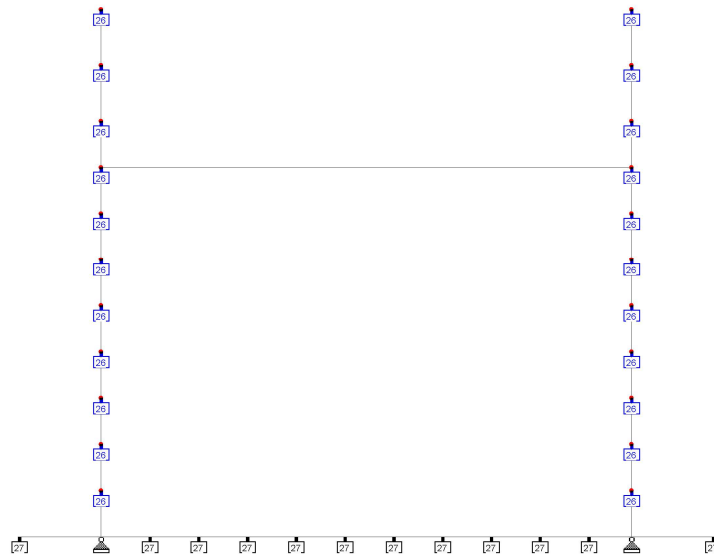
Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

Y
Z-x



Load 1

SUPPORTS

Handwritten signatures:
1. [Signature]
2. [Signature]
3. [Signature]
4. [Signature]
5. [Signature]



Software licensed to

Job No

Sheet No

12

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

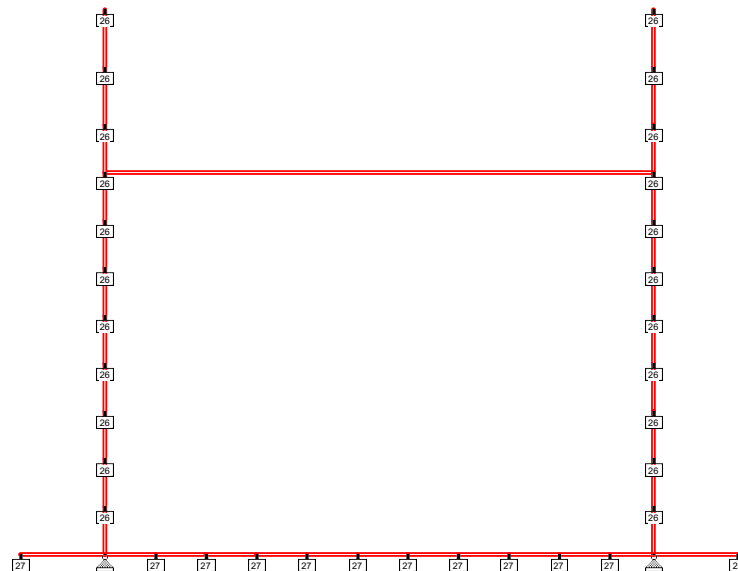
Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

Y
Z-X



Load 1

DL(SELF WEIGHT)

Handwritten signatures and initials:
1. *Amir*
2. *Rob*
3. *CSA*
4. *CSA*



Software licensed to

Job No

Sheet No

13

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

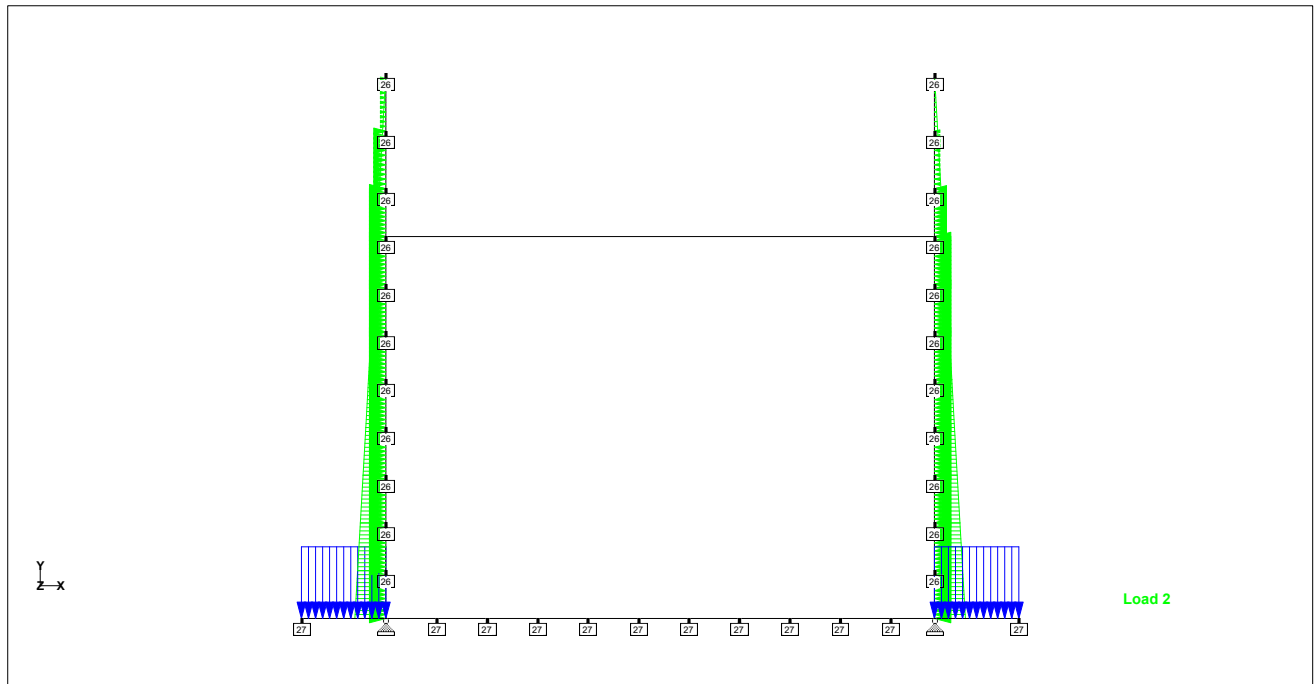
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53



EP(WT AT GROUND)

Handwritten signatures and initials:
[Signature]
[Signature]
[Signature]
[Signature]
[Signature]



Software licensed to

Job No

Sheet No

14

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

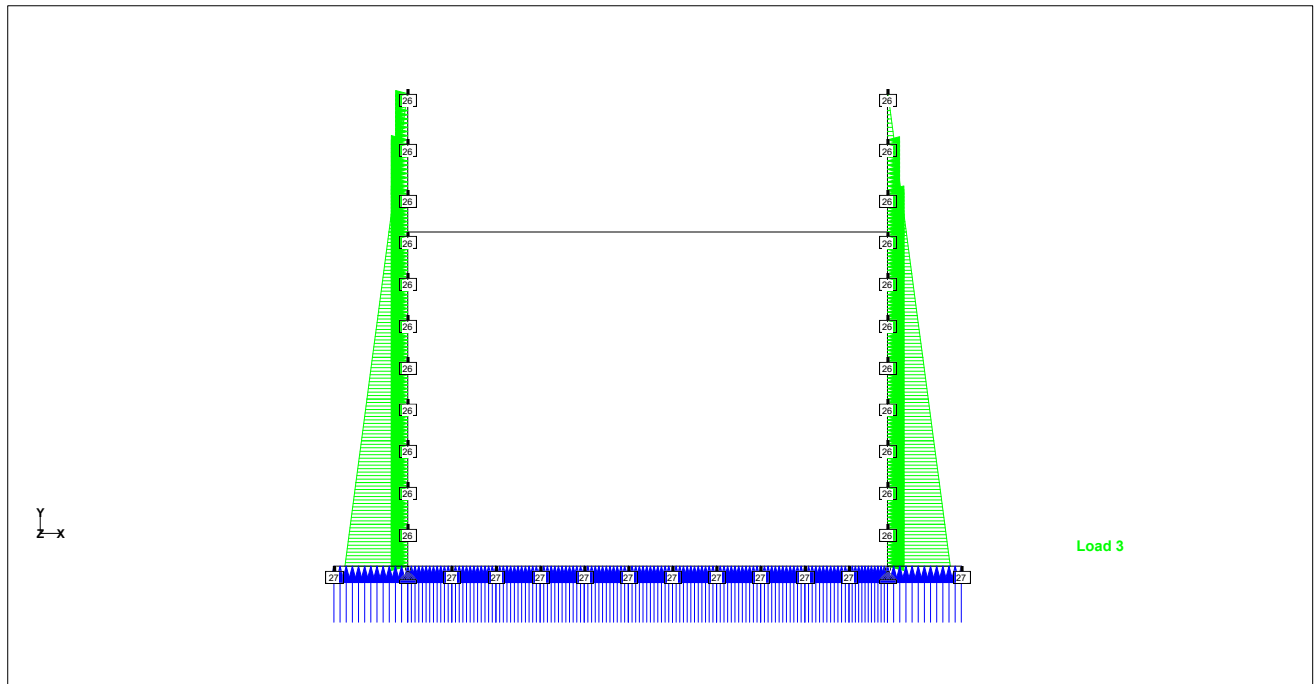
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53



WATER(WT AT GROUND)

Handwritten signatures and initials:
1. *Handwritten signature*
2. *Handwritten signature*
3. *Handwritten signature*
4. *Handwritten signature*
5. *Handwritten signature*



Software licensed to

Job No

Sheet No

15

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

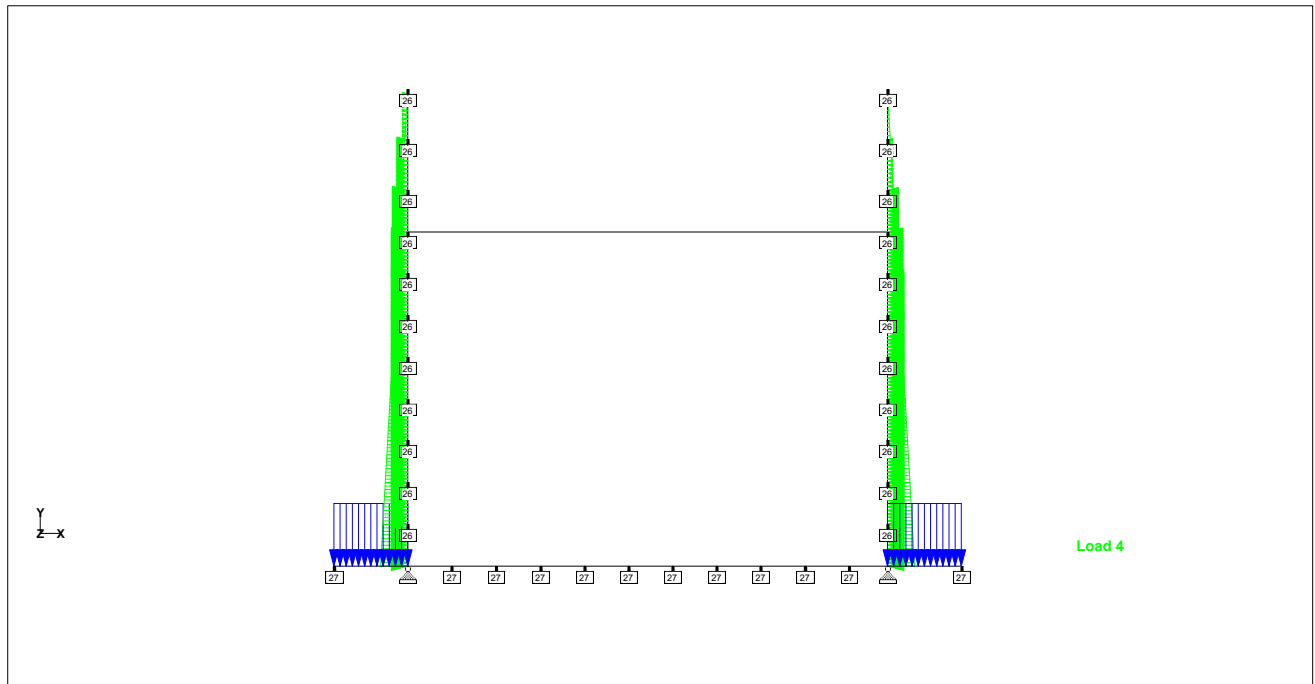
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53



EP(DRY)

Handwritten signatures and initials:
[Signature]
[Signature]
[Signature]
[Signature]
[Signature]



Software licensed to

Job No

Sheet No

16

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

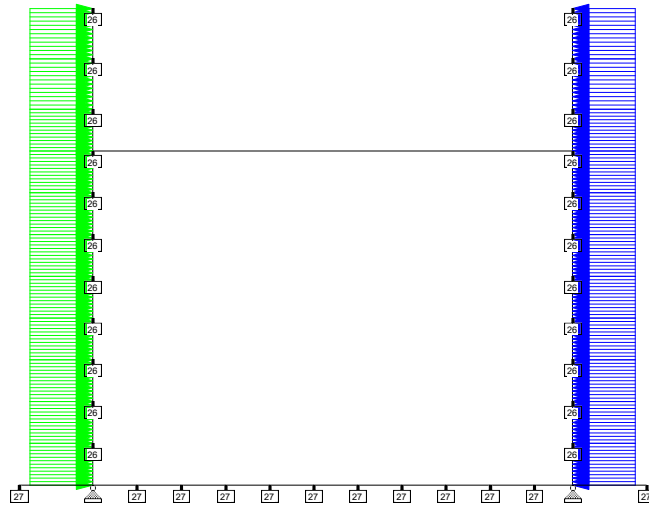
Chd CSa

Client

File I40172_RAMP (2 lane) wi

Date/Time 11-Sep-2024 12:53

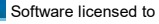
Y
Z-X



Load 7

SURCHARGE

Handwritten signatures and initials:
[Signature]
[Signature]
[Signature]
[Signature]
[Signature]



Sheet No

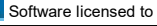
Rev

Chd CSa

Date/Time 11-Sep-2024 12:53



Handwritten signatures: Langhorne, ~~Adair~~, Ross, Wm. Leno, Wm. Leno



Sheet No

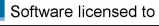
Rev

Chd CSa

Date/Time 11-Sep-2024 12:53



Handwritten signatures: Langhorne, ~~Adair~~, Ross, Wm. Leno, Wm. Leno



Sheet No

Rev

Chd CSa

Date/Time 11-Sep-2024 12:53



Handwritten signatures: Handwritten, ~~Handwritten~~, Rob, Handwritten, Handwritten



Software licensed to

Job No

Sheet No

1

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

Job Information

	Engineer	Checked	Approved
Name:	KCh	CSa	SPa
Date:	03-Sep-24		

Project ID

Project Name

Structure Type

SPACE FRAME

Number of Nodes	40	Highest Node	64
Number of Elements	40	Highest Beam	64

Number of Basic Load Cases	5
Number of Combination Load Cases	6

Included in this printout are data for:

All

The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL (SELF WEIGHT)
Primary	2	EARTH PRESSURE (WT AT GROUND)
Primary	3	HYDROSTATIC (WT AT GROUND)
Primary	4	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYMM
Combination	101	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)
Combination	102	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE
Combination	103	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE
Combination	201	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)
Combination	202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE
Combination	203	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.000	9.700	0.000
19	13.450	7.650	0.000
20	13.450	6.800	0.000
21	13.450	5.950	0.000
22	13.450	5.100	0.000
23	13.450	4.250	0.000
24	13.450	3.400	0.000
25	13.450	2.550	0.000
26	13.450	1.700	0.000

Signature
Date
Rob
CSa
SPa



Software licensed to

Job No

Sheet No

2

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
30	0.000	2.550	0.000
31	0.000	3.400	0.000
32	0.000	4.250	0.000
33	0.000	5.100	0.000
34	0.000	5.950	0.000
35	0.000	6.800	0.000
36	0.000	7.650	0.000
41	8.967	0.000	0.000
42	8.070	0.000	0.000
43	7.173	0.000	0.000
44	6.277	0.000	0.000
45	5.380	0.000	0.000
46	4.483	0.000	0.000
47	3.587	0.000	0.000
48	2.690	0.000	0.000
49	1.793	0.000	0.000
50	0.897	0.000	0.000
51	9.750	0.000	0.000
53	13.450	0.000	0.000
54	13.450	9.700	0.000
58	10.675	0.000	0.000
59	11.600	0.000	0.000
60	12.525	0.000	0.000
61	0.000	8.675	0.000
62	13.450	8.675	0.000
63	-1.500	0.000	0.000
64	14.950	0.000	0.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
2	54	62	1.025	1	0
4	1	28	0.850	1	0
19	19	20	0.850	1	0
20	20	21	0.850	1	0
21	21	22	0.850	1	0
22	22	23	0.850	1	0
23	23	24	0.850	1	0
24	24	25	0.850	1	0
25	25	26	0.850	1	0
26	26	27	0.850	1	0
27	27	53	0.850	1	0
28	28	29	0.850	1	0
29	29	30	0.850	1	0
30	30	31	0.850	1	0

Handwritten signatures and initials:
1. *Amir*
2. *Adai*
3. *Rob*
4. *CSA*
5. *John*



Software licensed to

Job No

Sheet No

3

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
31	31	32	0.850	1	0
32	32	33	0.850	1	0
33	33	34	0.850	1	0
34	34	35	0.850	1	0
35	35	36	0.850	1	0
36	36	61	1.025	1	0
41	41	42	0.897	1	0
42	42	43	0.897	1	0
43	43	44	0.897	1	0
44	44	45	0.897	1	0
45	45	46	0.897	1	0
46	46	47	0.897	1	0
47	47	48	0.897	1	0
48	48	49	0.897	1	0
49	49	50	0.897	1	0
50	50	1	0.897	1	0
51	51	41	0.783	1	0
56	51	58	0.925	1	0
57	58	59	0.925	1	0
58	59	60	0.925	1	0
59	60	53	0.925	1	0
60	61	2	1.025	1	0
61	62	19	1.025	1	0
62	1	63	1.500	1	0
63	53	64	1.500	1	0
64	35	20	13.450	2	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 1.00x1.00	10E+3	8.33E+6	8.33E+6	14.1E+6	CONCRETE
2	Prismatic General	600.000	180E+3	360E+3	180E+3	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6



Software licensed to

Job No

Sheet No

4

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN`m/deg)	rY (kN`m/deg)	rZ (kN`m/deg)
1	Fixed	Fixed	Fixed	-	-	-
2	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
32	-	-	-	-	-	-
33	-	-	-	-	-	-
34	-	-	-	-	-	-
35	-	-	-	-	-	-
36	-	-	-	-	-	-
41	-	-	-	-	-	-
42	-	-	-	-	-	-
43	-	-	-	-	-	-
44	-	-	-	-	-	-
45	-	-	-	-	-	-
46	-	-	-	-	-	-
47	-	-	-	-	-	-
48	-	-	-	-	-	-
49	-	-	-	-	-	-
50	-	-	-	-	-	-
51	-	-	-	-	-	-
53	Fixed	Fixed	Fixed	-	-	-
54	-	-	-	-	-	-
58	-	-	-	-	-	-
59	-	-	-	-	-	-
60	-	-	-	-	-	-
61	-	-	-	-	-	-
62	-	-	-	-	-	-
63	-	-	-	-	-	-
64	-	-	-	-	-	-

Releases

There is no data of this type.

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

5

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT AT GROUND)	Live
3	HYDROSTATIC (WT AT GROUND)	Live
4	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYMM	Live

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
101	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT AT GROUND)	1.50
		3	HYDROSTATIC (WT AT GROUND)	1.50
102	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE	1	DL (SELF WEIGHT)	1.50
		4	EARTH PRESSURE (DRY)	1.50
		7	SURCHARGE SYMM	1.50
103	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT AT GROUND)	1.50
		3	HYDROSTATIC (WT AT GROUND)	1.50
		7	SURCHARGE SYMM	1.50
201	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT AT GROUND)	1.00
		3	HYDROSTATIC (WT AT GROUND)	1.00
202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	1	DL (SELF WEIGHT)	1.00
		7	SURCHARGE SYMM	1.00
		4	EARTH PRESSURE (DRY)	1.00
203	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT AT GROUND)	1.00
		7	SURCHARGE SYMM	1.00
		3	HYDROSTATIC (WT AT GROUND)	1.00

Load Generators

There is no data of this type.

1 DL (SELF WEIGHT) : Selfweight

Direction	Factor	Assigned Geometry
Y	-1.000	ALL

Handwritten signatures and initials:
1. *Amir*
2. *Rob*
3. *CSA*
4. *John*



Software licensed to

Job No

Sheet No

6

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

2 EARTH PRESSURE (WT AT GROUND) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	TRAP kN/m	GX	0.000	-	-4.015	-	-
4	TRAP kN/m	GX	38.000	-	34.670	-	-
19	TRAP kN/m	GX	-8.031	-	-11.361	-	-
20	TRAP kN/m	GX	-11.361	-	-14.691	-	-
21	TRAP kN/m	GX	-14.691	-	-18.021	-	-
22	TRAP kN/m	GX	-18.021	-	-21.351	-	-
23	TRAP kN/m	GX	-21.351	-	-24.680	-	-
24	TRAP kN/m	GX	-24.680	-	-28.010	-	-
25	TRAP kN/m	GX	-28.010	-	-31.340	-	-
26	TRAP kN/m	GX	-31.340	-	-34.670	-	-
27	TRAP kN/m	GX	-34.670	-	-38.000	-	-
28	TRAP kN/m	GX	34.670	-	31.340	-	-
29	TRAP kN/m	GX	31.340	-	28.010	-	-
30	TRAP kN/m	GX	28.010	-	24.680	-	-
31	TRAP kN/m	GX	24.680	-	21.351	-	-
32	TRAP kN/m	GX	21.351	-	18.021	-	-
33	TRAP kN/m	GX	18.021	-	14.691	-	-
34	TRAP kN/m	GX	14.691	-	11.361	-	-
35	TRAP kN/m	GX	11.361	-	8.031	-	-
36	TRAP kN/m	GX	8.031	-	4.015	-	-
60	TRAP kN/m	GX	4.015	-	0.000	-	-
61	TRAP kN/m	GX	-4.015	-	-8.031	-	-
62	UNI kN/m	GY	-88.000	-	-	-	-
63	UNI kN/m	GY	-88.000	-	-	-	-

3 HYDROSTATIC (WT AT GROUND) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	TRAP kN/m	GX	0.000	-	-10.250	-	-
4	TRAP kN/m	GX	97.000	-	88.500	-	-
19	TRAP kN/m	GX	-20.500	-	-29.000	-	-
20	TRAP kN/m	GX	-29.000	-	-37.500	-	-
21	TRAP kN/m	GX	-37.500	-	-46.000	-	-
22	TRAP kN/m	GX	-46.000	-	-54.500	-	-
23	TRAP kN/m	GX	-54.500	-	-63.000	-	-
24	TRAP kN/m	GX	-63.000	-	-71.500	-	-
25	TRAP kN/m	GX	-71.500	-	-80.000	-	-
26	TRAP kN/m	GX	-80.000	-	-88.500	-	-
27	TRAP kN/m	GX	-88.500	-	-97.000	-	-
28	TRAP kN/m	GX	88.500	-	80.000	-	-
29	TRAP kN/m	GX	80.000	-	71.500	-	-
30	TRAP kN/m	GX	71.500	-	63.000	-	-
31	TRAP kN/m	GX	63.000	-	54.500	-	-
32	TRAP kN/m	GX	54.500	-	46.000	-	-
33	TRAP kN/m	GX	46.000	-	37.500	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

7

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

3 HYDROSTATIC (WT AT GROUND) : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
34	TRAP kN/m	GX	37.500	-	29.000	-	-
35	TRAP kN/m	GX	29.000	-	20.500	-	-
36	TRAP kN/m	GX	20.500	-	10.250	-	-
41	UNI kN/m	GY	97.000	-	-	-	-
42	UNI kN/m	GY	97.000	-	-	-	-
43	UNI kN/m	GY	97.000	-	-	-	-
44	UNI kN/m	GY	97.000	-	-	-	-
45	UNI kN/m	GY	97.000	-	-	-	-
46	UNI kN/m	GY	97.000	-	-	-	-
47	UNI kN/m	GY	97.000	-	-	-	-
48	UNI kN/m	GY	97.000	-	-	-	-
49	UNI kN/m	GY	97.000	-	-	-	-
50	UNI kN/m	GY	97.000	-	-	-	-
51	UNI kN/m	GY	97.000	-	-	-	-
56	UNI kN/m	GY	97.000	-	-	-	-
57	UNI kN/m	GY	97.000	-	-	-	-
58	UNI kN/m	GY	97.000	-	-	-	-
59	UNI kN/m	GY	97.000	-	-	-	-
60	TRAP kN/m	GX	10.250	-	0.000	-	-
61	TRAP kN/m	GX	-10.250	-	-20.500	-	-
62	UNI kN/m	GY	97.000	-	-	-	-
63	UNI kN/m	GY	97.000	-	-	-	-

4 EARTH PRESSURE (DRY) : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	TRAP kN/m	GX	0.000	-	-8.454	-	-
4	TRAP kN/m	GX	80.000	-	72.990	-	-
19	TRAP kN/m	GX	-16.907	-	-23.917	-	-
20	TRAP kN/m	GX	-23.917	-	-30.928	-	-
21	TRAP kN/m	GX	-30.928	-	-37.938	-	-
22	TRAP kN/m	GX	-37.938	-	-44.949	-	-
23	TRAP kN/m	GX	-44.949	-	-51.959	-	-
24	TRAP kN/m	GX	-51.959	-	-58.969	-	-
25	TRAP kN/m	GX	-58.969	-	-65.979	-	-
26	TRAP kN/m	GX	-65.979	-	-72.990	-	-
27	TRAP kN/m	GX	-72.990	-	-80.000	-	-
28	TRAP kN/m	GX	72.990	-	65.979	-	-
29	TRAP kN/m	GX	65.979	-	58.969	-	-
30	TRAP kN/m	GX	58.969	-	51.959	-	-
31	TRAP kN/m	GX	51.959	-	44.949	-	-
32	TRAP kN/m	GX	44.949	-	37.938	-	-
33	TRAP kN/m	GX	37.938	-	30.928	-	-
34	TRAP kN/m	GX	30.928	-	23.917	-	-
35	TRAP kN/m	GX	23.917	-	16.907	-	-

Handwritten signatures and initials:
- Top signature: [unclear]
- Middle signature: [unclear]
- Below that: Rob
- Below that: [unclear]
- Bottom signature: [unclear]



Software licensed to

Job No

Sheet No

8

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

4 EARTH PRESSURE (DRY) : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
36	TRAP kN/m	GX	16.907	-	8.454	-	-
60	TRAP kN/m	GX	8.454	-	0.000	-	-
61	TRAP kN/m	GX	-8.454	-	-16.907	-	-
62	UNI kN/m	GY	-185.000	-	-	-	-
63	UNI kN/m	GY	-185.000	-	-	-	-

7 SURCHARGE SYMM : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	UNI kN/m	GX	-30.000	-	-	-	-
4	UNI kN/m	GX	30.000	-	-	-	-
19	UNI kN/m	GX	-30.000	-	-	-	-
20	UNI kN/m	GX	-30.000	-	-	-	-
21	UNI kN/m	GX	-30.000	-	-	-	-
22	UNI kN/m	GX	-30.000	-	-	-	-
23	UNI kN/m	GX	-30.000	-	-	-	-
24	UNI kN/m	GX	-30.000	-	-	-	-
25	UNI kN/m	GX	-30.000	-	-	-	-
26	UNI kN/m	GX	-30.000	-	-	-	-
27	UNI kN/m	GX	-30.000	-	-	-	-
28	UNI kN/m	GX	30.000	-	-	-	-
29	UNI kN/m	GX	30.000	-	-	-	-
30	UNI kN/m	GX	30.000	-	-	-	-
31	UNI kN/m	GX	30.000	-	-	-	-
32	UNI kN/m	GX	30.000	-	-	-	-
33	UNI kN/m	GX	30.000	-	-	-	-
34	UNI kN/m	GX	30.000	-	-	-	-
35	UNI kN/m	GX	30.000	-	-	-	-
36	UNI kN/m	GX	30.000	-	-	-	-
60	UNI kN/m	GX	30.000	-	-	-	-
61	UNI kN/m	GX	-30.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

9

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

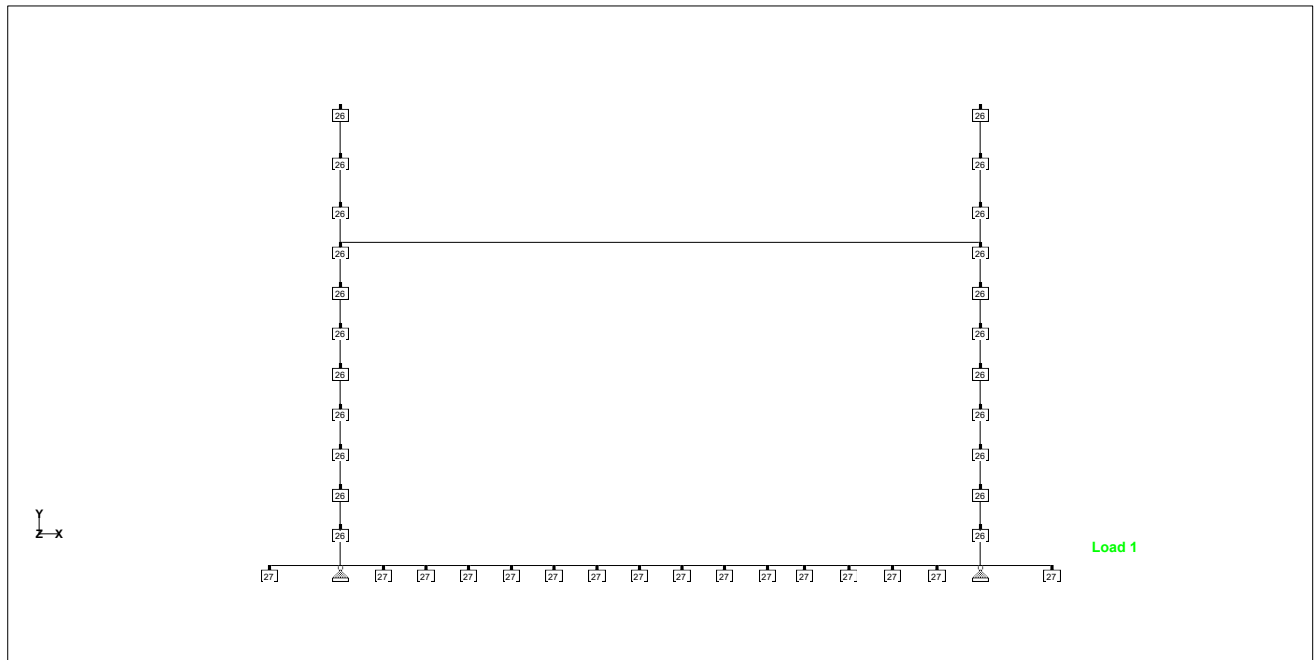
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02



Whole Structure (Input data was modified after picture taken)

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

10

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

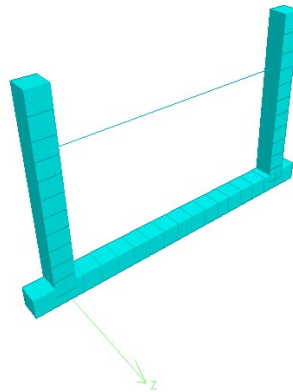
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02



3D Rendered View (Input data was modified after picture taken)

Signature
ADai
Rob
CSA
Signature



Software licensed to

Job No

Sheet No

11

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

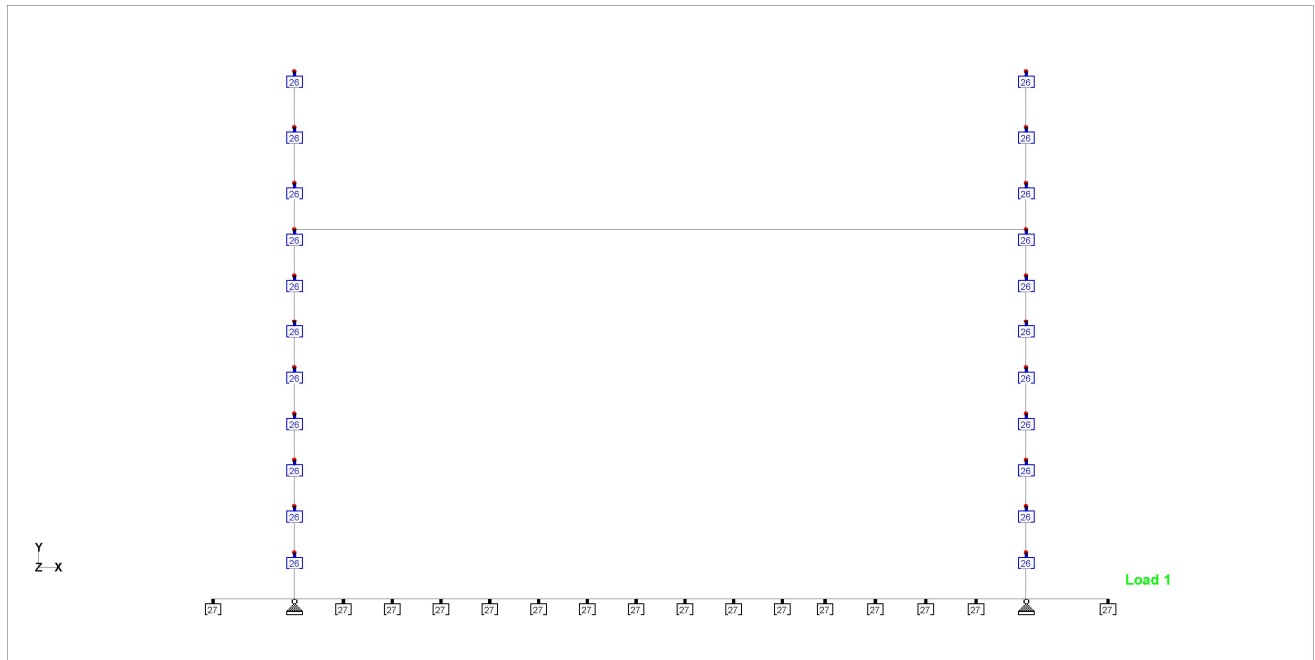
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02



SUPPORTS (Input data was modified after picture taken)

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

12

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

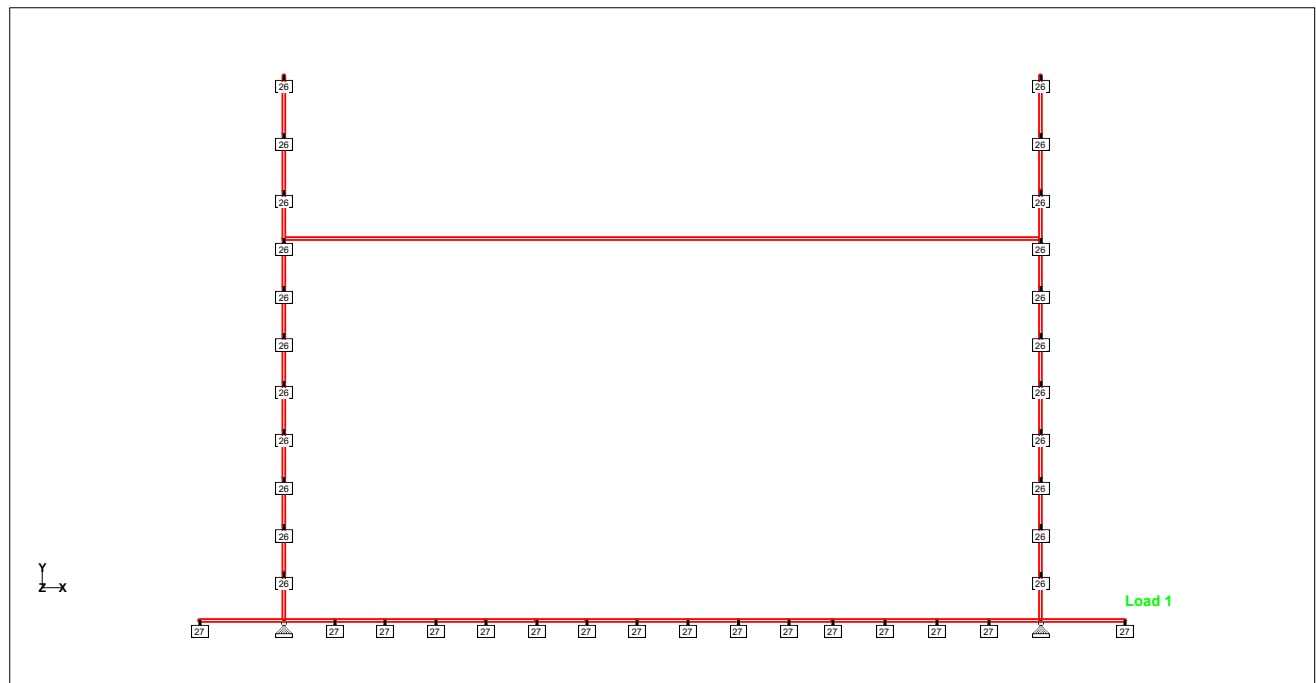
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02



DL (Input data was modified after picture taken)

Handwritten signatures and initials:
[Signature]
[Signature]
[Signature]
[Signature]
[Signature]



Software licensed to

Job No

Sheet No

13

Rev

A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

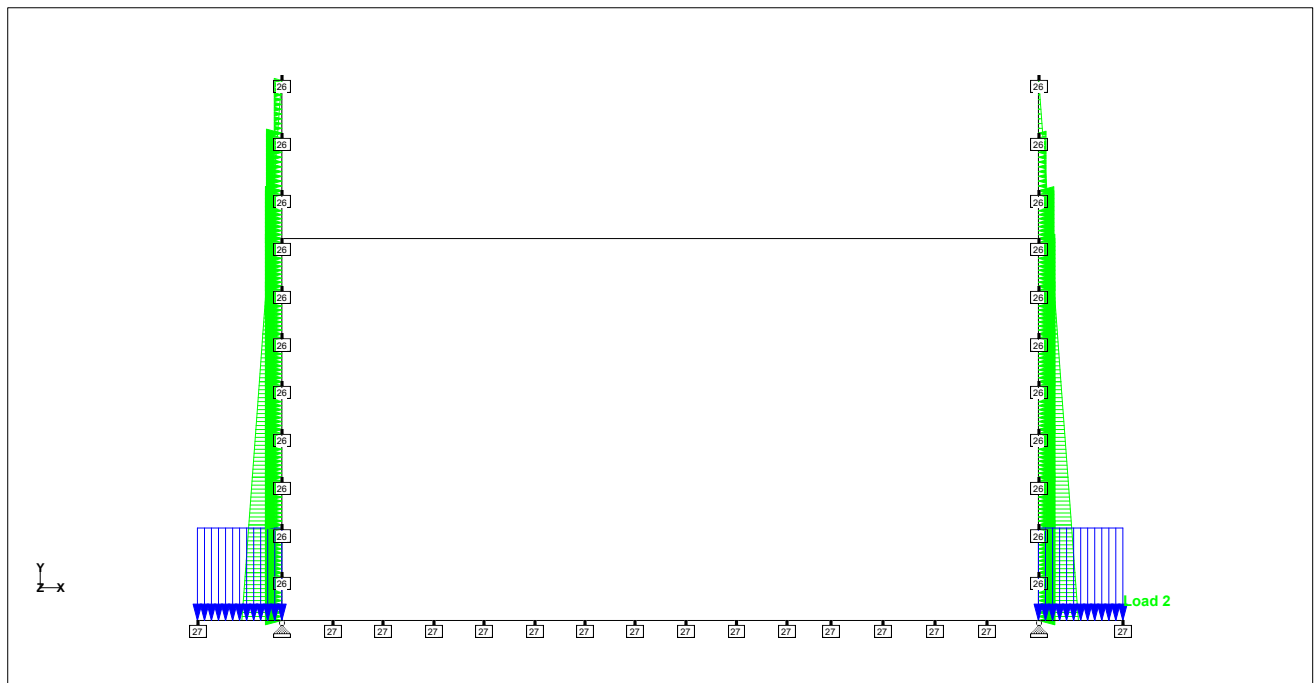
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02



EP (Input data was modified after picture taken)

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

14

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

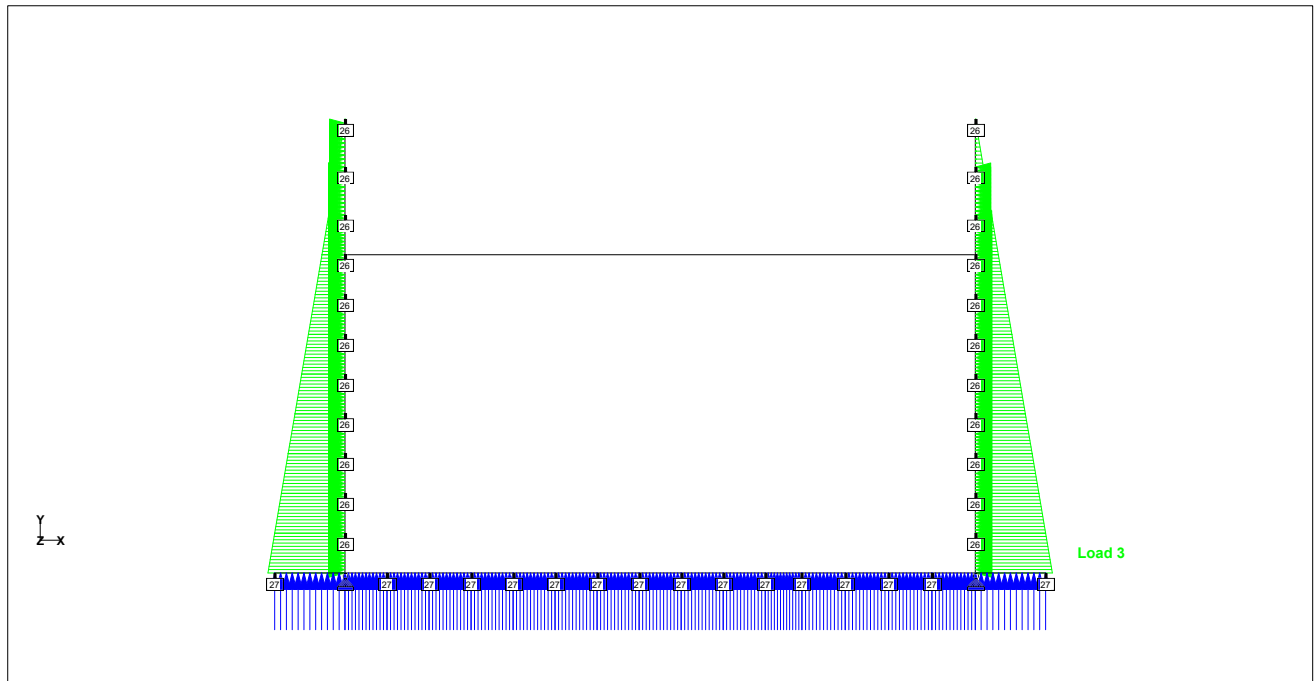
Date 03-Sep-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02



WATER (Input data was modified after picture taken)

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

15

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

Date 03-Sep-24

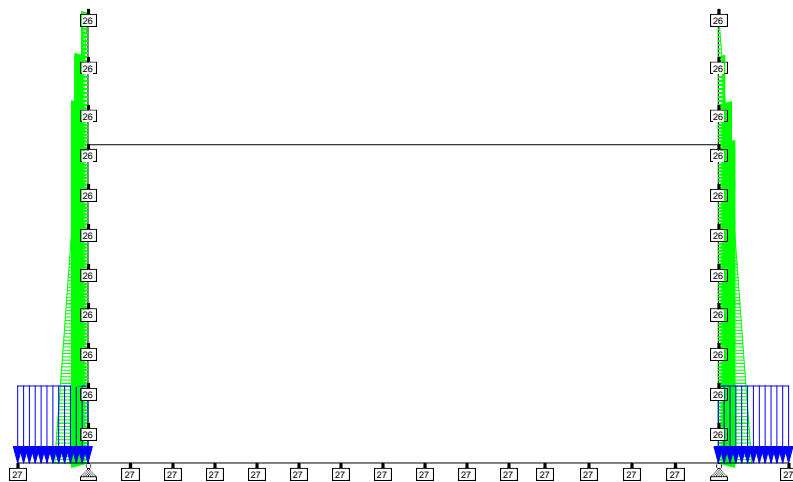
Chd CSa

Client

File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02

Y
Z-X



EP(DRY) (Input data was modified after picture taken)

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

16

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

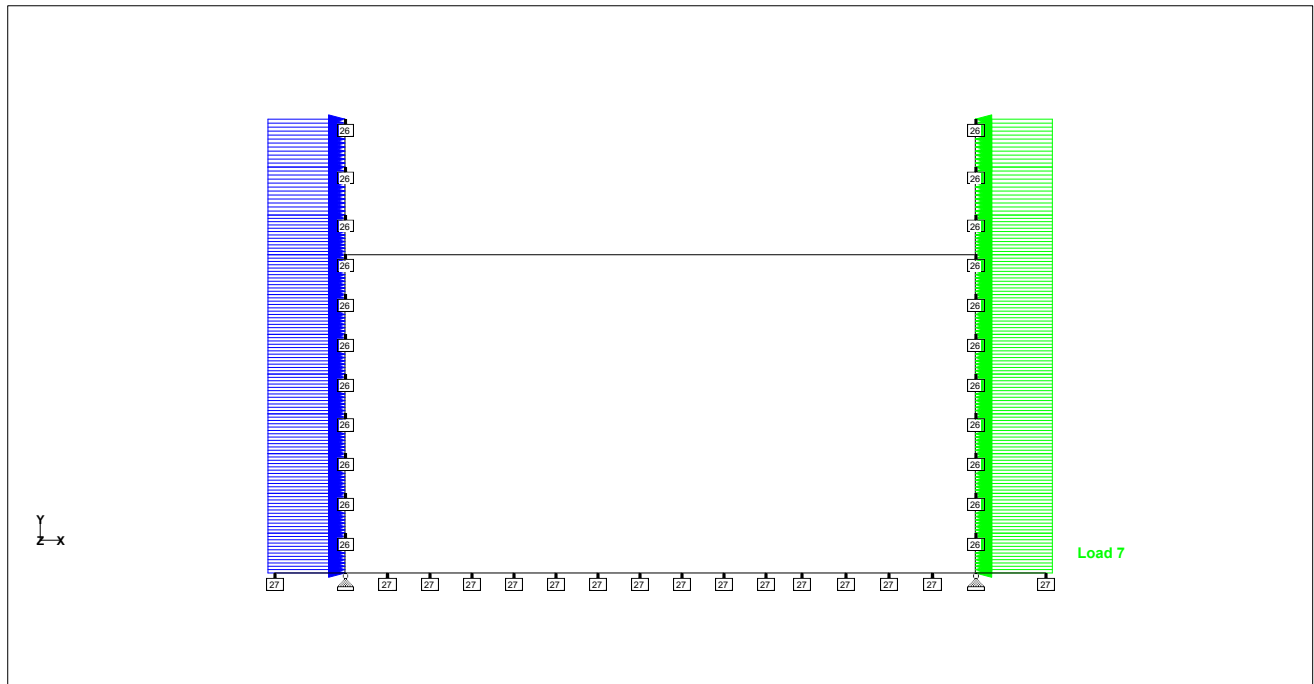
Date 03-Sep-24

Chd CSa

Client

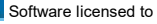
File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02



SURCHARGE (Input data was modified after picture taken)

Signature
Rob
CSA
Signature

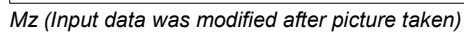


Sheet No

Rev

Chd CSa

Date/Time 11-Sep-2024 16:02



Lachner
~~Adair~~
 Rob
 P. S. Low
 J. S. Low



Software licensed to

Job No

Sheet No

18

Rev
A

Part

Job Title I40172_C&C (3 lane)

Ref

By KCh

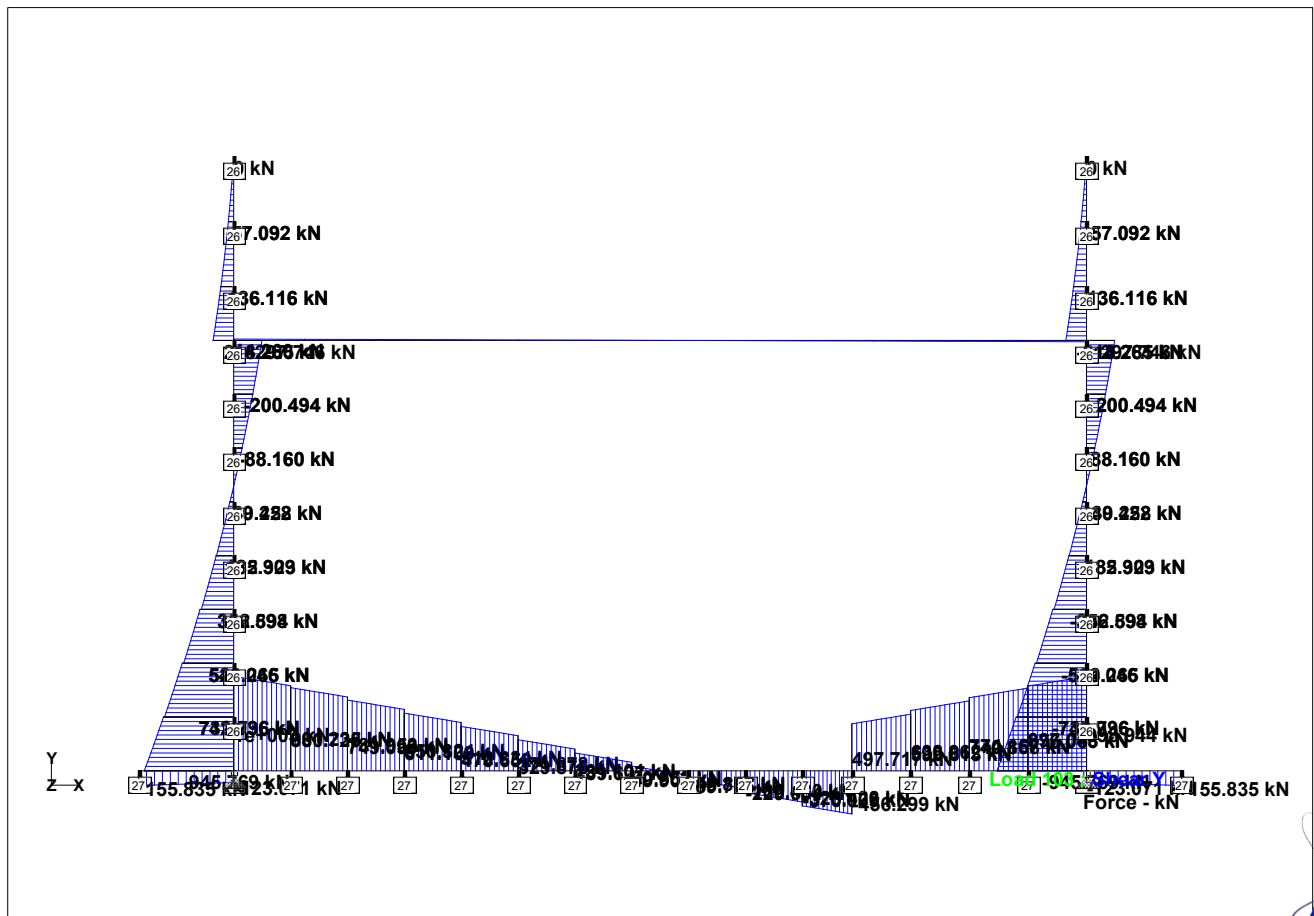
Date 03-Sep-24

Chd CSa

Client

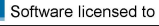
File I40172_RAMP section (3

Date/Time 11-Sep-2024 16:02



SHEAR

[Handwritten signatures and initials]



Sheet No

Rev

Chd CSa

Date/Time 11-Sep-2024 16:02



Handwritten signatures: Handwritten, ~~Handwritten~~, Rob, Handwritten, Handwritten

	GEOCONSULT India Pvt Ltd	APPENDIX-2	
	A company of the GEOCONSULT group	Job no:	I40172
		Page No.:	2
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for	Design of Base Slab(1000mm thk) - RAMP (2 lane)		

DESIGN OF BASE SLAB- RAMP

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1000 mm
Unit width of slab	b	=	1000 mm

3)Design for Support Moment (Earth Face)

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (From STAAD)		=	1230 kNm
Effective Thickness		=	1103 mm
d'		=	101 mm
Mu/bd ²		=	1.012
Mulim		=	5658.18 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	14557.86
Mu2	$=Mu - Mulim$	=	-4428.18
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-10164.48
Ast	$=Astlim + Ast2$	=	4393.38
d'/d	0.09	=	0.10
fsc	Refer Table F SP 16 pg 13	=	412.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-11154.54







Minimum area of steel required (0.12% on each face in one direction)	=	1323.00 mm ²	
Required area of steel	Ast =	0.40%	4393.38 mm ²
Refer Table 2 SP 16 pg 48	Asc =	-1.01%	-11154.54 mm ²
Side Face bars are required			
Tension Reinforcement (Ast)			
Required spacing of bars	=	111.7 mm	
Provided spacing	=	100 mm	
Provide 1 layers	25mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	9817.5 mm ²	OK
Compression Reinforcement (Asc)			
Required spacing of bars	=	-44.0 mm	
Provided spacing	=	100 mm	
Provide 1 layer	25mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	4908.7 mm ²	OK

2m from sidewall

Design Moments

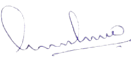
Minimum thickness of the slab	D =	1000 mm	
Max factored bending moment (From STAAD)	=	0 kNm	
Effective Thickness	2m+0.5m away from the support	913 mm	
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
Minimum area of steel required (0.12% on each face in one direction)	=	0.00 mm ²	
Required area of steel	=	1095.00 mm ²	
Required spacing of bars	=	448.3 mm	
Provided spacing	=	100 mm	
Provide 1 layers	25mm dia bars @ 100 mm c/c on bottom face		
Area of steel provided	=	4908.7 mm ²	OK

4) Design for Span Moment (Inside)

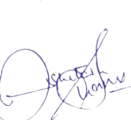
Gross area	Ag =	1000000 mm ²	
Design Moments			
Minimum thickness of the slab	D =	1000 mm	
Max factored bending moment (from STAAD)	=	563 kNm	
Effective Thickness	=	913 mm	
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
Minimum area of steel required (0.12% on each face in one direction)	=	1452.08 mm ²	
Required area of steel	=	1095.00 mm ²	
Required spacing of bars	=	325 mm	
Provided spacing	=	100 mm	
Provide 1 layers	25mm dia bars @ 100 mm c/c on both faces		
Area of steel provided	=	4908.7 mm ²	OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of			
0.12 % of Cross Sectional Area	=	1323 mm ²	
0.2 Times of Main Bar	=	982 mm ²	
Longitudinal Bar Required at Each Face	=	1323 mm ²	
Steel Provided			
16 Dia Bar at 150 mm c/c			
Area of Steel Provided	=	1340 mm ²	



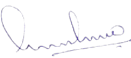




6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	690.0	kN	
Effective Shear Area	=	1000000	mm ²	
Shear Stress in Base Slab	=	0.69	N/mm ²	
Allowable Shear Stress	=	0.40	N/mm ²	
Shear force against which stirrups required	=	228	KN	
Considering 8mm Dia shear link at 100 mm c/c				
Spacing of stirrups	=	398	mm	61.92570736
Provide shear reinforcement at	=	200	mm c/c	
Provide this Shear Reinforcement up to 2m from sidewall .				235.619449







	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1000mm thk) - C&C box (2 lane)			

Check for crack width For Base Slab (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

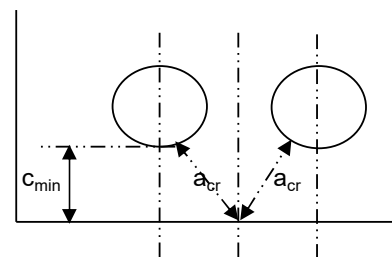
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	820000000	
Axial Force (P) (N) =	1453000	
Tension R/F=	25T	100c/c
	T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	890
A_{st} (mm ² /m) =	4908.738521
p_t (ratio)=	0.005515437
x (mm) =	212.12
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	18432550962

safe



(fig 1)

[Handwritten signatures and initials]

$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.001019472$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00112$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00010$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00102$$

$$\text{Average strain } e_m = 0.000726461$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min}(mm) = 45 - 30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(mm) = 63.70 \text{ mm}$$

$$\text{crack width (mm) } w = 0.133 < 0.2 \text{ mm}$$

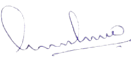
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

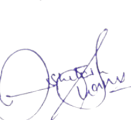
$$a_{cr}(mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0981 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd	APPENDIX-2	
	A company of the GEOCONSULT group	Job no:	I40172
		Page No.:	2
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for	Design of Side Wall(1000mm thk) - RAMP (2 lane)		

DESIGN OF SIDE WALL (1000 mm THK)-RAMP

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Side Wall

Minimum thickness of the Wall	D	=	1000 mm
Unit width of Wall	b	=	1000 mm

3)Design for Reinforcement Earth Side

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	1236 kNm
Effective Thickness		=	903 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_u / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	3324.91 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1083.00 mm ²
Required area of steel		=	3324.91 mm ²
Required spacing of bars		=	147.6 mm
Provided spacing		=	100 mm
Provide 1 layers 25mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	4908.7 mm ²

OK

Above 2m from base slab

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	182 kNm
Effective Thickness		=	915 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_u / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	460.80 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1098.00 mm ²
Required area of steel		=	1098.00 mm ²
Required spacing of bars		=	286.1 mm
Provided spacing		=	100 mm
Provide 1 layers 20mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	3141.6 mm ²

OK








4) Design for Reinforcement Open Side

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (from STAAD)		=	281 kNm
Effective Thickness		=	915 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	714.30 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1098.00 mm ²
Required area of steel		=	1098.00 mm ²
Required spacing of bars		=	275 mm
Provided spacing		=	100 mm
Provide 20mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	3141.6 mm ²

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of			
0.12 % of Cross Sectional Area		=	1083 mm ²
0.2 Times of Main Bar		=	628 mm ²
Longitudinal Bar Required at Each Face		=	1083 mm ²
Steel Provided			
16 Dia Bar at 150 mm c/c			
Area of Steel Provided	=	1340 mm ²	OK

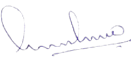
6) Check For Shear

Upto 2m from base slab

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	820.0 kN	
Effective Shear Area	=	1000000 mm ²	
Shear Stress in Side Wall	=	0.82 N/mm ²	109.5604119
Allowable Shear Stress	=	0.40 N/mm ²	
Shear force against which stirrups required	=	330 KN	
Considering 8mm Dia shear link at 200 mm c/c			
Spacing of stirrups	=	275 mm	314.1592654
Provide shear reinforcement at	=	200 mm c/c	

Provide this Shear Reinforcement up to 2m of height from baseslab .








	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Side wall (1000mm thk)			

Check for crack width For Side Wall (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

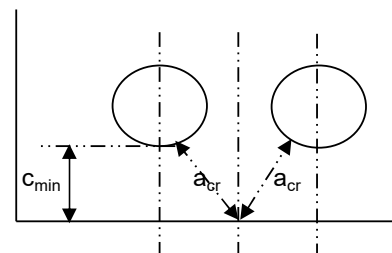
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	824000000	
Axial Force (P) (N) =	2988000	
Tension R/F=	25T	100c/c
	T	85c/c
	T	85c/c
	T	mm
Diameter of Spacer Bar=	T	
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	890
A_{st} (mm ² /m) =	4908.738521
p_t (ratio)=	0.005515437
x (mm) =	212.12
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	18432550962

safe



(fig 1)

[Handwritten signatures and initials]

$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.001024445$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00113$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00021$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00092$$

$$\text{Average strain } e_m = 0.000622973$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 - 30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr} (mm) = 63.70 \text{ mm}$$

$$\text{crack width (mm) } w = 0.114 < 0.2 \text{ mm}$$

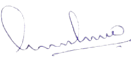
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0841 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	2	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Base Slab(1000mm thk) - RAMP (3 lane)			

DESIGN OF BASE SLAB- RAMP

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1000 mm
Unit width of slab	b	=	1000 mm

3)Design for Support Moment (Earth Face)

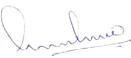
Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	2099 kNm
Effective Thickness		=	899 mm
d'		=	101 mm
Mu/bd ²		=	2.597
Mulim		=	3762.18 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{b^2 - 4ac})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	11870.76
Mu2	$=Mu - Mulim$	=	-1663.18
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-4791.22
Ast	$=Astlim + Ast2$	=	7079.55
d'/d	0.11	=	0.15
fsc	Refer Table F SP 16 pg 13	=	395.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-5493.50







Minimum area of steel required (0.12% on each face in one direction)	=	1078.80 mm ²
Required area of steel	Ast =	0.79% = 7079.55 mm ²
Refer Table 2 SP 16 pg 48	Asc =	-0.61% = -5493.50 mm ²

Side Face bars are required

Tension Reinforcement (Ast)

Required spacing of bars	=	113.6 mm
Provided spacing	=	100 mm
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	8042.5 mm ²

OK

Compression Reinforcement (Asc)

Required spacing of bars	=	-89.4 mm
Provided spacing	=	100 mm
Provide 1 layer	25mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	4908.7 mm ²

OK

2m from sidewall

Design Moments

Minimum thickness of the slab	D =	1200 mm
Max factored bending moment (From STAAD)	=	0 kNm

2m+0.5m away from the support

Effective Thickness	=	1109 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$

Minimum area of steel required (0.12% on each face in one direction)	=	1330.80 mm ²
--	---	-------------------------

Required area of steel	=	1330.80 mm ²
Required spacing of bars	=	604.3 mm
Provided spacing	=	100 mm
Provide 1 layers	32mm dia bars @ 100 mm c/c on bottom face	
Area of steel provided	=	8042.5 mm ²

OK

4) Design for Span Moment (Inside)

Gross area	Ag =	1000000 mm ²
------------	------	-------------------------

Design Moments

Minimum thickness of the slab	D =	1000 mm
Max factored bending moment (from STAAD)	=	1395 kNm

Effective Thickness	=	913 mm
---------------------	---	--------

Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$
------------------------	---	---

	=	3734.51 mm ²
--	---	-------------------------

Minimum area of steel required (0.12% on each face in one direction)	=	1095.00 mm ²
--	---	-------------------------

Required area of steel	=	3734.51 mm ²
------------------------	---	-------------------------

Required spacing of bars	=	125 mm
--------------------------	---	--------

Provided spacing	=	100 mm
------------------	---	--------

Provide 1 layers	25mm dia bars @ 100 mm c/c on both faces	
------------------	--	--

Area of steel provided	=	4908.7 mm ²
------------------------	---	------------------------

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.12 % of Cross Sectional Area	=	1078.8 mm ²
--------------------------------	---	------------------------

0.2 Times of Main Bar	=	982 mm ²
-----------------------	---	---------------------

Longitudinal Bar Required at Each Face	=	1079 mm ²
--	---	----------------------

Steel Provided

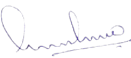
16	Dia Bar	at	150	mm c/c
Area of Steel Provided	=	1340	mm ²	

[Handwritten signatures and initials]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	1656.0	kN	
Effective Shear Area	=	1000000	mm ²	
Shear Stress in Base Slab	=	1.66	N/mm ²	
Allowable Shear Stress	=	0.40	N/mm ²	
Shear force against which stirrups required	=	986	KN	
Considering 10mm Dia shear link at 100 mm c/c				
Spacing of stirrups	=	287	mm	328.9133674
Provide shear reinforcement at	=	100	mm	c/c
Provide this Shear Reinforcement up to 2m from sidewall .				235.619449







	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1000mm thk) - RAMP sec (3 lane)			

Check for crack width For Base Slab (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

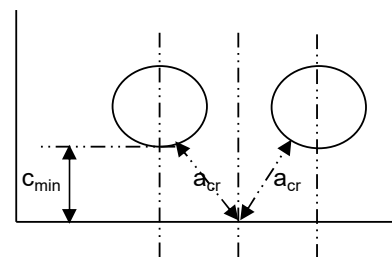
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1399333333	
Axial Force (P) (N) =	1443000	
Tension R/F=	32T	100c/c
	T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	883
A_{st} (mm ² /m) =	8042.477193
p_t (ratio)=	0.009108128
x (mm) =	260.24
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	26963965868

safe



(fig 1)

[Handwritten signatures and initials]

$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.001092574$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00123$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00010$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00113$$

$$\text{Average strain } e_m = 0.000952965$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 - 30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr} (mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.171 < 0.2 \text{ mm}$$

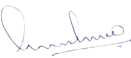
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1287 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Base Slab(1000mm thk) - C&C box (2 lane)			

Check for crack width For Base Slab (At mid)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

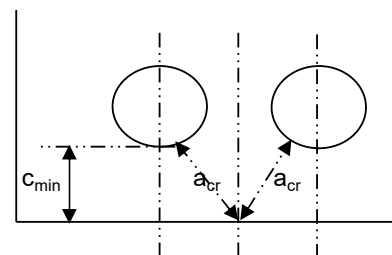
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	930000000	
Axial Force (P) (N) =	1008000	
Tension R/F=	25T	100c/c
	T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	890
A_{st} (mm ² /m) =	4908.738521
p_t (ratio)=	0.005515437
x (mm) =	212.12
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	18432550962

safe



(fig 1)

[Handwritten signatures and initials]

$$a'(\text{mm}) = 960$$

Strain in concrete at the level of steel

$$e_s = 0.00115623$$

Strain in concrete at the outer most tension face

$$e_1 = 0.00128$$

Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00007$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00120$$

$$\text{Average strain } e_m = 0.000908933$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{\min}(\text{mm}) = 45$$

$$-30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr}(\text{mm}) = 63.70 \text{ mm}$$

$$\text{crack width (mm) } w = 0.166 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr}(\text{mm}) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1227 < 0.2 \text{ mm}$$

OK

Handwritten signatures:
 1. *[Signature]*
 2. *[Signature]*
 3. *[Signature]*
 4. *[Signature]*
 5. *[Signature]*

	GEOCONSULT India Pvt Ltd	APPENDIX-2	
	A company of the GEOCONSULT group	Job no:	I40172
		Page No.:	2
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for	Design of Side Wall(1000mm thk) - RAMP (3 lane)		

DESIGN OF SIDE WALL (1000 mm THK)-RAMP

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Side Wall

Minimum thickness of the Wall	D	=	1000 mm
Unit width of Wall	b	=	1000 mm

3)Design for Reinforcement Earth Side

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	1890 kNm
Effective Thickness		=	899 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	5278.05 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1078.80 mm ²
Required area of steel		=	5278.05 mm ²
Required spacing of bars		=	152.4 mm
Provided spacing		=	100 mm
Provide 1 layers 32mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	8042.5 mm ²

OK

Above 2m from base slab

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	632 kNm
Effective Thickness		=	909 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	1641.46 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1090.80 mm ²
Required area of steel		=	1641.46 mm ²
Required spacing of bars		=	490.0 mm
Provided spacing		=	100 mm
Provide 1 layers 32mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	8042.5 mm ²

OK








4) Design for Reinforcement Open Side

Design Moments

Minimum thickness of the slab	D	=	1200 mm
Max factored bending moment (from STAAD)		=	0 kNm
Effective Thickness		=	1115 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_e / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	0.00 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1338.00 mm ²
Required area of steel		=	1338.00 mm ²
Required spacing of bars		=	225 mm
Provided spacing		=	100 mm
Provide 20mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	3141.6 mm ²

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of			
0.12 % of Cross Sectional Area		=	1078.8 mm ²
0.2 Times of Main Bar		=	628 mm ²
Longitudinal Bar Required at Each Face		=	1079 mm ²
Steel Provided			
16 Dia Bar at 150 mm c/c			
Area of Steel Provided	=	1340 mm ²	OK

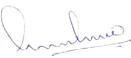
6) Check For Shear

Upto 2m from base slab

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u	=	945.0 kN	
Effective Shear Area	=	1000000 mm ²	
Shear Stress in Side Wall	=	0.95 N/mm ²	142.7211666
Allowable Shear Stress	=	0.40 N/mm ²	
Shear force against which stirrups required	=	428 KN	
Considering 10mm Dia shear link at 200 mm c/c			
Spacing of stirrups	=	331 mm	314.1592654
Provide shear reinforcement at	=	200 mm c/c	

Provide this Shear Reinforcement up to 2m of height from baseslab .







	GEOCONSULT India Pvt Ltd		APPENDIX-2	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Crack Width Check For Side wall (1000mm thk)			

Check for crack width For Side Wall (At Support)

$$w = \frac{3 a_{cr} e_m}{1+2* \left[\frac{a_{cr} - C_{min}}{D - x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

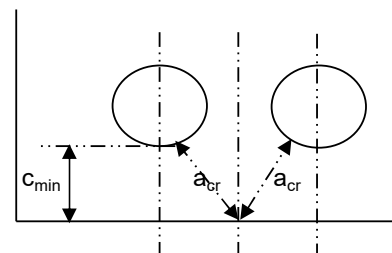
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1260000000	
Axial Force (P) (N) =	2988000	
Tension R/F=	32T	100c/c
	T	85c/c
	T	85c/c
	T	mm
Diameter of Spacer Bar=	T	
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	883
A_{st} (mm ² /m) =	8042.477193
p_t (ratio)=	0.009108128
x (mm) =	260.24
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	26963965868

safe



(fig 1)

[Handwritten signatures and initials]

$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.000983785$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00111$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00021$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00089$$

$$\text{Average strain } e_m = 0.000721041$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 - 30$$

Width of crack at a point on tension face midway between two bars.(fig. 1)

$$a_{cr} (mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.130 < 0.2 \text{ mm}$$

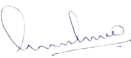
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0973 < 0.2 \text{ mm}$$

OK










Software licensed to

Job No

Sheet No

1

Rev

A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 03-Jan-2025 23:14

Job Information

	Engineer	Checked	Approved
Name:	KMp	CSa	SPa
Date:	23-Dec-24		

Project ID

Project Name

Structure Type

PLANE FRAME

Number of Nodes	56	Highest Node	80
Number of Elements	57	Highest Beam	82

Number of Basic Load Cases	11
Number of Combination Load Cases	0

Included in this printout are data for:

All

The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL (SELF WEIGHT)
Primary	2	EARTH PRESSURE (WT AT GROUND)
Primary	3	HYDROSTATIC (WT AT GROUND)
Primary	4	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYMM
Primary	101	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)
Primary	102	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE
Primary	103	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE
Primary	201	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)
Primary	202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE
Primary	204	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE

Nodes

Node	X (m)	Y (m)	Z (m)
1	-0.100	0.000	0.000
2	-0.100	9.700	0.000
19	26.800	7.650	0.000
20	26.800	6.800	0.000
21	26.800	5.950	0.000
22	26.800	5.100	0.000
23	26.800	4.250	0.000
24	26.800	3.400	0.000
25	26.800	2.550	0.000
26	26.800	1.700	0.000

Signature
Date
Rob
CSa
Date



Software licensed to

Job No

Sheet No

2Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By Kmp

Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 03-Jan-2025 23:14

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
30	-0.100	2.550	0.000
31	-0.100	3.400	0.000
32	-0.100	4.250	0.000
33	-0.100	5.100	0.000
34	-0.100	5.950	0.000
35	-0.100	6.800	0.000
36	-0.100	7.650	0.000
41	9.250	0.000	0.000
42	8.325	0.000	0.000
43	7.400	0.000	0.000
44	6.475	0.000	0.000
45	5.550	0.000	0.000
46	4.625	0.000	0.000
47	3.700	0.000	0.000
48	2.775	0.000	0.000
49	1.850	0.000	0.000
50	0.500	0.000	0.000
51	10.175	0.000	0.000
53	26.800	0.000	0.000
54	26.800	9.700	0.000
58	11.100	0.000	0.000
59	12.025	0.000	0.000
60	26.200	0.000	0.000
61	-0.100	8.675	0.000
62	26.800	8.675	0.000
63	-1.600	0.000	0.000
64	28.300	0.000	0.000
65	12.750	0.000	0.000
66	13.950	0.000	0.000
67	14.675	0.000	0.000
68	15.600	0.000	0.000
69	16.525	0.000	0.000
70	17.450	0.000	0.000
71	18.375	0.000	0.000
72	19.300	0.000	0.000
73	20.225	0.000	0.000
74	21.150	0.000	0.000
75	22.075	0.000	0.000
76	23.000	0.000	0.000
77	23.925	0.000	0.000
78	24.850	0.000	0.000
79	13.350	0.000	0.000
80	13.350	9.700	0.000

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

3

Rev

A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMP

Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3)

Date/Time 03-Jan-2025 23:14

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
2	54	62	1.025	1	0
4	1	28	0.600	1	0
19	19	20	0.850	1	0
20	20	21	0.850	1	0
21	21	22	0.850	1	0
22	22	23	0.850	1	0
23	23	24	0.850	1	0
24	24	25	0.850	1	0
25	25	26	0.850	1	0
26	26	27	1.100	1	0
27	27	53	0.600	1	0
28	28	29	1.100	1	0
29	29	30	0.850	1	0
30	30	31	0.850	1	0
31	31	32	0.850	1	0
32	32	33	0.850	1	0
33	33	34	0.850	1	0
34	34	35	0.850	1	0
35	35	36	0.850	1	0
36	36	61	1.025	1	0
41	41	42	0.925	2	0
42	42	43	0.925	2	0
43	43	44	0.925	2	0
44	44	45	0.925	2	0
45	45	46	0.925	2	0
46	46	47	0.925	2	0
47	47	48	0.925	2	0
48	48	49	0.925	2	0
49	49	50	1.350	2	0
50	50	1	0.600	2	0
51	51	41	0.925	2	0
56	51	58	0.925	2	0
57	58	59	0.925	2	0
58	59	65	0.725	2	0
59	60	53	0.600	2	0
60	61	2	1.025	1	0
61	62	19	1.025	1	0
62	1	63	1.500	2	0
63	53	64	1.500	2	0
65	65	79	0.600	2	0
66	66	67	0.725	2	0
67	67	68	0.925	2	0
68	68	69	0.925	2	0
69	69	70	0.925	2	0
70	70	71	0.925	2	0
71	71	72	0.925	2	0

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

4

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMP

Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3)

Date/Time 03-Jan-2025 23:14

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
72	72	73	0.925	2	0
73	73	74	0.925	2	0
74	74	75	0.925	2	0
75	75	76	0.925	2	0
76	76	77	0.925	2	0
77	77	78	0.925	2	0
78	78	60	1.350	2	0
79	79	66	0.600	2	0
80	79	80	9.700	1	0
81	2	80	13.450	3	0
82	80	54	13.450	3	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 1.20x1.00	12E+3	10E+6	14.4E+6	19.8E+6	CONCRETE
2	Rect 1.20x1.00	12E+3	10E+6	14.4E+6	19.8E+6	CONCRETE
3	Prismatic General	6E+3	180E+3	360E+3	180E+3	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT AT GROUND)	Live
3	HYDROSTATIC (WT AT GROUND)	Live
4	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYMM	Live
101	1.5DL + 1.5EP(GWT) + 1.5WL(GWT)	None
102	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE	None
103	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.5SURCHARGE	None
201	1.0DL + 1.0EP(GWT) + 1.0WL(GWT)	None
202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	None
204	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.0SURCHARGE	None

Handwritten signatures and initials:
- Top right: *Handwritten signature*
- Middle right: *Handwritten signature*
- Bottom right: *Handwritten signature*
- Far right: *Handwritten signature*



Software licensed to

Job No

Sheet No

5

Rev

A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 03-Jan-2025 23:14

Combination Load Cases

There is no data of this type.

Signature

Adair

Rob

CSA

CSA

CSA



Software licensed to

Job No

Sheet No

6

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

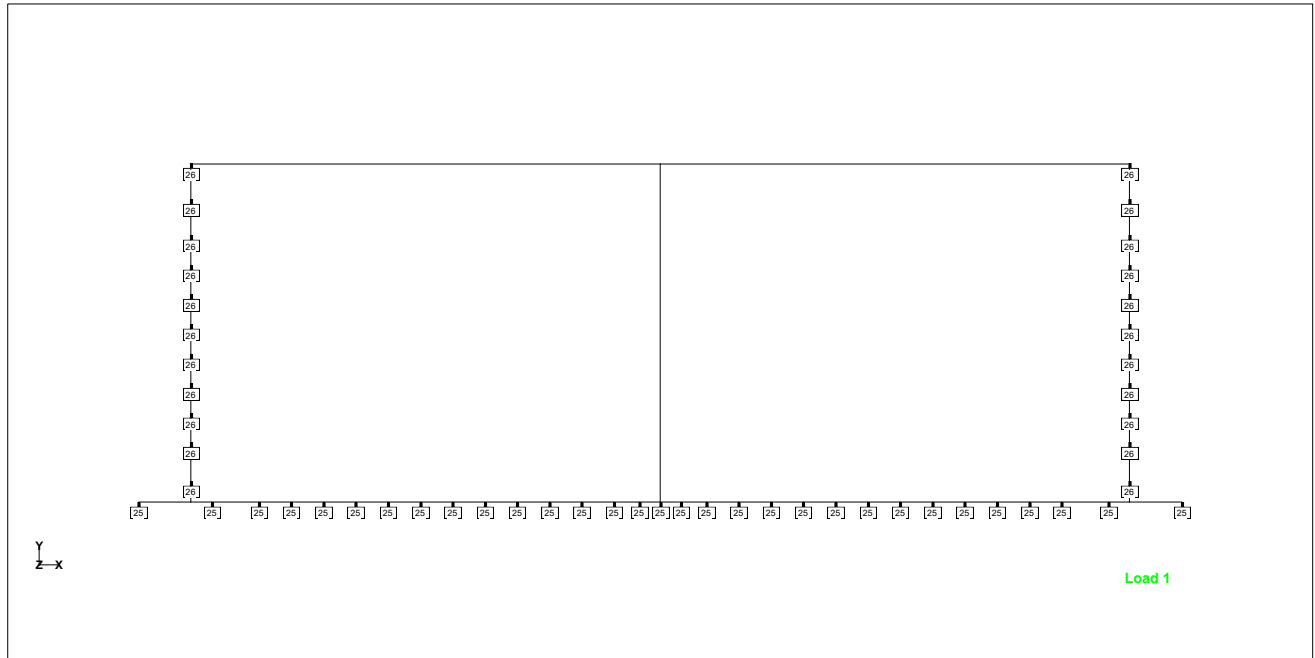
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3)

Date/Time 03-Jan-2025 23:14



Whole Structure

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

7

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

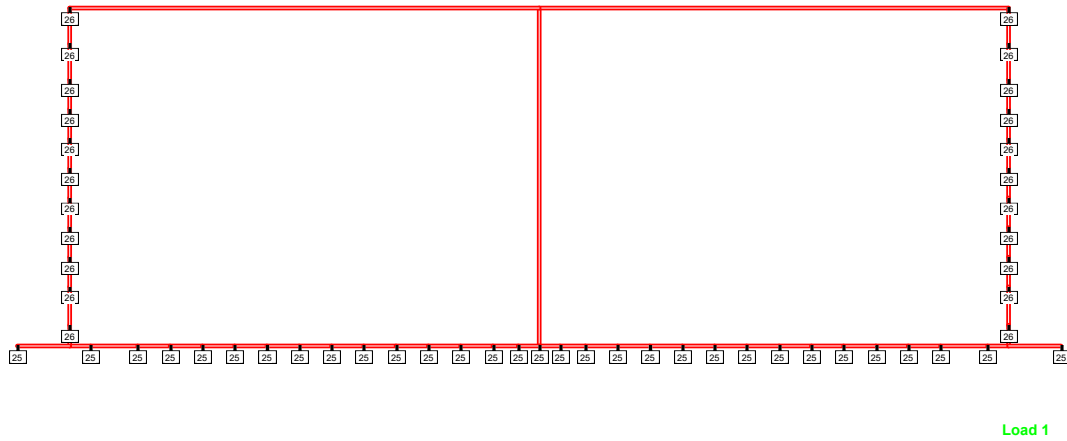
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3)

Date/Time 03-Jan-2025 23:14



Self Weight

Handwritten signatures and initials:
1. *Amrutha*
2. *Adar*
3. *Rob*
4. *CSA*
5. *CSA*



Software licensed to

Job No

Sheet No

8

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

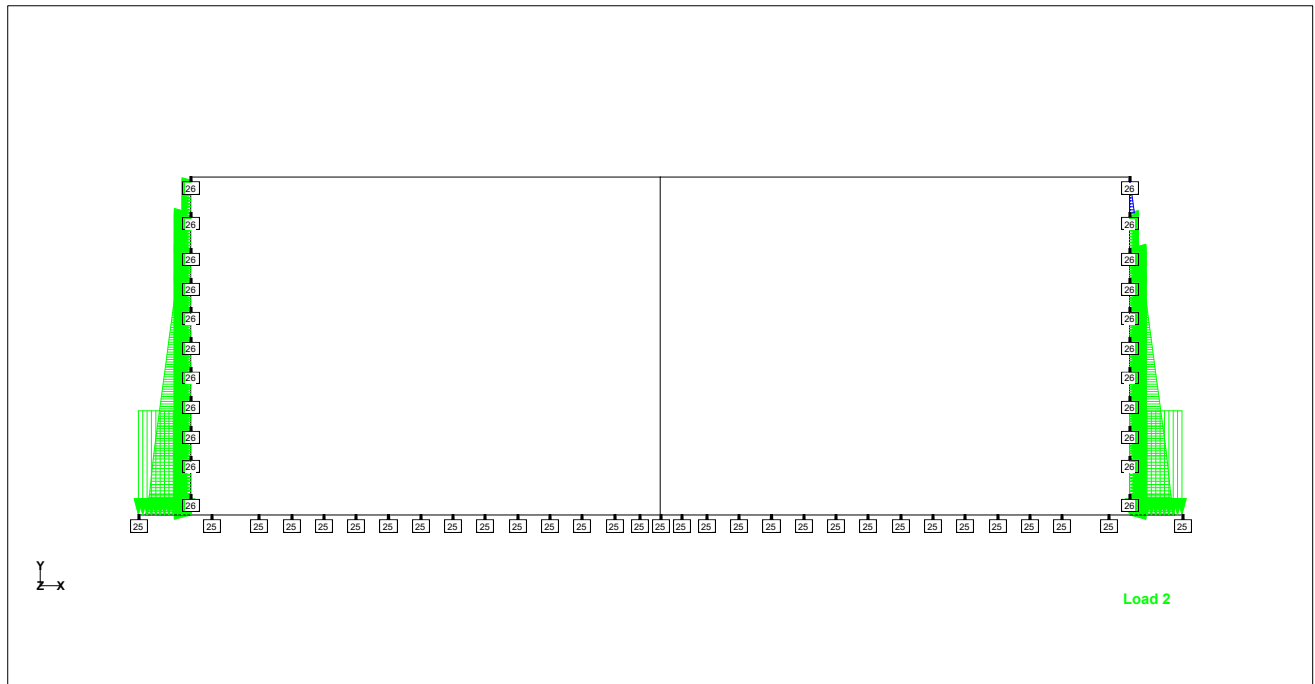
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3)

Date/Time 03-Jan-2025 23:14



Earth Pressure at Ground

Handwritten signatures and initials:
[Signature]
[Signature]
[Signature]
[Signature]
[Signature]



Software licensed to

Job No

Sheet No

9

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By Kmp

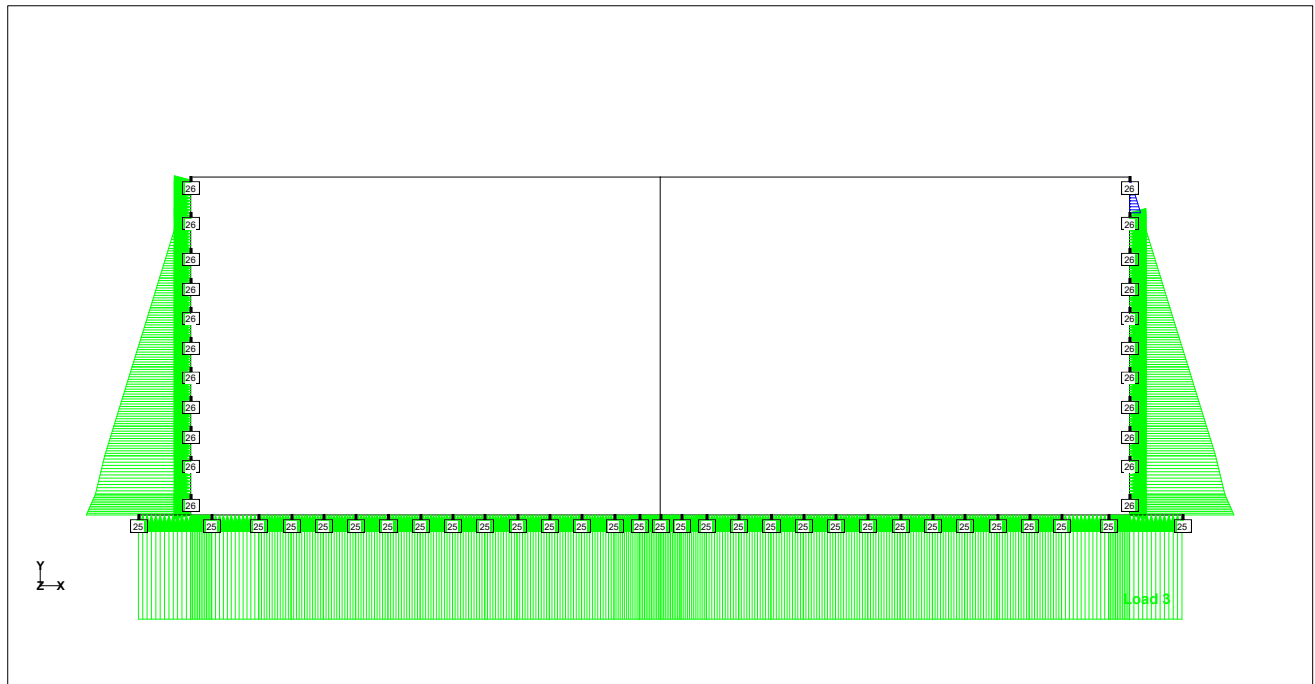
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3)

Date/Time 03-Jan-2025 23:14



Hydrostatic at Ground

Handwritten signatures and initials:
1. *Handwritten signature*
2. *Handwritten signature*
3. *Handwritten signature*
4. *Handwritten signature*
5. *Handwritten signature*



Software licensed to

Job No

Sheet No

10

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

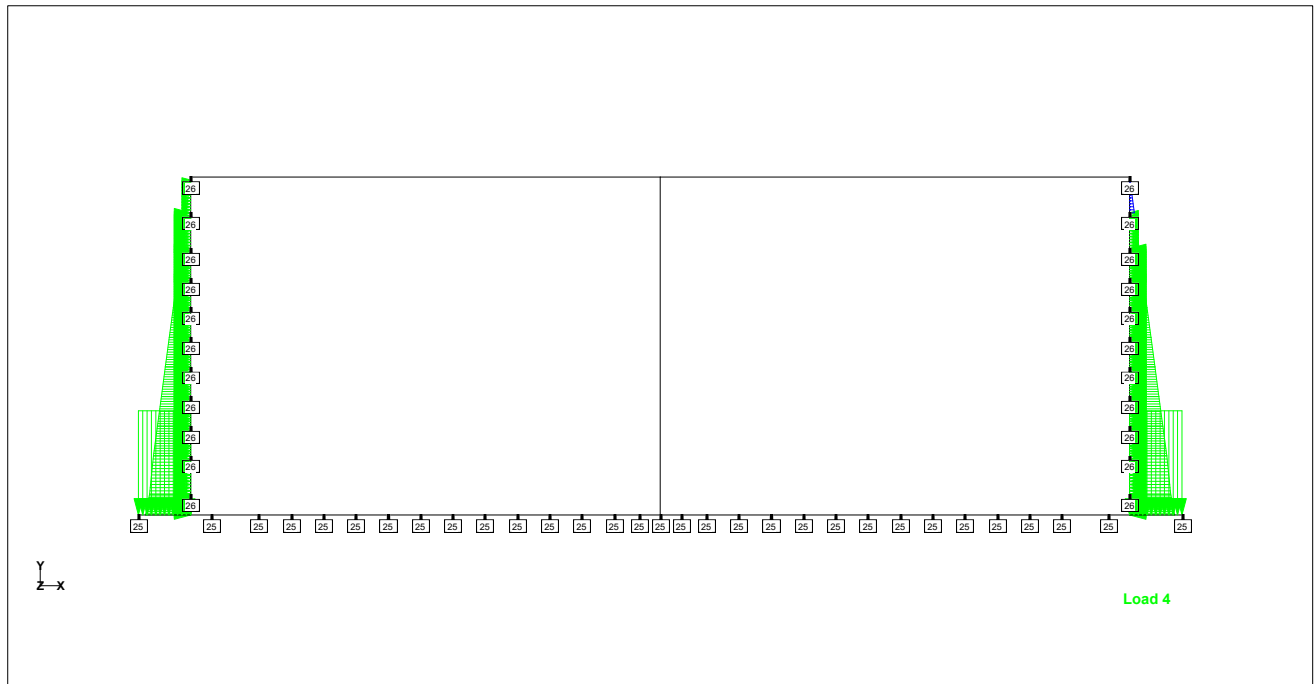
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 03-Jan-2025 23:14



Earth Pressure Dry

Handwritten signatures and initials:
[Signature]
[Signature]
[Signature]
[Signature]
[Signature]



Software licensed to

Job No

Sheet No

11

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

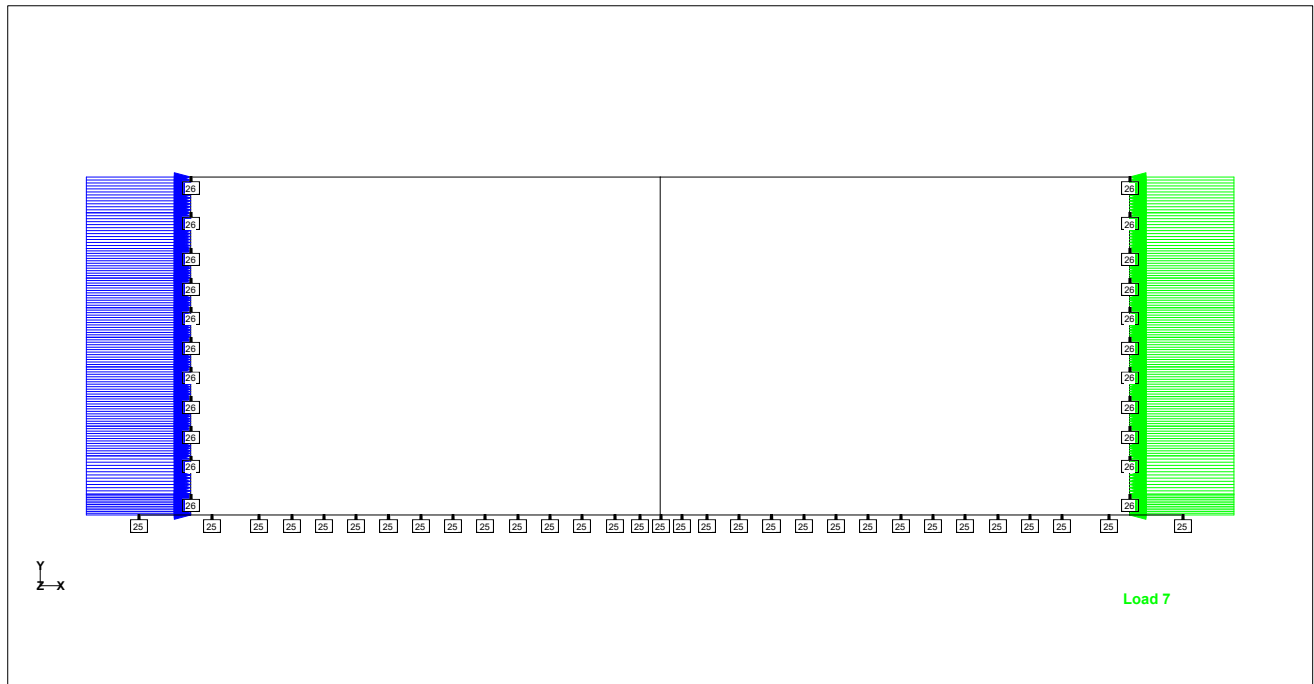
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 03-Jan-2025 23:14



Surcharge

Handwritten signatures and initials:
1. *Longhino*
2. *ADai*
3. *Rob*
4. *CSa*
5. *CSa*
6. *CSa*



Software licensed to

Job No

Sheet No

12

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

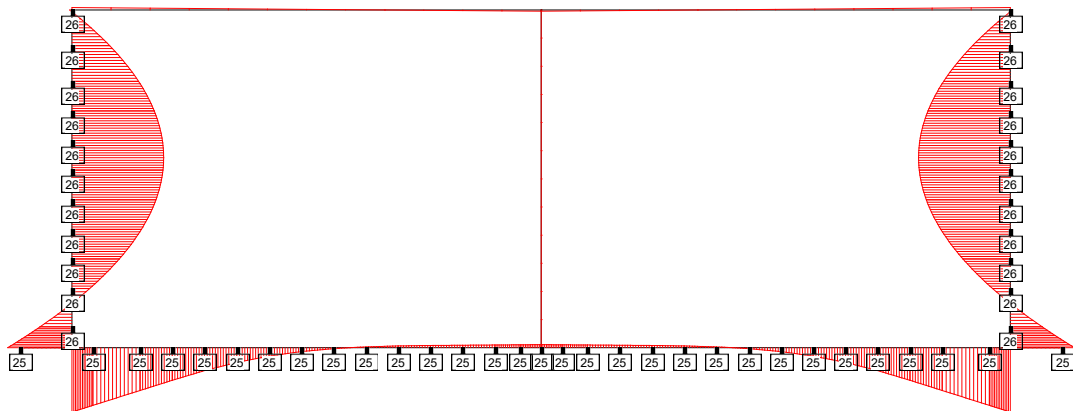
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3)

Date/Time 03-Jan-2025 23:14



Y
Z-X

Load 7 : Bending Z

Bending Moment

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

13

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

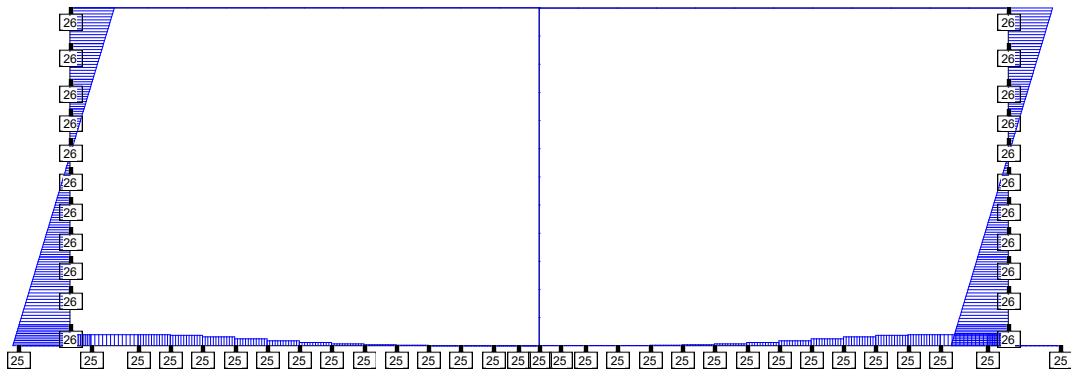
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3

Date/Time 03-Jan-2025 23:14



Shear Force

Load 7 : Shear Y

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

14

Rev
A

Part

Job Title I40172_C&C (Ramp Portion with median wall)

Ref

By KMp

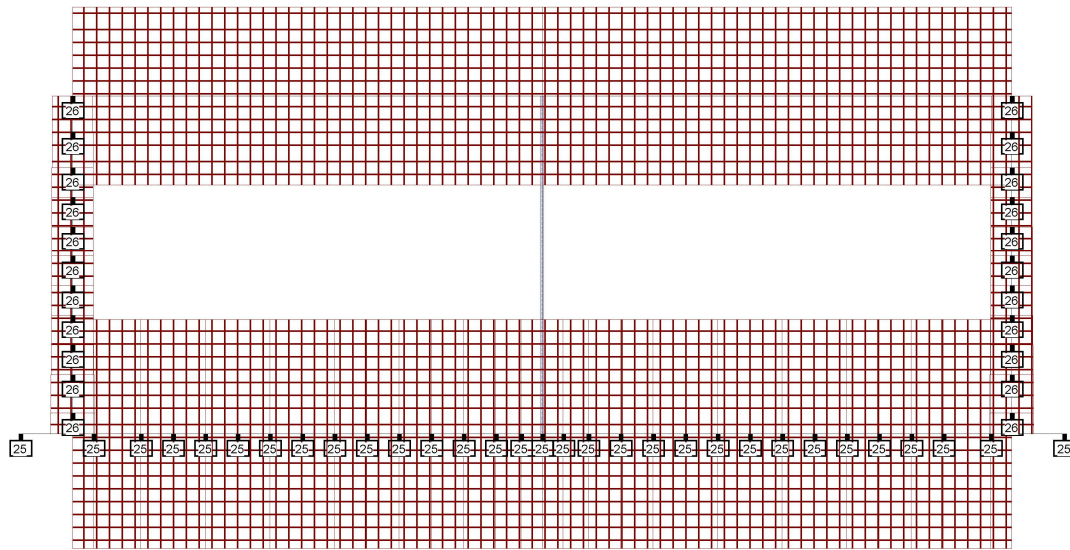
Date 23-Dec-24

Chd CSa

Client

File I40172_RAMP section (3)

Date/Time 03-Jan-2025 23:14



Y
Z - X

Load 7 : Axial Force

Axial Force

[Handwritten signatures and initials]

	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group	Job no:	I40172	
		Page No.:	-	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC			
Calculation for	Design of Base Slab (1000mm thk.) - Ramp with Median Wall			

Design of Base Slab Ramp

1) Material specifications

Chracteristic strength of concrete, Fck	=	35	N/mm ²
Chracteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Base Slab

Minimum thickness of the slab	D	=	1000 mm
Unit width of slab	b	=	1000 mm

3) Design for Support Moment (Earth Face)

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	2774 kNm
Effective Thickness		=	867 mm
d'		=	133 mm
Mu/bd ²		=	3.690
Mulim		=	3499.11 kNm
Mulim/bd ²		=	4.66
Garde Check			11.50

Designed as Singly Reinforced Section

Steel Calculation

a	$=(0.87435/100) * (fy/fck)^2$	=	0.62
b	$=(0.87/100) * (fy)$	=	-4.35
c	$=Mulim/bd^2$	=	4.66
p	$=(b \pm \sqrt{(b^2 - 4ac)})/2a$	=	1.32
Astlim	$=(p*b*d)/100$	=	11448.22
Mu2	$=Mu - Mulim$	=	-725.11
Ast2	$=Mu2/((0.87*fy)*(d-d'))$	=	-2271.01
Ast	$=Astlim + Ast2$	=	9177.21
d'/d	0.15	=	0.20
fsc	Refer Table F SP 16 pg 13	=	370.00
fcc	$=0.446*fck$	=	15.61
Asc	$=Mu2/((fsc-fcc)*(d-d'))$	=	-2787.58







Minimum area of steel required (0.12% on each face in one direction)		=		1040.40 mm ²
Required area of steel	Ast	=	1.06%	9177.21 mm ²
Refer Table 2 SP 16 pg 48	Asc	=	-0.32%	-2787.58 mm ²

Side Face bars are required

Tension Reinforcement (Ast)				
Required spacing of bars		=		87.6 mm
Provided spacing		=		100 mm
Provide 2 layers	32mm	dia bars	@ 100 mm c/c on bottom face	
Area of steel provided		=		16085.0 mm ²

OK

Compression Reinforcement (Asc)				
Required spacing of bars		=		-176.1 mm
Provided spacing		=		100 mm
Provide 1 layer	25mm	dia bars	@ 100 mm c/c on bottom face	
Area of steel provided		=		4908.7 mm ²

OK

4) Design for Span Moment (Inside)

Gross area	Ag	=		1000000 mm ²
------------	----	---	--	-------------------------

Design Moments

Minimum thickness of the slab	D	=		1200 mm
Max factored bending moment (from STAAD)		=		1722 kNm

Effective Thickness		=		1113 mm
---------------------	--	---	--	---------

Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_z / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$
------------------------	---	---

	=			3739.67 mm ²
--	---	--	--	-------------------------

Minimum area of steel required (0.12% on each face in one direction)		=		1335.00 mm ²
--	--	---	--	-------------------------

Required area of steel		=		3739.67 mm ²
------------------------	--	---	--	-------------------------

Required spacing of bars		=		125 mm
--------------------------	--	---	--	--------

Provided spacing		=		100 mm
------------------	--	---	--	--------

Provide 2 layers	25mm	dia bars	@ 100 mm c/c on both faces	
------------------	------	----------	----------------------------	--

Area of steel provided		=		4908.7 mm ²
------------------------	--	---	--	------------------------

OK

5) Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.12 % of Cross Sectional Area		=		1040.4 mm ²
--------------------------------	--	---	--	------------------------

0.2 Times of Main Bar		=		982 mm ²
-----------------------	--	---	--	---------------------

Longitudinal Bar Required at Each Face		=		1040 mm ²
--	--	---	--	----------------------

Steel Provided

	20	Dia Bar	at	150	mm c/c
Area of Steel Provided			=	2094	mm ²

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_o)

Factored Shear Force V_u	=	876	kN
Effective Shear Area	=	1000000	mm ²
Pt%	=	1.9	%
Shear Stress in Base Slab	=	0.88	N/mm ²
Allowable Shear Stress	=	0.4	N/mm ²
Shear force against which shear force is required	=	373.8	kN
Provide Diameter	=	10.0	mm
Spacing of the Stirrups	=	505.7	mm
Provide Stirrups	=	150.0	mm C/C











	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Base slab Ramp with Median Wall		

Crack width For Base Slab (1000mm Thick Ramp with Median Wall)_At Support

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{gr}-C_{min}}{D-x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

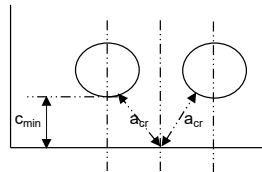
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1849333333	
Axial Force (P) (N) =	0	
Tension R/F=	32T	100c/c
	25T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

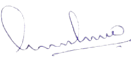
(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	858
A_{st} (mm ² /m) =	12951.21571
p_t (ratio)=	0.015094657
x (mm) =	309.84
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	36226803399

safe



(fig 1)








$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.000945995$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00112$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00112$$

$$\text{Average strain } e_m = 0.001016681$$

$$c_{min} (mm) = 45$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.182 < 0.2 \text{ mm}$$

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1373 < 0.2 \text{ mm}$$

OK

Signature

Signature

Signature

Signature

Signature

	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Base slab_Ramp with Median Wall		

Crack width For Base Slab (1000mm Thick Ramp with Median Wall)_At Mid

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{gr}-C_{min}}{D-x} \right]}$$

Crack width= w

a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

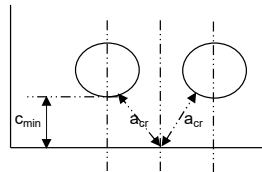
C_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1148000000	
Axial Force (P) (N) =	0	
Tension R/F=	25T	100c/c
	T	100c/c
	T	85c/c
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

(1st Layer)
(2nd Layer)
(3rd Layer)

d (mm) =	890
A_{st} (mm ² /m) =	4908.738521
p_t (ratio)=	0.005515437
x (mm) =	212.12
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	18432550962

safe



(fig 1)

[Handwritten signatures]

$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.00142726$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00157$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00157$$

$$\text{Average strain } e_m = 0.001279512$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 - 30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 63.70 \text{ mm}$$

$$\text{crack width (mm) } w = 0.233 < 0.3 \text{ mm}$$

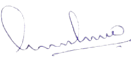
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1727 < 0.3 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd	APPENDIX	
	A company of the GEOCONSULT group	Job no.: I40172	
		Page No.: -	
Project:	I40172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for	Design of Side Wall - 1000mm Thk. for Ramp with Median Wall		

Design of Side Wall - 1000mm Thk. for Ramp with Median Wall

1) Material specifications

Characteristic strength of concrete, Fck	=	35	N/mm ²
Characteristic strength of steel, Fy	=	500	N/mm ²
Clear Cover to main reinforcement	=	75	mm

2) Detail of Side Wall

Minimum thickness of the slab	D	=	1000 mm
Unit width of slab	b	=	1000 mm

3) Design for Earth Face (Support)

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (From STAAD)		=	2705 kNm
Effective Thickness		=	877 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	8185.49 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1052.40 mm ²
Required area of steel		=	8185.49 mm ²
Required spacing of bars		=	98 mm
Provided spacing		=	100 mm
Provide 2 Layer 32mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	16085.0 mm ²

OK

4) Design for Inner Side Reinforcement

Design Moments

Minimum thickness of the slab	D	=	1000 mm
Max factored bending moment (from STAAD)		=	510 kNm
Maximum factored axial force		=	1044 kN
Effective Thickness		=	913 mm
Area of steel required	=	$\frac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 \times M_x / (f_{ck} \times b d^2)]^{0.5}\}}{f_y}$	
		=	1312.45 mm ²
Minimum area of steel required (0.12% on each face in one direction)		=	1095.00 mm ²
Required area of steel		=	1312.45 mm ²
Required spacing of bars		=	374 mm
Provided spacing		=	100 mm
Provide 25mm dia bars @ 100 mm c/c on both faces			
Area of steel provided		=	4908.7 mm ²

OK

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

5)Design for Longitudinal Bar

Longitudinal Bar shall be Maxima of

0.2% of Cross Sectional Area

= 877 mm²

0.2 Times of Main Bar

= 982 mm²

Longitudinal Bar Required at Each Face

= 982 mm²

Steel Provided

20

Dia Bar

at

150

mm c/c

Area of Steel Provided

=

2094

mm²

OK

6)Check For Shear

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force V_u

=

1040

kN

Effective Shear Area

=

1000000

mm²

Shear Stress in Side Wall

=

1.04

N/mm²

Allowable Shear Stress

=

0.40

N/mm²

Shear force against which stirrups required

=

503

kN

Provided Diameter

=

10

Spacing of Stirrups

=

376

Stirrups provided

10

mm Dia.

150

mm Spacing

Ok











	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Side wall		

Check for crack width For Side Wall - 1000mm Thk_At Support

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

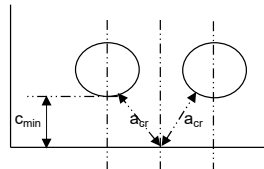
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

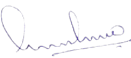
F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	1803333333	
Axial Force (P) (N) =	0	
Tension R/F=	32T	100c/c (1st Layer)
	25T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	858
Ast (mm ² /m) =	12951.21571
p_t (ratio)=	0.015094657
x (mm) =	309.84
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	36226803399

safe



(fig 1)







$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.000922464$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00109$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00109$$

$$\text{Average strain } e_m = 0.000988772$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$c_{min} (mm) = 45 \quad -30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 62.87 \text{ mm}$$

$$\text{crack width (mm) } w = 0.177 < 0.2 \text{ mm}$$

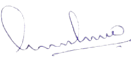
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.1335 < 0.2 \text{ mm}$$

OK







	GEOCONSULT India Pvt Ltd		APPENDIX	
	A company of the GEOCONSULT group		Job no.:	140172
Project:		140172 Road Tunnel DPR BBMP - Support for RODIC		
Calculation for		Crack Width Check For Side wall (1000mm Thk.)		

Check for crack width For Side Wall - 1000mm Thk._At Mid

$$w = \frac{3 a_{cr} e_m}{1+2 \left[\frac{a_{cr} - c_{min}}{D - x} \right]}$$

Crack width= w

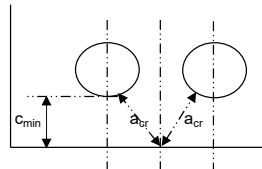
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

c_{min} = minimum cover to bar.

F_{ck} (N/mm ²) =	35	
F_y (N/mm ²) =	500	
E_s (N/mm ²) =	200000	
E_c (N/mm ²) =	29580.4	
Creep Co-Efficient (q) =	1.1	(As Per IS 456: Cl. 6.2.5.1)
E_{eff} =	14086	
D (mm) =	1000	
b (mm) =	1000	
clear cover (mm) =	75	
Moment (Nmm) =	340000000	
Axial Force (P) (N) =	0	
Tension R/F=	20T	100c/c (1st Layer)
	T	100c/c (2nd Layer)
	T	85c/c (3rd Layer)
Diameter of Spacer Bar=	T	mm
Dia of Link Bar=	10	mm

d (mm) =	895
A_{st} (mm ² /m) =	3141.592654
p_t (ratio)=	0.003510159
x (mm) =	174.90
modular ratio (m) =	6.761234038
I_g (mm ⁴) =	83333333333
I_{cr} (mm ⁴) =	12797813289

safe



(fig 1)

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

$a'(mm) = 960$
 Strain in concrete at the level of steel
 $e_s = 0.00064674$
 Strain in concrete at the outer most tension face
 $e_1 = 0.00071$
 Strain at the level considered, calculated considering the stiffening effect of concrete due to Axial load, $e_2 = ((P/b \cdot h) / E_{eff})$

$$e_2 = 0.00000$$

Net effective Strain $e'_1 = e_1 - e_2$

$$e'_1 = 0.00071$$

$$\text{Average strain } e_m = 0.00022788$$

$$c_{min} (mm) = 45$$

$$e_m = e_1 - \frac{b \cdot (D - x) \cdot (a' - x)}{3 \cdot E_s \cdot A_{st} \cdot (d - x)}$$

$$-30$$

Width of crack at a point on tension face midway between two bars (fig. 1)

$$a_{cr} (mm) = 64.33 \text{ mm}$$

$$\text{crack width (mm) } w = 0.042 < 0.3 \text{ mm}$$

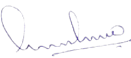
OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

$$a_{cr} (mm) = 45 \text{ mm}$$

$$\text{crack width (mm) } w = 0.0308 < 0.3 \text{ mm}$$

OK







ANNEXURE – 5
NATM ENLARGED
INTERSECTION

Signature

Signature

Signature

Signature

Signature

Amelia

Adri

Rob

Emma

James

Stiffness Calculation

CASE1				
Chainage		=		m
Bore Hole No	B.H	=		
Ground Level	G.L	=		m
Rail Level	R.L	=		m
Water Table below G.L		=		m
Design Water Table Elevation		=		m
Youngs Modulus	E=	=	1600.000	MPa
Poisson ratio	V=	=	0.3	

5200
0.7
0.52
1.346153846
7000

Beam	Node1	Node2	Beam 1-length	Beam 2-length	Effective Length of beam	Radius outer										
			0.377	0	0.189	14	1	INC REF	0.013	1.000	0.000	FIXED BUT MX MY MZ	KFX	16571.43	KFY	16571.44
1	1	2	0.000	0.377	0.189	14	2	INC REF	0.404	0.995	0.000	FIXED BUT MX MY MZ	KFX	16571.43	KFY	16571.44
2	2	3	0.377	0.377	0.377	14	3	INC REF	0.807	0.979	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
3	3	4	0.377	0.377	0.377	14	4	INC REF	1.210	0.953	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
4	4	5	0.377	0.377	0.377	14	5	INC REF	1.611	0.916	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
5	5	6	0.377	0.377	0.377	14	6	INC REF	2.012	0.868	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
6	6	7	0.377	0.377	0.377	14	7	INC REF	2.412	0.810	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
7	7	8	0.377	0.377	0.377	14	8	INC REF	2.809	0.742	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
8	8	9	0.377	0.377	0.377	14	9	INC REF	3.205	0.663	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
9	9	10	0.377	0.377	0.377	14	10	INC REF	3.599	0.574	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
10	10	11	0.377	0.377	0.377	14	11	INC REF	3.990	0.475	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
11	11	12	0.377	0.377	0.377	14	12	INC REF	4.378	0.366	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
12	12	13	0.377	0.377	0.377	14	13	INC REF	4.764	0.246	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
13	13	14	0.377	0.377	0.377	14	14	INC REF	5.150	0.115	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
14	14	15	0.377	0.377	0.377	14	15	INC REF	5.537	-0.031	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
15	15	16	0.377	0.377	0.377	14	16	INC REF	5.920	-0.193	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
16	16	17	0.377	0.377	0.377	14	17	INC REF	6.296	-0.369	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
17	17	18	0.377	0.377	0.377	14	18	INC REF	6.665	-0.560	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
18	18	19	0.377	0.377	0.377	10	19	INC REF	7.027	-0.764	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
19	19	20	0.377	0.377	0.377	10	20	INC REF	7.381	-0.982	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
20	20	21	0.377	0.377	0.377	10	21	INC REF	7.726	-1.214	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
21	21	22	0.377	0.377	0.377	10	22	INC REF	8.062	-1.458	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
22	22	23	0.377	0.377	0.377	10	23	INC REF	8.389	-1.715	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
23	23	24	0.377	0.377	0.377	10	24	INC REF	8.705	-1.985	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
24	24	25	0.377	0.377	0.377	10	25	INC REF	9.011	-2.266	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
25	25	26	0.377	0.377	0.377	10	26	INC REF	9.306	-2.559	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
26	26	27	0.377	0.377	0.377	10	27	INC REF	9.590	-2.863	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
27	27	28	0.377	0.377	0.377	10	28	INC REF	9.862	-3.177	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
28	28	29	0.377	0.377	0.377	10	29	INC REF	10.128	-3.510	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
29	29	30	0.377	0.377	0.377	6	30	INC REF	10.381	-3.869	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
30	30	31	0.377	0.377	0.377	6	31	INC REF	10.612	-4.245	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
31	31	32	0.377	0.377	0.377	6	32	INC REF	10.818	-4.636	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
32	32	33	0.377	0.377	0.377	6	33	INC REF	10.999	-5.038	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
33	33	34	0.377	0.377	0.377	6	34	INC REF	11.154	-5.452	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
34	34	35	0.377	0.377	0.377	6	35	INC REF	11.282	-5.875	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
35	35	36	0.377	0.377	0.377	6	36	INC REF	11.382	-6.305	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
36	36	37	0.377	0.377	0.377	6	37	INC REF	11.455	-6.740	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
37	37	38	0.377	0.377	0.377	6	38	INC REF	11.500	-7.180	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
38	38	39	0.377	0.377	0.377	6	39	INC REF	11.516	-7.621	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
39	39	40	0.377	0.377	0.377	6	40	INC REF	11.504	-8.062	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
40	40	41	0.377	0.377	0.377	6	41	INC REF	11.463	-8.502	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
41	41	42	0.377	0.377	0.377	6	42	INC REF	11.391	-8.938	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
42	42	43	0.377	0.377	0.377	6	43	INC REF	11.298	-9.369	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
43	43	44	0.377	0.377	0.377	6	44	INC REF	11.174	-9.793	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
44	44	45	0.377	0.377	0.377	6	45	INC REF	11.023	-10.208	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
45	45	46	0.377	0.377	0.377	6	46	INC REF	10.846	-10.613	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
46	46	47	0.377	0.377	0.377	6	47	INC REF	10.643	-11.005	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
47	47	48	0.377	0.377	0.377	6	48	INC REF	10.416	-11.383	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
48	48	49	0.377	0.377	0.377	6	49	INC REF	10.165	-11.747	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
49	49	50	0.377	0.377	0.377	6	50	INC REF	9.890	-12.093	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
50	50	51	0.377	0.377	0.377	6	51	INC REF	9.595	-12.421	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
51	51	52	0.377	0.377	0.377	6	52	INC REF	9.278	-12.729	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
52	52	53	0.377	0.377	0.377	6	53	INC REF	8.943	-13.016	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
53	53	54	0.377	0.377	0.377	6	54	INC REF	8.590	-13.281	0.000	FIXED BUT MX MY MZ	KFX	7733.33	KFY	7733.33
54	54	55	0.377	0.377	0.377	20	55	INC REF	8.219	-13.524	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
55	55	56	0.377	0.377	0.377	20	56	INC REF	7.821	-13.748	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
56	56	57	0.377	0.377	0.377	20	57	INC REF	7.398	-13.937	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
57	57	58	0.377	0.377	0.377	20	58	INC REF	6.996	-14.080	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
58	58	59	0.377	0.377	0.377	20	59	INC REF	6.619	-14.205	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
59	59	60	0.377	0.377	0.377	20	60	INC REF	6.242	-14.323	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
60	60	61	0.377	0.377	0.377	20	61	INC REF	5.862	-14.434	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
61	61	62	0.377	0.377	0.377	20	62	INC REF	5.489	-14.539	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
62	62	63	0.377	0.377	0.377	20	63	INC REF	5.097	-14.636	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
63	63	64	0.377	0.377	0.377	20	64	INC REF	4.711	-14.726	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
64	64	65	0.377	0.377	0.377	20	65	INC REF	4.324	-14.809	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
65	65	66	0.377	0.377	0.377	20	66	INC REF	3.936	-14.885	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
66	66	67	0.377	0.377	0.377	20	67	INC REF	3.546	-14.954	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
67	67	68	0.377	0.377	0.377	20	68	INC REF	3.156	-15.015	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
68	68	69	0.377	0.377	0.377	20	69	INC REF	2.764	-15.070	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
69	69	70	0.377	0.377	0.377	20	70	INC REF	2.371	-15.117	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
70	70	71	0.377	0.377	0.377	20	71	INC REF	1.977	-15.158	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
71	71	72	0.377	0.377	0.377	20	72	INC REF	1.583	-15.191	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
72	72	73	0.377	0.377	0.377	20	73	INC REF	1.188	-15.216	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
73	73	74	0.377	0.377	0.377	20	74	INC REF	0.793	-15.235	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
74	74	75	0.377	0.377	0.377	20	75	INC REF	0.397	-15.246	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
75	75	76	0.377	0.377	0.377	20	76	INC REF	0.000	-15.250	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
76	76	77	0.377	0.377	0.377	20	77	INC REF	-0.396	-15.246	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
77	77	78	0.377	0.377	0.377	20	78	INC REF	-0.792	-15.235	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
78	78	79	0.377	0.377	0.377	20	79	INC REF	-1.187	-15.216	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
79	79	80	0.377	0.377	0.377	20	80	INC REF	-1.582	-15.191	0.000	FIXED BUT MX				

97	97	98	0.377	0.377	0.377	20	98	INC REF	-8.589	-13.281	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
98	98	99	0.377	0.377	0.377	20	99	INC REF	-8.942	-13.016	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
99	99	100	0.377	0.377	0.377	20	100	INC REF	-9.278	-12.729	0.000	FIXED BUT MX MY MZ	KFX	23200.00	KFY	2320.00
100	100	101	0.377	0.377	0.377	6	101	INC REF	-9.594	-12.421	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
101	101	102	0.377	0.377	0.377	6	102	INC REF	-9.890	-12.093	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
102	102	103	0.377	0.377	0.377	6	103	INC REF	-10.164	-11.747	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
103	103	104	0.377	0.377	0.377	6	104	INC REF	-10.415	-11.383	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
104	104	105	0.377	0.377	0.377	6	105	INC REF	-10.643	-11.005	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
105	105	106	0.377	0.377	0.377	6	106	INC REF	-10.846	-10.613	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
106	106	107	0.377	0.377	0.377	6	107	INC REF	-11.023	-10.208	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
107	107	108	0.377	0.377	0.377	6	108	INC REF	-11.174	-9.793	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
108	108	109	0.377	0.377	0.377	6	109	INC REF	-11.298	-9.369	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
109	109	110	0.377	0.377	0.377	6	110	INC REF	-11.394	-8.938	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
110	110	111	0.377	0.377	0.377	6	111	INC REF	-11.463	-8.502	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
111	111	112	0.377	0.377	0.377	6	112	INC REF	-11.502	-8.062	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
112	112	113	0.377	0.377	0.377	6	113	INC REF	-11.515	-7.621	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
113	113	114	0.377	0.377	0.377	6	114	INC REF	-11.499	-7.180	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
114	114	115	0.377	0.377	0.377	6	115	INC REF	-11.454	-6.740	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
115	115	116	0.377	0.377	0.377	6	116	INC REF	-11.382	-6.305	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
116	116	117	0.377	0.377	0.377	6	117	INC REF	-11.281	-5.875	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
117	117	118	0.377	0.377	0.377	6	118	INC REF	-11.153	-5.452	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
118	118	119	0.377	0.377	0.377	6	119	INC REF	-10.999	-5.038	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
119	119	120	0.377	0.377	0.377	6	120	INC REF	-10.818	-4.636	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
120	120	121	0.377	0.377	0.377	6	121	INC REF	-10.611	-4.245	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
121	121	122	0.377	0.377	0.377	6	122	INC REF	-10.380	-3.869	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
122	122	123	0.377	0.377	0.377	6	123	INC REF	-10.127	-3.510	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
123	123	124	0.377	0.377	0.377	6	124	INC REF	-9.861	-3.177	0.000	FIXED BUT MX MY MZ	KFX	77333.33	KFY	7733.33
124	124	125	0.377	0.377	0.377	10	125	INC REF	-9.589	-2.863	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
125	125	126	0.377	0.377	0.377	10	126	INC REF	-9.306	-2.559	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
126	126	127	0.377	0.377	0.377	10	127	INC REF	-9.011	-2.266	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
127	127	128	0.377	0.377	0.377	10	128	INC REF	-8.705	-1.985	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
128	128	129	0.377	0.377	0.377	10	129	INC REF	-8.388	-1.715	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
129	129	130	0.377	0.377	0.377	10	130	INC REF	-8.062	-1.458	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
130	130	131	0.377	0.377	0.377	10	131	INC REF	-7.726	-1.214	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
131	131	132	0.377	0.377	0.377	10	132	INC REF	-7.380	-0.982	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
132	132	133	0.377	0.377	0.377	10	133	INC REF	-7.027	-0.764	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
133	133	134	0.377	0.377	0.377	10	134	INC REF	-6.665	-0.560	0.000	FIXED BUT MX MY MZ	KFX	46400.00	KFY	4640.00
134	134	135	0.377	0.377	0.377	14	135	INC REF	-6.295	-0.369	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
135	135	136	0.377	0.377	0.377	14	136	INC REF	-5.919	-0.193	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
136	136	137	0.377	0.377	0.377	14	137	INC REF	-5.536	-0.031	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
137	137	138	0.377	0.377	0.377	14	138	INC REF	-5.149	0.115	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
138	138	139	0.377	0.377	0.377	14	139	INC REF	-4.763	0.246	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
139	139	140	0.377	0.377	0.377	14	140	INC REF	-4.378	0.366	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
140	140	141	0.377	0.377	0.377	14	141	INC REF	-3.989	0.475	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
141	141	142	0.377	0.377	0.377	14	142	INC REF	-3.598	0.574	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
142	142	143	0.377	0.377	0.377	14	143	INC REF	-3.204	0.663	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
143	143	144	0.377	0.377	0.377	14	144	INC REF	-2.809	0.742	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
144	144	145	0.377	0.377	0.377	14	145	INC REF	-2.411	0.810	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
145	145	146	0.377	0.377	0.377	14	146	INC REF	-2.011	0.868	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
146	146	147	0.377	0.377	0.377	14	147	INC REF	-1.611	0.916	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
147	147	148	0.377	0.377	0.377	14	148	INC REF	-1.209	0.953	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
148	148	149	0.377	0.377	0.377	14	149	INC REF	-0.806	0.979	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
149	149	150	0.377	0.377	0.377	14	150	INC REF	-0.416	0.994	0.000	FIXED BUT MX MY MZ	KFX	33142.86	KFY	3314.29
150	150	1	0.377	0.377	0.377	14										

Signature

Signature

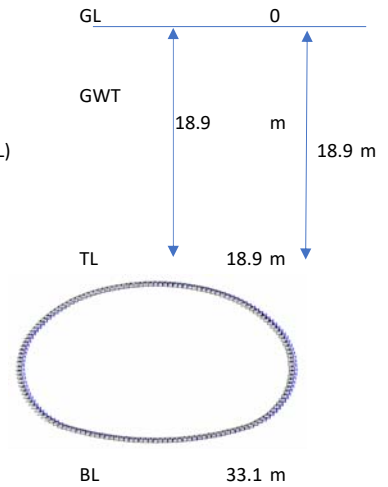
Signature

Signature

Signature

ANNEXURE 2 (Case 2 - Water level at ground)

Ground level at NATM location	0 m	
Top level at NATM location	18.9 m	
Base level at C&C location	33.1 m	
unit weight of compacted backfill	19.1 kn/m3	
height of overburden	18.9 m	
height of watertable	0 m	
height of water table above crown	18.9 m	(5m below GL)
height of water table +1m above crown	0	
unit weight of water	10 kn/m3	
K0	0.43	
poisson ratio	0.3	



OVERBURDEN PRESSURE (SUBMERGED)

overburden pressure at top slab	(unit weight of rock - unit weight of water) x overburden height	171.99
side earth pressure at wall top	k0 x overburden pressure at wall top	73.9557
side earth pressure at wall bottom	k0 x overburden pressure at Invert	129.5203

HYDROSTATIC PRESSURE

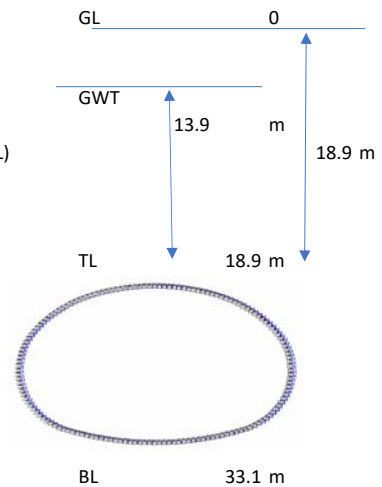
Hydrostratic pressure at top slab	height of water table above top slab x unit weight of water	189
bottom	height of water table at Invert x unit weight of water	331

DRY OVERBURDEN

overburden pressure at top slab	360.99
side earth pressure at wall top	155.2257
side earth pressure at wall bottom	271.8503

ANNEXURE 2 (Case 2 - Water level at 5m below ground)

Ground level at NATM location	0 m	
Top level at NATM location	18.9 m	
Base level at C&C location	33.1 m	
unit weight of compacted backfill	19.1 kn/m3	
height of overburden	18.9 m	
height of watertable	5 m	
height of water table above crown	13.9 m	(5m below GL)
height of water table +1m above crown	0	
unit weight of water	10 kn/m3	
K0	0.43	
poisson ratio	0.3	



OVERBURDEN PRESSURE (SUBMERGED)

overburden pressure at top slab	(unit weight of rock - unit weight of water) x overburden height	221.99
side earth pressure at wall top	k0 x overburden pressure at wall top	95.4557
side earth pressure at wall bottom	k0 x overburden pressure at Invert	205.4553

HYDROSTATIC PRESSURE

Hydrostratic pressure at top slab	height of water table above top slab x unit weight of water	139
bottom	height of water table at Invert x unit weight of water	331

DRY OVERBURDEN

overburden pressure at top slab	360.99
side earth pressure at wall top	155.2257
side earth pressure at wall bottom	271.8503



Software licensed to

Job No

1

Sheet No

1

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT Date/Time 22-Oct-2024 11:23

Job Information

	Engineer	Checked	Approved
Name:	KCh	CSa	SPa
Date:	21-Oct-24		

Project ID

Project Name

Structure Type

SPACE FRAME

Number of Nodes	150	Highest Node	150
Number of Elements	150	Highest Beam	150

Number of Basic Load Cases	5
Number of Combination Load Cases	6

Included in this printout are data for:

All

The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEA LOAD
Primary	2	EARTH PRESSURE
Primary	3	HYDROSTATIC
Primary	4	EARTH PRESSURE DRY
Primary	5	SURCHARGE
Combination	101	1.5DL + 1.5EP + 1.5WL
Combination	102	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE
Combination	103	1.5DL + 1.5EP + 1.5WL + 1.5SURCHARGE
Combination	201	1.0DL + 1.0EP + 1.0WL
Combination	202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE
Combination	203	1.0DL + 1.0EP + 1.0WL + 1.0SURCHARGE

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.377	-0.005	0.000
3	0.754	-0.020	0.000
4	1.131	-0.044	0.000
5	1.507	-0.079	0.000
6	1.882	-0.123	0.000
7	2.255	-0.177	0.000
8	2.627	-0.241	0.000
9	2.997	-0.315	0.000
10	3.365	-0.398	0.000

Signature
Date
Rob
CSa
SPa



Software licensed to

Job No

1

Sheet No

2

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
14	4.812	-0.826	0.000
15	5.165	-0.960	0.000
16	5.513	-1.107	0.000
17	5.855	-1.267	0.000
18	6.190	-1.440	0.000
19	6.519	-1.625	0.000
20	6.840	-1.823	0.000
21	7.154	-2.033	0.000
22	7.459	-2.255	0.000
23	7.755	-2.489	0.000
24	8.042	-2.734	0.000
25	8.320	-2.989	0.000
26	8.588	-3.255	0.000
27	8.846	-3.531	0.000
28	9.092	-3.816	0.000
29	9.328	-4.111	0.000
30	9.545	-4.419	0.000
31	9.743	-4.741	0.000
32	9.919	-5.075	0.000
33	10.074	-5.419	0.000
34	10.206	-5.772	0.000
35	10.316	-6.133	0.000
36	10.401	-6.501	0.000
37	10.463	-6.873	0.000
38	10.501	-7.248	0.000
39	10.515	-7.626	0.000
40	10.505	-8.003	0.000
41	10.470	-8.378	0.000
42	10.412	-8.751	0.000
43	10.329	-9.120	0.000
44	10.224	-9.482	0.000
45	10.095	-9.836	0.000
46	9.943	-10.182	0.000
47	9.770	-10.517	0.000
48	9.575	-10.841	0.000
49	9.361	-11.151	0.000
50	9.126	-11.447	0.000
51	8.873	-11.727	0.000
52	8.603	-11.990	0.000
53	8.317	-12.236	0.000
54	8.015	-12.462	0.000
55	7.699	-12.669	0.000
56	7.371	-12.854	0.000
57	7.026	-13.008	0.000
58	6.670	-13.134	0.000
59	6.312	-13.253	0.000

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

3

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
60	5.952	-13.366	0.000
61	5.590	-13.472	0.000
62	5.226	-13.571	0.000
63	4.860	-13.664	0.000
64	4.492	-13.750	0.000
65	4.123	-13.829	0.000
66	3.753	-13.902	0.000
67	3.381	-13.967	0.000
68	3.009	-14.026	0.000
69	2.635	-14.078	0.000
70	2.260	-14.123	0.000
71	1.885	-14.162	0.000
72	1.509	-14.193	0.000
73	1.132	-14.218	0.000
74	0.755	-14.235	0.000
75	0.378	-14.246	0.000
76	0.000	-14.250	0.000
77	-0.377	-14.246	0.000
78	-0.754	-14.235	0.000
79	-1.131	-14.218	0.000
80	-1.508	-14.193	0.000
81	-1.884	-14.162	0.000
82	-2.259	-14.123	0.000
83	-2.634	-14.078	0.000
84	-3.008	-14.026	0.000
85	-3.381	-13.967	0.000
86	-3.752	-13.902	0.000
87	-4.123	-13.829	0.000
88	-4.492	-13.750	0.000
89	-4.859	-13.664	0.000
90	-5.225	-13.571	0.000
91	-5.589	-13.472	0.000
92	-5.951	-13.366	0.000
93	-6.312	-13.253	0.000
94	-6.670	-13.134	0.000
95	-7.025	-13.008	0.000
96	-7.370	-12.854	0.000
97	-7.699	-12.669	0.000
98	-8.014	-12.462	0.000
99	-8.316	-12.236	0.000
100	-8.603	-11.990	0.000
101	-8.873	-11.727	0.000
102	-9.126	-11.447	0.000
103	-9.360	-11.151	0.000
104	-9.575	-10.841	0.000
105	-9.769	-10.517	0.000

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

4

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
106	-9.943	-10.182	0.000
107	-10.094	-9.836	0.000
108	-10.223	-9.482	0.000
109	-10.329	-9.120	0.000
110	-10.411	-8.751	0.000
111	-10.470	-8.378	0.000
112	-10.504	-8.003	0.000
113	-10.515	-7.626	0.000
114	-10.501	-7.248	0.000
115	-10.463	-6.873	0.000
116	-10.401	-6.501	0.000
117	-10.315	-6.133	0.000
118	-10.205	-5.772	0.000
119	-10.073	-5.419	0.000
120	-9.919	-5.075	0.000
121	-9.742	-4.741	0.000
122	-9.545	-4.419	0.000
123	-9.327	-4.111	0.000
124	-9.092	-3.816	0.000
125	-8.845	-3.531	0.000
126	-8.587	-3.255	0.000
127	-8.320	-2.989	0.000
128	-8.042	-2.734	0.000
129	-7.754	-2.489	0.000
130	-7.458	-2.255	0.000
131	-7.153	-2.033	0.000
132	-6.839	-1.823	0.000
133	-6.518	-1.625	0.000
134	-6.189	-1.440	0.000
135	-5.854	-1.267	0.000
136	-5.512	-1.107	0.000
137	-5.165	-0.960	0.000
138	-4.812	-0.826	0.000
139	-4.454	-0.705	0.000
140	-4.094	-0.593	0.000
141	-3.730	-0.491	0.000
142	-3.365	-0.398	0.000
143	-2.997	-0.315	0.000
144	-2.626	-0.241	0.000
145	-2.254	-0.177	0.000
146	-1.881	-0.123	0.000
147	-1.506	-0.079	0.000
148	-1.130	-0.044	0.000
149	-0.754	-0.020	0.000
150	-0.377	-0.005	0.000

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

5

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	1	2	0.377	1	0
2	2	3	0.377	1	0
3	3	4	0.377	1	0
4	4	5	0.377	1	0
5	5	6	0.377	1	0
6	6	7	0.377	1	0
7	7	8	0.377	1	0
8	8	9	0.377	1	0
9	9	10	0.377	1	0
10	10	11	0.377	1	0
11	11	12	0.377	1	0
12	12	13	0.377	1	0
13	13	14	0.377	1	0
14	14	15	0.377	1	0
15	15	16	0.377	1	0
16	16	17	0.377	1	0
17	17	18	0.377	1	0
18	18	19	0.377	1	0
19	19	20	0.377	1	0
20	20	21	0.377	1	0
21	21	22	0.377	1	0
22	22	23	0.377	1	0
23	23	24	0.377	1	0
24	24	25	0.377	1	0
25	25	26	0.377	1	0
26	26	27	0.377	1	0
27	27	28	0.377	1	0
28	28	29	0.377	1	0
29	29	30	0.377	1	0
30	30	31	0.377	1	0
31	31	32	0.377	1	0
32	32	33	0.377	1	0
33	33	34	0.377	1	0
34	34	35	0.377	1	0
35	35	36	0.377	1	0
36	36	37	0.377	1	0
37	37	38	0.377	1	0
38	38	39	0.377	1	0
39	39	40	0.377	1	0
40	40	41	0.377	1	0
41	41	42	0.377	1	0
42	42	43	0.377	1	0
43	43	44	0.377	1	0
44	44	45	0.377	1	0
45	45	46	0.377	1	0
46	46	47	0.377	1	0

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

6

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSE(Date/Time 22-Oct-2024 11:23

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
47	47	48	0.377	1	0
48	48	49	0.377	1	0
49	49	50	0.377	1	0
50	50	51	0.377	1	0
51	51	52	0.377	1	0
52	52	53	0.377	1	0
53	53	54	0.377	1	0
54	54	55	0.377	1	0
55	55	56	0.377	1	0
56	56	57	0.377	1	0
57	57	58	0.377	1	0
58	58	59	0.377	1	0
59	59	60	0.377	1	0
60	60	61	0.377	1	0
61	61	62	0.377	1	0
62	62	63	0.377	1	0
63	63	64	0.377	1	0
64	64	65	0.377	1	0
65	65	66	0.377	1	0
66	66	67	0.377	1	0
67	67	68	0.377	1	0
68	68	69	0.377	1	0
69	69	70	0.377	1	0
70	70	71	0.377	1	0
71	71	72	0.377	1	0
72	72	73	0.377	1	0
73	73	74	0.377	1	0
74	74	75	0.377	1	0
75	75	76	0.377	1	0
76	76	77	0.377	1	0
77	77	78	0.377	1	0
78	78	79	0.377	1	0
79	79	80	0.377	1	0
80	80	81	0.377	1	0
81	81	82	0.377	1	0
82	82	83	0.377	1	0
83	83	84	0.377	1	0
84	84	85	0.377	1	0
85	85	86	0.377	1	0
86	86	87	0.377	1	0
87	87	88	0.377	1	0
88	88	89	0.377	1	0
89	89	90	0.377	1	0
90	90	91	0.377	1	0
91	91	92	0.377	1	0
92	92	93	0.377	1	0

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

7

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSE(Date/Time 22-Oct-2024 11:23

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
93	93	94	0.377	1	0
94	94	95	0.377	1	0
95	95	96	0.377	1	0
96	96	97	0.377	1	0
97	97	98	0.377	1	0
98	98	99	0.377	1	0
99	99	100	0.377	1	0
100	100	101	0.377	1	0
101	101	102	0.377	1	0
102	102	103	0.377	1	0
103	103	104	0.377	1	0
104	104	105	0.377	1	0
105	105	106	0.377	1	0
106	106	107	0.377	1	0
107	107	108	0.377	1	0
108	108	109	0.377	1	0
109	109	110	0.377	1	0
110	110	111	0.377	1	0
111	111	112	0.377	1	0
112	112	113	0.377	1	0
113	113	114	0.377	1	0
114	114	115	0.377	1	0
115	115	116	0.377	1	0
116	116	117	0.377	1	0
117	117	118	0.377	1	0
118	118	119	0.377	1	0
119	119	120	0.377	1	0
120	120	121	0.377	1	0
121	121	122	0.377	1	0
122	122	123	0.377	1	0
123	123	124	0.377	1	0
124	124	125	0.377	1	0
125	125	126	0.377	1	0
126	126	127	0.377	1	0
127	127	128	0.377	1	0
128	128	129	0.377	1	0
129	129	130	0.377	1	0
130	130	131	0.377	1	0
131	131	132	0.377	1	0
132	132	133	0.377	1	0
133	133	134	0.377	1	0
134	134	135	0.377	1	0
135	135	136	0.377	1	0
136	136	137	0.377	1	0
137	137	138	0.377	1	0
138	138	139	0.377	1	0

[Handwritten signatures]



Software licensed to

Job No

1

Sheet No

8

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
139	139	140	0.377	1	0
140	140	141	0.377	1	0
141	141	142	0.377	1	0
142	142	143	0.377	1	0
143	143	144	0.377	1	0
144	144	145	0.377	1	0
145	145	146	0.377	1	0
146	146	147	0.377	1	0
147	147	148	0.377	1	0
148	148	149	0.377	1	0
149	149	150	0.377	1	0
150	150	1	0.377	1	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 0.70x1.00	7E+3	5.83E+6	2.86E+6	6.49E+6	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN·m/deg)	rY (kN·m/deg)	rZ (kN·m/deg)
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
11	-	-	-	-	-	-
12	-	-	-	-	-	-
13	-	-	-	-	-	-

Handwritten signatures and initials:
- Top right: *Handwritten signature*
- Middle right: *Handwritten signature*
- Bottom right: *Handwritten signature*
- Far right: *Handwritten signature*



Software licensed to

Job No

1

Sheet No

9

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Supports Cont...

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN·m/deg)	rY (kN·m/deg)	rZ (kN·m/deg)
14	-	-	-	-	-	-
15	-	-	-	-	-	-
16	-	-	-	-	-	-
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
32	-	-	-	-	-	-
33	-	-	-	-	-	-
34	-	-	-	-	-	-
35	-	-	-	-	-	-
36	-	-	-	-	-	-
37	-	-	-	-	-	-
38	-	-	-	-	-	-
39	-	-	-	-	-	-
40	-	-	-	-	-	-
41	-	-	-	-	-	-
42	-	-	-	-	-	-
43	-	-	-	-	-	-
44	-	-	-	-	-	-
45	-	-	-	-	-	-
46	-	-	-	-	-	-
47	-	-	-	-	-	-
48	-	-	-	-	-	-
49	-	-	-	-	-	-
50	-	-	-	-	-	-
51	-	-	-	-	-	-
52	-	-	-	-	-	-
53	-	-	-	-	-	-
54	-	-	-	-	-	-
55	-	-	-	-	-	-
56	-	-	-	-	-	-
57	Fixed	Fixed	Fixed	-	-	-
58	-	-	-	-	-	-
59	-	-	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

10

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Supports Cont...

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN`m/deg)	rY (kN`m/deg)	rZ (kN`m/deg)
60	-	-	-	-	-	-
61	-	-	-	-	-	-
62	-	-	-	-	-	-
63	-	-	-	-	-	-
64	-	-	-	-	-	-
65	-	-	-	-	-	-
66	-	-	-	-	-	-
67	-	-	-	-	-	-
68	-	-	-	-	-	-
69	-	-	-	-	-	-
70	-	-	-	-	-	-
71	-	-	-	-	-	-
72	-	-	-	-	-	-
73	-	-	-	-	-	-
74	-	-	-	-	-	-
75	-	-	-	-	-	-
76	-	-	-	-	-	-
77	-	-	-	-	-	-
78	-	-	-	-	-	-
79	-	-	-	-	-	-
80	-	-	-	-	-	-
81	-	-	-	-	-	-
82	-	-	-	-	-	-
83	-	-	-	-	-	-
84	-	-	-	-	-	-
85	-	-	-	-	-	-
86	-	-	-	-	-	-
87	-	-	-	-	-	-
88	-	-	-	-	-	-
89	-	-	-	-	-	-
90	-	-	-	-	-	-
91	-	-	-	-	-	-
92	-	-	-	-	-	-
93	Fixed	Fixed	Fixed	-	-	-
94	-	-	-	-	-	-
95	-	-	-	-	-	-
96	-	-	-	-	-	-
97	-	-	-	-	-	-
98	-	-	-	-	-	-
99	-	-	-	-	-	-
100	-	-	-	-	-	-
101	-	-	-	-	-	-
102	-	-	-	-	-	-
103	-	-	-	-	-	-
104	-	-	-	-	-	-
105	-	-	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

11

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Supports Cont...

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN·m/deg)	rY (kN·m/deg)	rZ (kN·m/deg)
106	-	-	-	-	-	-
107	-	-	-	-	-	-
108	-	-	-	-	-	-
109	-	-	-	-	-	-
110	-	-	-	-	-	-
111	-	-	-	-	-	-
112	-	-	-	-	-	-
113	-	-	-	-	-	-
114	-	-	-	-	-	-
115	-	-	-	-	-	-
116	-	-	-	-	-	-
117	-	-	-	-	-	-
118	-	-	-	-	-	-
119	-	-	-	-	-	-
120	-	-	-	-	-	-
121	-	-	-	-	-	-
122	-	-	-	-	-	-
123	-	-	-	-	-	-
124	-	-	-	-	-	-
125	-	-	-	-	-	-
126	-	-	-	-	-	-
127	-	-	-	-	-	-
128	-	-	-	-	-	-
129	-	-	-	-	-	-
130	-	-	-	-	-	-
131	-	-	-	-	-	-
132	-	-	-	-	-	-
133	-	-	-	-	-	-
134	-	-	-	-	-	-
135	-	-	-	-	-	-
136	-	-	-	-	-	-
137	-	-	-	-	-	-
138	-	-	-	-	-	-
139	-	-	-	-	-	-
140	-	-	-	-	-	-
141	-	-	-	-	-	-
142	-	-	-	-	-	-
143	-	-	-	-	-	-
144	-	-	-	-	-	-
145	-	-	-	-	-	-
146	-	-	-	-	-	-
147	-	-	-	-	-	-
148	-	-	-	-	-	-
149	-	-	-	-	-	-
150	-	-	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

12

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

Releases

There is no data of this type.

Primary Load Cases

Number	Name	Type
1	DEA LOAD	Dead
2	EARTH PRESSURE	Live
3	HYDROSTRATIC	Live
4	EARTH PRESSURE DRY	Live
5	SURCHARGE	Live

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
101	1.5DL + 1.5EP + 1.5WL	1	DEA LOAD	1.50
		2	EARTH PRESSURE	1.50
		3	HYDROSTRATIC	1.50
102	1.5DL + 1.5EP(DRY) + 1.5SURCHARGE	1	DEA LOAD	1.50
		4	EARTH PRESSURE DRY	1.50
		5	SURCHARGE	1.50
103	1.5DL + 1.5EP + 1.5WL + 1.5SURCHARGE	1	DEA LOAD	1.50
		2	EARTH PRESSURE	1.50
		3	HYDROSTRATIC	1.50
		5	SURCHARGE	1.50
201	1.0DL + 1.0EP + 1.0WL	1	DEA LOAD	1.00
		2	EARTH PRESSURE	1.00
		3	HYDROSTRATIC	1.00
202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	1	DEA LOAD	1.00
		4	EARTH PRESSURE DRY	1.00
		5	SURCHARGE	1.00
203	1.0DL + 1.0EP + 1.0WL + 1.0SURCHARGE	1	DEA LOAD	1.00
		2	EARTH PRESSURE	1.00
		3	HYDROSTRATIC	1.00
		5	SURCHARGE	1.00

Load Generators

There is no data of this type.

1 DEA LOAD : Selfweight

Direction	Factor	Assigned Geometry
Y	-1.000	ALL

Handwritten signatures and initials:
1. A signature in blue ink.
2. The initials "AD" in blue ink.
3. The initials "Rob" in blue ink.
4. The initials "CSa" in blue ink.
5. A signature in blue ink.



Software licensed to

Job No

1

Sheet No

13

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

2 EARTH PRESSURE : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-95.000	-	-95.038	-	-
2	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-95.038	-	-95.152	-	-
3	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-95.152	-	-95.343	-	-
4	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-95.343	-	-95.609	-	-
5	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-95.609	-	-95.952	-	-
6	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-95.952	-	-96.369	-	-
7	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-96.369	-	-96.862	-	-
8	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-96.862	-	-97.430	-	-
9	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-97.430	-	-98.073	-	-
10	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-98.073	-	-98.789	-	-
11	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-98.789	-	-99.580	-	-
12	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-99.580	-	-100.443	-	-
13	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-100.443	-	-101.379	-	-
14	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-101.379	-	-102.410	-	-
15	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-102.410	-	-103.543	-	-
16	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-103.543	-	-104.778	-	-
17	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-104.778	-	-106.113	-	-
18	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-106.113	-	-107.545	-	-
19	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-107.545	-	-109.074	-	-
20	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-109.074	-	-110.696	-	-
21	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-110.696	-	-112.410	-	-
22	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-112.410	-	-114.213	-	-
23	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-114.213	-	-116.101	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

14

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

2 EARTH PRESSURE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
24	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-116.101	-	-118.073	-	-
25	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-118.073	-	-120.126	-	-
26	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-120.126	-	-122.255	-	-
27	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-122.255	-	-124.459	-	-
28	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-124.459	-	-126.736	-	-
29	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-126.736	-	-129.115	-	-
30	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-129.115	-	-131.597	-	-
31	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-131.597	-	-134.172	-	-
32	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-134.172	-	-136.829	-	-
33	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-136.829	-	-139.557	-	-
34	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-139.557	-	-142.346	-	-
35	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-142.346	-	-145.182	-	-
36	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-145.182	-	-148.055	-	-
37	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-148.055	-	-150.953	-	-
38	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	-150.953	-	-153.864	-	-
39	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-153.864	-	-156.776	-	-
40	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-156.776	-	-159.676	-	-
41	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-159.676	-	-162.554	-	-
42	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-162.554	-	-165.396	-	-
43	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-165.396	-	-168.192	-	-
44	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-168.192	-	-170.930	-	-
45	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-170.930	-	-173.598	-	-
46	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-173.598	-	-176.185	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

15

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

2 EARTH PRESSURE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
47	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-176.185	-	-178.682	-	-
48	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-178.682	-	-181.076	-	-
49	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-181.076	-	-183.360	-	-
50	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-183.360	-	-185.523	-	-
51	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-185.523	-	-187.555	-	-
52	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-187.555	-	-189.450	-	-
53	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-189.450	-	-191.199	-	-
54	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-191.199	-	-192.794	-	-
55	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-192.794	-	-194.224	-	-
56	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-194.224	-	-195.410	-	-
57	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-195.410	-	-196.388	-	-
58	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-196.388	-	-197.307	-	-
59	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-197.307	-	-198.177	-	-
60	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-198.177	-	-198.994	-	-
61	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-198.994	-	-199.762	-	-
62	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-199.762	-	-200.477	-	-
63	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-200.477	-	-201.140	-	-
64	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-201.140	-	-201.752	-	-
65	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-201.752	-	-202.311	-	-
66	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-202.311	-	-202.819	-	-
67	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-202.819	-	-203.272	-	-
68	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-203.272	-	-203.675	-	-
69	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-203.675	-	-204.023	-	-



Software licensed to

Job No

1

Sheet No

16

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

2 EARTH PRESSURE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
70	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-204.023	-	-204.319	-	-
71	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-204.319	-	-204.562	-	-
72	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-204.562	-	-204.751	-	-
73	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-204.751	-	-204.887	-	-
74	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-204.887	-	-204.971	-	-
75	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	-204.971	-	-205.000	-	-
76	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	205.000	-	204.971	-	-
77	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	204.971	-	204.887	-	-
78	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	204.887	-	204.751	-	-
79	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	204.751	-	204.562	-	-
80	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	204.562	-	204.319	-	-
81	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	204.319	-	204.023	-	-
82	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	204.023	-	203.675	-	-
83	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	203.675	-	203.272	-	-
84	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	203.272	-	202.819	-	-
85	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	202.819	-	202.311	-	-
86	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	202.311	-	201.752	-	-
87	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	201.752	-	201.140	-	-
88	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	201.140	-	200.477	-	-
89	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	200.477	-	199.762	-	-
90	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	199.762	-	198.994	-	-
91	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	198.994	-	198.177	-	-
92	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	198.177	-	197.307	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

17

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

2 EARTH PRESSURE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
93	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	197.307	-	196.388	-	-
94	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	196.388	-	195.410	-	-
95	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	195.410	-	194.224	-	-
96	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	194.224	-	192.794	-	-
97	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	192.794	-	191.199	-	-
98	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	191.199	-	189.450	-	-
99	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	189.450	-	187.555	-	-
100	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	187.555	-	185.523	-	-
101	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	185.523	-	183.360	-	-
102	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	183.360	-	181.076	-	-
103	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	181.076	-	178.682	-	-
104	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	178.682	-	176.185	-	-
105	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	176.185	-	173.598	-	-
106	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	173.598	-	170.930	-	-
107	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	170.930	-	168.192	-	-
108	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	168.192	-	165.396	-	-
109	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	165.396	-	162.554	-	-
110	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	162.554	-	159.676	-	-
111	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	159.676	-	156.776	-	-
112	UNI kN/m	GY	222.000	-	-	-	-
	TRAP kN/m	GX	156.776	-	153.864	-	-
113	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	153.864	-	150.953	-	-
114	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	150.953	-	148.055	-	-
115	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	148.055	-	145.182	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

18

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

2 EARTH PRESSURE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
116	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	145.182	-	142.346	-
117	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	142.346	-	139.557	-
118	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	139.557	-	136.829	-
119	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	136.829	-	134.172	-
120	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	134.172	-	131.597	-
121	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	131.597	-	129.115	-
122	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	129.115	-	126.736	-
123	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	126.736	-	124.459	-
124	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	124.459	-	122.255	-
125	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	122.255	-	120.126	-
126	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	120.126	-	118.073	-
127	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	118.073	-	116.101	-
128	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	116.101	-	114.213	-
129	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	114.213	-	112.410	-
130	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	112.410	-	110.696	-
131	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	110.696	-	109.074	-
132	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	109.074	-	107.545	-
133	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	107.545	-	106.113	-
134	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	106.113	-	104.778	-
135	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	104.778	-	103.543	-
136	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	103.543	-	102.410	-
137	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	102.410	-	101.379	-
138	UNI	kN/m	GY	-222.000	-	-	-
	TRAP	kN/m	GX	101.379	-	100.443	-



Software licensed to

Job No

1

Sheet No

19

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

2 EARTH PRESSURE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
139	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	100.443	-	99.580	-	-
140	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	99.580	-	98.789	-	-
141	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	98.789	-	98.073	-	-
142	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	98.073	-	97.430	-	-
143	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	97.430	-	96.862	-	-
144	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	96.862	-	96.369	-	-
145	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	96.369	-	95.952	-	-
146	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	95.952	-	95.609	-	-
147	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	95.609	-	95.343	-	-
148	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	95.343	-	95.152	-	-
149	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	95.152	-	95.038	-	-
150	UNI kN/m	GY	-222.000	-	-	-	-
	TRAP kN/m	GX	95.038	-	95.000	-	-

3 HYDROSTRATIC : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	TRAP kN/m	Y	-139.000	-	-139.066	-	-
2	TRAP kN/m	Y	-139.066	-	-139.265	-	-
3	TRAP kN/m	Y	-139.265	-	-139.598	-	-
4	TRAP kN/m	Y	-139.598	-	-140.063	-	-
5	TRAP kN/m	Y	-140.063	-	-140.661	-	-
6	TRAP kN/m	Y	-140.661	-	-141.390	-	-
7	TRAP kN/m	Y	-141.390	-	-142.250	-	-
8	TRAP kN/m	Y	-142.250	-	-143.242	-	-
9	TRAP kN/m	Y	-143.242	-	-144.364	-	-
10	TRAP kN/m	Y	-144.364	-	-145.614	-	-
11	TRAP kN/m	Y	-145.614	-	-146.994	-	-
12	TRAP kN/m	Y	-146.994	-	-148.500	-	-
13	TRAP kN/m	Y	-148.500	-	-150.135	-	-
14	TRAP kN/m	Y	-150.135	-	-151.933	-	-
15	TRAP kN/m	Y	-151.933	-	-153.911	-	-
16	TRAP kN/m	Y	-153.911	-	-156.067	-	-
17	TRAP kN/m	Y	-156.067	-	-158.397	-	-

Handwritten signatures and initials:
1. *Amal*
2. *Adar*
3. *Rob*
4. *CSA*
5. *John*



Software licensed to

Job No

1

Sheet No

20

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

3 HYDROSTATIC : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
18	TRAP kN/m	Y	-158.397	-	-160.897	-	-
19	TRAP kN/m	Y	-160.897	-	-163.565	-	-
20	TRAP kN/m	Y	-163.565	-	-166.397	-	-
21	TRAP kN/m	Y	-166.397	-	-169.389	-	-
22	TRAP kN/m	Y	-169.389	-	-172.535	-	-
23	TRAP kN/m	Y	-172.535	-	-175.830	-	-
24	TRAP kN/m	Y	-175.830	-	-179.273	-	-
25	TRAP kN/m	Y	-179.273	-	-182.855	-	-
26	TRAP kN/m	Y	-182.855	-	-186.573	-	-
27	TRAP kN/m	Y	-186.573	-	-190.420	-	-
28	TRAP kN/m	Y	-190.420	-	-194.393	-	-
29	TRAP kN/m	Y	-194.393	-	-198.546	-	-
30	TRAP kN/m	Y	-198.546	-	-202.879	-	-
31	TRAP kN/m	Y	-202.879	-	-207.374	-	-
32	TRAP kN/m	Y	-207.374	-	-212.011	-	-
33	TRAP kN/m	Y	-212.011	-	-216.773	-	-
34	TRAP kN/m	Y	-216.773	-	-221.639	-	-
35	TRAP kN/m	Y	-221.639	-	-226.590	-	-
36	TRAP kN/m	Y	-226.590	-	-231.605	-	-
37	TRAP kN/m	Y	-231.605	-	-236.664	-	-
38	TRAP kN/m	Y	-236.664	-	-241.745	-	-
39	TRAP kN/m	Y	241.745	-	246.827	-	-
40	TRAP kN/m	Y	246.827	-	251.889	-	-
41	TRAP kN/m	Y	251.889	-	256.912	-	-
42	TRAP kN/m	Y	256.912	-	261.873	-	-
43	TRAP kN/m	Y	261.873	-	266.753	-	-
44	TRAP kN/m	Y	266.753	-	271.533	-	-
45	TRAP kN/m	Y	271.533	-	276.189	-	-
46	TRAP kN/m	Y	276.189	-	280.705	-	-
47	TRAP kN/m	Y	280.705	-	285.063	-	-
48	TRAP kN/m	Y	285.063	-	289.242	-	-
49	TRAP kN/m	Y	289.242	-	293.228	-	-
50	TRAP kN/m	Y	293.228	-	297.003	-	-
51	TRAP kN/m	Y	297.003	-	300.551	-	-
52	TRAP kN/m	Y	300.551	-	303.859	-	-
53	TRAP kN/m	Y	303.859	-	306.910	-	-
54	TRAP kN/m	Y	306.910	-	309.695	-	-
55	TRAP kN/m	Y	309.695	-	312.191	-	-
56	TRAP kN/m	Y	312.191	-	314.262	-	-
57	TRAP kN/m	Y	314.262	-	315.967	-	-
58	TRAP kN/m	Y	315.967	-	317.572	-	-
59	TRAP kN/m	Y	317.572	-	319.091	-	-
60	TRAP kN/m	Y	319.091	-	320.517	-	-
61	TRAP kN/m	Y	320.517	-	321.857	-	-
62	TRAP kN/m	Y	321.857	-	323.106	-	-
63	TRAP kN/m	Y	323.106	-	324.263	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

21

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

3 HYDROSTATIC : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
64	TRAP kN/m	Y	324.263	-	325.332	-	-
65	TRAP kN/m	Y	325.332	-	326.307	-	-
66	TRAP kN/m	Y	326.307	-	327.192	-	-
67	TRAP kN/m	Y	327.192	-	327.985	-	-
68	TRAP kN/m	Y	327.985	-	328.687	-	-
69	TRAP kN/m	Y	328.687	-	329.294	-	-
70	TRAP kN/m	Y	329.294	-	329.812	-	-
71	TRAP kN/m	Y	329.812	-	330.235	-	-
72	TRAP kN/m	Y	330.235	-	330.565	-	-
73	TRAP kN/m	Y	330.565	-	330.803	-	-
74	TRAP kN/m	Y	330.803	-	330.949	-	-
75	TRAP kN/m	Y	330.949	-	331.000	-	-
76	TRAP kN/m	Y	331.000	-	330.949	-	-
77	TRAP kN/m	Y	330.949	-	330.803	-	-
78	TRAP kN/m	Y	330.803	-	330.565	-	-
79	TRAP kN/m	Y	330.565	-	330.235	-	-
80	TRAP kN/m	Y	330.235	-	329.812	-	-
81	TRAP kN/m	Y	329.812	-	329.294	-	-
82	TRAP kN/m	Y	329.294	-	328.687	-	-
83	TRAP kN/m	Y	328.687	-	327.985	-	-
84	TRAP kN/m	Y	327.985	-	327.192	-	-
85	TRAP kN/m	Y	327.192	-	326.307	-	-
86	TRAP kN/m	Y	326.307	-	325.332	-	-
87	TRAP kN/m	Y	325.332	-	324.263	-	-
88	TRAP kN/m	Y	324.263	-	323.106	-	-
89	TRAP kN/m	Y	323.106	-	321.857	-	-
90	TRAP kN/m	Y	321.857	-	320.517	-	-
91	TRAP kN/m	Y	320.517	-	319.091	-	-
92	TRAP kN/m	Y	319.091	-	317.572	-	-
93	TRAP kN/m	Y	317.572	-	315.967	-	-
94	TRAP kN/m	Y	315.967	-	314.262	-	-
95	TRAP kN/m	Y	314.262	-	312.191	-	-
96	TRAP kN/m	Y	312.191	-	309.695	-	-
97	TRAP kN/m	Y	309.695	-	306.910	-	-
98	TRAP kN/m	Y	306.910	-	303.859	-	-
99	TRAP kN/m	Y	303.859	-	300.551	-	-
100	TRAP kN/m	Y	300.551	-	297.003	-	-
101	TRAP kN/m	Y	297.003	-	293.228	-	-
102	TRAP kN/m	Y	293.228	-	289.242	-	-
103	TRAP kN/m	Y	289.242	-	285.063	-	-
104	TRAP kN/m	Y	285.063	-	280.705	-	-
105	TRAP kN/m	Y	280.705	-	276.189	-	-
106	TRAP kN/m	Y	276.189	-	271.533	-	-
107	TRAP kN/m	Y	271.533	-	266.753	-	-
108	TRAP kN/m	Y	266.753	-	261.873	-	-
109	TRAP kN/m	Y	261.873	-	256.912	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

22

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

3 HYDROSTATIC : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
110	TRAP kN/m	Y	256.912	-	251.889	-	-
111	TRAP kN/m	Y	251.889	-	246.827	-	-
112	TRAP kN/m	Y	246.827	-	241.745	-	-
113	TRAP kN/m	Y	-241.745	-	-236.664	-	-
114	TRAP kN/m	Y	-236.664	-	-231.605	-	-
115	TRAP kN/m	Y	-231.605	-	-226.590	-	-
116	TRAP kN/m	Y	-226.590	-	-221.639	-	-
117	TRAP kN/m	Y	-221.639	-	-216.773	-	-
118	TRAP kN/m	Y	-216.773	-	-212.011	-	-
119	TRAP kN/m	Y	-212.011	-	-207.374	-	-
120	TRAP kN/m	Y	-207.374	-	-202.879	-	-
121	TRAP kN/m	Y	-202.879	-	-198.546	-	-
122	TRAP kN/m	Y	-198.546	-	-194.393	-	-
123	TRAP kN/m	Y	-194.393	-	-190.420	-	-
124	TRAP kN/m	Y	-190.420	-	-186.573	-	-
125	TRAP kN/m	Y	-186.573	-	-182.855	-	-
126	TRAP kN/m	Y	-182.855	-	-179.273	-	-
127	TRAP kN/m	Y	-179.273	-	-175.830	-	-
128	TRAP kN/m	Y	-175.830	-	-172.535	-	-
129	TRAP kN/m	Y	-172.535	-	-169.389	-	-
130	TRAP kN/m	Y	-169.389	-	-166.397	-	-
131	TRAP kN/m	Y	-166.397	-	-163.565	-	-
132	TRAP kN/m	Y	-163.565	-	-160.897	-	-
133	TRAP kN/m	Y	-160.897	-	-158.397	-	-
134	TRAP kN/m	Y	-158.397	-	-156.067	-	-
135	TRAP kN/m	Y	-156.067	-	-153.911	-	-
136	TRAP kN/m	Y	-153.911	-	-151.933	-	-
137	TRAP kN/m	Y	-151.933	-	-150.135	-	-
138	TRAP kN/m	Y	-150.135	-	-148.500	-	-
139	TRAP kN/m	Y	-148.500	-	-146.994	-	-
140	TRAP kN/m	Y	-146.994	-	-145.614	-	-
141	TRAP kN/m	Y	-145.614	-	-144.364	-	-
142	TRAP kN/m	Y	-144.364	-	-143.242	-	-
143	TRAP kN/m	Y	-143.242	-	-142.250	-	-
144	TRAP kN/m	Y	-142.250	-	-141.390	-	-
145	TRAP kN/m	Y	-141.390	-	-140.661	-	-
146	TRAP kN/m	Y	-140.661	-	-140.063	-	-
147	TRAP kN/m	Y	-140.063	-	-139.598	-	-
148	TRAP kN/m	Y	-139.598	-	-139.265	-	-
149	TRAP kN/m	Y	-139.265	-	-139.066	-	-
150	TRAP kN/m	Y	-139.066	-	-139.000	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

23

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

4 EARTH PRESSURE DRY : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	155.200	-	155.240	-	-
2	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-155.200	-	-155.321	-	-
3	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-155.321	-	-155.523	-	-
4	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-155.523	-	-155.806	-	-
5	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-155.806	-	-156.169	-	-
6	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-156.169	-	-156.612	-	-
7	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-156.612	-	-157.135	-	-
8	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-157.135	-	-157.737	-	-
9	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-157.737	-	-158.419	-	-
10	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-158.419	-	-159.179	-	-
11	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-159.179	-	-160.018	-	-
12	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-160.018	-	-160.933	-	-
13	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-160.933	-	-161.926	-	-
14	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-161.926	-	-163.019	-	-
15	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-163.019	-	-164.221	-	-
16	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-164.221	-	-165.531	-	-
17	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-165.531	-	-166.947	-	-
18	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-166.947	-	-168.466	-	-
19	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-168.466	-	-170.087	-	-
20	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-170.087	-	-171.808	-	-
21	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-171.808	-	-173.626	-	-
22	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-173.626	-	-175.538	-	-
23	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-175.538	-	-177.540	-	-



Software licensed to

Job No

1

Sheet No

24

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

4 EARTH PRESSURE DRY : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
24	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-177.540	-	-179.632	-	-
25	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-179.632	-	-181.809	-	-
26	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-181.809	-	-184.068	-	-
27	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-184.068	-	-186.406	-	-
28	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-186.406	-	-188.820	-	-
29	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-188.820	-	-191.344	-	-
30	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-191.344	-	-193.977	-	-
31	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-193.977	-	-196.708	-	-
32	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-196.708	-	-199.526	-	-
33	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-199.526	-	-202.420	-	-
34	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-202.420	-	-205.377	-	-
35	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-205.377	-	-208.385	-	-
36	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-208.385	-	-211.432	-	-
37	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-211.432	-	-214.507	-	-
38	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	-214.507	-	-217.594	-	-
39	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-217.594	-	-220.682	-	-
40	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-220.682	-	-223.758	-	-
41	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-223.758	-	-226.811	-	-
42	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-226.811	-	-229.825	-	-
43	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-229.825	-	-232.791	-	-
44	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-232.791	-	-235.695	-	-
45	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-235.695	-	-238.525	-	-
46	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-238.525	-	-241.269	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

25

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

4 EARTH PRESSURE DRY : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
47	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-241.269	-	-243.917	-	-
48	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-243.917	-	-246.457	-	-
49	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-246.457	-	-248.878	-	-
50	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-248.878	-	-251.173	-	-
51	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-251.173	-	-253.328	-	-
52	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-253.328	-	-255.338	-	-
53	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-255.338	-	-257.193	-	-
54	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-257.193	-	-258.885	-	-
55	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-258.885	-	-260.401	-	-
56	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-260.401	-	-261.660	-	-
57	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-261.660	-	-262.696	-	-
58	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-262.696	-	-263.671	-	-
59	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-263.671	-	-264.594	-	-
60	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-264.594	-	-265.461	-	-
61	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-265.461	-	-266.275	-	-
62	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-266.275	-	-267.034	-	-
63	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-267.034	-	-267.737	-	-
64	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-267.737	-	-268.387	-	-
65	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-268.387	-	-268.979	-	-
66	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-268.979	-	-269.517	-	-
67	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-269.517	-	-269.999	-	-
68	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-269.999	-	-270.425	-	-
69	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-270.425	-	-270.795	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

26

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

4 EARTH PRESSURE DRY : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
70	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-270.795	-	-271.109	-	-
71	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-271.109	-	-271.366	-	-
72	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-271.366	-	-271.567	-	-
73	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-271.567	-	-271.712	-	-
74	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	-271.712	-	-271.800	-	-
75	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	271.769	-	271.800	-	-
76	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	271.800	-	271.769	-	-
77	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	271.769	-	271.681	-	-
78	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	271.681	-	271.536	-	-
79	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	271.536	-	271.335	-	-
80	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	271.335	-	271.078	-	-
81	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	271.078	-	270.764	-	-
82	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	270.764	-	270.395	-	-
83	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	270.395	-	269.969	-	-
84	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	269.969	-	269.488	-	-
85	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	269.488	-	268.950	-	-
86	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	268.950	-	268.358	-	-
87	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	268.358	-	267.709	-	-
88	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	267.709	-	267.006	-	-
89	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	267.006	-	266.247	-	-
90	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	266.247	-	265.434	-	-
91	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	265.434	-	264.568	-	-
92	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	264.568	-	263.645	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

27

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

4 EARTH PRESSURE DRY : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
93	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	263.645	-	262.671	-	-
94	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	262.671	-	261.635	-	-
95	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	261.635	-	260.377	-	-
96	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	260.377	-	258.862	-	-
97	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	258.862	-	257.171	-	-
98	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	257.171	-	255.317	-	-
99	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	255.317	-	253.308	-	-
100	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	253.308	-	251.154	-	-
101	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	251.154	-	248.861	-	-
102	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	248.861	-	246.441	-	-
103	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	246.441	-	243.903	-	-
104	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	243.903	-	241.257	-	-
105	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	241.257	-	238.514	-	-
106	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	238.514	-	235.686	-	-
107	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	235.686	-	232.784	-	-
108	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	232.784	-	229.820	-	-
109	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	229.820	-	226.807	-	-
110	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	226.807	-	223.757	-	-
111	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	223.757	-	220.683	-	-
112	UNI kN/m	GY	361.000	-	-	-	-
	TRAP kN/m	GX	220.683	-	217.596	-	-
113	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	217.596	-	214.511	-	-
114	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	214.511	-	211.438	-	-
115	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	211.438	-	208.393	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

28

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

4 EARTH PRESSURE DRY : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
116	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	208.393	-	205.386	-	-
117	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	205.386	-	202.431	-	-
118	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	202.431	-	199.539	-	-
119	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	199.539	-	196.723	-	-
120	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	196.723	-	193.993	-	-
121	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	193.993	-	191.362	-	-
122	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	191.362	-	188.840	-	-
123	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	188.840	-	186.427	-	-
124	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	186.427	-	184.091	-	-
125	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	184.091	-	181.833	-	-
126	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	181.833	-	179.657	-	-
127	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	179.657	-	177.567	-	-
128	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	177.567	-	175.565	-	-
129	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	175.565	-	173.655	-	-
130	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	173.655	-	171.838	-	-
131	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	171.838	-	170.118	-	-
132	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	170.118	-	168.498	-	-
133	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	168.498	-	166.979	-	-
134	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	166.979	-	165.565	-	-
135	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	165.565	-	164.256	-	-
136	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	164.256	-	163.054	-	-
137	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	163.054	-	161.962	-	-
138	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	161.962	-	160.969	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

29

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

4 EARTH PRESSURE DRY : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
139	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	160.969	-	160.055	-	-
140	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	160.055	-	159.217	-	-
141	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	159.217	-	158.457	-	-
142	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	158.457	-	157.776	-	-
143	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	157.776	-	157.174	-	-
144	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	157.174	-	156.652	-	-
145	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	156.652	-	156.209	-	-
146	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	156.209	-	155.846	-	-
147	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	155.846	-	155.563	-	-
148	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	155.563	-	155.361	-	-
149	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	155.361	-	155.240	-	-
150	UNI kN/m	GY	-361.000	-	-	-	-
	TRAP kN/m	GX	155.240	-	155.200	-	-

5 SURCHARGE : Beam Loads

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
1	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
2	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
3	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
4	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
5	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
6	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
7	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
8	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
9	UNI kN/m	GY	-60.000	-	-	-	-

Handwritten signatures and initials:
1. *Amir*
2. *Adi*
3. *Rob*
4. *CSA*
5. *CSA*



Software licensed to

Job No

1

Sheet No

30

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

5 SURCHARGE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
9	UNI kN/m	GX	-30.000	-	-	-	-
10	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
11	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
12	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
13	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
14	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
15	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
16	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
17	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
18	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
19	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
20	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
21	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
22	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
23	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
24	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
25	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
26	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
27	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
28	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
29	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
30	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
31	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
32	UNI kN/m	GY	-60.000	-	-	-	-



Software licensed to

Job No

1

Sheet No

31

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

5 SURCHARGE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
32	UNI kN/m	GX	-30.000	-	-	-	-
33	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
34	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
35	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
36	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
37	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
38	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	-30.000	-	-	-	-
39	UNI kN/m	GX	-30.000	-	-	-	-
40	UNI kN/m	GX	-30.000	-	-	-	-
41	UNI kN/m	GX	-30.000	-	-	-	-
42	UNI kN/m	GX	-30.000	-	-	-	-
43	UNI kN/m	GX	-30.000	-	-	-	-
44	UNI kN/m	GX	-30.000	-	-	-	-
45	UNI kN/m	GX	-30.000	-	-	-	-
46	UNI kN/m	GX	-30.000	-	-	-	-
47	UNI kN/m	GX	-30.000	-	-	-	-
48	UNI kN/m	GX	-30.000	-	-	-	-
49	UNI kN/m	GX	-30.000	-	-	-	-
50	UNI kN/m	GX	-30.000	-	-	-	-
51	UNI kN/m	GX	-30.000	-	-	-	-
52	UNI kN/m	GX	-30.000	-	-	-	-
53	UNI kN/m	GX	-30.000	-	-	-	-
54	UNI kN/m	GX	-30.000	-	-	-	-
55	UNI kN/m	GX	-30.000	-	-	-	-
56	UNI kN/m	GX	-30.000	-	-	-	-
57	UNI kN/m	GX	-30.000	-	-	-	-
58	UNI kN/m	GX	-30.000	-	-	-	-
59	UNI kN/m	GX	-30.000	-	-	-	-
60	UNI kN/m	GX	-30.000	-	-	-	-
61	UNI kN/m	GX	-30.000	-	-	-	-
62	UNI kN/m	GX	-30.000	-	-	-	-
63	UNI kN/m	GX	-30.000	-	-	-	-
64	UNI kN/m	GX	-30.000	-	-	-	-
65	UNI kN/m	GX	-30.000	-	-	-	-
66	UNI kN/m	GX	-30.000	-	-	-	-
67	UNI kN/m	GX	-30.000	-	-	-	-
68	UNI kN/m	GX	-30.000	-	-	-	-
69	UNI kN/m	GX	-30.000	-	-	-	-
70	UNI kN/m	GX	-30.000	-	-	-	-
71	UNI kN/m	GX	-30.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

32

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT Date/Time 22-Oct-2024 11:23

5 SURCHARGE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
72	UNI kN/m	GX	-30.000	-	-	-	-
73	UNI kN/m	GX	-30.000	-	-	-	-
74	UNI kN/m	GX	-30.000	-	-	-	-
75	UNI kN/m	GX	-30.000	-	-	-	-
76	UNI kN/m	GX	30.000	-	-	-	-
77	UNI kN/m	GX	30.000	-	-	-	-
78	UNI kN/m	GX	30.000	-	-	-	-
79	UNI kN/m	GX	30.000	-	-	-	-
80	UNI kN/m	GX	30.000	-	-	-	-
81	UNI kN/m	GX	30.000	-	-	-	-
82	UNI kN/m	GX	30.000	-	-	-	-
83	UNI kN/m	GX	30.000	-	-	-	-
84	UNI kN/m	GX	30.000	-	-	-	-
85	UNI kN/m	GX	30.000	-	-	-	-
86	UNI kN/m	GX	30.000	-	-	-	-
87	UNI kN/m	GX	30.000	-	-	-	-
88	UNI kN/m	GX	30.000	-	-	-	-
89	UNI kN/m	GX	30.000	-	-	-	-
90	UNI kN/m	GX	30.000	-	-	-	-
91	UNI kN/m	GX	30.000	-	-	-	-
92	UNI kN/m	GX	30.000	-	-	-	-
93	UNI kN/m	GX	30.000	-	-	-	-
94	UNI kN/m	GX	30.000	-	-	-	-
95	UNI kN/m	GX	30.000	-	-	-	-
96	UNI kN/m	GX	30.000	-	-	-	-
97	UNI kN/m	GX	30.000	-	-	-	-
98	UNI kN/m	GX	30.000	-	-	-	-
99	UNI kN/m	GX	30.000	-	-	-	-
100	UNI kN/m	GX	30.000	-	-	-	-
101	UNI kN/m	GX	30.000	-	-	-	-
102	UNI kN/m	GX	30.000	-	-	-	-
103	UNI kN/m	GX	30.000	-	-	-	-
104	UNI kN/m	GX	30.000	-	-	-	-
105	UNI kN/m	GX	30.000	-	-	-	-
106	UNI kN/m	GX	30.000	-	-	-	-
107	UNI kN/m	GX	30.000	-	-	-	-
108	UNI kN/m	GX	30.000	-	-	-	-
109	UNI kN/m	GX	30.000	-	-	-	-
110	UNI kN/m	GX	30.000	-	-	-	-
111	UNI kN/m	GX	30.000	-	-	-	-
112	UNI kN/m	GX	30.000	-	-	-	-
113	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
114	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
115	UNI kN/m	GY	-60.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

33

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

5 SURCHARGE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
115	UNI kN/m	GX	30.000	-	-	-	-
116	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
117	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
118	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
119	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
120	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
121	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
122	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
123	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
124	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
125	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
126	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
127	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
128	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
129	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
130	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
131	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
132	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
133	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
134	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
135	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
136	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
137	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
138	UNI kN/m	GY	-60.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

34

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23

5 SURCHARGE : Beam Loads Cont...

Beam	Type	Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
138	UNI kN/m	GX	30.000	-	-	-	-
139	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
140	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
141	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
142	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
143	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
144	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
145	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
146	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
147	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
148	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
149	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-
150	UNI kN/m	GY	-60.000	-	-	-	-
	UNI kN/m	GX	30.000	-	-	-	-

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

35

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



Whole Structure

[Handwritten signatures and initials]



Software licensed to

Job No

1

Sheet No

36

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

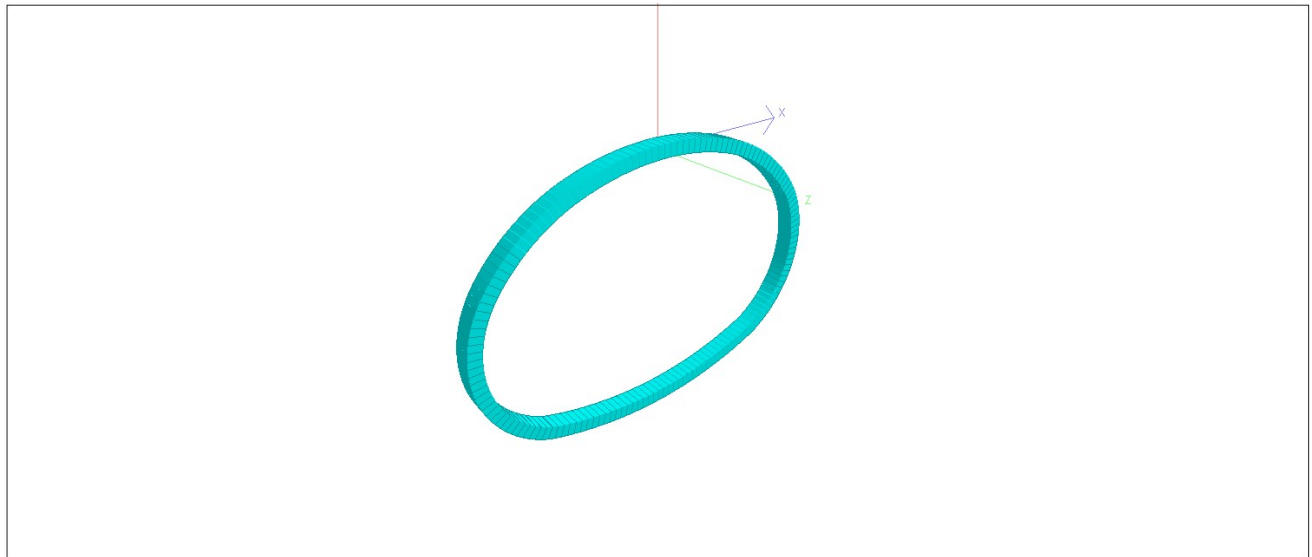
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



3D Rendered View

Handwritten signatures:
1. [Signature]
2. [Signature]
3. [Signature]
4. [Signature]
5. [Signature]



Software licensed to

Job No

1

Sheet No

37

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

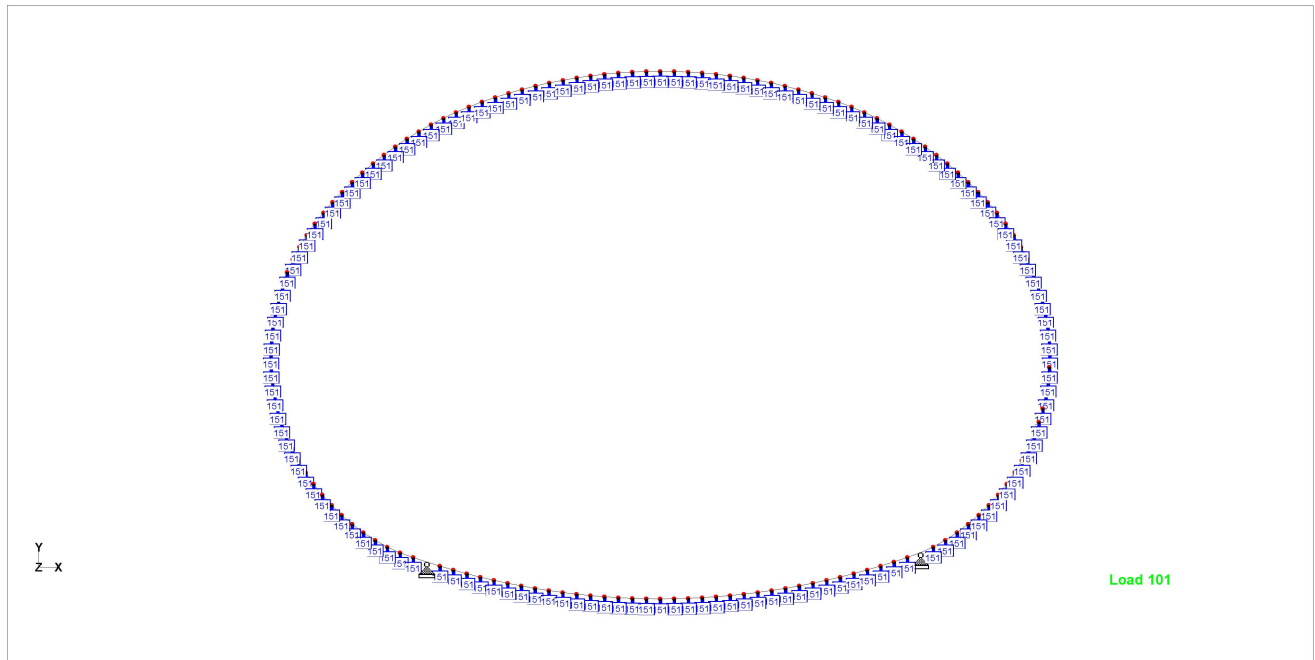
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



SUPPORTS

[Handwritten signatures and initials]



Software licensed to

Job No

1

Sheet No

38

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

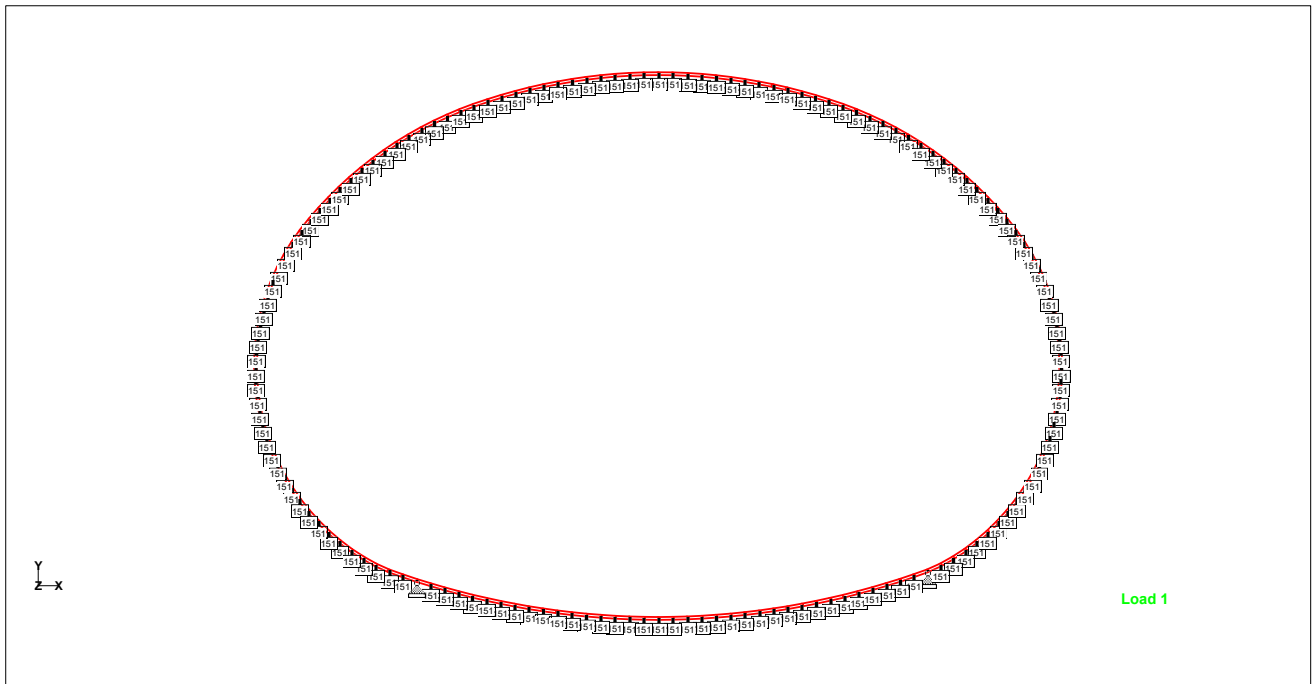
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



DL(SELF WEIGHT)

Handwritten signatures and initials:
1. *Handwritten signature*
2. *Handwritten signature*
3. *Handwritten signature*
4. *Handwritten signature*
5. *Handwritten signature*



Software licensed to

Job No

1

Sheet No

39

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

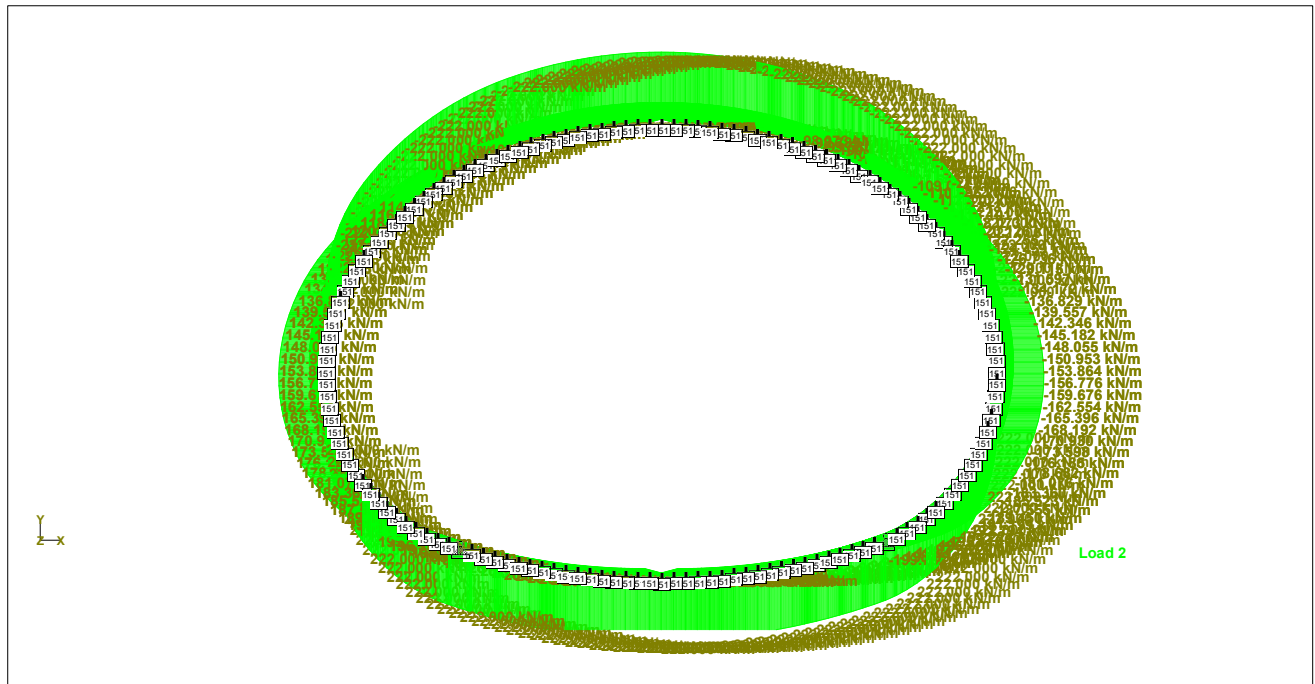
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



EARTH PRESSURE

[Handwritten signatures and initials]



Software licensed to

Job No

1

Sheet No

40

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

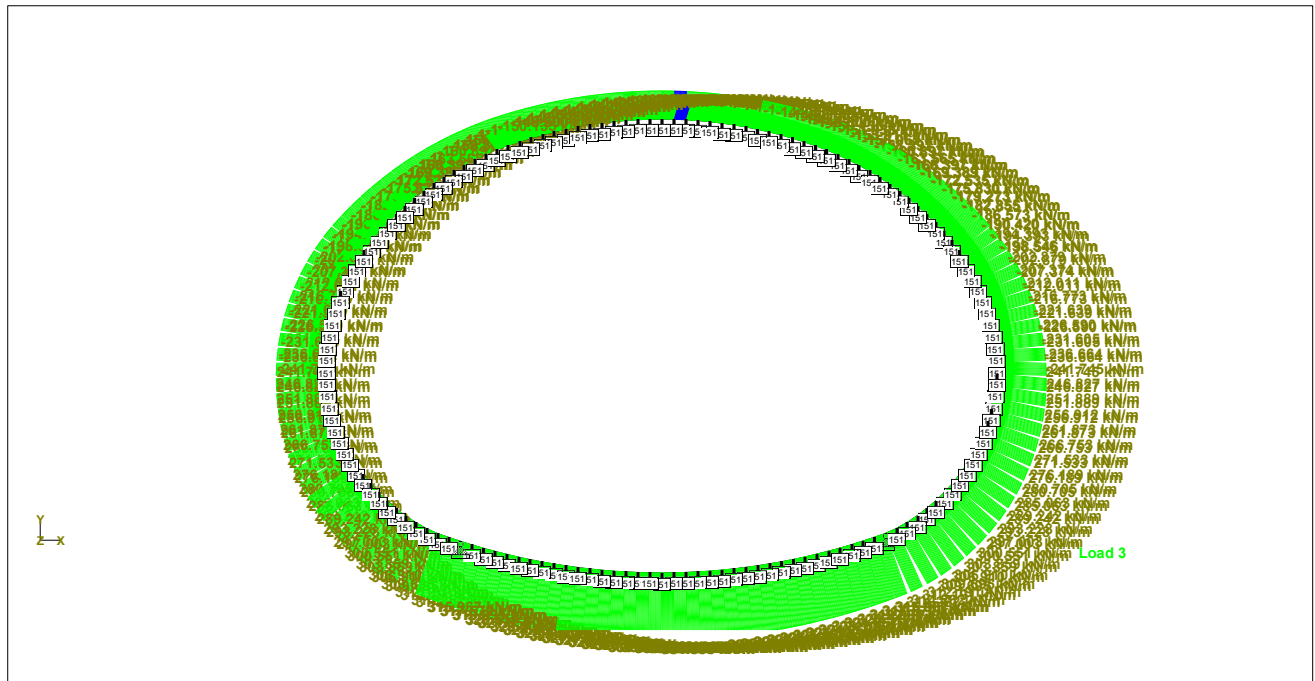
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSE

Date/Time 22-Oct-2024 11:23



HYDROSTRATIC

Handwritten signatures and initials:
1. *Handwritten signature*
2. *Handwritten signature*
3. *Handwritten signature*
4. *Handwritten signature*
5. *Handwritten signature*



Software licensed to

Job No

1

Sheet No

41

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

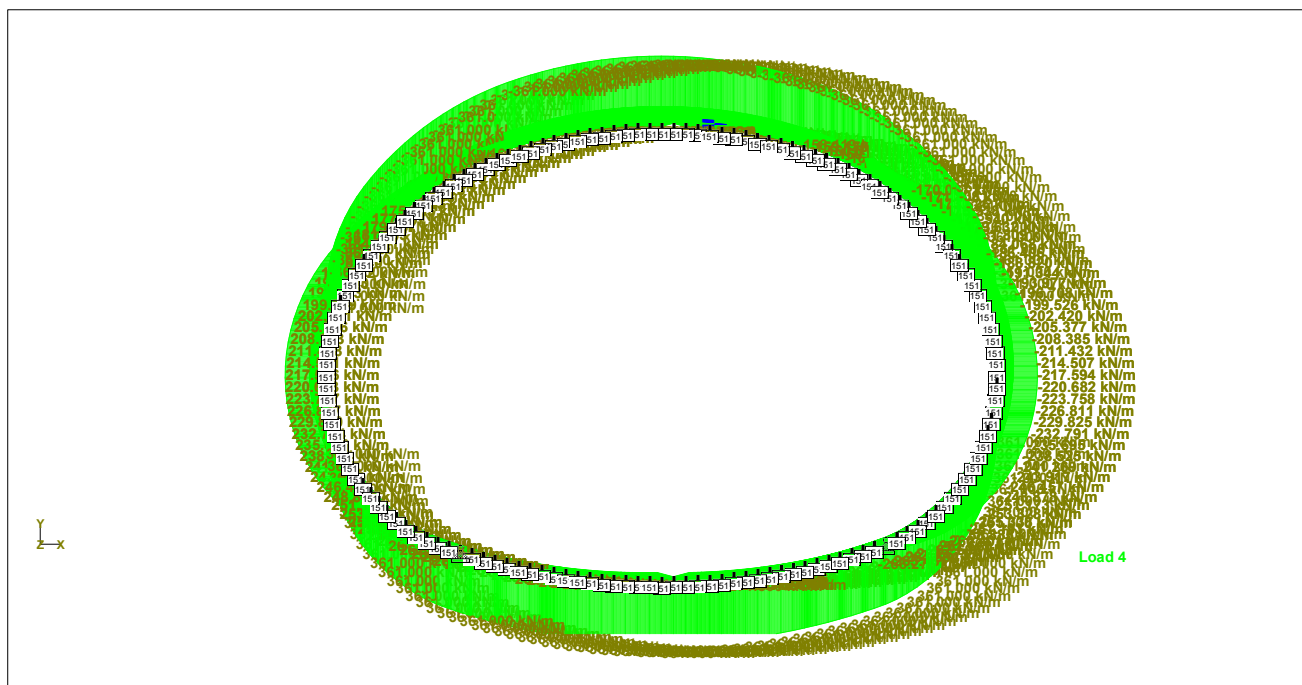
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSE

Date/Time 22-Oct-2024 11:23



EARTH PRESSURE DRY

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

42

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

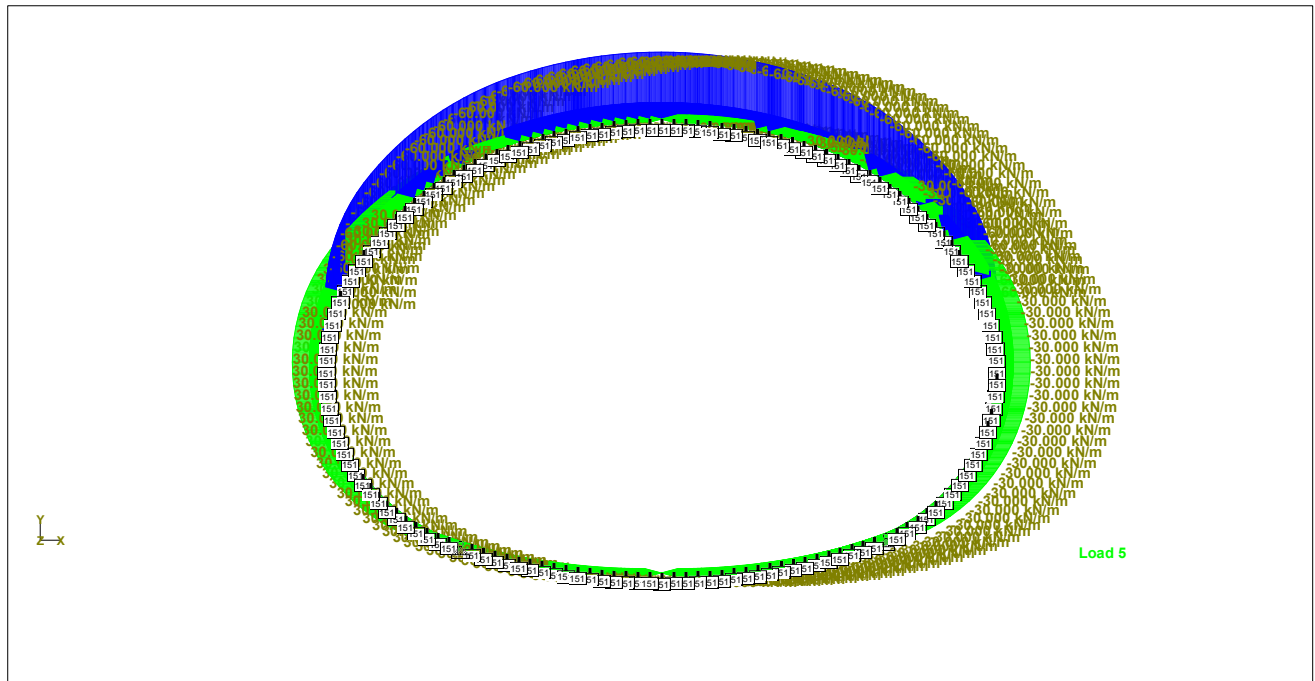
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



SURCHARGE

Handwritten signatures and initials:
1. *Amir*
2. *Rob*
3. *CSA*
4. *John*



Software licensed to

Job No

1

Sheet No

43

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

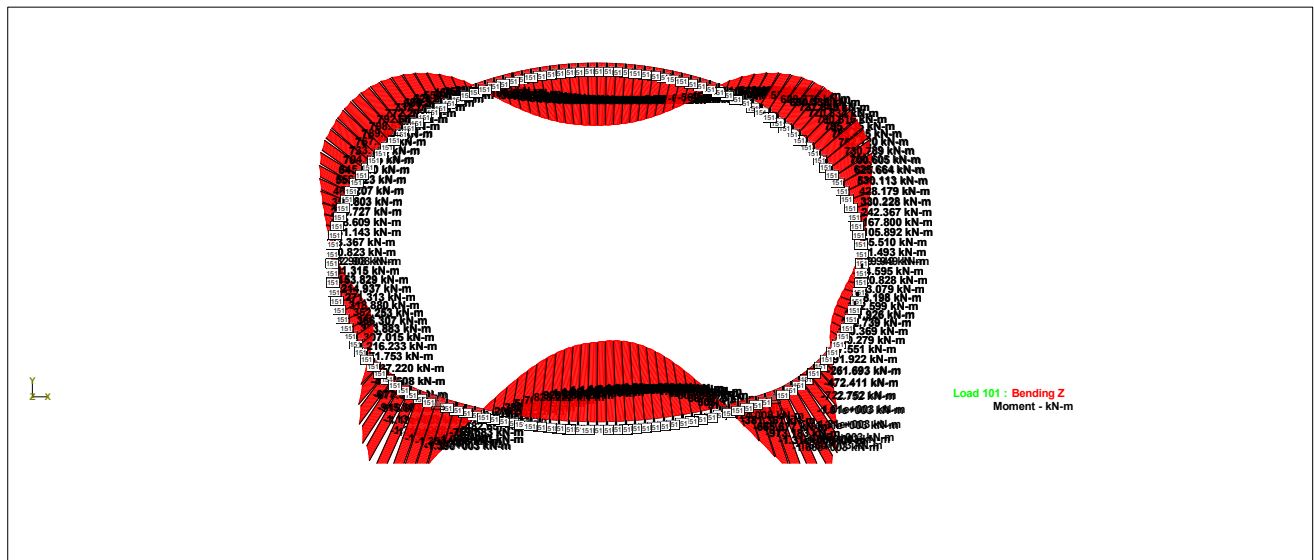
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



BM(Mz)

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

1

Sheet No

44

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

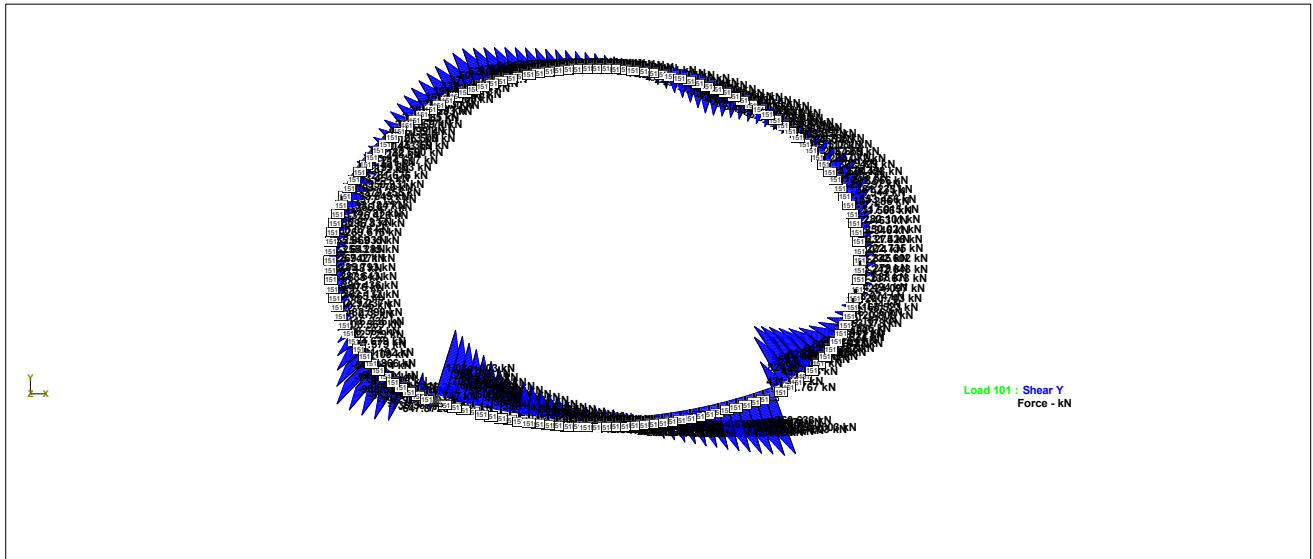
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



SHEAR

Handwritten signatures:
1. *[Signature]*
2. *[Signature]*
3. *[Signature]*
4. *[Signature]*
5. *[Signature]*



Software licensed to

Job No

1

Sheet No

45

Rev

A

Part

Job Title I40172_NATM INTERSECTION_PINNED

Ref

By KCh

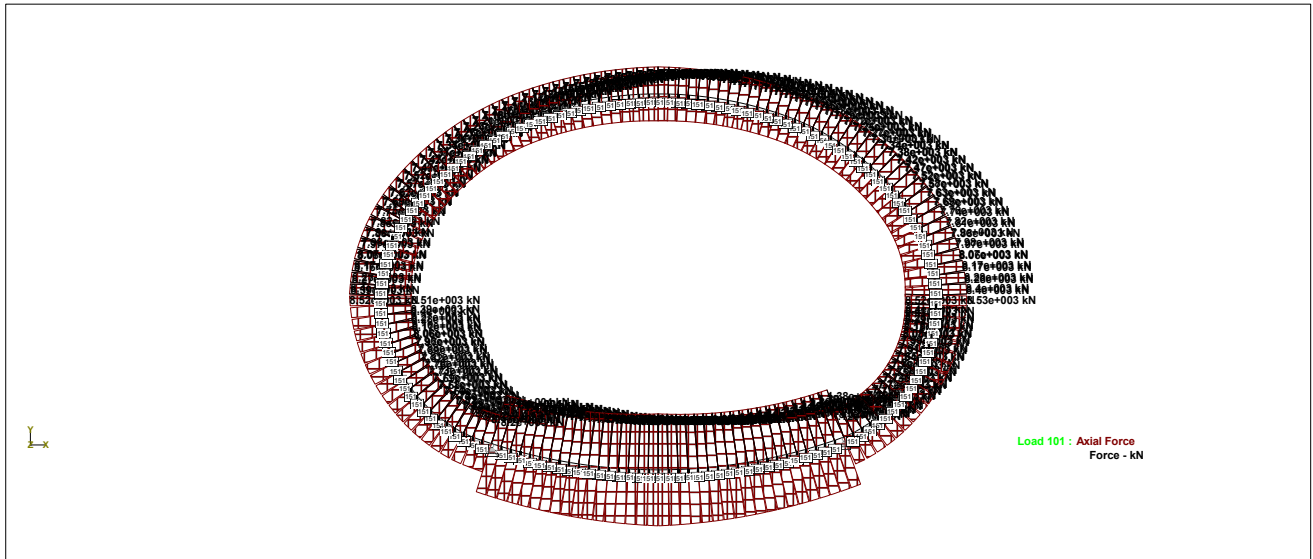
Date 21-Oct-24

Chd CSa

Client

File I40172_NATM INTERSECT

Date/Time 22-Oct-2024 11:23



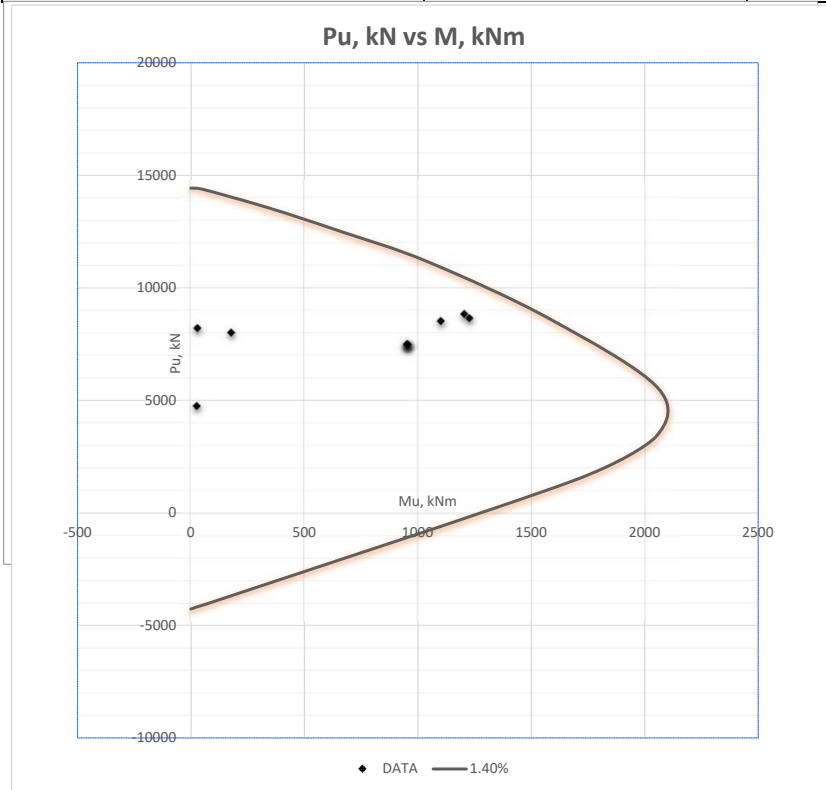
AXIAL

Handwritten signatures and initials:
1. *Signature*
2. *Signature*
3. *Signature*
4. *Signature*
5. *Signature*

	GEOCONSULT India Pvt Ltd		APPENDIX - 7	
	A company of the GEOCONSULT group		Job no:	I40172
		Page No.:		-
Project:	I40172 Road Tunnel DPR BBMP - Consultancy services for preparation of DPR for the work of Construction of underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction			
Calculation for	NATM INTERSECTION Structural Analysis Check- 700mm thk Crown 5mbgl			
Section Verification - Axial & Bending Moment				
Interaction charts As per IS 456 :2000				

DATA INPUT :

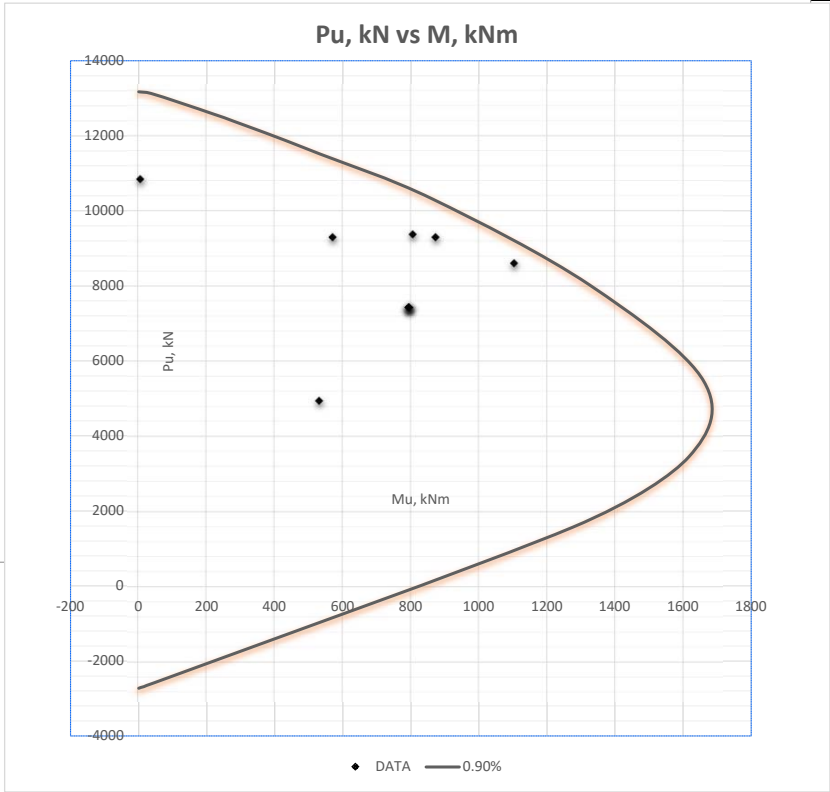
Concrete		Steel		Section		
Characteristic Strength f_{ck} , N/mm ²	35	Yield strength of Steel f_y , N/mm ²	500	Width of Member B, mm	1000	
Material Factor of Safety Concrete (γ_c)	1.5	Material Factor of Safety Steel γ_s (γ_s)	1.15	Depth of Member D, mm	700	
Modulus of Elasticity Concrete E_c , N/mm ²	29580	Modulus of Elasticity of Steel E_s , N/mm ²	200000	Clear cover, mm	40	
Strain at Yield Point Concrete = ϵ_{cy}	0.0020			Reinforcement	Nos	Dia, mm
Ultimate Strain in concrete = ϵ_{cu}	0.0035			Top	10.00	25
C1	0.67			Middle	0.00	0
				Bot	10.00	25



MAXIMA FOR DIFFERENT LOAD COMBINATIONS			
LOAD CASE	CONDITION	Pu/kN	Mu, kNm
	Max value	14432	0.0
	Min value	-4262	0.0
1	Max Pu	8837	1205
	Min Pu	4749	30
2	Max Pu	8010	181
	Min Pu	8202	33
3	Max Pu	7478	955
	Min Pu	7478	955
4	Max Pu	7478	955
	Min Pu	7478	955
5	Max Pu	7478	955
	Min Pu	7478	955
6	Max Pu	8516	1102
	Min Pu	8653	1228
7	Max Pu		
	Min Pu		
8	Max Pu		
	Min Pu		
9	Max Pu		
	Min Pu		
10	Max Pu		
	Min Pu		
11	Max Pu		
	Min Pu		
12	Max Pu		
	Min Pu		

	GEOCONSULT India Pvt Ltd	APPENDIX -7	
	A company of the GEOCONSULT group	Job no: I40172	
		Page No.: -	
Project:	I40172 Road Tunnel DPR BBMP - Consultancy services for preparation of DPR for the work of Construction of underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction		
Calculation for	NATM INTERSECTION Structural Analysis Check- 700mm thk SW		
Section Verification - Axial & Bending Moment			
Interaction charts As per IS 456 :2000			

DATA INPUT :					
Concrete		Steel		Section	
Characteristic Strength fck,N/mm2	35	Yeild strength of Steel fy, N/mm2	500	Width of Member B, mm	1000
Material Factor of Safety Concrete (Yc)	1.5	Material Factor of Safety Steel e (Ys)	1.15	Depth of Member D, mm	700
Modulus of Elasticity Concrete Ec, N/mm2	29580	Modulus of Elasticity of Steel Es,N/mm2	200000	Clear cover, mm	40
Strain at Yeild Point Concrete = ecy	0.0020			Reinforcement	Nos Dia, mm
Ultimate Strain in concrete = ecu	0.0035			Top	10.00 20
C1	0.67			Middle	0.00 0
				Bot	10.00 20

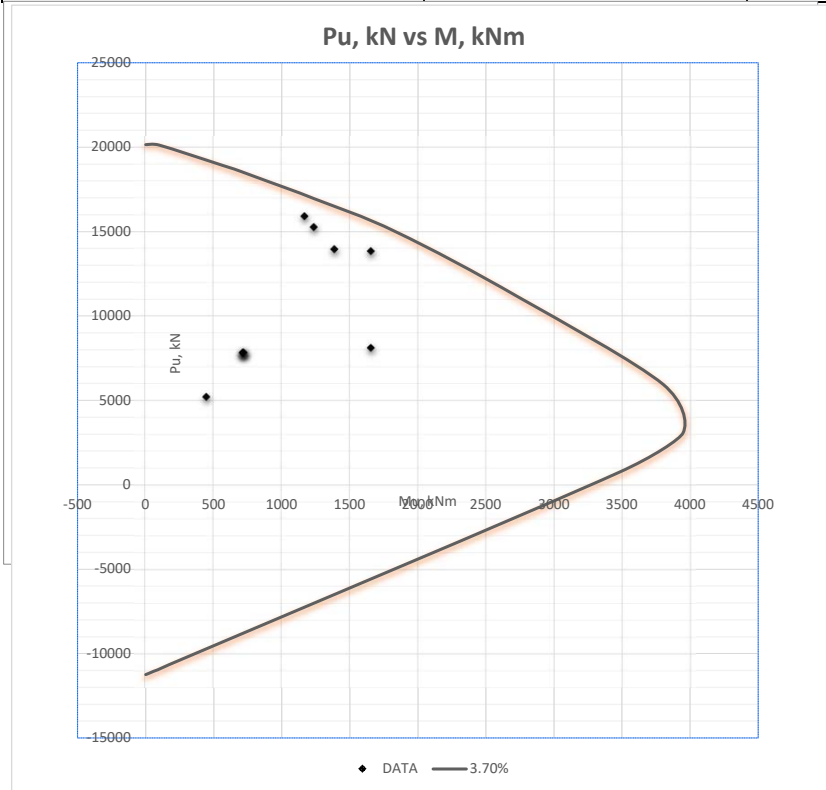


MAXIMA FOR DIFFERENT LOAD COMBINATIONS			
LOAD CASE	CONDITION	Pu/kN	Mu, kNm
	Max value	13176	0.0
	Min value	-2727	0.0
1	Max Pu	10842	8
	Min Pu	4945	532
2	Max Pu	9374	807
	Min Pu	9300	572
3	Max Pu	7424	795
	Min Pu	7424	795
4	Max Pu	7424	795
	Min Pu	7424	795
5	Max Pu	7424	795
	Min Pu	7424	795
6	Max Pu	8606	1104
	Min Pu	9298	873
7	Max Pu		
	Min Pu		
8	Max Pu		
	Min Pu		
9	Max Pu		
	Min Pu		
10	Max Pu		
	Min Pu		
11	Max Pu		
	Min Pu		
12	Max Pu		
	Min Pu		

	GEOCONSULT India Pvt Ltd		APPENDIX -7	
	A company of the GEOCONSULT group		Job no:	I40172
			Page No.:	-
Project:	I40172 Road Tunnel DPR BBMP - Consultancy services for preparation of DPR for the work of Construction of underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction			
Calculation for	NATM INTERSECTION Structural Analysis Check- 700mm thk INVERT			
Section Verification - Axial & Bending Moment				
Interaction charts As per IS 456 :2000				

DATA INPUT :

Concrete		Steel		Section		
Characteristic Strength f_{ck} , N/mm ²	35	Yield strength of Steel f_y , N/mm ²	500	Width of Member B, mm	1000	
Material Factor of Safety Concrete (γ_c)	1.5	Material Factor of Safety Steel (γ_s)	1.15	Depth of Member D, mm	700	
Modulus of Elasticity Concrete E_c , N/mm ²	29580	Modulus of Elasticity of Steel E_s , N/mm ²	200000	Clear cover, mm	40	
Strain at Yield Point Concrete = ϵ_{cy}	0.0020			Reinforcement	Nos	Dia, mm
Ultimate Strain in concrete = ϵ_{cu}	0.0035			Top	10.00	40.6
C1	0.67			Middle	0.00	0
				Bot	10.00	40.6

**MAXIMA FOR DIFFERENT LOAD COMBINATIONS**

LOAD CASE	CONDITION	Pu/kN	Mu, kNm
	Max value	20144	0.0
	Min value	-11240	0.0
1	Max Pu	15905	1171
	Min Pu	5216	452
2	Max Pu	13964	1390
	Min Pu	13839	1658
3	Max Pu	7843	723
	Min Pu	7843	723
4	Max Pu	7843	723
	Min Pu	7843	723
5	Max Pu	7843	723
	Min Pu	7843	723
6	Max Pu	15262	1238
	Min Pu	8120	1658
7	Max Pu		
	Min Pu		
8	Max Pu		
	Min Pu		
9	Max Pu		
	Min Pu		
10	Max Pu		
	Min Pu		
11	Max Pu		
	Min Pu		
12	Max Pu		
	Min Pu		

CALCULATION OF CRACK WIDTHS IN CONCRETE MEMBERS

h	depth of member
d	distance to steel
A_{SC}, A_{ST} ..	compression / tension reinforcement
s	spacing of steel bars
N	axial force due to service load
M	bending moment due to service load
x_c	depth of compression zone
f_c	compressive concrete stress
f_s	tensile steel stress
ε_T	strain at tension face
w_F	crack width

$$N = b \left[\frac{x}{2} f_c + \frac{(x-d')}{x} (\alpha-1) A_{sc} f_c - \frac{(d-x)}{x} \alpha \cdot A_{st} f_c \right]$$

$$M = b \left[\frac{x}{2} f_c \cdot \left(\frac{h}{2} - \frac{x}{3} \right) + \frac{(x-d')}{x} (\alpha-1) A_{sc} f_c \cdot \left(\frac{h}{2} - d' \right) - \frac{(d-x)}{x} \alpha \cdot A_{st} f_c \cdot \left(\frac{h}{2} - d' \right) \right]$$

$$f_s = \frac{(d-x)}{x} \alpha f_c \quad \varepsilon \approx \frac{(h-x)}{x} \cdot \frac{f_s}{E_s} - \frac{b(h-x)^2}{3E_s A_s (d-x)}$$

$$w_{cr} = \frac{3a_{cr}\epsilon_m}{1 + 2\left(\frac{a_{cr} - c_{min}}{h - x}\right)} \quad \text{where} \quad a_{cr} = \sqrt{c_{min}^2 + \left(\frac{s}{2}\right)^2} - \frac{d_b}{2}$$

Concrete:	Steel:
E_C 29,580 N/mm ²	E_S 205,000 N/mm ²
f_{CU} 35.0 N/mm ²	f_y 500.0 N/mm ²
b 1,000 mm	c_{MIN} 40.0 mm
f_{CT} 0.55 N/mm ²	d_b 25.0 mm
α 13.9	d_{ink} 10.0 mm

Calculation performed for :
long - term case

Solve Crack

PRESS BUTTON
to solve crack equations

Crack width limit	0.2
-------------------	-----

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CASE	h [mm]	d [mm]	d' [mm]	A _{s,c} [mm²]	A _{s,t} [mm²]	s [mm]	a _{cr} [mm]	N [kN]	M [kNm]	x [mm]	f _c [N/mm²]	f _s [N/mm²]	ε [*1000]	W _{CR}		f _s ' [N/mm²]	N _i [kN]	M _i [kNm]	STATUS
1	700	638	63	4906	4906	100	60	5891.4	803.3	695	14.3	-16.5	0.01	0.000	-	181	5891.4	803.3	OK
2	700	638	63	4906	4906	100	60	4749.1	30.5	1078	7.6	-43.0	-0.18	0.000	-	99	4749.1	30.5	OK
3	700	638	63	4906	4906	100	60	5339.8	120.5	1027	8.9	-46.9	-0.19	0.000	-	116	5339.8	120.5	OK
4	700	638	63	4906	4906	100	60	5468.0	22.1	1086	8.7	-49.6	-0.21	0.000	-	113	5468.0	22.1	OK
5	700	638	63	4906	4906	100	60	4985.6	636.4	718	11.8	-18.2	-0.02	0.000	-	149	4985.6	636.4	OK
6	700	638	63	4906	4906	100	60	4985.6	636.4	718	11.8	-18.2	-0.02	0.000	-	149	4985.6	636.4	OK
7	700	638	63	4906	4906	100	60	4985.6	636.4	718	11.8	-18.2	-0.02	0.000	-	149	4985.6	636.4	OK
8	700	638	63	4906	4906	100	60	4985.6	636.4	718	11.8	-18.2	-0.02	0.000	-	149	4985.6	636.4	OK
9	700	638	63	4906	4906	100	60	4985.6	636.4	718	11.8	-18.2	-0.02	0.000	-	149	4985.6	636.4	OK
10	700	638	63	4906	4906	100	60	4985.6	636.4	718	11.8	-18.2	-0.02	0.000	-	149	4985.6	636.4	OK
11	700	638	63	4906	4906	100	60	5677.3	734.9	713	13.5	-19.8	-0.02	0.000	-	170	5677.3	734.9	OK

Immanuel
~~Adai~~
Rob
Emerson
James

CALCULATION OF CRACK WIDTHS IN CONCRETE MEMBERS

E_C ...	E-modulus of concrete	h	depth of member
f_{CU} ...	characteristic strength of concrete	d	distance to steel
f_{CT} ...	tensile capacity of concrete at reinforcement level	A_{SC} , A_{ST} ..	compression / tension reinforcement
E_S ...	E-modulus of steel	s	spacing of steel bars
f_y ...	characteristic strength of steel	N	axial force due to service load
c_{MIN} ..	min. cover to steel	M	bending moment due to service load
		x	depth of compression zone
		f_C	compressive concrete stress
		f_s	tensile steel stress
		w_T	strain at tension face
		c_r	crack width

$$N = b \left[\frac{x}{2} f_c + \frac{(x-d')}{x} (\alpha-1) A_{sc} f_c - \frac{(d-x)}{x} \alpha \cdot A_{st} f_c \right]$$

$$M = b \left[\frac{x}{2} f_c \cdot \left(\frac{h}{2} - \frac{x}{3} \right) + \frac{(x-d')}{x} (\alpha - 1) A_{sc} f_c \cdot \left(\frac{h}{2} - d' \right) - \frac{(d-x)}{x} \alpha \cdot A_{st} f_c \cdot \left(\frac{h}{2} - d' \right) \right]$$

$$f_s = \frac{(d-x)}{x} \alpha f_c \quad \varepsilon \approx \frac{(h-x)}{x} \cdot \frac{f_s}{E_s} - \frac{b(h-x)^2}{3E_s A_s (d-x)}$$

$$w_{cr} = \frac{3a_{cr}\varepsilon_m}{1 + 2\left(\frac{a_{cr} - c_{min}}{h - x}\right)} \quad \text{where} \quad a_{cr} = \sqrt{c_{min}^2 + \left(\frac{s}{2}\right)^2} - \frac{d_b}{2}$$

Concrete:			Steel:		
E_C	29,580	N/mm ²	E_S	205,000	N/mm ²
f_{CU}	35.0	N/mm ²	f_y	500.0	N/mm ²
b	1,000	mm	C_{MIN}	40.0	mm
f_{CT}	0.55	N/mm ²	d_b	20.0	mm
α	13.9		d_{link}	10.0	mm

Calculation performed for :
long - term case

Solve Crack

PRESS BUTTON
to solve crack equations

Crack width limit	0.2
-------------------	-----

Crack width limit 0.2																			
CASE	h [mm]	d [mm]	d' [mm]	A _{s,c} [mm²]	A _{s,t} [mm²]	s [mm]	a _{c,f} [mm]	N [kN]	M [kNm]	x [mm]	f _c [N/mm²]	f _s [N/mm²]	s [°1000]	W _{CR} [mm]		f _{s'} [N/mm²]	N _i [kN]	M _i [kNm]	STATUS
1	700	640	60	3140	3140	100	61	7227.7	5.2	1080	12.1	-68.5	-0.29	0.000	-	159	7227.7	5.2	OK
2	700	640	60	3140	3140	100	61	4945.3	532.3	759	11.7	-25.4	-0.06	0.000	-	149	4945.3	532.3	OK
3	700	640	60	3140	3140	100	61	6249.3	538.2	821	13.7	-41.7	-0.14	0.000	-	175	6249.3	538.2	OK
4	700	640	60	3140	3140	100	61	6199.8	381.2	894	12.5	-49.1	-0.18	0.000	-	161	6199.8	381.2	OK
5	700	640	60	3140	3140	100	61	4949.6	530.2	761	11.7	-25.6	-0.06	0.000	-	149	4949.6	530.2	OK
6	700	640	60	3140	3140	100	61	4949.6	530.2	761	11.7	-25.6	-0.06	0.000	-	149	4949.6	530.2	OK
7	700	640	60	3140	3140	100	61	4949.6	530.2	761	11.7	-25.6	-0.06	0.000	-	149	4949.6	530.2	OK
8	700	640	60	3140	3140	100	61	4949.6	530.2	761	11.7	-25.6	-0.06	0.000	-	149	4949.6	530.2	OK
9	700	640	60	3140	3140	100	61	4949.6	530.2	761	11.7	-25.6	-0.06	0.000	-	149	4949.6	530.2	OK
10	700	640	60	3140	3140	100	61	4949.6	530.2	761	11.7	-25.6	-0.06	0.000	-	149	4949.6	530.2	OK
11	700	640	60	3140	3140	100	61	5737.4	736.2	702	14.6	-18.0	0.00	0.000	-	186	5737.4	736.2	OK

Immanuel
~~Adai~~
Rob
Emerson
James

GEOCONSULT India Pvt Ltd
A company of the GEOCONSULT group

Annexure - 7
Page No.: -

Project Title : I40172 Road Tunnel DPR BBMP - Consultancy services for preparation of DPR for the work of Construction of underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction
Job No. : I40172 NATM enlarged intersection_ 700 mm Invert

CALCULATION OF CRACK WIDTHS IN CONCRETE MEMBERS

E_c ... E-modulus of concrete
 f_{cu} ... characteristic strength of concrete
 f_{ct} ... tensile capacity of concrete at reinforcement level
 E_s ... E-modulus of steel
 f_y ... characteristic strength of steel
 c_{min} ... min. cover to steel

h depth of member
 d' distance to steel
 A_{sc}, A_{st} .. compression / tension reinforcement
 s spacing of steel bars
 N axial force due to service load
 M bending moment due to service load
 x depth of compression zone
 f_c compressive concrete stress
 f_s tensile steel stress
 ϵ_T strain at tension face
 w_{CR} crack width

$$N = b \left[\frac{x}{2} f_c + \frac{(x-d')}{x} (\alpha-1) A_{sc} f_c - \frac{(d-x)}{x} \alpha \cdot A_s f_c \right]$$

$$M = b \left[\frac{x}{2} f_c \cdot \left(\frac{h}{2} - \frac{x}{3} \right) + \frac{(x-d')}{x} (\alpha-1) A_{sc} f_c \cdot \left(\frac{h}{2} - d' \right) - \frac{(d-x)}{x} \alpha \cdot A_s f_c \cdot \left(\frac{h}{2} - d' \right) \right]$$

$$f_s = \frac{(d-x)}{x} \alpha f_c \quad \epsilon \approx \frac{(h-x)}{x} \cdot \frac{f_s}{E_s} - \frac{b(h-x)^2}{3E_s A_s (d-x)}$$

$$w_{cr} = \frac{3a_{cr} \epsilon_m}{1 + 2 \left(\frac{a_{cr} - c_{min}}{h-x} \right)} \quad \text{where } a_{cr} = \sqrt{c_{min}^2 + \left(\frac{s}{2} \right)^2} - \frac{d_b}{2}$$

Concrete:
 E_c 29,580 N/mm²
 f_{cu} 35.0 N/mm²
 b 1,000 mm
 f_{ct} 0.55 N/mm²
 α 13.9

Steel:
 E_s 205,000 N/mm²
 f_y 500.0 N/mm²
 c_{min} 40.0 mm
 d_b 40.6 mm
 d_{link} 10.0 mm

Calculation performed for :
long - term case

Solve Crack

PRESS BUTTON to solve crack equations

Crack width limit 0.2

CASE	h (mm)	d (mm)	d' (mm)	A _{sc} (mm ²)	A _{st} (mm ²)	s (mm)	a _{cr} (mm)	N (kN)	M (kNm)	x (mm)	f _c (N/mm ²)	f _s (N/mm ²)	ε (*1000)	w _{CR} (mm)	f _s ' (N/mm ²)	N _i (kN)	M _i (kNm)	STATUS
1	700	630	70	12944	12944	100	58	10603.6	781.0	909	16.0	-68.1	-0.25	0.000	204	10603.6	781.0	OK
2	700	630	70	12944	12944	100	58	5216.3	451.7	869	8.2	-31.3	-0.11	0.000	104	5216.3	451.7	OK
3	700	630	70	12944	12944	100	58	9309.0	926.8	831	15.2	-51.1	-0.16	0.000	193	9309.0	926.8	OK
4	700	630	70	12944	12944	100	58	9226.2	1105.1	774	16.1	-41.8	-0.10	0.000	203	9226.2	1105.1	OK
5	700	630	70	12944	12944	100	58	5228.5	481.8	852	8.4	-30.3	-0.10	0.000	106	5228.5	481.8	OK
6	700	630	70	12944	12944	100	58	5228.5	481.8	852	8.4	-30.3	-0.10	0.000	106	5228.5	481.8	OK
7	700	630	70	12944	12944	100	58	5228.5	481.8	852	8.4	-30.3	-0.10	0.000	106	5228.5	481.8	OK
8	700	630	70	12944	12944	100	58	5228.5	481.8	852	8.4	-30.3	-0.10	0.000	106	5228.5	481.8	OK
9	700	630	70	12944	12944	100	58	5228.5	481.8	852	8.4	-30.3	-0.10	0.000	106	5228.5	481.8	OK
10	700	630	70	12944	12944	100	58	5228.5	481.8	852	8.4	-30.3	-0.10	0.000	106	5228.5	481.8	OK
11	700	630	70	12944	12944	100	58	10174.4	825.5	886	15.7	-62.9	-0.22	0.000	200	10174.4	825.5	OK

GEOCONSULT INDIA Pvt. Ltd.

Design SLS check_crack width_INVERT

SHEAR AT THE INTERFACE BETWEEN CONCRETE CAST AT DIFFERENT TIMES

EN 1992-1-1:2004 Sec-6.2.5 - Eurocode 2: Design of concrete structures - Part 1-1:
General rules and rules for building

PROJECT: I40172 Road Tunnel DPR BBMP - Consultancy services for preparation of DPR for the work of Construction of underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction

PID: I40172

Section: NATM INTERSECTION_SHEAR CHECK OVERT

The design value of the shear stress in the interface = V_{Edi}

The design shear resistance at the interface = V_{Rdi}

The shear stress at the interface between concrete cast at different times should also satisfy

$$V_{Edi} \leq V_{Rdi}$$

Msd = **75.7 KN-m**

Nsd = **8110.8 KN**

Vsd = **597.2 KN**

Characteristic compressive strength of concrete (f_{ck}) = **35 N/mm²**

$$V_{Edi} = \beta \cdot V_{Ed} / (z \cdot b_i)$$

Where,

β = The ratio of the longitudinal force in the new concrete area and the total longitudinal force either in the compression or tension zone, both calculated for the section considered = **1**

V_{ed} = The transverse shear force = **597.2 KN**

z = Lever arm of composite section = **0.65 m**

b_i = Width of interface = **1 m**

$$V_{Rdi} = c \cdot f_{ctd} + \mu \cdot \sigma_n + \rho \cdot f_{yd} (\mu \cdot \sin \alpha + \cos \alpha) \leq 0.5 \cdot v \cdot f_{cd}$$

c = Factor which depend on the roughness of the interface = **0.45**
 (Rough surface)

f_{ctd} = Value of design tensile strength of concrete strength class (M35) = **1.50 N/mm²**

μ = Factor which depend on the roughness of the interface = **0.7**
 (Rough surface)

σ_n = Stress per unit area caused by the minimum external normal force across the interface that can act simultaneously with the shear force = **12.48 N/mm²**

$\rho = A_s / A_i$ = **0**

(No reinforcement considered)

f_{yd} = Design yield strength of reinforcement = **-**

(No reinforcement considered)

α = Angle of reinforcement with surface = **-**

(No reinforcement considered)

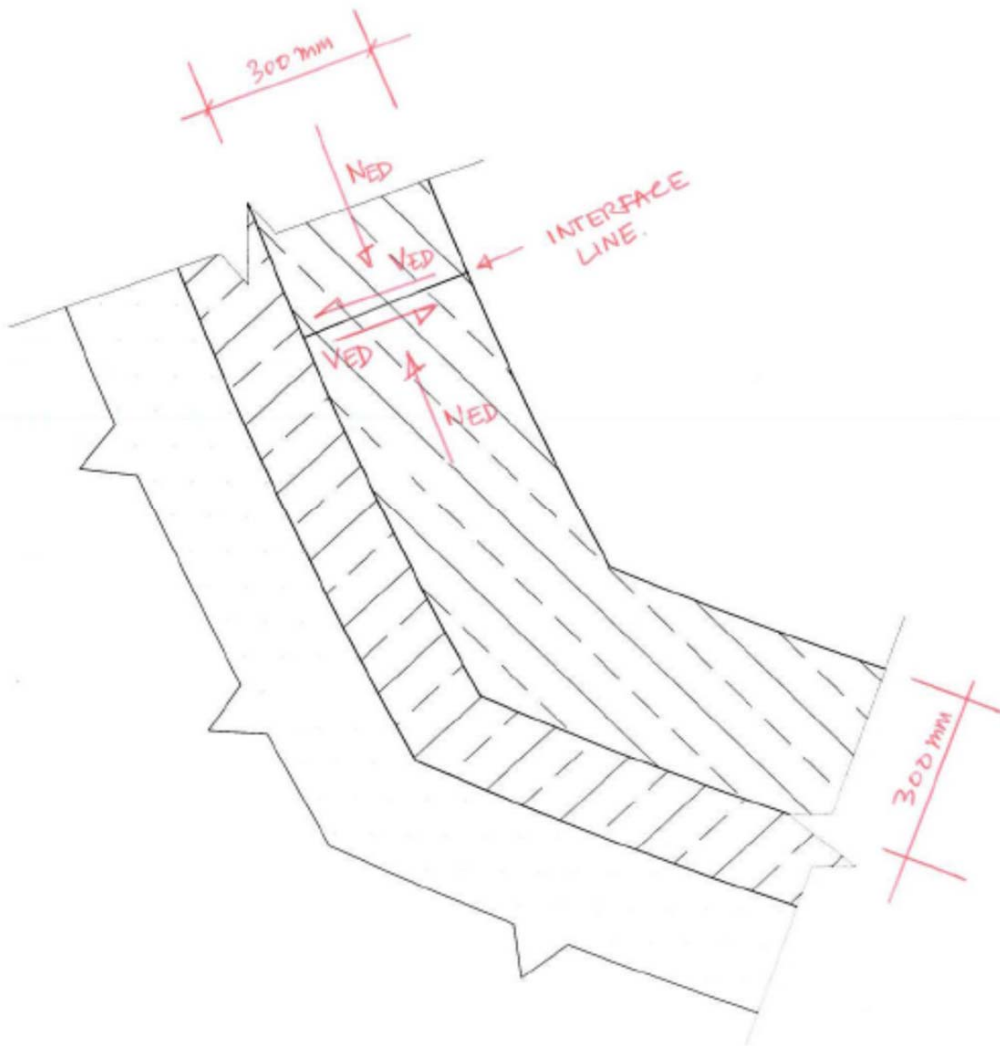
$$0.5 \cdot v \cdot f_{cd}$$

Where,

$v =$ Strength reduction factor	$=$	0.516
$f_{cd} =$ Design value of concrete compressive strength	$=$	23.3 N/mm ²
$V_{Rdi} = c \cdot f_{ctd} + \mu \cdot \sigma_n + \rho \cdot f_{yd} (\mu \cdot \sin \alpha + \cos \alpha)$	$\leq$	$0.5 \cdot v \cdot f_{cd}$
$V_{Rdi} = 9.409 \text{ N/mm}^2$	$\leq$	6.020 N/mm^2
$V_{Edi} = 0.919 \text{ N/mm}^2$		
$V_{Edi} \leq V_{Rdi}$		

Factor of safety (FOS) $= V_{Rdi} / V_{Edi}$
 $= 10$

No shear Reinforcement is required



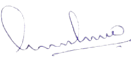
Handwritten signatures:
 [Signature]
 [Signature]
 [Signature]

Handwritten signature:
 [Signature]

Handwritten signature:
 [Signature]

Check for Shear Reinforcement at Overt

Characteristic strength of shear reinforcement $f_y =$	500 N/mm ²	
Design Yield strength of shear reinforcement $f_{ywd} =$	348 N/mm ²	
Depth of the section $D =$	0.700 m	
Width of the section $b_w =$	1.000 m	
Effective depth $d_t =$	0.628 m	
Characteristic Strength of concrete $f_{ck} =$	35 N/mm ²	
$V_{ED,MAX} \leq 0.5 b_w d v fcd$	3511.67 kN	refer 6.5 EC2
$fcd = \alpha_{cc} * f_{ck} / \gamma_c$	19.444 N/mm ²	
$v = 0.6 * (1 - f_{ck}/250)$	0.52	
$K = 1 + \text{SQRT}(200/d) \leq 0.2$	1.56	refer 6.2.b
$\rho_1 = A_{sl}/(b_w.d) \leq 0.02$	0.02	
$V_{min} = 0.035 K^{3/2} f_{ck}^{0.5}$	0.28 N/mm ²	refer 6.3n
$V_{RD,c} = (C_{RD,C} * K(100.\rho_1 .f_{ck})^{0.33} + K_1 \sigma_{cp}) * b_w.d$	1876.49 kN	refer 6.2a
$V_{RD,c,min} = (v_{min} + K_1 \sigma_{cp}) * b_w.d$	1378.02 kN	refer 6.2b
$C_{RD,C} = 0.18/\gamma_c$	0.12	
K_1	0.15	recommended value
$\sigma_{op} = N_{ed}/A_c$	12.79 N/mm ²	
V_{ED} (from stadd)	597.2 kN	
$V_{ED} \leq V_{RDC}$	NO SHEAR REINFORCEMENT REQUIRED	







SHEAR AT THE INTERFACE BETWEEN CONCRETE CAST AT DIFFERENT TIMES**EN 1992-1-1:2004 Sec-6.2.5 - Eurocode 2: Design of concrete structures - Part 1-1:****General rules and rules for building**

PROJECT: I40172 Road Tunnel DPR BBMP - Consultancy services for preparation of DPR for the work of Construction of underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction

PID: I40172

Section: NATM INTERSECTION_SHEAR CHECK SW

The design value of the shear stress in the interface = V_{Edi}

The design shear resistance at the interface = V_{Rdi}

The shear stress at the interface between concrete cast at different times should also satisfy

$$V_{Edi} \leq V_{Rdi}$$

Msd = **580.9 KN-m**

Nsd = **9182.2 KN**

Vsd = **659.5 KN**

Characteristic compressive strength of concrete (f_{ck}) = 35 N/mm²

$$V_{Edi} = \beta \cdot V_{Ed} / (z \cdot b_i)$$

Where,

β = The ratio of the longitudinal force in the new concrete area and the total longitudinal force either in the compression or tension zone, both calculated for the section considered = 1

V_{ed} = The transverse shear force = 659.5 KN

z = Lever arm of composite section = 0.65 m

b_i = Width of interface = 1 m

$$V_{Rdi} = c \cdot f_{ctd} + \mu \cdot \sigma_n + \rho \cdot f_{yd} (\mu \cdot \sin \alpha + \cos \alpha) \leq 0.5 \cdot v \cdot f_{cd}$$

c = Factor which depend on the roughness of the interface = 0.45
(Rough surface)

f_{ctd} = Value of design tensile strength of concrete strength class (M35) = 1.50 N/mm²

μ = Factor which depend on the roughness of the interface = 0.7
(Rough surface)

σ_n = Stress per unit area caused by the minimum external normal force across the interface that can act simultaneously with the shear force = 14.13 N/mm²

ρ = A_s / A_i = 0

(No reinforcement considered)

f_{yd} = Design yield strength of reinforcement = -

(No reinforcement considered)

α = Angle of reinforcement with surface = -

(No reinforcement considered)

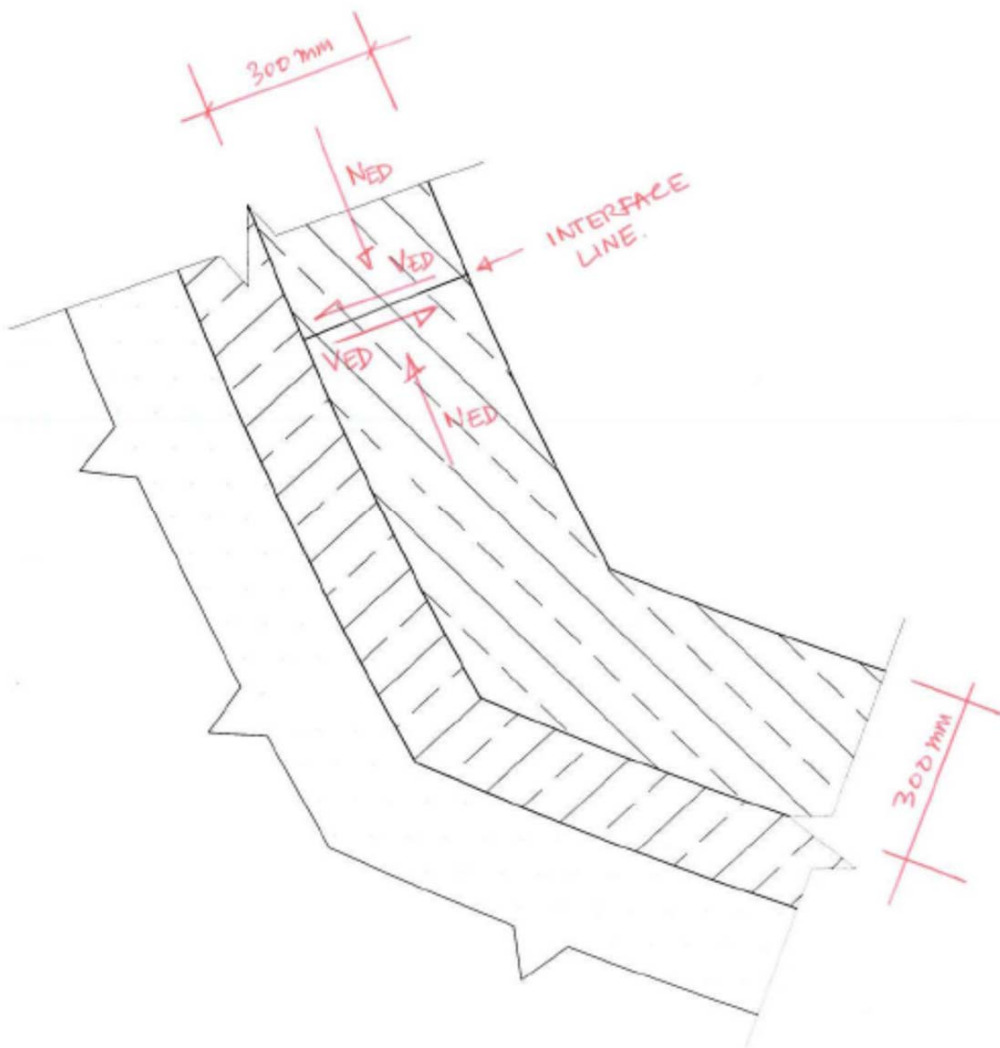
$$0.5 \cdot v \cdot f_{cd}$$

Where,

$v =$ Strength reduction factor	$=$	0.516
$f_{cd} =$ Design value of concrete compressive strength	$=$	23.3 N/mm ²
$V_{Rdi} = c * f_{ctd} + \mu * \sigma_n + \rho * f_{yd} (\mu * \sin \alpha + \cos \alpha)$	$\leq$	0.5 * $v * f_{cd}$
$V_{Rdi} = 10.563 \text{ N/mm}^2$	$\leq$	6.020 N/mm ²
$V_{Edi} = 1.015 \text{ N/mm}^2$		
$V_{Edi} \leq V_{Rdi}$		

Factor of safety (FOS) $= V_{Rdi} / V_{Edi}$
 $= 10$

No shear Reinforcement is required



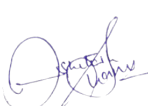
Handwritten signatures:
 [Signature]
 [Signature]
 [Signature]
 [Signature]
 [Signature]

Check for Shear Reinforcement at SW

Characteristic strength of shear reinforcement f_y =	500 N/mm ²	
Design Yield strength of shear reinforcement f_{ywd} =	348 N/mm ²	
Depth of the section D =	0.700 m	
Width of the section b_w =	1.000 m	
Effective depth d_t =	0.628 m	
Characteristic Strength of concrete f_{ck} =	35 N/mm ²	
$V_{ED,MAX} \leq 0.5 b_w d v fcd$	3511.67 kN	refer 6.5 EC2
$fcd = \alpha_{cc} * f_{ck} / \gamma_c$	19.444 N/mm ²	
$v = 0.6 * (1 - f_{ck}/250)$	0.52	
$K = 1 + \text{SQRT}(200/d) \leq 0.2$	1.56	refer 6.2.b
$\rho_1 = A_{sl}/(b_w.d) \leq 0.02$	0.02	
$V_{min} = 0.035 K^{3/2} f_{ck}^{0.5}$	0.28 N/mm ²	refer 6.3n
$V_{RD,c} = (C_{RD,C} * K(100.\rho_1 .f_{ck})^{0.33} + K_1 \sigma_{cp}) * b_w.d$	2172.98 kN	refer 6.2a
$V_{RD,c,min} = (v_{min} + K_1 \sigma_{cp}) * b_w.d$	1643.80 kN	refer 6.2b
$C_{RD,C} = 0.18/\gamma_c$	0.12	
K_1	0.15	recommended value
$\sigma_{op} = N_{ed}/A_c$	15.61 N/mm ²	
V_{ED} (from stadd)	659.5 kN	
$V_{ED} \leq V_{RDC}$	NO SHEAR REINFORCEMENT REQUIRED	
A_{sw}	785 mm ²	
spacing, s	200 mm	
$f_{ywd} = f_{yk}/\gamma_c$	348 N/mm ²	
θ Angle assumed	25	
$z = 0.9 d$	630	
$V_{RD,s} = A_{sw} z f_{ywd} \cot(\theta) / s$	1846.32 kN	refer 6.8 EC2
$V_{RD,max} = \alpha_{cw} b_w z v_1 fcd / (\cot(\theta) + \tan(\theta))$	2815.21 kN	refer 6.9 EC2
v_1	0.6	
α_{cw}	1	recommended value
$V_{RD,S} \leq V_{ED}$	ÖK	







SHEAR AT THE INTERFACE BETWEEN CONCRETE CAST AT DIFFERENT TIMES**EN 1992-1-1:2004 Sec-6.2.5 - Eurocode 2: Design of concrete structures - Part 1-1:****General rules and rules for building**

PROJECT: I40172 Road Tunnel DPR BBMP - Consultancy services for preparation of DPR for the work of Construction of underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction

PID: I40172

Section: NATM INTERSECTION_SHEAR CHECK INVERT

The design value of the shear stress in the interface = V_{Edi}

The design shear resistance at the interface = V_{Rdi}

The shear stress at the interface between concrete cast at different times should also satisfy

$$V_{Edi} \leq V_{Rdi}$$

Msd = **914.2 KN-m**

Nsd = **9519.0 KN**

Vsd = **930.0 KN**

Characteristic compressive strength of concrete (f_{ck}) = 35 N/mm²

$$V_{Edi} = \beta \cdot V_{Ed} / (z \cdot b_i)$$

Where,

β = The ratio of the longitudinal force in the new concrete area and the total longitudinal force either in the compression or tension zone, both calculated for the section considered = 1

V_{ed} = The transverse shear force = 930.0 KN

z = Lever arm of composite section = 0.65 m

b_i = Width of interface = 1 m

$$V_{Rdi} = c \cdot f_{ctd} + \mu \cdot \sigma_n + \rho \cdot f_{yd} (\mu \cdot \sin \alpha + \cos \alpha) \leq 0.5 \cdot v \cdot f_{cd}$$

c = Factor which depend on the roughness of the interface = 0.45
(Rough surface)

f_{ctd} = Value of design tensile strength of concrete strength class (M35) = 1.50 N/mm²

μ = Factor which depend on the roughness of the interface = 0.7
(Rough surface)

σ_n = Stress per unit area caused by the minimum external normal force across the interface that can act simultaneously with the shear force = 14.64 N/mm²

ρ = A_s / A_i = 0

(No reinforcement considered)

f_{yd} = Design yield strength of reinforcement = -

(No reinforcement considered)

α = Angle of reinforcement with surface = -

(No reinforcement considered)

$$0.5 \cdot v \cdot f_{cd}$$

Where,

v = Strength reduction factor

$$= 0.516$$

f_{cd} = Design value of concrete compressive strength

$$= 23.3 \text{ N/mm}^2$$

$$V_{Rdi} = c \cdot f_{ctd} + \mu \cdot \sigma_n + \rho \cdot f_{yd} (\mu \cdot \sin \alpha + \cos \alpha)$$

$$\leq 0.5 \cdot v \cdot f_{cd}$$

$$V_{Rdi} = 10.925 \text{ N/mm}^2$$

$$\leq 6.020 \text{ N/mm}^2$$

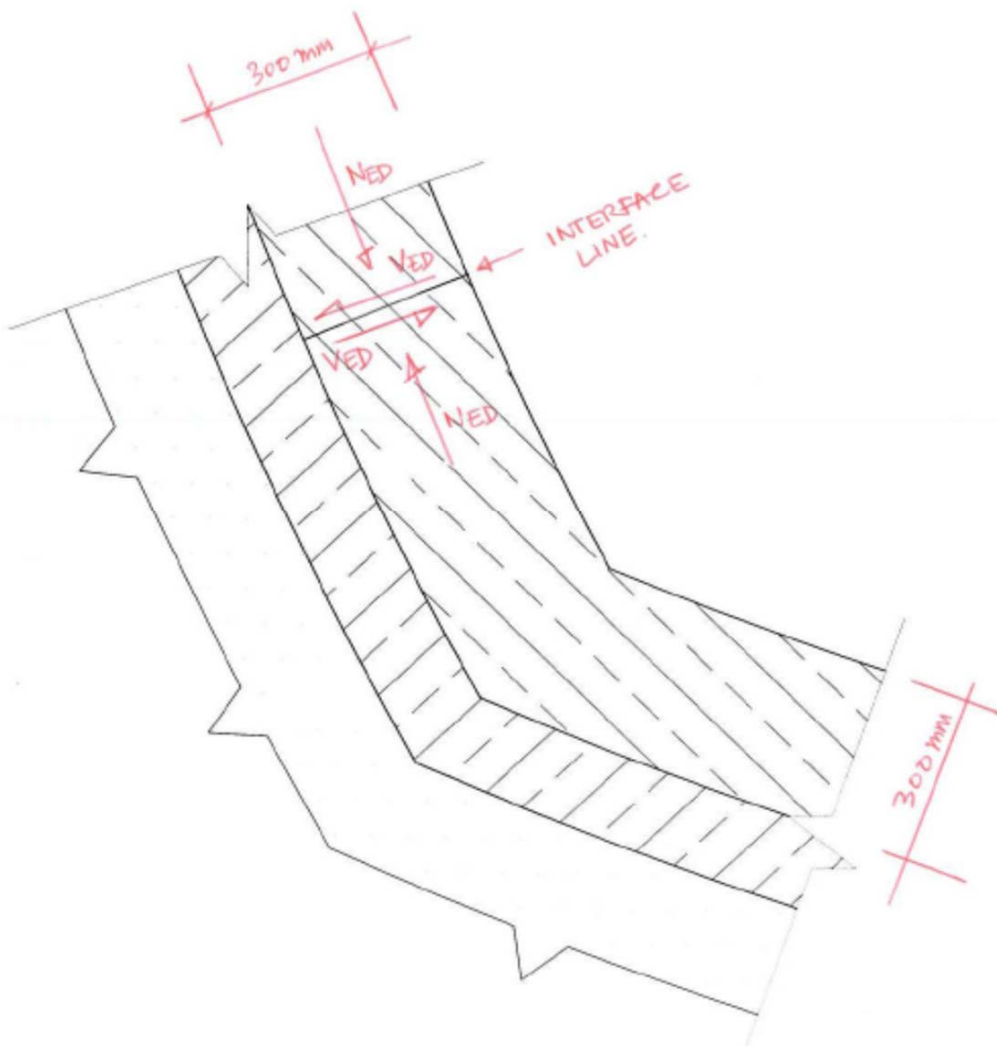
$$V_{Edi} = 1.431 \text{ N/mm}^2$$

$$V_{Edi} \leq V_{Rdi}$$

$$\text{Factor of safety (FOS)} = V_{Rdi} / V_{Edi}$$

$$= 8$$

No shear Reinforcement is required



[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

Check for Shear Reinforcement at SW

Characteristic strength of shear reinforcement f_y =	500 N/mm ²	
Design Yield strength of shear reinforcement f_{ywd} =	348 N/mm ²	
Depth of the section D =	0.700 m	
Width of the section b_w =	1.000 m	
Effective depth d_t =	0.628 m	
Characteristic Strength of concrete f_{ck} =	35 N/mm ²	
$V_{ED,MAX} \leq 0.5 b_w d v fcd$	3511.67 kN	refer 6.5 EC2
$fcd = \alpha_{cc} * f_{ck} / \gamma_c$	19.444 N/mm ²	
$v = 0.6 * (1 - f_{ck}/250)$	0.52	
$K = 1 + \text{SQRT}(200/d) \leq 0.2$	1.56	refer 6.2.b
$\rho_1 = A_{sl}/(b_w.d) \leq 0.02$	0.02	
$V_{min} = 0.035 K^{3/2} f_{ck}^{0.5}$	0.28 N/mm ²	refer 6.3n
$V_{RD,c} = (C_{RD,C} * K(100.\rho_1 .f_{ck})^{0.33} + K_1 \sigma_{cp}) * b_w.d$	2735.82 kN	refer 6.2a
$V_{RD,c,min} = (v_{min} + K_1 \sigma_{cp}) * b_w.d$	2148.35 kN	refer 6.2b
$C_{RD,C} = 0.18/\gamma_c$	0.12	
K_1	0.15	recommended value
$\sigma_{op} = N_{ed}/A_c$	20.97 N/mm ²	
V_{ED} (from stadd)	930.0 kN	
$V_{ED} \leq V_{RDC}$	NO SHEAR REINFORCEMENT REQUIRED	
A_{sw}	785 mm ²	
spacing, s	200 mm	
$f_{ywd} = f_{yk}/\gamma_c$	348 N/mm ²	
θ Angle assumed	25	
$z = 0.9 d$	630	
$V_{RD,s} = A_{sw} z f_{ywd} \cot(\theta) / s$	1846.32 kN	refer 6.8 EC2
$V_{RD,max} = \alpha_{cw} b_w z v_1 fcd / (\cot(\theta) + \tan(\theta))$	2815.21 kN	refer 6.9 EC2
v_1	0.6	
α_{cw}	1	recommended value
$V_{RD,S} \leq V_{ED}$	ÖK	

[Handwritten signatures]

ANNEXURE – 6
PAVEMENT SLAB/ROAD DECK
SLAB IN TUNNEL

Signature

Signature

Signature

Signature

Signature

Amelia

Adri

Rob

Emma

James



Software licensed to

Job No

Sheet No

1

Rev

Part

Job Title

Ref

By

Date 10-Jan-25

Chd

Client

File I40172_BBMP_Platform i

Date/Time 23-Jan-2025 17:19

Job Information

	Engineer	Checked	Approved
Name:			
Date:	10-Jan-25		

Project ID	
Project Name	

Structure Type	PLANE FRAME
----------------	-------------

Number of Nodes	8	Highest Node	8
Number of Elements	7	Highest Beam	7

Number of Basic Load Cases	1
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure
-----	---------------------

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DL
Generation	2	LOAD GENERATION, LOAD #2, (1 of 12)
Generation	3	LOAD GENERATION, LOAD #3, (2 of 12)
Generation	4	LOAD GENERATION, LOAD #4, (3 of 12)
Generation	5	LOAD GENERATION, LOAD #5, (4 of 12)
Generation	6	LOAD GENERATION, LOAD #6, (5 of 12)
Generation	7	LOAD GENERATION, LOAD #7, (6 of 12)
Generation	8	LOAD GENERATION, LOAD #8, (7 of 12)
Generation	9	LOAD GENERATION, LOAD #9, (8 of 12)
Generation	10	LOAD GENERATION, LOAD #10, (9 of 12)
Generation	11	LOAD GENERATION, LOAD #11, (10 of 12)
Generation	12	LOAD GENERATION, LOAD #12, (11 of 12)
Generation	13	LOAD GENERATION, LOAD #13, (12 of 12)

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	4.000	0.000	0.000
3	7.500	0.000	0.000
4	12.000	0.000	0.000
5	4.000	-3.500	0.000
6	7.500	-3.500	0.000
7	0.150	0.000	0.000

Signature
Date
Rob
Date
Date



Software licensed to

Job No

Sheet No

2

Rev

Part

Job Title

Ref

By

Date 10-Jan-25

Chd

Client

File I40172_BBMP_Platform i

Date/Time 23-Jan-2025 17:19

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	1	7	0.150	1	0
2	2	3	3.500	1	0
3	3	8	4.350	1	0
4	5	2	3.500	1	0
5	6	3	3.500	1	0
6	7	2	3.850	1	0
7	8	4	0.150	1	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 0.20x1.00	2E+3	1.67E+6	66.7E+3	233E+3	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN·m/deg)	rY (kN·m/deg)	rZ (kN·m/deg)
1	Fixed	Fixed	Fixed	-	-	-
4	Fixed	Fixed	Fixed	-	-	-
5	Fixed	Fixed	Fixed	-	-	-
6	Fixed	Fixed	Fixed	-	-	-

Primary Load Cases

Number	Name	Type
1	DL	None

Combination Load Cases

There is no data of this type.

Handwritten signatures and initials:
1. A signature starting with 'L' and 'h' (likely L. H. ...).
2. A signature starting with 'A' and 'd' (likely A. D. ...).
3. A signature starting with 'R' and 'o' (likely R. O. ...).
4. A signature starting with 'C' and 'S' (likely C. S. ...).
5. A signature starting with 'D' and 'J' (likely D. J. ...).



Software licensed to

Job No

Sheet No

3

Rev

Part

Job Title

Ref

By

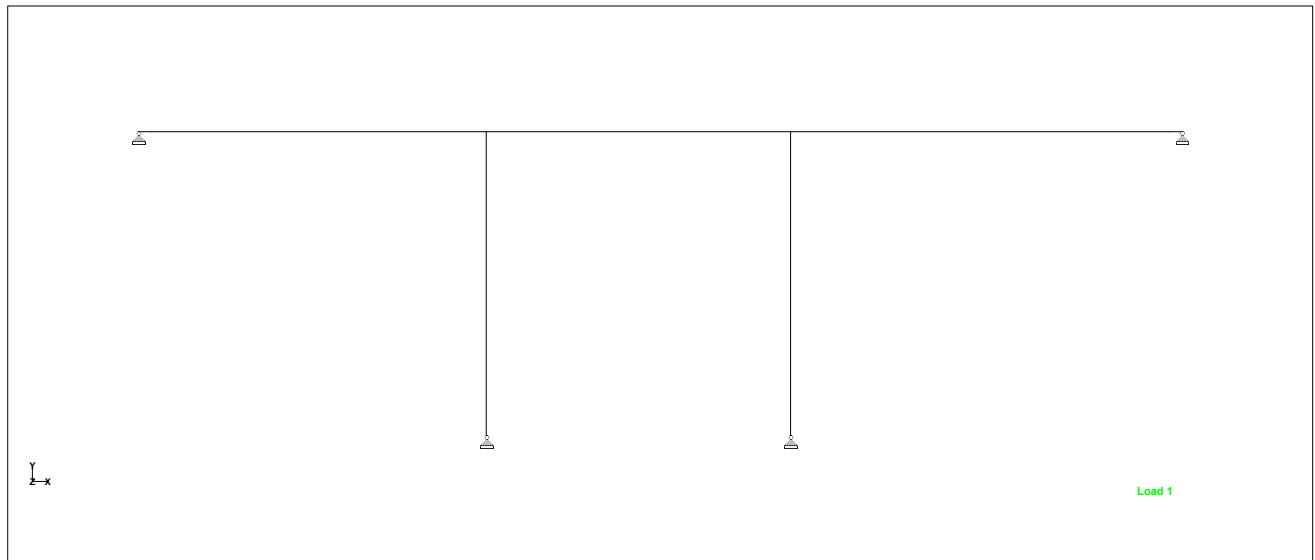
Date 10-Jan-25

Chd

Client

File I40172_BBMP_Platform i

Date/Time 23-Jan-2025 17:19



Whole Structure

[Handwritten signatures]



Software licensed to

Job No

Sheet No

4

Rev

Part

Job Title

Ref

By

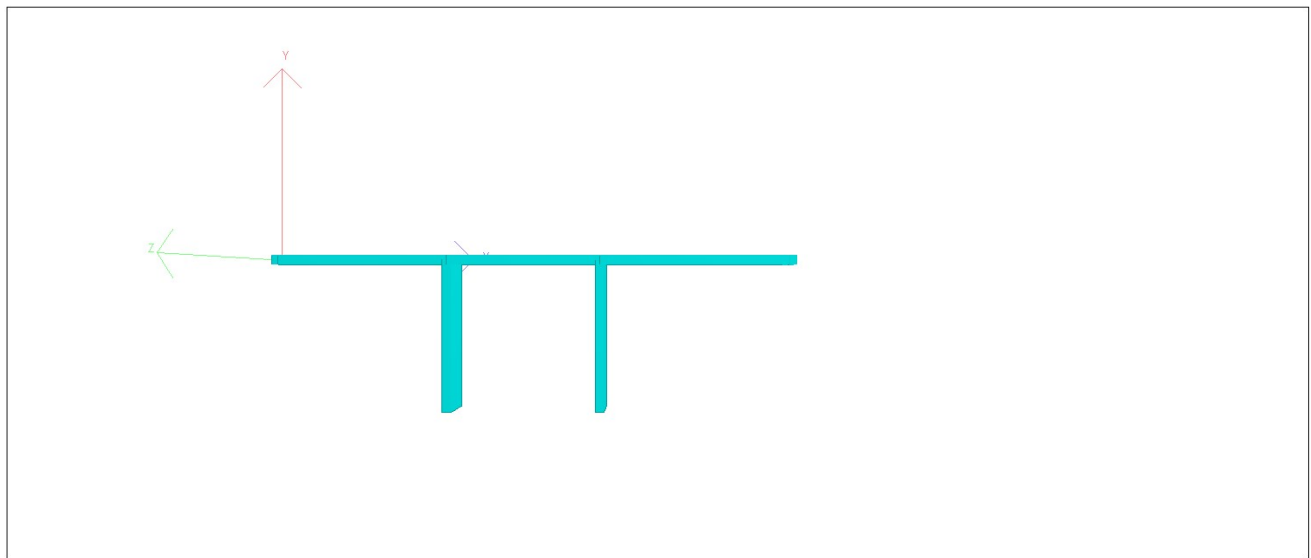
Date 10-Jan-25

Chd

Client

File I40172_BBMP_Platform i

Date/Time 23-Jan-2025 17:19



3D Rendered View

[Handwritten signatures]



Software licensed to

Job No

Sheet No

5

Rev

Part

Job Title

Ref

By

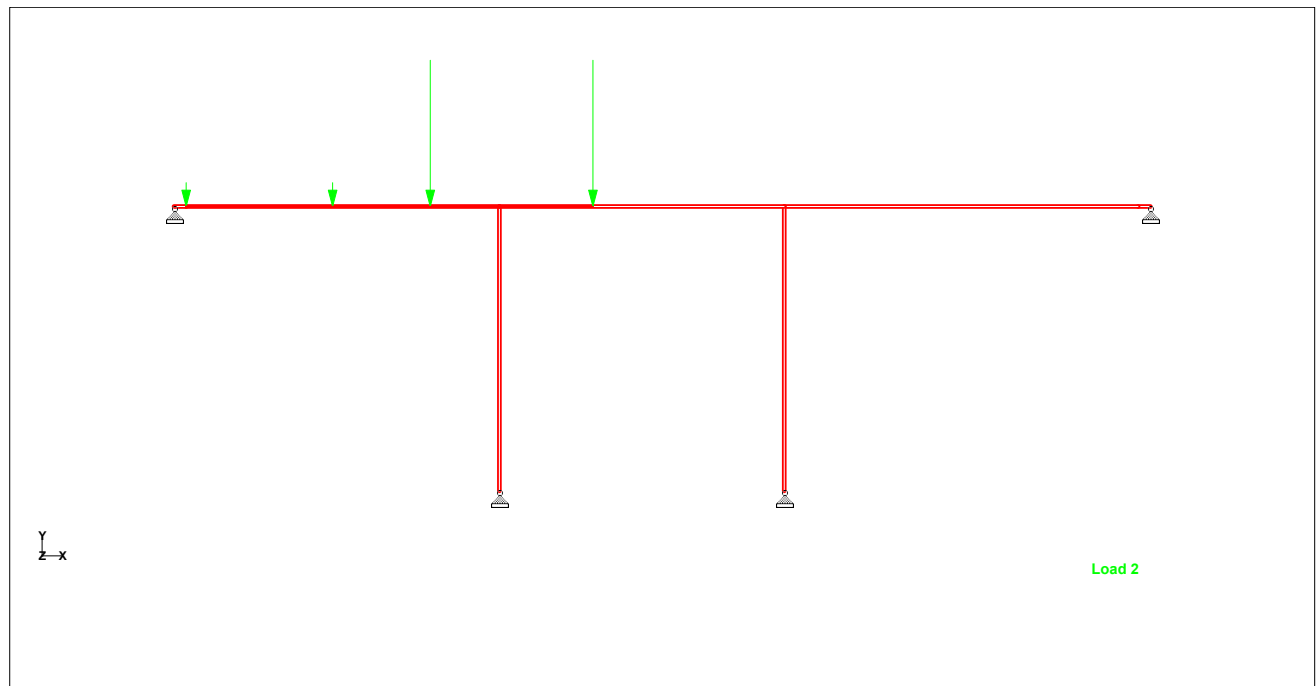
Date 10-Jan-25

Chd

Client

File I40172_BBMP_Platform i

Date/Time 23-Jan-2025 17:19



Loading

[Handwritten signatures]



Software licensed to

Job No

Sheet No

6

Rev

Part

Job Title

Ref

By

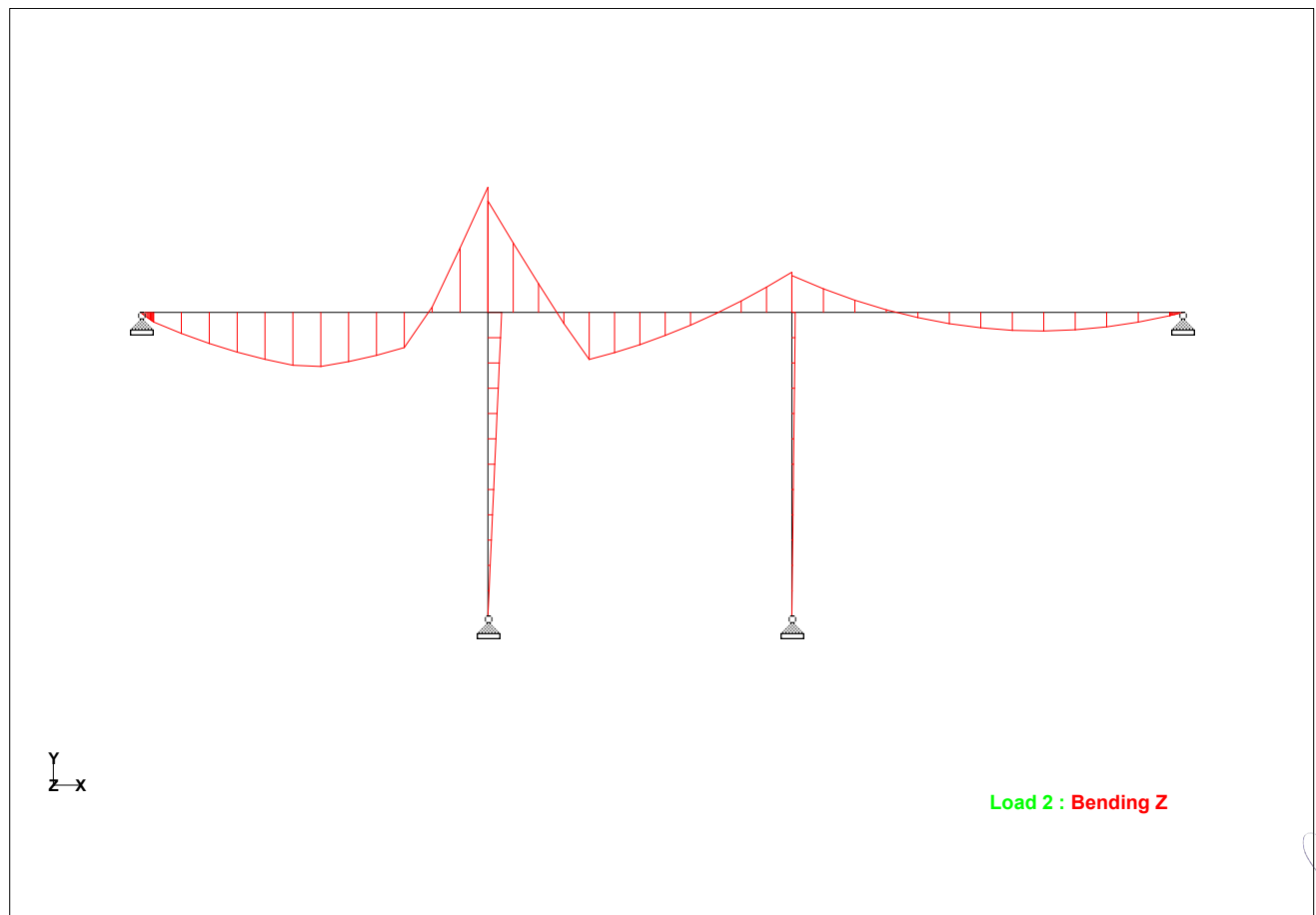
Date 10-Jan-25

Chd

Client

File I40172_BBMP_Platform i

Date/Time 23-Jan-2025 17:19



Bending Moment

Load 2 : Bending Z

Handwritten signatures and initials:
1. *Amal*
2. *Adi*
3. *Rob*
4. *CS*
5. *Wahne*



Software licensed to

Job No

Sheet No

7

Rev

Part

Job Title

Ref

By

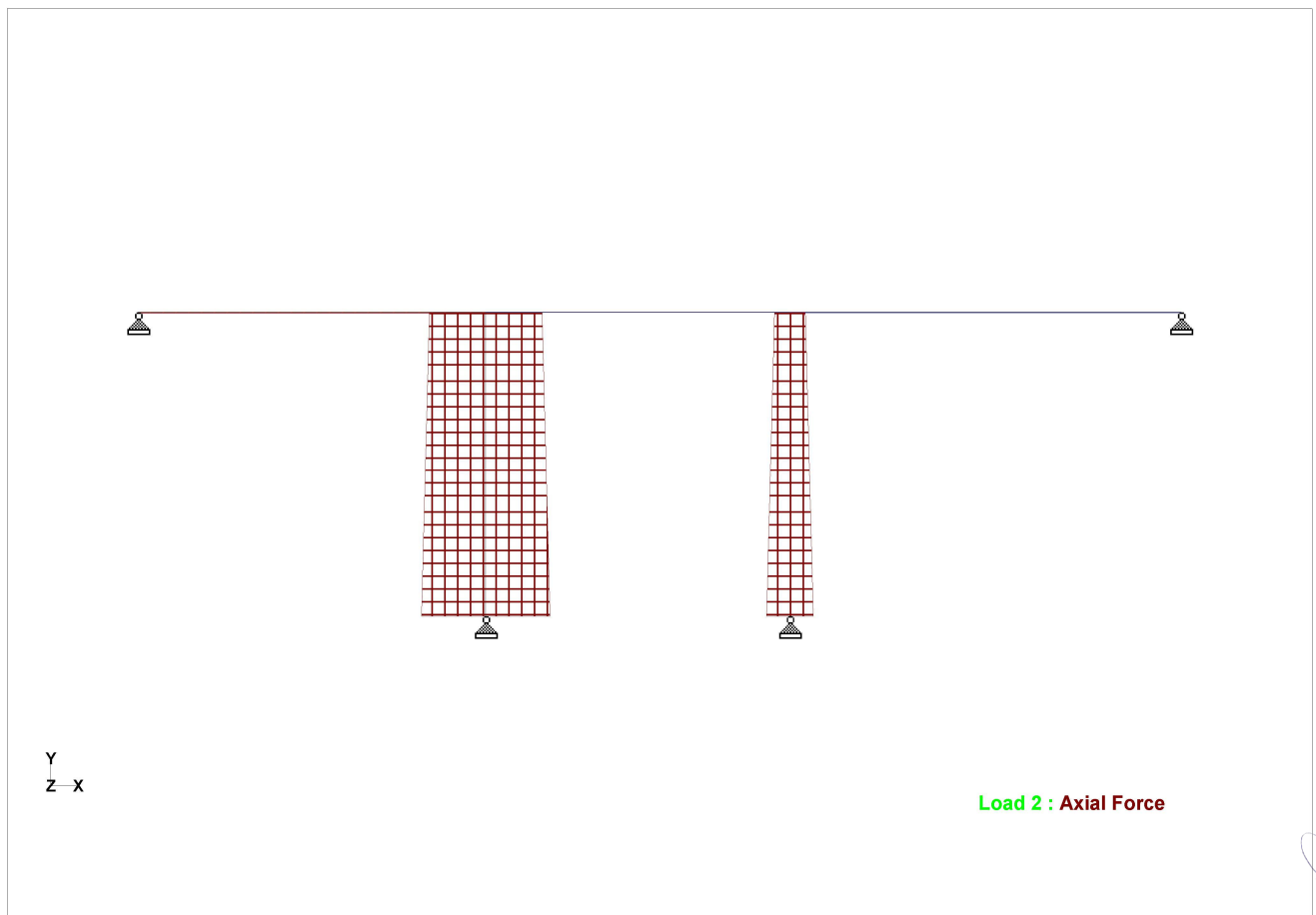
Date 10-Jan-25

Chd

Client

File I40172_BBMP_Platform i

Date/Time 23-Jan-2025 17:19



Axial Force

Load 2 : Axial Force

[Handwritten signatures]



Software licensed to

Job No

Sheet No

8

Rev

Part

Job Title

Ref

By

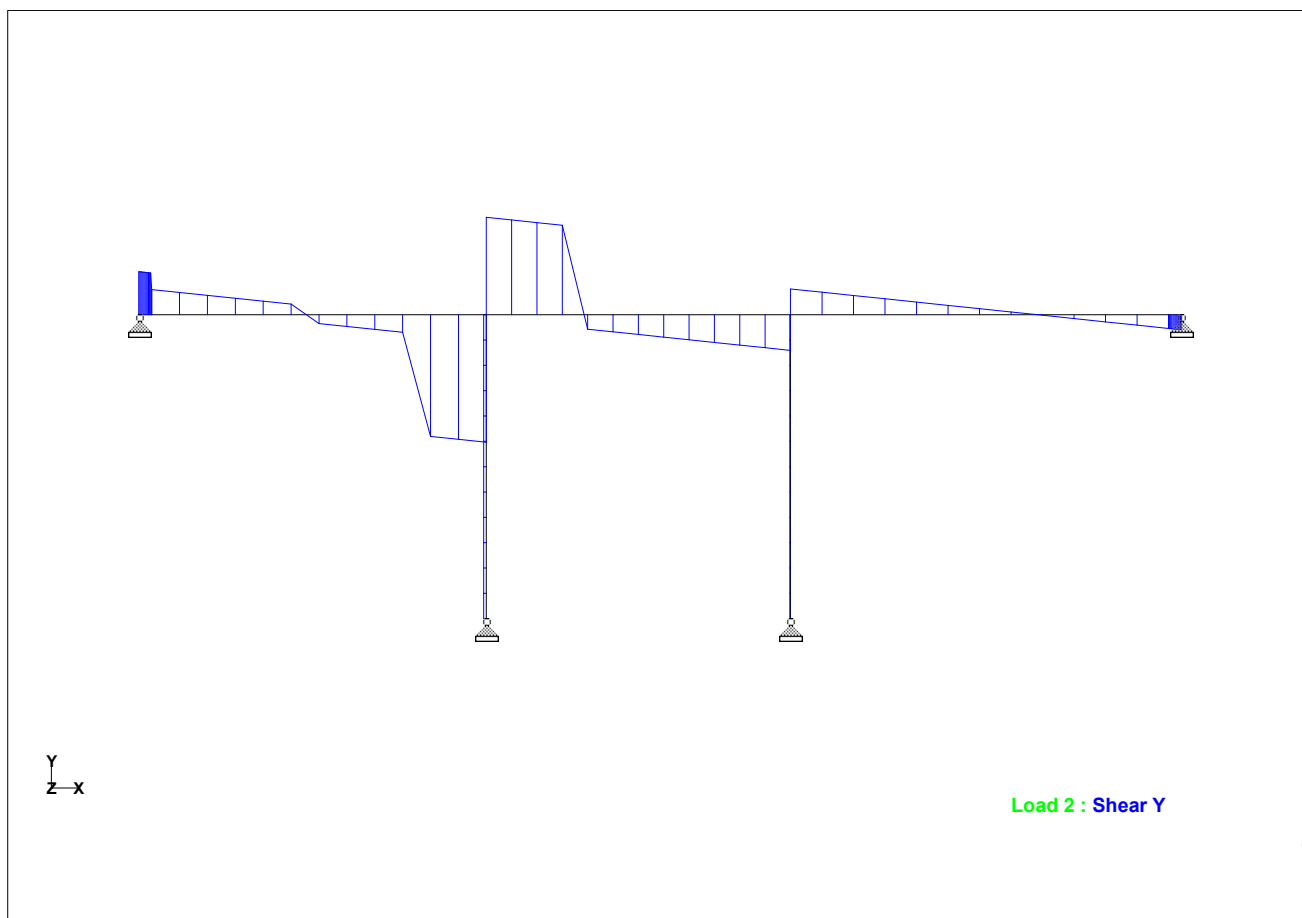
Date 10-Jan-25

Chd

Client

File I40172_BBMP_Platform i

Date/Time 23-Jan-2025 17:19



Shear Force

Y
Z-X

Load 2 : Shear Y

[Handwritten signatures]



I40172

Geoconsult India PVT Ltd

Design of Junction

Section Number		OVERT LEFT Jn_Next to CP
-----------------------	--	-----------------------------

Type1

a) Factored Max. B.M.(ULS)	kN-m	95
b) Factored Max. B.M.(SLS)	kN-m	63
Corresponding axial force	kN	10
b.i) Load case for Max. B.M. from STAAD SLS		
c) Factored Max. S.F. (ULS)	kN	150
c.i) Load case for Max. S.F. from STAAD ULS		

Calculations of Flexural Reinforcement (ULS Design)

<u>Design Parameters</u>	↓	
Actual Clear Cover (c)	mm	40
Nominal cover (C_{nom}) (For Calculating Crack Width)	mm	40
Width of Section (b)	mm	1000
Concrete Grade (f_{ck})	N/mm ²	35
Main R/f Steel Grade (f_y)	N/mm ²	500
Stirrup Steel Grade (f_{ys})	N/mm ²	415
Dia of each leg of stirrup provided	mm	8
Diameter of distribution reinforcement	mm	0
Maximum Permissible Crack Width for Soil Face	mm	0.3
Modulus of Elasticity of Steel (E_s)	N/mm ²	200000
$X_{u(max)} / d$		0.456
Total Depth of Section (D)	mm	350
Distance of compression face to point of crack (a)	mm	350
Dia.of 1st layer of tension R/f Provided (Φ_{1t})	mm	16
Total Number of Bars in 1st Layer of Tension R/f (n_{1t})	mm	6.67
Spacer Bar Between Layer 1 and Layer 2	mm	0
Dia.of 2nd layer of tension R/f Provided (Φ_{2t})	mm	0
Total Number of Bars in 2nd Layer of Tension R/f (n_{2t})	mm	6.67
Dia.of 3rd layer of tension R/f Provided (Φ_{3t})	mm	0
Total Number of Bars in 3rd Layer of Tension R/f (n_{3t})	mm	6.67
CG. Of Steel from Bottom = Effective Cover (h) _{BOTTOM}	mm	56
Effective Depth of Section from Bottom (d_{eff}) _{BOTTOM}	mm	294
Dia.of 1st layer of compression R/f Provided (Φ_{1c})	mm	12
Spacing of Bars in 1st Layer of Comp. R/f (s_{1c})	mm	150
Dia.of 2nd layer of compression R/f Provided (Φ_{2c})	mm	0
Spacing of Bars in 2nd Layer of Comp. R/f (s_{2c})	mm	150
Dia.of 3rd layer of compression R/f Provided (Φ_{3c})	mm	0
Spacing of Bars in 3rd Layer of Comp. R/f (s_{3c})	mm	149.9250375









140172

Geoconsult India PVT Ltd

CG. Of Steel from Top = Effective Cover (h) _{TOP}	mm	54
Factored Moment on Section = M _u	kN-m	95
Limiting Moment of Resistance = M _{u(lim)}	kN-m	402
Type of Section		Singly R/f
A _{st,required}	mm ²	768
A _{st,provided}	mm ²	1341
A _{sc, required} = $0.87 * f_y * (\Delta A_{sc})_{reqd} / (f_{sc} - 0.46 * f_{ck})$	mm ²	0
A _{sc, provided}	mm ²	0

Servicability Checks

<u>Section Number</u>		OVERT LEFT Jn Next to CP
Modular Ratio (m) = $280 / f_{ck}$		8.00
Percent Reinforcement prov.(p) = $(A_{st})_{provided} / (b * d)$		0.46%
Eccentricity (e)	mm	6300.00
$1/2nbd(1/3nd+e-D/2)+(m-1)Asc(nd-d'c)/kd.(d'c+e-D/2) = Ast.m(1-n)/n(e+D/2-d')$		0
Calculating neutral Axis Depth by WSM (n*d)	mm	71

Crack Width Check

Maximum Permissible Crack Width	mm	0.3
Moment (SLS Normal Case)	kN-m	63
In Tension Steel (f_{st})	kN/m ²	169539
	MPa	170
		OK
Strain at the centroid of tension steel (e)= f_{st} / E_s =		8.5E-04
Strain at the Tension Face (e_1) =		1.1E-03

Crack Width As Per IS-456 / BS-8110

Reduction in strain due to tension stiffning (e_2) =		4.3E-04
$b * (D-x) * (a-x)$		
$(3 * E_s * A_{st} * (d-x))$		
Avg. steel strain at level considered (e_m) = $e_1 - e_2$ =		0.000626
Crack Width (W_{cr}) =		0.127
$3 * a_{cr} * e_m$	mm	
$(1+2 * (a_{cr}-C_{nom}) / (D-x))$		

* Negative Crack Width indicates absence of Cracking

Calculations of Shear Reinforcement

UOM

<u>Section Number</u>		OVERT LEFT Jn Next to CP
$t_{c,max} = 0.62 * (f_{ck})^{0.5}$ (Approximately)	N/mm ²	3.67

		140172
Geoconsult India PVT Ltd		
$t_{c,max}$ (Approximately)	kN/m^2	3668
Shear Force (V_u)	t	150
Shear Stresses (t_v) = $V_u / (b*d)$	kN/m^2	510
Check for Adequacy of Section in Shear		O.K.
Design Shear Strength of Concrete = $(t_c) * k*\delta$	kN/m^2	485
maximum Vertical stirrup spacing as per caluse 26.5.1.5	mm	220.5
Spacing of Stirrups Provided	mm	300
Total width of beam	mm	1000
No. of Legs of Shear Stirrups Provided in total length		6.67
Dia of each leg of stirrup provided	mm	8
Minimum Shear R/f $A_{sv(Required)min} \geq b*S_v*0.4/(0.87*f_y)$	mm^2	0
$V_{us} = V_u - (t_c*k*\delta)*b*d$	N	7440
Shear R/f $A_{sv(Required)Act.} = V_{us}*S_v/(0.87*f_y*d)$	mm^2	21
Actual $A_{sv(Required)}$	mm^2	21
Total Shear R/f Provided $A_{sv(Provided)}$	mm^2	335

Signature

Signature

Signature

Signature

Signature

Amelia

Adri

Rob

Emma

James

ANNEXURE – 7
HANGING DUCT /
INTERMEDIATE SLAB FOR
VENTILATION

Signature

Signature

Signature

Signature

Signature

Amelia

Adri

Rob

Emma

James



Software licensed to

Job No

Sheet No

1

Rev

Part

Job Title

Ref

By

Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03

Job Information

	Engineer	Checked	Approved
Name:			
Date:	23-Jan-25		

Project ID	
Project Name	

Structure Type	SPACE FRAME
----------------	-------------

Number of Nodes	18	Highest Node	91
Number of Elements	19	Highest Beam	93

Number of Basic Load Cases	3
Number of Combination Load Cases	3

Included in this printout are data for:

All	The Whole Structure
-----	---------------------

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEAD
Primary	2	LIVE
Primary	3	LL-2
Combination	4	COMBINATION LOAD CASE 4
Combination	5	COMBINATION LOAD CASE 5
Combination	6	COMBINATION LOAD CASE 6

Nodes

Node	X (m)	Y (m)	Z (m)
49	5.910	3.798	1.000
50	5.309	4.600	1.000
51	4.600	5.309	1.000
52	3.798	5.910	1.000
53	2.918	6.390	1.000
54	1.979	6.740	1.000
55	1.000	6.953	1.000
56	-0.000	7.025	1.000
57	-1.000	6.953	1.000
58	-1.979	6.740	1.000
59	-2.918	6.390	1.000
60	-3.798	5.910	1.000
61	-4.600	5.309	1.000
62	-5.309	4.600	1.000

Signature
Date
Rob
Date
Date



Software licensed to

Job No

Sheet No

2

Rev

Part

Job Title

Ref

By

Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03

Nodes Cont...

Node	X (m)	Y (m)	Z (m)
91	0.075	3.798	1.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
49	49	50	1.002	2	0
50	50	51	1.002	2	0
51	51	52	1.002	2	0
52	52	53	1.002	2	0
53	53	54	1.002	2	0
54	54	55	1.002	2	0
55	55	56	1.002	2	0
56	56	57	1.002	2	0
57	57	58	1.002	2	0
58	58	59	1.002	2	0
59	59	60	1.002	2	0
60	60	61	1.002	2	0
61	61	62	1.002	2	0
62	62	63	1.002	2	0
89	89	91	0.075	1	0
90	89	90	0.075	1	0
91	56	89	3.227	1	0
92	90	63	5.835	1	0
93	91	49	5.835	1	0

Section Properties

Prop	Section	Area (cm ²)	I_{yy} (cm ⁴)	I_{zz} (cm ⁴)	J (cm ⁴)	Material
1	Rect 0.15x1.00	1.5E+3	1.25E+6	28.1E+3	102E+3	CONCRETE
2	Rect 0.55x1.00	5.5E+3	4.58E+6	1.39E+6	3.64E+6	CONCRETE

Materials

Mat	Name	E (kN/mm ²)	ν	Density (kg/m ³)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	CONCRETE	21.718	0.170	2.4E+3	10E -6

Handwritten signatures and initials:
- Top: A signature in blue ink.
- Middle: The name "Adai" in blue ink.
- Below: The name "Rob" in blue ink.
- Below: The name "C. S. S. S. S." in blue ink.
- Bottom: A signature in blue ink.



Software licensed to

Job No

Sheet No

3

Rev

Part

Job Title

Ref

By

Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN`m/deg)	rY (kN`m/deg)	rZ (kN`m/deg)
49	Fixed	Fixed	Fixed	-	-	-
56	Fixed	Fixed	Fixed	-	-	-
63	Fixed	Fixed	Fixed	-	-	-

Primary Load Cases

Number	Name	Type
1	DEAD	Dead
2	LIVE	Live
3	LL-2	Live

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
4	COMBINATION LOAD CASE 4	1	DEAD	1.50
		2	LIVE	1.50
5	COMBINATION LOAD CASE 5	1	DEAD	1.50
		3	LL-2	1.50
6	COMBINATION LOAD CASE 6	1	DEAD	1.50
		2	LIVE	1.50
		3	LL-2	1.50

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

4

Rev

Part

Job Title

Ref

By

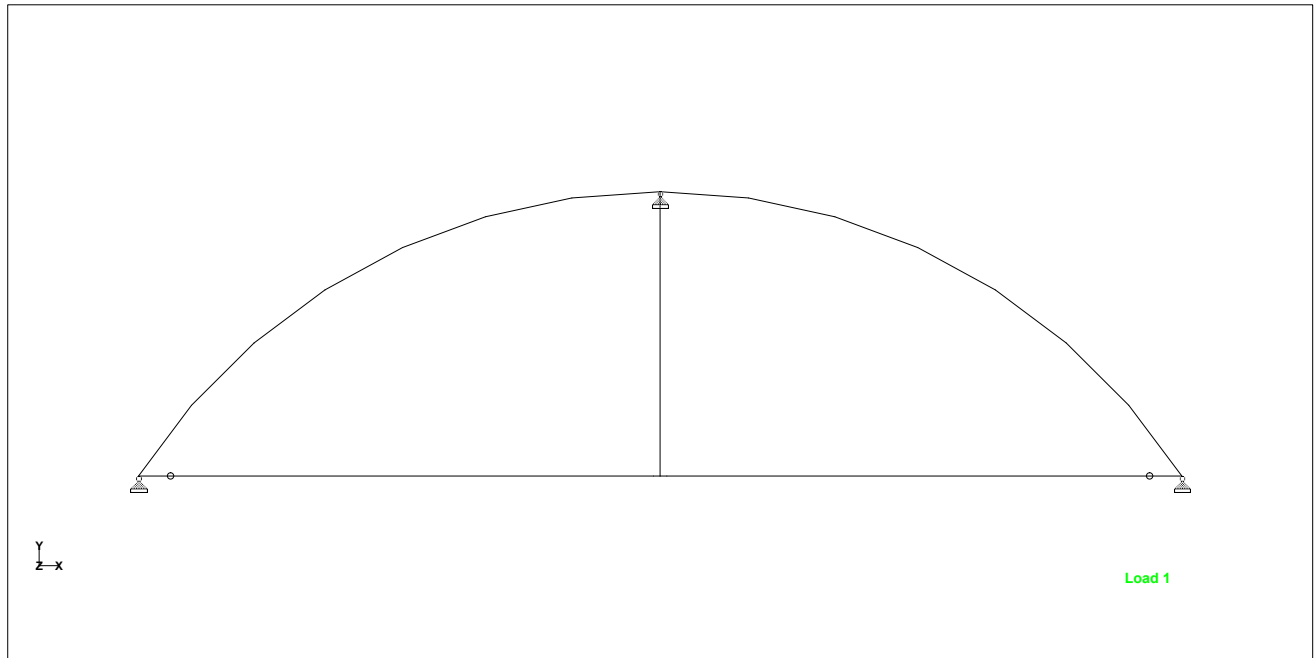
Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03



Whole Structure

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

5

Rev

Part

Job Title

Ref

By

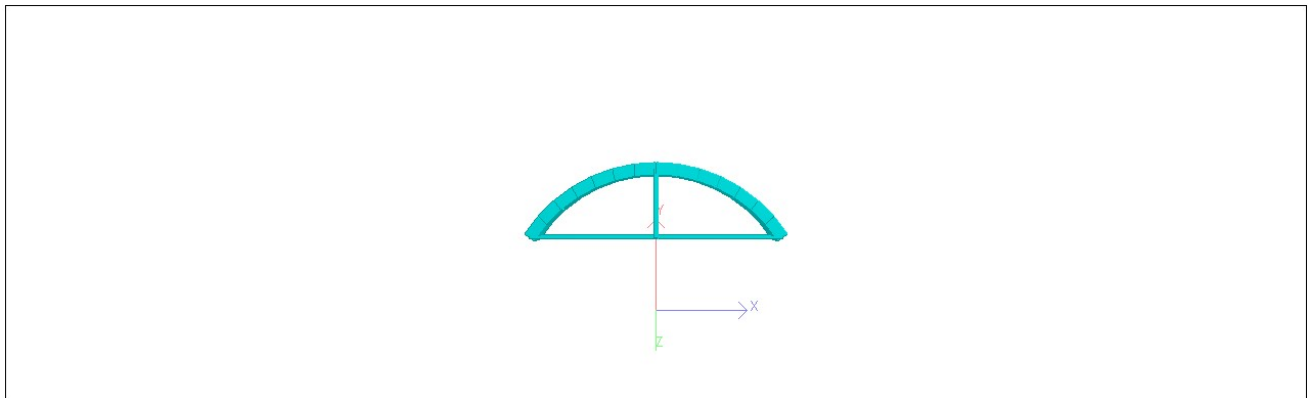
Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03



3D Rendered View

Signature
Signature
Signature
Signature
Signature



Software licensed to

Job No

Sheet No

6

Rev

Part

Job Title

Ref

By

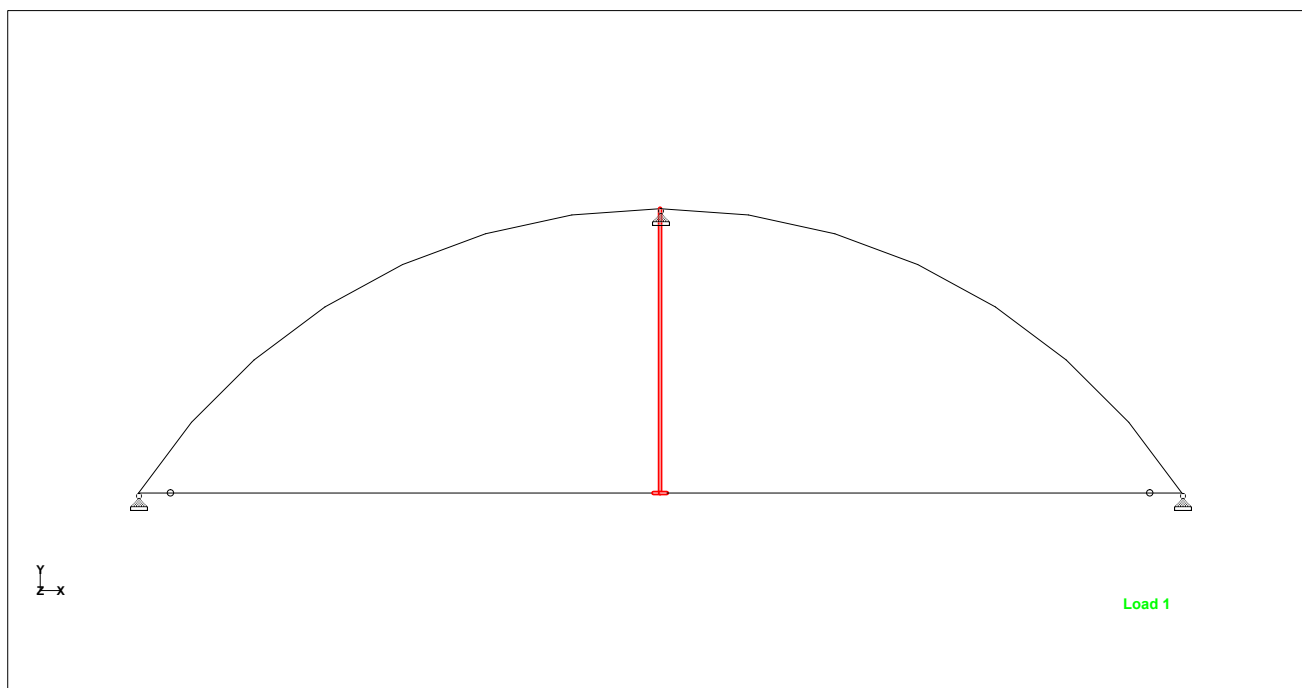
Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03



Dead Load

[Handwritten signatures]



Software licensed to

Job No

Sheet No

7

Rev

Part

Job Title

Ref

By

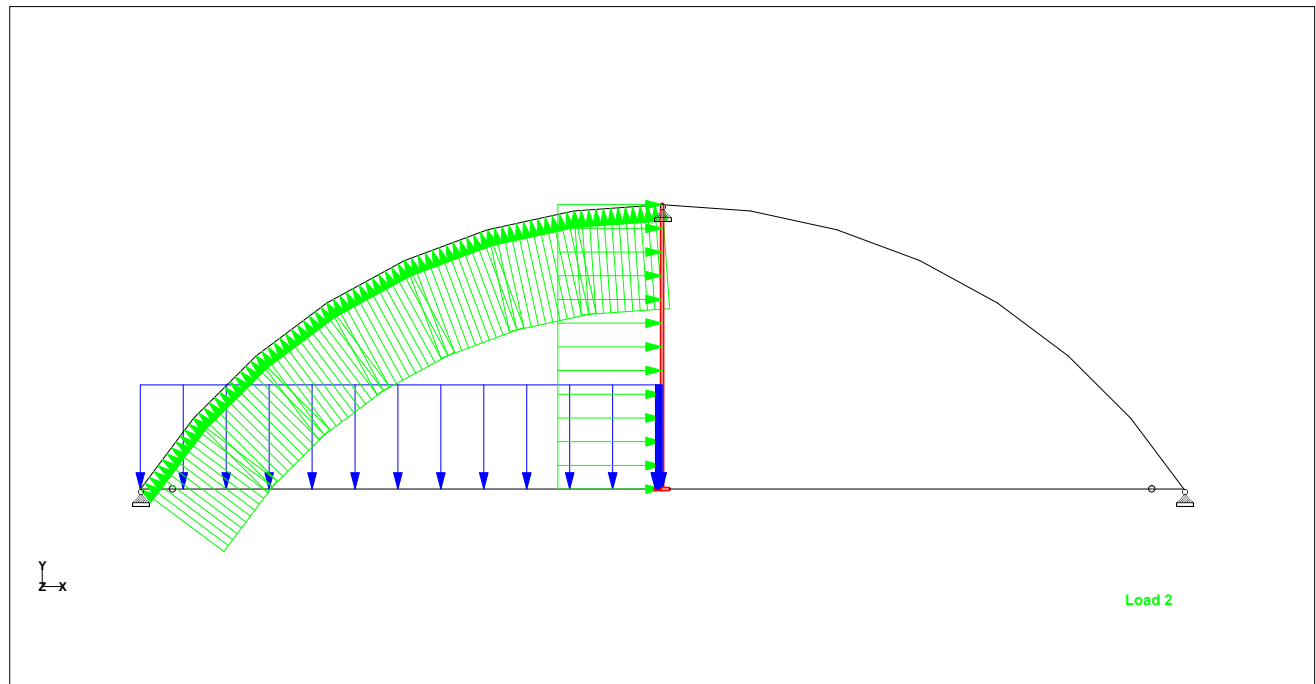
Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03



Live Load 1

Handwritten signatures and initials:
1. *Amr*
2. *Adi*
3. *Rob*
4. *CS*
5. *Amr*



Software licensed to

Job No

Sheet No

8

Rev

Part

Job Title

Ref

By

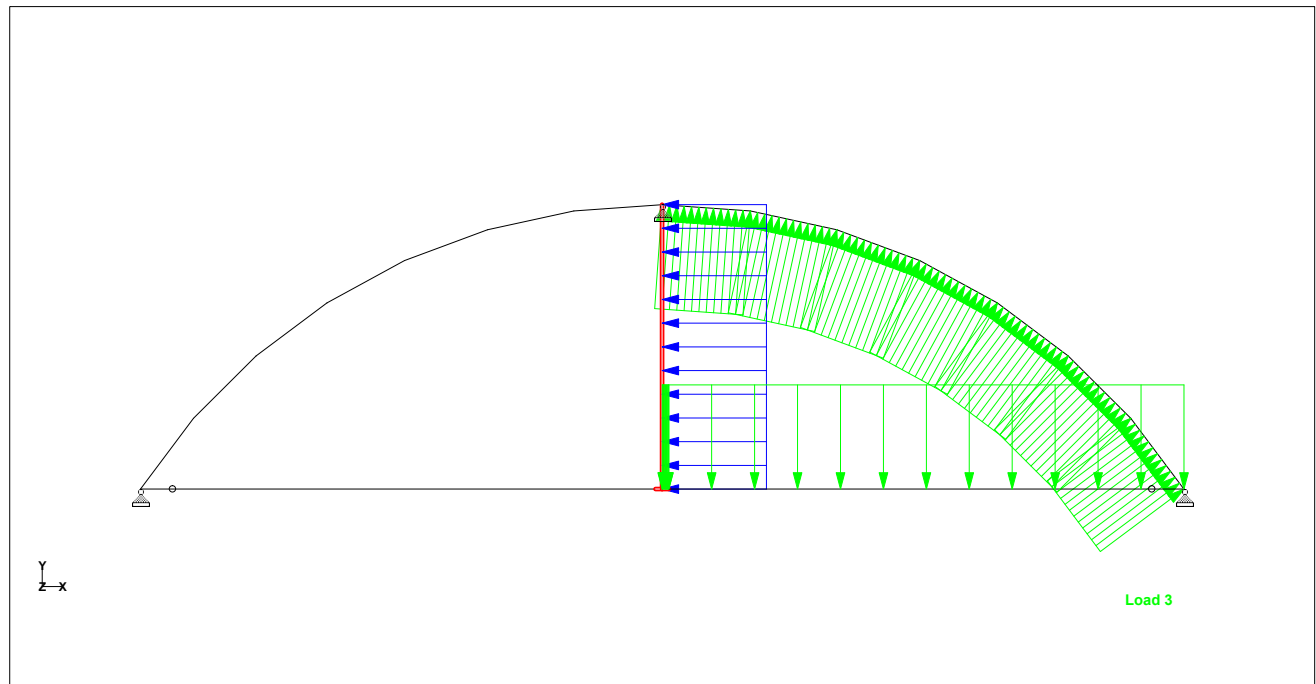
Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03



Live Load 2

Handwritten signatures and initials:
1. *Amr*
2. *Adi*
3. *Rob*
4. *CS*
5. *Wahne*



Software licensed to

Job No

Sheet No

9

Rev

Part

Job Title

Ref

By

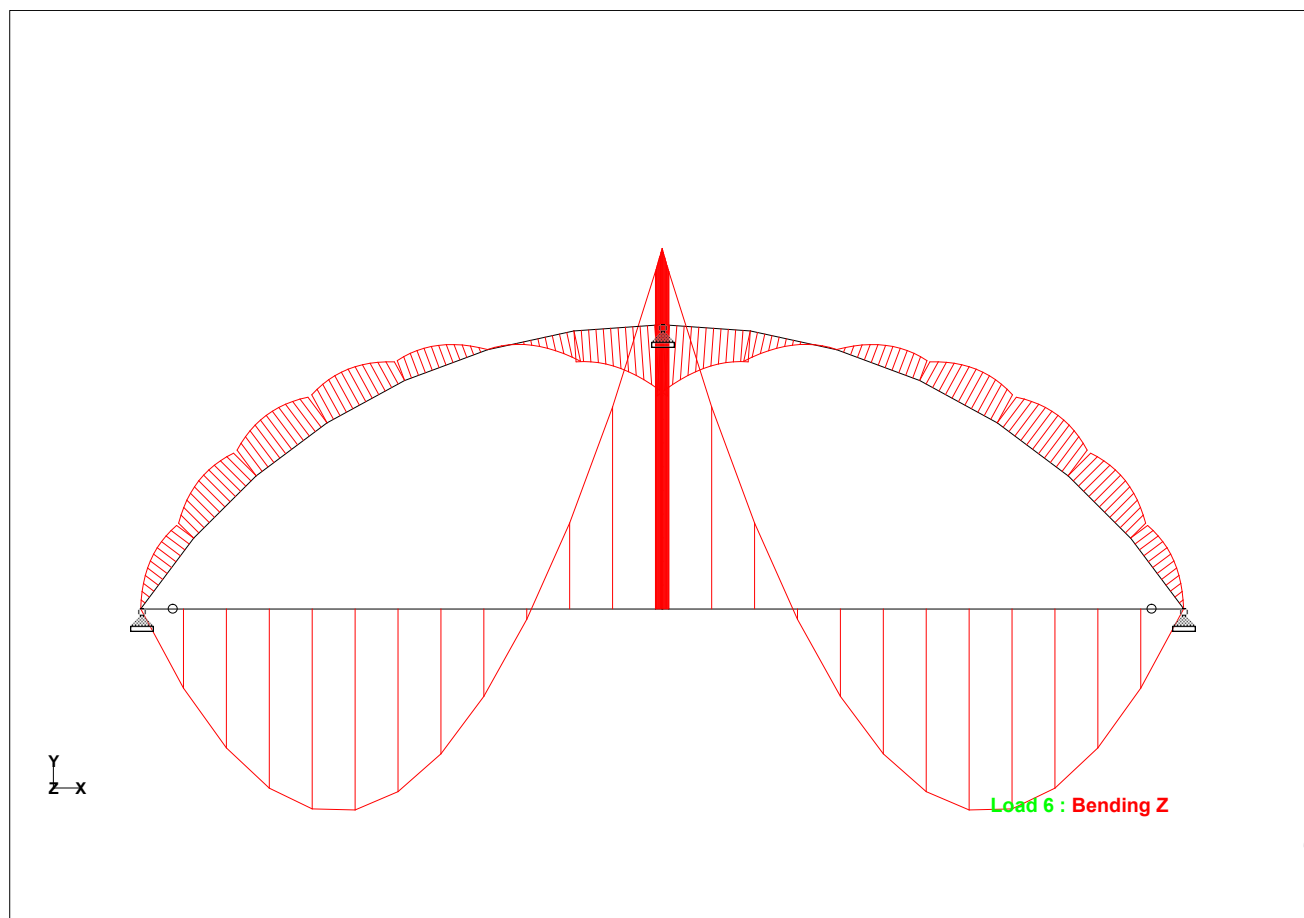
Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03



Bending Moment

Handwritten signatures and initials:
1. [Signature]
2. [Signature]
3. [Signature]
4. [Signature]



Software licensed to

Job No

Sheet No

10

Rev

Part

Job Title

Ref

By

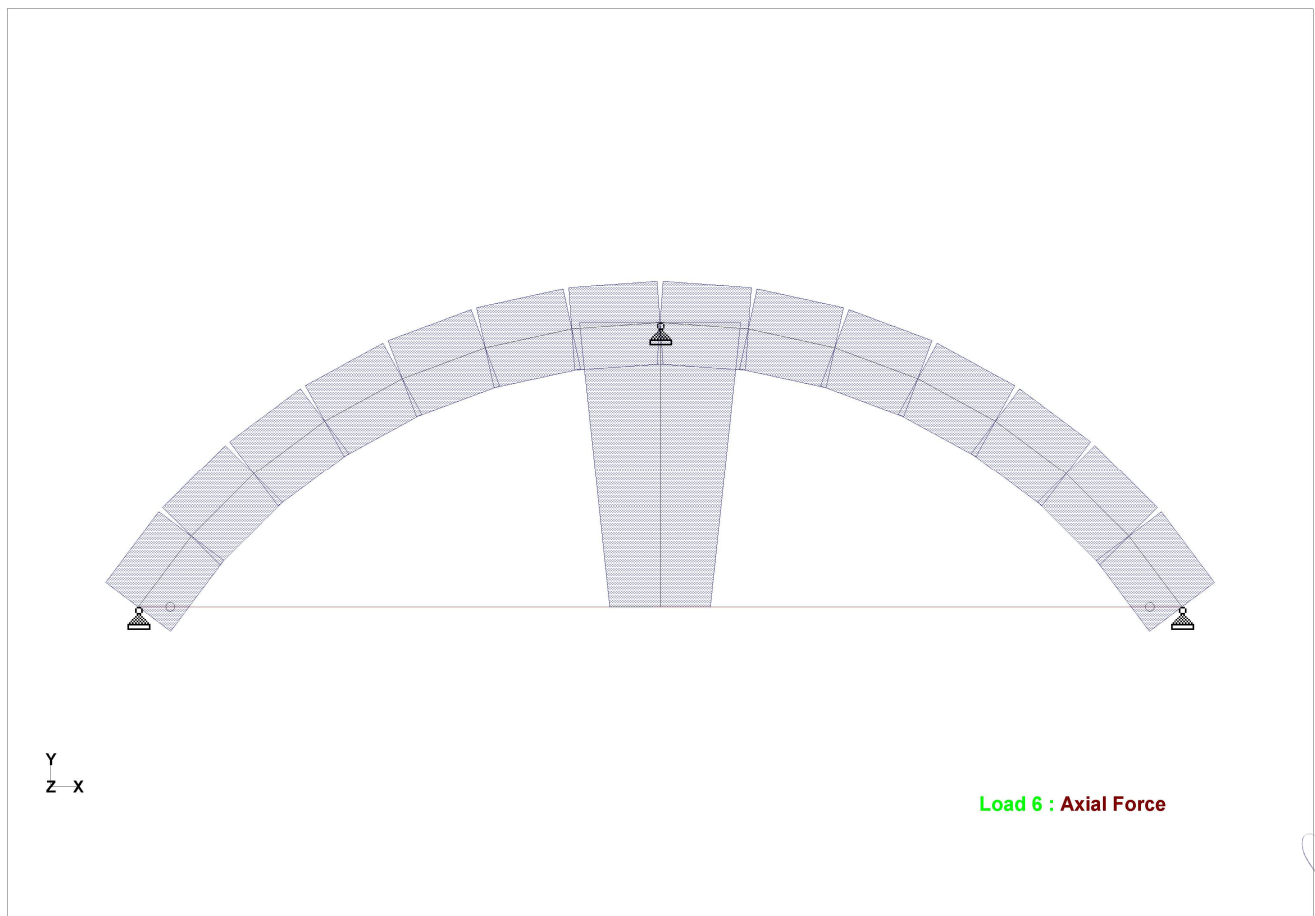
Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03



Axial Force

[Handwritten signatures and initials]



Software licensed to

Job No

Sheet No

11

Rev

Part

Job Title

Ref

By

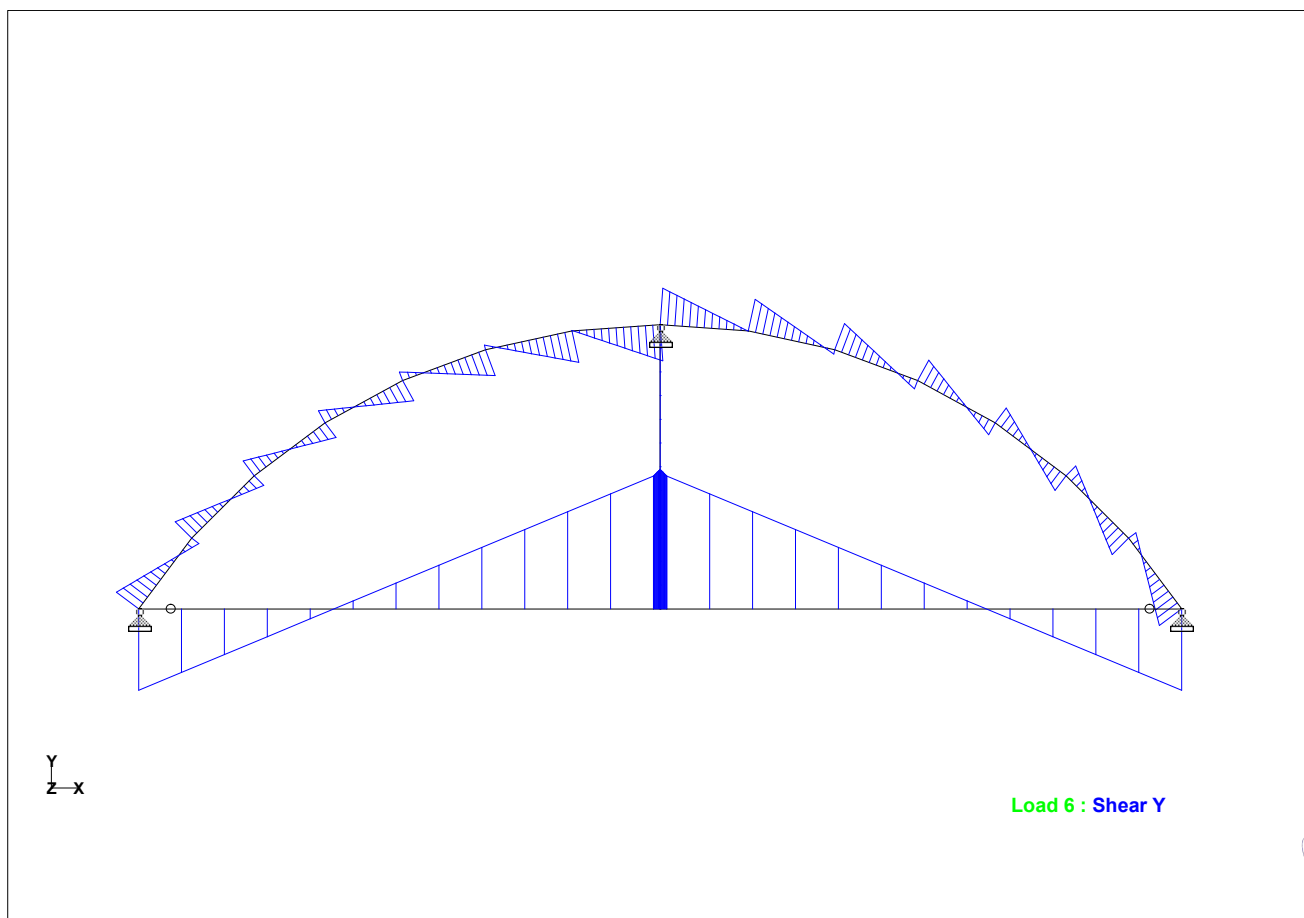
Date 23-Jan-25

Chd

Client

File Duct.std

Date/Time 23-Jan-2025 15:03



Shear Force

Handwritten signatures and initials:
1. *Amal*
2. *Rob*
3. *CS*
4. *John*



I40172

Geoconsult India PVT Ltd

Design of Junction

Section Number		OVERT LEFT Jn_Next to CP
-----------------------	--	-----------------------------

Type1

a) Factored Max. B.M.(ULS)	kN-m	16
b) Factored Max. B.M.(SLS)	kN-m	11
Corresponding axial force	kN	10
b.i) Load case for Max. B.M. from STAAD SLS		
c) Factored Max. S.F. (ULS)	kN	14
c.i) Load case for Max. S.F. from STAAD ULS		

Calculations of Flexural Reinforcement (ULS Design)

<u>Design Parameters</u>	↓	
Actual Clear Cover (c)	mm	40
Nominal cover (C_{nom}) (For Calculating Crack Width)	mm	40
Width of Section (b)	mm	1000
Concrete Grade (f_{ck})	N/mm ²	35
Main R/f Steel Grade (f_y)	N/mm ²	500
Stirrup Steel Grade (f_{ys})	N/mm ²	415
Dia of each leg of stirrup provided	mm	10
Diameter of distribution reinforcement	mm	0
Maximum Permissible Crack Width for Soil Face	mm	0.3
Modulus of Elasticity of Steel (E_s)	N/mm ²	200000
$X_{u(max)} / d$		0.456
Total Depth of Section (D)	mm	175
Distance of compression face to point of crack (a)	mm	175
Dia.of 1st layer of tension R/f Provided (Φ_{1t})	mm	12
Total Number of Bars in 1st Layer of Tension R/f (n_{1t})	mm	6.67
Spacer Bar Between Layer 1 and Layer 2	mm	0
Dia.of 2nd layer of tension R/f Provided (Φ_{2t})	mm	0
Total Number of Bars in 2nd Layer of Tension R/f (n_{2t})	mm	6.67
Dia.of 3rd layer of tension R/f Provided (Φ_{3t})	mm	0
Total Number of Bars in 3rd Layer of Tension R/f (n_{3t})	mm	6.67
CG. Of Steel from Bottom = Effective Cover (h) _{BOTTOM}	mm	56
Effective Depth of Section from Bottom (d_{eff}) _{BOTTOM}	mm	119
Dia.of 1st layer of compression R/f Provided (Φ_{1c})	mm	12
Spacing of Bars in 1st Layer of Comp. R/f (s_{1c})	mm	150
Dia.of 2nd layer of compression R/f Provided (Φ_{2c})	mm	0
Spacing of Bars in 2nd Layer of Comp. R/f (s_{2c})	mm	150
Dia.of 3rd layer of compression R/f Provided (Φ_{3c})	mm	0
Spacing of Bars in 3rd Layer of Comp. R/f (s_{3c})	mm	149.9250375









140172

Geoconsult India PVT Ltd

CG. Of Steel from Top = Effective Cover (h) _{TOP}	mm	56
Factored Moment on Section = M _u	kN-m	16
Limiting Moment of Resistance = M _{u(lim)}	kN-m	66
Type of Section		Singly R/f
A _{st,required}	mm ²	322
A _{st,provided}	mm ²	754
A _{sc, required} = $0.87 * f_y * (\Delta A_{sc})_{reqd} / (f_{sc} - 0.46 * f_{ck})$	mm ²	0
A _{sc, provided}	mm ²	0

Servicability Checks

<u>Section Number</u>		OVERT LEFT Jn Next to CP
Modular Ratio (m) = $280 / f_{ck}$		8.00
Percent Reinforcement prov.(p) = $(A_{st})_{provided} / (b * d)$		0.63%
Eccentricity (e)	mm	1066.67
$1/2nbd(1/3nd+e-D/2)+(m-1)Asc(nd-d'c)/kd.(d'c+e-D/2) = Ast.m(1-n)/n(e+D/2-d')$		0
Calculating neutral Axis Depth by WSM (n*d)	mm	34

Crack Width Check

Maximum Permissible Crack Width	mm	0.3
Moment (SLS Normal Case)	kN-m	11
In Tension Steel (f_{st})	kN/m ²	121859
	MPa	122
		OK
Strain at the centroid of tension steel (e)= f_{st} / E_s =		6.1E-04
Strain at the Tension Face (e_1) =		1.0E-03

Crack Width As Per IS-456 / BS-8110

Reduction in strain due to tension stiffning (e_2) =		5.2E-04
$b * (D-x) * (a-x)$		
$(3 * E_s * A_{st} * (d-x))$		
Avg. steel strain at level considered (e_m) = $e_1 - e_2$ =		0.000493
Crack Width (W_{cr}) =		0.084
$3 * a_{cr} * e_m$	mm	
$(1 + 2 * (a_{cr} - C_{nom}) / (D - x))$		

* Negative Crack Width indicates absence of Cracking

Calculations of Shear Reinforcement

UOM

<u>Section Number</u>		OVERT LEFT Jn Next to CP
$t_{c,max} = 0.62 * (f_{ck})^{0.5}$ (Approximately)	N/mm ²	3.67








**I40172**

Geoconsult India PVT Ltd

$t_{c,max}$ (Approximately)	kN/m^2	3668
Shear Force (V_u)	t	14
Shear Stresses (t_v) = $V_u / (b*d)$	kN/m^2	118
Check for Adequacy of Section in Shear		O.K.
Design Shear Strength of Concrete = $(t_c) * k * \delta$	kN/m^2	698
maximum Vertical stirrup spacing as per caluse 26.5.1.5	mm	89.25
Spacing of Stirrups Provided	mm	300
Total width of beam	mm	1000
No. of Legs of Shear Stirrups Provided in total length		6.67
Dia of each leg of stirrup provided	mm	8
Minimum Shear R/f $A_{sv(Required)min} \geq b * S_v * 0.4 / (0.87 * f_y)$	mm^2	0
$V_{us} = V_u - (t_c * k * \delta) * b * d$	N	0
Shear R/f $A_{sv(Required)Act.} = V_{us} * S_v / (0.87 * f_y * d)$	mm^2	0
Actual $A_{sv(Required)}$	mm^2	0
Total Shear R/f Provided $A_{sv(Provided)}$	mm^2	335

ANNEXURE – 8
TEMPORARY SECANT PILE &
STEEL WALER FOR SHAFT &
C&C

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

Amelia

Adri

Rob

Emma

James

	GEOCONSULT India Pvt Ltd	APPENDIX	
	A company of the GEOCONSULT group	Job no:	I40172
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction		
Calculation for	DESIGN OF 23 m LONG HARD PILE SECTION		

DESIGN OF 23 m LONG HARD PILE SECTION

FACTORED BENDING MOMENT, SHEAR FORCE AND AXIAL FORCE PER RUNNING OF THE EXCAVATION IS GIVEN BELOW:

Output From PLEXIS: (For Shaft & C&C)

C/C Distance B/W Two Hard Piles	=	1.6 m
Unfactored B.M. (M) (Normal case governing)	=	789.6 kN-m/m
Max. Factored B.M (With C/C Distance)	M x 1.5 =	1895.0 kN.m
Unfactored Shear Force (V)	=	300 kN/m
Max. Factored S.F (With C/C Distance)	V x 1.5 =	720.0 kN
Unfactored Axial Force (N)	=	463.9 kN/m
Max. Factored Axial Force	N x 1.5 =	1113.4 kN
Grade of Concrete	=	35 N/mm ²

1 PILE SECTION DESIGN

- 1.1 The pile section is designed as column under shear force & bending moments for the design values as per above Table using limit state design concept.

Area of Pile Section	Ap	=	0.785 m ²	
Thickness/Dia of Pile Beam wall	D	=	1000 mm	Effective Dia = 793 mm
Diameter of Reinforced Bar	d	=	25 mm (Assumed)	Perimeter = 2491.3 mm
Clear Cover	cc	=	75 mm (Assumed)	
Effective cover	d'	=	103.5 mm	

$$\frac{d'}{D} = 0.104$$

$$\frac{pu}{f_{ck} D^2} = 0.03, \quad \frac{Mu}{f_{ck} D^3} = 0.054$$

From Sp 16, Chart 60 $P_t/f_{ck} = 0.042$, $P_{tc} = 1.47$

Minimum Steel Required as per IS 2911-2010, $P_{tm} = 0.4\%$

Design reinforcement, $P_t = 1.5\%$

Reinforcement to be provided $= 11545 \text{ mm}^2$

Using 25 mm tor steel $= 490.87 \text{ mm}^2$ $(25 + 0.0)^*$
 $(0 + 0.0)^*$

Number of Bars Required $= 23.5$

Provide 26 Nos tor steel of 25 mm dia @ spacing of 96 mm C/C

Steel area provided $= 12763 \text{ mm}^2$ ($P_t = 1.63\%$) > 11545

OK

1.2 Check for Shear:

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force $V_u = 720.0 \text{ kN}$

Effective Shear Area of secant pile $= 1130973 \text{ mm}^2$

Shear Stress in secant Pile $= 0.64 \text{ N/mm}^2$

Allowable Shear Stress $= 0.75 \text{ N/mm}^2$

Shear force against which stirrups required $= -85 \text{ KN}$

Considering 10 mm Dia stirrups 10 mm

Spacing of stirrups $= -665 \text{ mm}$

Provide shear reinforcement at $= 180 \text{ mm}$

1.3 Transverse Reinforcement:

Spacing of transverse steel shall be least of

a) Least dimension of compression member (80% of pile Dia) $= 800.0 \text{ mm}$

b) Sixteen times the smallest dia of longitudinal bar ($16d$) $= 400.0 \text{ mm}$

c) Minimum of 300 mm $= 300.0 \text{ mm}$

d) Forty eight times the smallest dia of transverse bar ($48dt$) $= 480.0 \text{ mm}$

Using 10 mm tor diameter steel ties at 180.0 mm

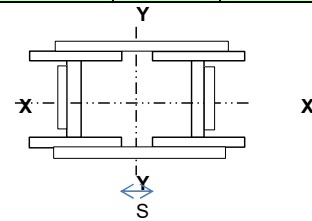
OK

Properties of Waler WB (Shaft & C&C)

Proposed Section of Strut	UB	610	229	101.20
Width Extra Flange Plate	=	0	mm	
Thickness of Extra Flange Plate	=	0	mm	
Area of Additional Plate	=	0	cm ²	
Width Extra web Plate	=	0	mm	
Thickness of Extra web Plate	=	0	mm	
Area of Additional Plate	=	0	cm ²	
Properties of	UB	610	229	101.2

Depth	Area (A ₁)	Self Wt.	Flange Thk	Flange Width	Web Thk		
(mm)	(cm ²)	(kg/m)	(mm)	(mm)	(mm)		
610	128.9	101.2	14.8	228	10.5		
I _{xx}	I _{yy}	r _{xx}	r _{yy}	Z _{xx}	Z _{yy}	Z _{px}	Z _{py}
(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)	(cm ³)	(cm ³)
75780	2915.0	24.25	4.76	2484.59	255.70	2892.7	400.7

Gross Cross Section Area (A) = $1 \times 128.9 + 0.0 \times 2 + 0 \times 2$
 = 128.9 cm^2



Say "S" = 0 mm

Moment of Inertia of Combined Section (I_{yy}) = 0.00 cm⁴
 Radius of Gyration of Combined Section (r_{yy}) = 0.00 cm
 Radius of Gyration of Combined Section (r_{xx}) = 0.00 cm
 Moment of Inertia of Combined Section (I_{xx}) = 75780.00 cm⁴

Properties of	UB	610	229	101.20	with	0 wide & 0 thk web plate	0 wide & 0 thk Flange plate
Depth	Area (A)	Self Wt.	Flange Thk	Flange Width	Web Thk		
(mm)	(cm ²)	(kg/m)	(mm)	(mm)	(mm)		
610	128.9	101.3154	14.8	228	10.5		
I _{xx}	I _{yy}	r _{xx}	r _{yy}	Z _{xx}	Z _{yy}	Z _{px}	Z _{py}
(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)	(cm ³)	(cm ³)
75780	2915	24.25	4.76	2484.59	255.70	2893	400.7

	Project		I40172
	Part of Structure		Secant Pile
	Calculations By	Checked By	Approved By
	RSh	CSa	-
Office of Origin: Geoconsult India Pvt. Ltd.			

Design of Waler WB (Shaft & C&C)

(Normal Case)

Summary of Forces

Design Axial Compression Force (N) =	1.5	200.3 kN
=		300.5 kN
Design Bending Moment (M_{uz}) =	1.5	266.5 kN-m
=		266.5 kN-m
Design Shear Force (V_u) =	1.5	416.3 kN
		1998.4 kN
Effective Length of Beam (l_z) =	3.20 m	
Effective Length of Beam (l_y) =	3.20 m	

$$f_y = 350 \text{ N/mm}^2$$

$$\gamma_{m0} =$$

Properties of Section with web Plate

UB

610
0 mm

229
0 mm

Depth of Section (D) = 610 mm

Width of Flange (b) = 228 mm

Thk of flange (t_f) = 14.8 mm

Area of Cross Section (A) = 12890 mm²

r_{zz} = 242.47 mm

r_{yy} = 47.55 mm

Radius at root (R) = 12.7 mm

Depth of web (d) = 555 mm

Thk of web (t_w) = 10.5 mm

Moment of Inertia about major axis I_{zz} = 7.58E+08 mm⁴

Moment of Inertia about minor axis I_{yy} = 2.92E+07 mm⁴

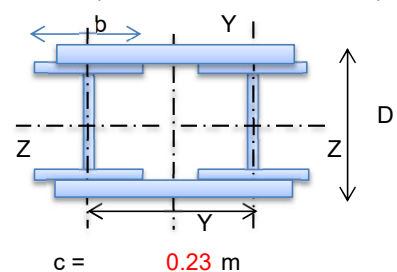
Elastic section modulus (Z_{ez}) = 2.48E+06 mm³

Elastic section modulus (Z_{ey}) = 2.56E+05 mm³

Plastic section modulus (Z_{pz}) = 2.89E+06 mm³

Plastic section modulus (Z_{py}) = 4.01E+05 mm³

1.1 (Refer Table 5 of IS 800:2007)



Section Classification

(Refer Table 2 page No. 18 of IS:800-2007)

$$\varepsilon = \sqrt{(250/f_y)} = 0.85$$

$$b / t_f = 7.70 < 7.94$$

$$d / t_w = 52.86 < 70.99$$

Hence the section is classified as a Plastic section

Member Buckling Resistance in Compression

(As per clause: 7.1.2 of IS:800-2007)

Effective Length (L_{eff})= L_z = 3.20 m

Effective Length (L_{eff})= L_y = 3.20 m

KL_z/r_z = 13.20

KL_y/r_y = 67.29

Effective Slenderness Ratio ($(KL_z/r_z)_e$) = 1.00 x 13.20 (As per clause: 7.6.1.5 of IS:800-2007)

= 13.20 (1.05 in case of lacing)

KL_y/r_y = 1.00 67.29

67.29

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

(Refer Table 10 page No. 44 of IS:800-2007)

D/b =	2.6754			
t_f =	14.8000	mm	<	40 mm
For Buckling about Axis	z-z		and Buckling Class	a
For Buckling about Axis	y-y		and Buckling Class	b

From Table 9(b) page No. 41 of IS:800-2007

	KL_y / r_y	Design Compressive Stress (f_{cd})		
	60	230.5		
	70	204		
Design Compressive Stress (f_{cd})	67.29	is	211.18 MPa	
Design Capacity of the Member along Y-Y axis ($P_{d,y}$) =	2722.1 kN	>	300.5 kN	

From Table 9(a) page No. 40 of IS:800-2007

	KL_z / r_z	Design Compressive Stress (f_{cd})		
	10	318		
	20	313.5		
Design Compressive Stress (f_{cd})	13.20	is	316.56 MPa	
Design Capacity of the Member along Z-Z axis ($P_{d,z}$) =	4080.5 kN	>	300.5 kN	
	0.11	Section is safe		

Design Shear Strength

Design Shear Strength (V_d) =	($h \times t_w \times f_y$) / ($\gamma_{m0} \times \sqrt{3}$)	=	2353.2 kN	
(As per Cl. 8.2.1.3 of IS800: 2007)	$0.6 \times V_d$	=	1411.9	< 1998.44 kN
			1.42	
	The design shear force $V_u < 0.6V_d$			

Member Buckling Resistance in Bending

Design Bending Strength (M_d) = $\beta_b \times Z_p \times f_{bd}$ (As per clause: 8.2.2 of IS:800-2007)

$\beta_b = 1.00$ for a Plastic and Compact section

So $M_d = Z_p \times f_{bd}$ (putting the value of β_b)

From Table 14 page No. 57 of IS:800-2007

	for $h_f / t_f =$	39.2		
	for $h_f / t_f =$	35		
	KL_z / r_z	Critical Stress ($f_{cr,b}$)		
	10	21763.1		
	20	5473.8		
Critical Stress ($f_{cr,b}$)	for 13.20	is	16554.23 MPa	
	for $h_f / t_f =$	40		
	KL_z / r_z	Critical Stress ($f_{cr,b}$)		
	10	21752.7		
	20	5463.5		
Critical Stress ($f_{cr,b}$)	for 13.20	is	16543.86 MPa	
	for $KL_z / r_z =$	13.20		
	h_f / t_f	Critical Stress ($f_{cr,b}$)		
	35	16554.23		
	40	16543.86		
Critical Stress ($f_{cr,b}$)	for 39.2	is	16545.48 MPa	

Handwritten signatures and initials:
 1. *Shubham*
 2. *Adar*
 3. *Rob*
 4. *CSL*
 5. *Shubham*

From Table 13(a) page No. 55 of IS:800-2007

for $f_y =$

350 MPa

and

$\alpha_{LT} =$

0.21

Critical Stress ($f_{cr,b}$)

f_{bd}

(for rolled section)

10000

318.2

8000

318.2

Design Bending Compressive Stress corresponding to Lateral Buckling (f_{bd}) for 16545.48

is 318.20 MPa

Design Bending Strength (M_d) = $Z_p \times f_{bd}$

= 920.5 kN-m

>

266.5 kN-m

0.29 Section is safe

Member Buckling Resistance in Combined Bending & Axial Compression

$P/P_{dy} + (K_{LT} M_z) / M_{dz} \leq 1.0$ (As per clause: 9.3.2.2 of IS:800-2007)

and $P/P_{dz} + (K_z C_{mz} M_z) / M_{dz} \leq 1.0$ (As per clause: 9.3.2.2 of IS:800-2007)

$$K_z = \left[1 + (\lambda_z - 0.2)n_z \right] \leq \left[1 + 0.8n_z \right]$$

$$K_{LT} = \left\{ 1 - (0.1\lambda_{LT} n_y) / (C_{mLT} - 0.25) \right\} \geq \left\{ 1 - (0.1n_y) / (C_{mLT} - 0.25) \right\}$$

$$n_z = (P / P_{dz}) = 0.074$$

$$n_y = (P / P_{dy}) = 0.110$$

$$f_{cr,z} = (\pi^2 E) / (KL / r_z)^2 = 11332.65 \text{ MPa}$$

$$\lambda_z = \sqrt{(f_y / f_{cr,z})} = 0.176$$

(As per clause: 7.1.2.1 of IS:800-2007)

$$\lambda_{LT} = \sqrt{(f_y / f_{cr,b})} = 0.145$$

(As per clause: 8.2.2 of IS:800-2007)

$$K_z = 0.998 \leq 1.06$$

Ratio of Min to max BM (ψ_z) = 1.00 (As per Table 18, pg 72 of IS:800-2007)

$$\alpha_s = M_s / M_h = 0.90$$

Equivalent Uniform Moment Factor (C_{mz}) = $0.2 + 0.8\alpha_s$

$$= 0.92 \geq 0.4$$

Equivalent Uniform Moment Factor for Lateral torsion (C_{mLT}) = 0.92

$$K_{LT} = 0.998 \geq 0.98$$

Check with Interaction Relationship

$$P/P_{dy} + (K_{LT} M_z) / M_{dz} = 0.362 \leq 1.0$$

$$P/P_{dz} + (K_z C_{mz} M_z) / M_{dz} = 0.339 \leq 1.0$$

Section is Safe

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

ANNEXURE – 9
TEMPORARY SECANT PILE &
STEEL WALER FOR RAMP
PORTION

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

Amelia

Adri

Rob

Emma

James

	GEOCONSULT India Pvt Ltd	APPENDIX	
	A company of the GEOCONSULT group	Job no:	I40172
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction		
Calculation for	DESIGN OF 15 m LONG HARD PILE SECTION		

DESIGN OF 15 m LONG HARD PILE SECTION

FACTORED BENDING MOMENT, SHEAR FORCE AND AXIAL FORCE PER RUNNING OF THE EXCAVATION IS GIVEN BELOW:

Output From PLEXIS: (For Ramp Portion)

C/C Distance B/W Two Hard Piles	=	1.3 m
Unfactored B.M. (M) (Normal case governing)	=	543.3 kN-m/m
Max. Factored B.M (With C/C Distance) M x 1.5	=	1059.4 kN.m
Unfactored Shear Force (V)	=	250 kN/m
Max. Factored S.F (With C/C Distance) V x 1.5	=	487.5 kN
Unfactored Axial Force (N)	=	297 kN/m
Max. Factored Axial Force N x 1.5	=	579.2 kN
Grade of Concrete	=	35 N/mm ²

1 PILE SECTION DESIGN

- 1.1 The pile section is designed as column under shear force & bending moments for the design values as per above Table using limit state design concept.

Area of Pile Section	Ap	=	0.503 m ²		
Thickness/Dia of Pile Beam wall	D	=	800 mm	Effective Dia	= 605 mm
Diameter of Reinforced Bar	d	=	25 mm (Assumed)	Perimeter	= 1900.7 mm
Clear Cover	cc	=	75 mm (Assumed)		
Effective cover	d'	=	97.5 mm		

$$\frac{d'}{D} = 0.122$$

$$\frac{p_u}{f_{ck} D^2} = 0.03, \quad \frac{M_u}{f_{ck} D^3} = 0.059$$

From Sp 16, Chart 60 $P_t/f_{ck} = 0.055$, $P_{tc} = 1.925$

Minimum Steel Required as per IS 2911-2010, $P_{tm} = 0.4\%$

Design reinforcement, $P_t = 1.9\%$

Reinforcement to be provided $= 9676.1 \text{ mm}^2$

Using 25 mm tor steel $= 490.87 \text{ mm}^2$ $(25 + 0.0)^*$
 $(0 + 0.0)^*$

Number of Bars Required $= 19.7$

Provide 22 Nos tor steel of 25 mm dia @ spacing of 86 mm C/C

Steel area provided $= 10799 \text{ mm}^2$ ($P_t = 2.15\%$) > 9676

OK

1.2 Check for Shear:

Check of shear Reinforcement for equivalent shear (v_e)

Factored Shear Force $V_u = 487.5 \text{ kN}$

Effective Shear Area of secant pile $= 1130973 \text{ mm}^2$

Shear Stress in secant Pile $= 0.43 \text{ N/mm}^2$

Allowable Shear Stress $= 0.81 \text{ N/mm}^2$

Shear force against which stirrups required $= -190 \text{ KN}$

Considering 10 mm Dia stirrups 10 mm

Spacing of stirrups $= -298 \text{ mm}$

Provide shear reinforcement at $= 180 \text{ mm}$

1.3 Transverse Reinforcement:

Spacing of transverse steel shall be least of

a) Least dimension of compression member (80% of pile Dia) $= 640.0 \text{ mm}$

b) Sixteen times the smallest dia of longitudinal bar ($16d$) $= 400.0 \text{ mm}$

c) Minimum of 300 mm $= 300.0 \text{ mm}$

d) Forty eight times the smallest dia of transverse bar ($48dt$) $= 480.0 \text{ mm}$

Using 10 mm tor diameter steel ties at 180.0 mm

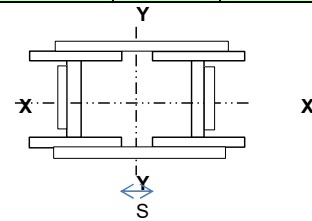
OK

Properties of Waler WB (Ramp Portion)

Proposed Section of Strut	UB	610	229	101.20
Width Extra Flange Plate	=	0	mm	
Thickness of Extra Flange Plate	=	0	mm	
Area of Additional Plate	=	0	cm ²	
Width Extra web Plate	=	0	mm	
Thickness of Extra web Plate	=	0	mm	
Area of Additional Plate	=	0	cm ²	
Properties of	UB	610	229	101.2

Depth	Area (A ₁)	Self Wt.	Flange Thk	Flange Width	Web Thk		
(mm)	(cm ²)	(kg/m)	(mm)	(mm)	(mm)		
610	128.9	101.2	14.8	228	10.5		
I _{xx}	I _{yy}	r _{xx}	r _{yy}	Z _{xx}	Z _{yy}	Z _{px}	Z _{py}
(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)	(cm ³)	(cm ³)
75780	2915.0	24.25	4.76	2484.59	255.70	2892.7	400.7

Gross Cross Section Area (A) = $1 \times 128.9 + 0.0 \times 2 + 0 \times 2$
 = 128.9 cm^2



Say "S" = 0 mm

Moment of Inertia of Combined Section (I_{yy}) = 0.00 cm⁴
 Radius of Gyration of Combined Section (r_{yy}) = 0.00 cm
 Radius of Gyration of Combined Section (r_{xx}) = 0.00 cm
 Moment of Inertia of Combined Section (I_{xx}) = 75780.00 cm⁴

Properties of	UB	610	229	101.20	with	0 wide & 0 thk web plate	0 wide & 0 thk Flange plate
Depth	Area (A)	Self Wt.	Flange Thk	Flange Width	Web Thk		
(mm)	(cm ²)	(kg/m)	(mm)	(mm)	(mm)		
610	128.9	101.3154	14.8	228	10.5		
I _{xx}	I _{yy}	r _{xx}	r _{yy}	Z _{xx}	Z _{yy}	Z _{px}	Z _{py}
(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)	(cm ³)	(cm ³)
75780	2915	24.25	4.76	2484.59	255.70	2893	400.7

Handwritten signatures and initials:
 [Signature]
 [Signature]
 [Signature]
 [Signature]
 [Signature]

	Project		I40172
	Part of Structure		Secant Pile
	Calculations By	Checked By	Approved By
	RSh	CSa	-
Office of Origin: Geoconsult India Pvt. Ltd.			

Design of Waler WB (Ramp Portion)

(Normal Case)

Summary of Forces

Design Axial Compression Force (N) =	1.5	183.8 kN
=		275.8 kN
Design Bending Moment (M_{uz}) =	1.5	142.8 kN-m
=		142.8 kN-m
Design Shear Force (V_u) =	1.5	270.0 kN
		1053.0 kN
Effective Length of Beam (l_z) =	2.60 m	
Effective Length of Beam (l_y) =	2.60 m	

$$f_y = 350 \text{ N/mm}^2$$

$$\gamma_{m0} = 1.1 \text{ (Refer Table 5 of IS 800:2007)}$$

Properties of Section with web Plate

UB

610
0 mm

229
0 mm

Depth of Section (D) = 610 mm

Width of Flange (b) = 228 mm

Thk of flange (t_f) = 14.8 mm

Area of Cross Section (A) = 12890 mm²

r_{zz} = 242.47 mm

r_{yy} = 47.55 mm

Radius at root (R) = 12.7 mm

Depth of web (d) = 555 mm

Thk of web (t_w) = 10.5 mm

Moment of Inertia about major axis I_{zz} = 7.58E+08 mm⁴

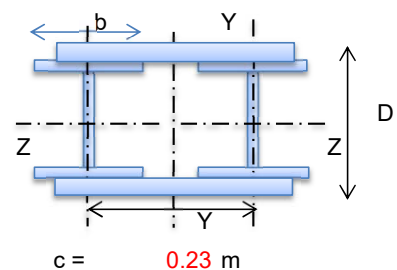
Moment of Inertia about minor axis I_{yy} = 2.92E+07 mm⁴

Elastic section modulus (Z_{ez}) = 2.48E+06 mm³

Elastic section modulus (Z_{ey}) = 2.56E+05 mm³

Plastic section modulus (Z_{pz}) = 2.89E+06 mm³

Plastic section modulus (Z_{py}) = 4.01E+05 mm³



Section Classification

(Refer Table 2 page No. 18 of IS:800-2007)

$\varepsilon = \sqrt{(250/f_y)} =$	0.85		
$b / t_f =$	7.70	<	7.94
$d / t_w =$	52.86	<	70.99

Hence the section is classified as a Plastic section

Member Buckling Resistance in Compression

(As per clause: 7.1.2 of IS:800-2007)

Effective Length (L_{eff})= L_z =	2.60 m		
Effective Length (L_{eff})= L_y =	2.60 m		
KL_z/r_z =	10.72		
KL_y/r_y =	54.67		
Effective Slenderness Ratio ($(KL_z/r_z)_e$) =	1.00	x 10.72	(As per clause: 7.6.1.5 of IS:800-2007)
=	10.72		(1.05 in case of lacing)
KL_y/r_y	1.00	54.67	
	54.67		

[Signature]

[Signature]

[Signature]

[Signature]

[Signature]

(Refer Table 10 page No. 44 of IS:800-2007)

D/b =	2.6754			
t_f =	14.8000	mm	<	40 mm
For Buckling about Axis	z-z		and Buckling Class	a
For Buckling about Axis	y-y		and Buckling Class	b

From Table 9(b) page No. 41 of IS:800-2007

	KL_y / r_y	Design Compressive Stress (f_{cd})		
	60	230.5		
	70	204		
Design Compressive Stress (f_{cd})	54.67	is	244.61 MPa	
Design Capacity of the Member along Y-Y axis ($P_{d,y}$) =	3153.1 kN	>	275.8 kN	

From Table 9(a) page No. 40 of IS:800-2007

	KL_z / r_z	Design Compressive Stress (f_{cd})		
	10	318		
	20	313.5		
Design Compressive Stress (f_{cd})	10.72	is	317.67 MPa	
Design Capacity of the Member along Z-Z axis ($P_{d,z}$) =	4094.8 kN	>	275.8 kN	
	0.09	Section is safe		

Design Shear Strength

Design Shear Strength (V_d) =	($h \times t_w \times f_y$) / ($\gamma_{m0} \times \sqrt{3}$)	=	2353.2 kN	
(As per Cl. 8.2.1.3 of IS800: 2007)	$0.6 \times V_d$	=	1411.9	> 1053.00 kN
	0.75			
The design shear force $V_u < 0.6V_d$				

Member Buckling Resistance in Bending

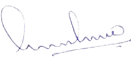
Design Bending Strength (M_d) = $\beta_b \times Z_p \times f_{bd}$ (As per clause: 8.2.2 of IS:800-2007)

$\beta_b = 1.00$ for a Plastic and Compact section

So $M_d = Z_p \times f_{bd}$ (putting the value of β_b)

From Table 14 page No. 57 of IS:800-2007

	for $h_f / t_f =$	39.2		
	for $h_f / t_f =$	35		
	KL_z / r_z	Critical Stress ($f_{cr,b}$)		
	10	21763.1		
	20	5473.8		
Critical Stress ($f_{cr,b}$)	for 10.72	is	20585.13 MPa	
	for $h_f / t_f =$	40		
	KL_z / r_z	Critical Stress ($f_{cr,b}$)		
	10	21752.7		
	20	5463.5		
Critical Stress ($f_{cr,b}$)	for 10.72	is	20574.74 MPa	
	for $KL_z / r_z =$	10.72		
	h_f / t_f	Critical Stress ($f_{cr,b}$)		
	35	20585.13		
	40	20574.74		
Critical Stress ($f_{cr,b}$)	for 39.2	is	20576.37 MPa	







From Table 13(a) page No. 55 of IS:800-2007

for $f_y =$

350 MPa

and

$\alpha_{LT} =$

0.21

Critical Stress ($f_{cr,b}$)

f_{bd}

(for rolled section)

10000

318.2

8000

318.2

Design Bending Compressive Stress corresponding to Lateral Buckling (f_{bd}) for 20576.37

is 318.20 MPa

Design Bending Strength (M_d) = $Z_p \times f_{bd}$

= 920.5 kN-m

>

142.8 kN-m

0.16 Section is safe

Member Buckling Resistance in Combined Bending & Axial Compression

$P/P_{dy} + (K_{LT} M_z) / M_{dz} \leq 1.0$ (As per clause: 9.3.2.2 of IS:800-2007)

and $P/P_{dz} + (K_z C_{mz} M_z) / M_{dz} \leq 1.0$ (As per clause: 9.3.2.2 of IS:800-2007)

$$K_z = \left[1 + (\lambda_z - 0.2)n_z \right] \leq \left[1 + 0.8n_z \right]$$

$$K_{LT} = \left\{ 1 - (0.1\lambda_{LT} n_y) / (C_{mLT} - 0.25) \right\} \geq \left\{ 1 - (0.1n_y) / (C_{mLT} - 0.25) \right\}$$

$$n_z = (P / P_{dz}) = 0.067$$

$$n_y = (P / P_{dy}) = 0.087$$

$$f_{cr,z} = (\pi^2 E) / (KL / r_z)^2 = 17166.62 \text{ MPa}$$

$$\lambda_z = \sqrt{(f_y / f_{cr,z})} = 0.143$$

(As per clause: 7.1.2.1 of IS:800-2007)

$$\lambda_{LT} = \sqrt{(f_y / f_{cr,b})} = 0.130$$

(As per clause: 8.2.2 of IS:800-2007)

$$K_z = 0.996 \leq 1.05$$

Ratio of Min to max BM (ψ_z) = 1.00 (As per Table 18, pg 72 of IS:800-2007)

$$\alpha_s = M_s / M_h = 0.90$$

Equivalent Uniform Moment Factor (C_{mz}) = $0.2 + 0.8\alpha_s$

$$= 0.92 \geq 0.4$$

Equivalent Uniform Moment Factor for Lateral torsion (C_{mLT}) = 0.92

$$K_{LT} = 0.998 \geq 0.99$$

Check with Interaction Relationship

$$P/P_{dy} + (K_{LT} M_z) / M_{dz} = 0.222 \leq 1.0$$

$$P/P_{dz} + (K_z C_{mz} M_z) / M_{dz} = 0.210 \leq 1.0$$

Section is Safe

[Handwritten signatures and initials]



RODIC CONSULTANTS PRIVATE LIMITED

**1st floor, Sarojini House 6,
Bhagwan Das Road, Mandi House,
New Delhi - 110001(INDIA)
e-mail: contact@rodiconsultants.com**