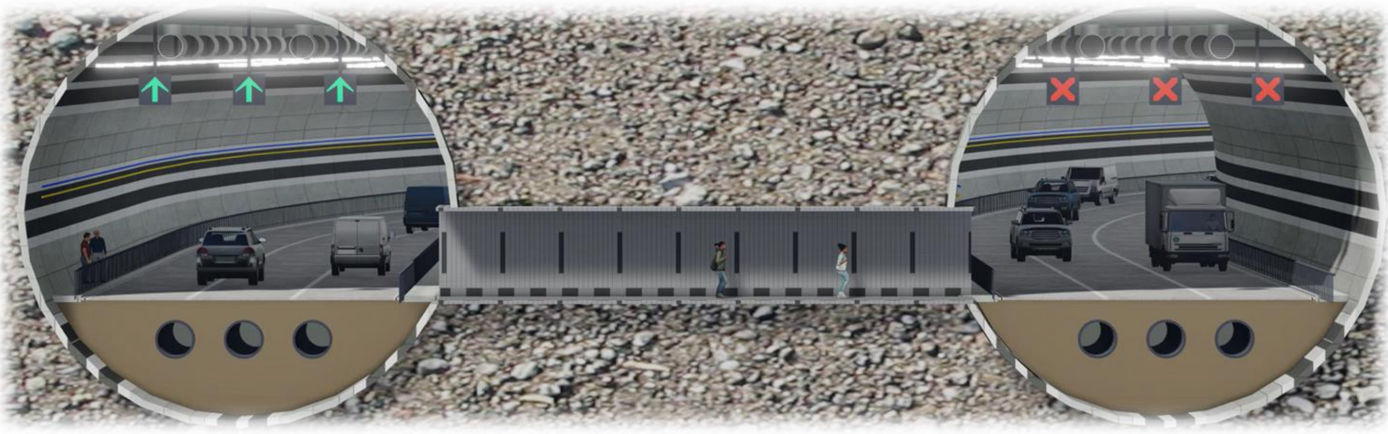
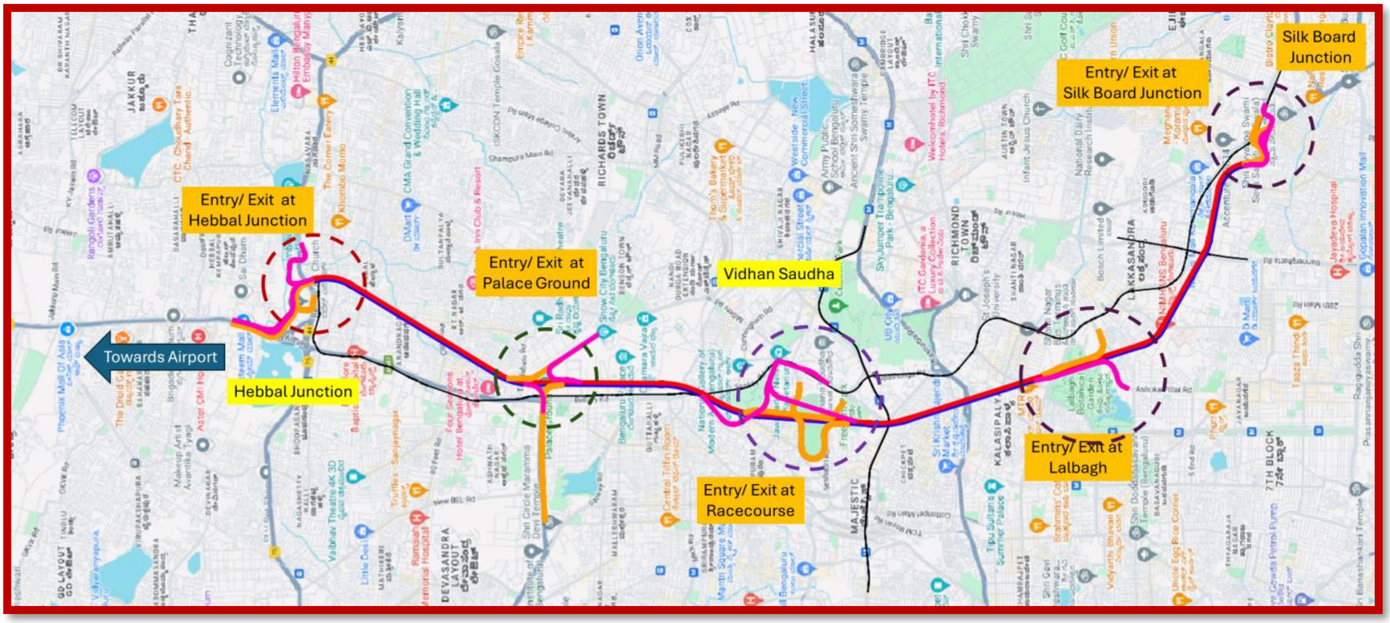
GOVERNMENT OF KARNATAKA



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



DRAFT DETAILED PROJECT REPORT

VOLUME - II B

STRUCTURAL DESIGN REPORT

September 2024

RODIC CONSULTANTS PVT. LTD

BRUHAT BENGALURU MAHANAGARA PALIKE

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INTRODUCTION

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 Hebbel 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.

CHAPTER 2
REFERENCES

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)

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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

CHAPTER 3
BORED TUNNEL

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**.

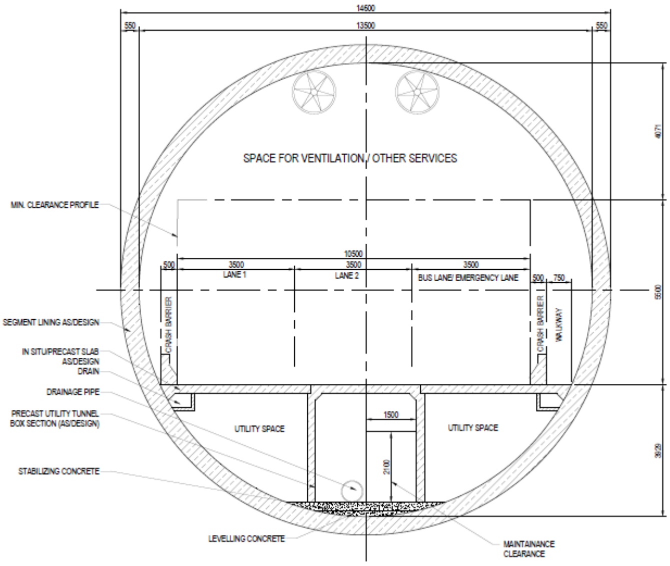

Figure 1: Typical Bored Tunnel Cross-Section

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.

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

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

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

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

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

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

$$p_h = k p_v$$

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

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

El : elastic modulus of the lining

Il : moment of inertia of the lining

Al : cross sectional area of the lining

νl : 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/m³

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/m3

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.

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 Design Summary

Table 1: Design Summary

Types	Main Reinforcement (mm2/segment)	Radial Joint Reinforcement (mm2/segment)	Circumferential Joint Reinforcement (mm2/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

CHAPTER 4
NATM

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.**

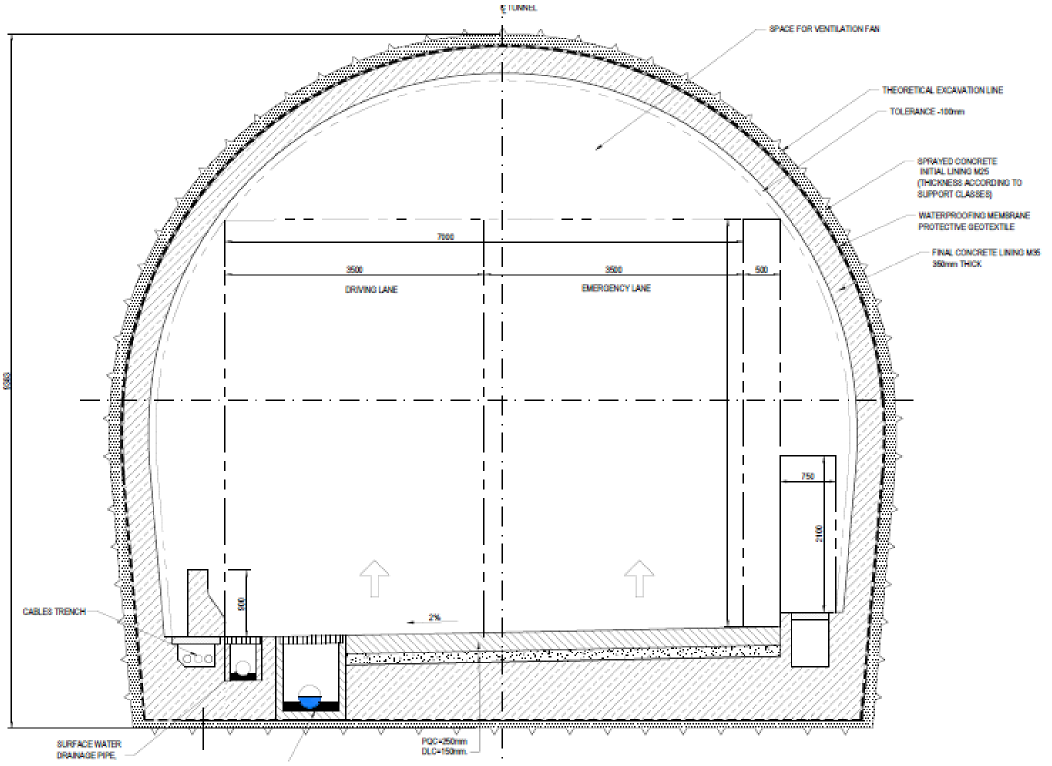

Figure 2: NATM Regular Cross-Section

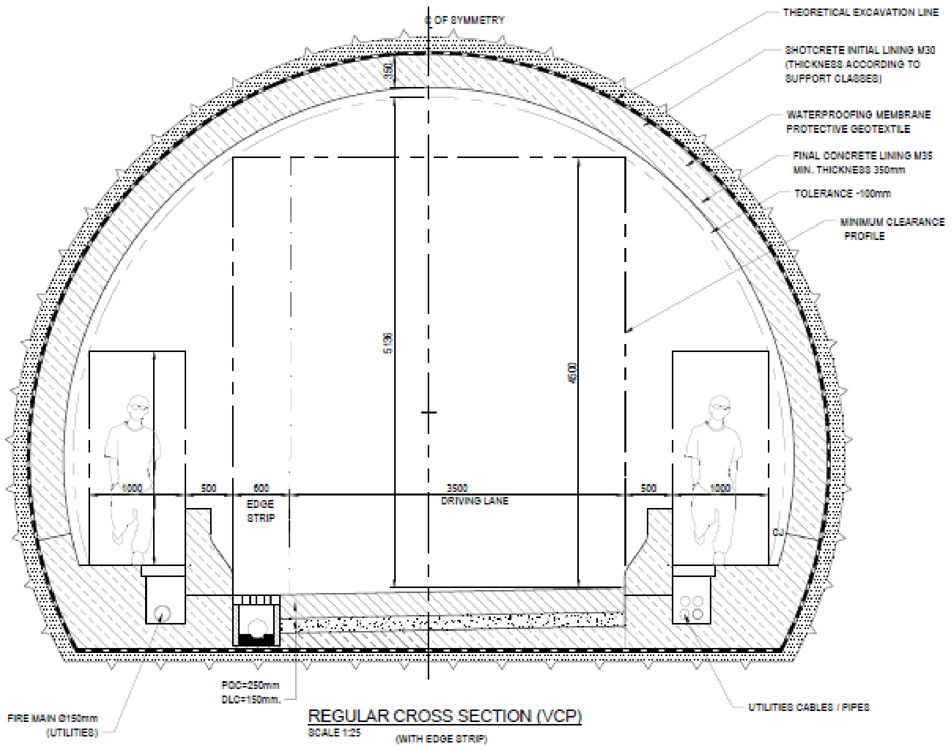

Figure 3: NATM Regular Cross-Section (VCP)

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 Ks, which is calculated from.

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

where:

E… Young's Modulus of soil/rock

□… Poisson's Ratio of soil/rock mass

R…. Radius of Tunnel (with R ≤ 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 Kt is calculated from:

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

The bending stiffness of the structural element is equal to Ec*Ig. The moment of inertia Ig 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/m³

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, fyk	500 MPa
Density γ	78.5 kN/m3

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

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 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
Side walls	T25-150mm c/c	T25-150mm c/c	@ 150mm x 300mm c/c

CHAPTER 5
CUT & COVER

CHAPTER 5: CUT & COVER

5.1 Geometry

The following Cross Sections of C&C Structures (C&C section of 2 lane and 3 lane) will be used as described in Figure 4 and Figure 5. 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) will casted over 0.2 m thick PCC and Side wall of 1.0 m thick (2-lane) & 1.2m thick (3-lane) and top slab with 1.0 m thick (2-lane) & 1.2m thick (3-lane).

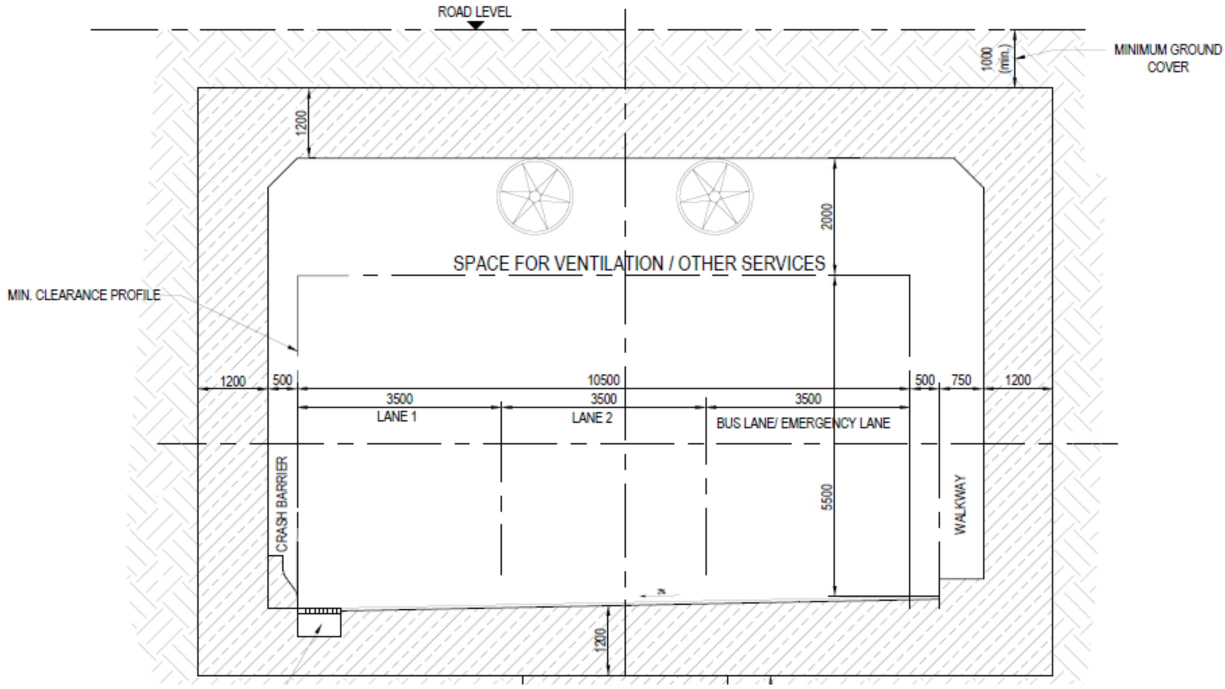

Figure 4: Typical Cross Section C&C Structure (3 LANE)

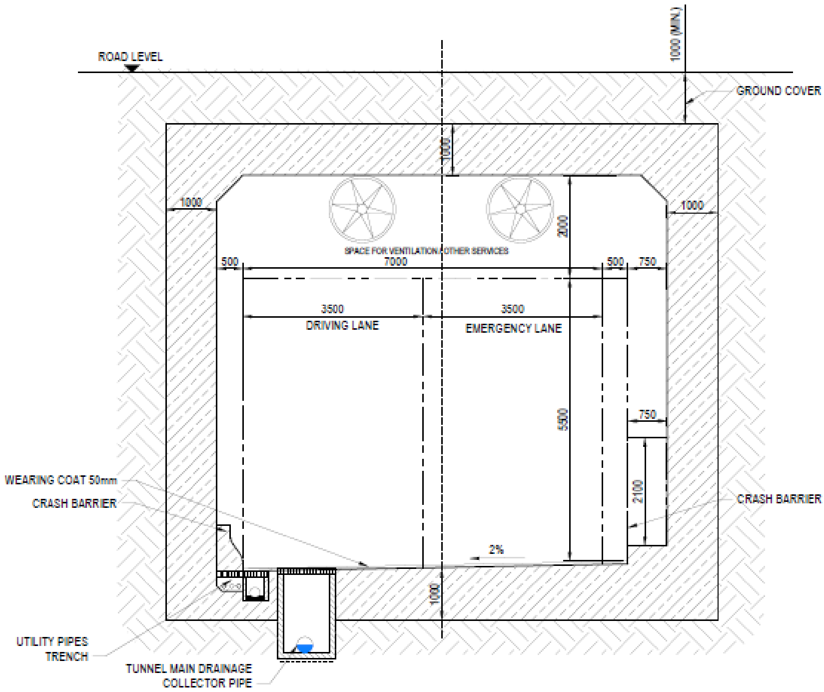

Figure 5: Typical Cross Section C&C Structure (2 LANE)

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 fck = 35 N/mm2 (Concrete Grade M35 according to IS 456:2000)
- Young's modulus: E = 29580 MPa
- Poisson's ratio: v = 0.2
- Unit weight: ϒ = 25 kN/m3

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 GPa

Yield strength fyk=500 MPa

5.2.3 Concrete Cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural	Nominal Cover
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:

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.

5.3.4 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×G1
II=1.50×G1+1.50×G2
III =1.50×G1+1.50×G2+1.5×G3
IV =1.50×G1+1.50×G2+1.5×G3+1.50×G5
V=1.50×G1+1.50×G4+1.50×G5

iii. Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

I =1.0×G1
II=1.0×G1+1.0×G2
III =1.0×G1+1.0×G2+1.0×G3
IV =1.0×G1+1.0×G2+1.0×G3+1.0×G5

V=1.0×G1+1.0×G4+1.0×G5

5.4 Design Summary

The reinforcement summary of two different sections has been given below in Table 2 and Table 3.The design calculations has given in **Annexure 3**.

Table 2: Summary of Steel Reinforcement C&C Structure (3 lane)

Component of RAMP 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	
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 3: Summary of Steel Reinforcement C&C Structure (2 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	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	

CHAPTER 6
RAMP STRUCTURE

CHAPTER 6: RAMP STRUCTURE

6.1 Geometry

The following Cross Sections of RAMP Structures (Ramp section of 2 lane and 3 lane) will be used as described in **Figure 6** & **Figure 7** . RAMP Structures will have side walls and Bottom Slab with Reinforced Concrete Structure in which Bottom Slab of 1 m thick will 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.

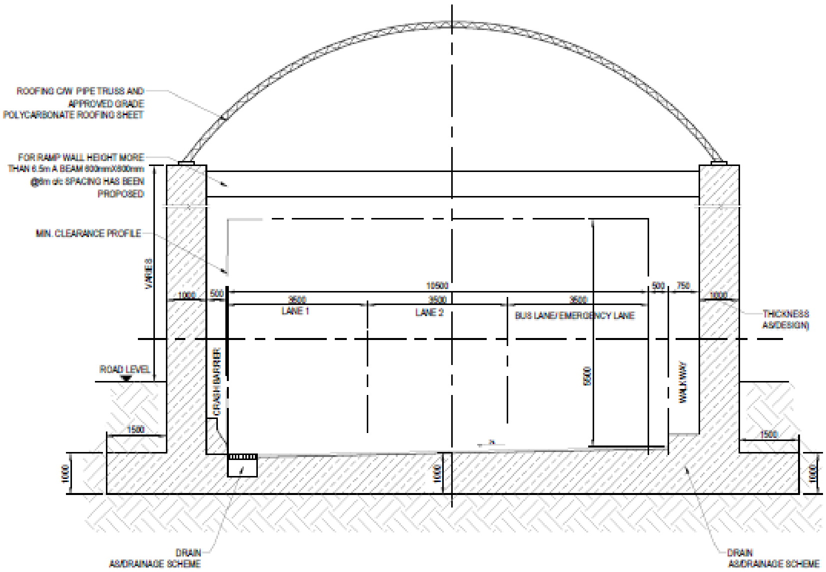

Figure 6: Typical Cross Section RAMP Structure (3 LANE)

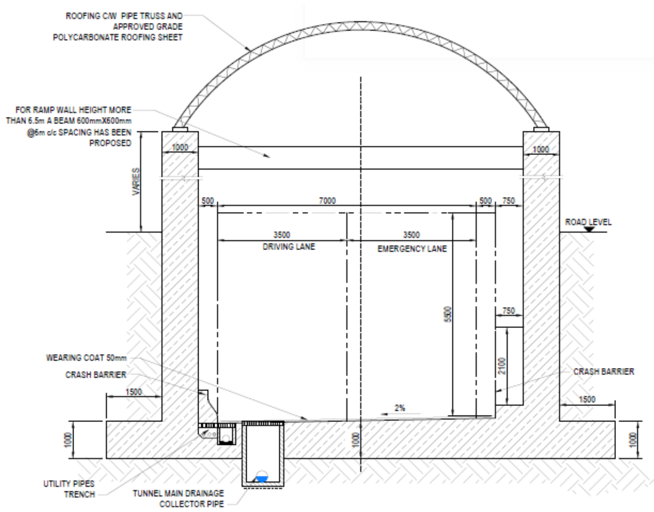

Figure 7: Typical Cross Section RAMP Structure (2 LANE)

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 fck = 35 N/mm2 (Concrete Grade M35 according to IS 456:2000)

- Young's modulus: E = 29580 MPa
- Poisson's ratio: v = 0.2
- Unit weight: ϒ = 25 kN/m3

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 GPa

Yield strength fyk=500 MPa

6.2.3 Concrete Cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural	Nominal Cover
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.

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×G1
II =1.50×G1+1.50×G2
III =1.50×G1+1.50×G2+1.5×G3
IV =1.50×G1+1.50×G2+1.5×G3+1.50×G5
V =1.50×G1+1.50×G4+1.50×G5

iii. Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

I =1.0×G1
II =1.0×G1+1.0×G2
III =1.0×G1+1.0×G2+1.0×G3
IV =1.0×G1+1.0×G2+1.0×G3+1.0×G5
V =1.0×G1+1.0×G4+1.0×G5

6.4 Design Summary

The reinforcement summary of two different sections has been given below in

Table 4 and **Table 5**. The design calculations have given in **Annexure 4**.

Table 4: 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 5: 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	

CHAPTER 7
TEMPORARY SECANT PILE

CHAPTER 7: TEMPORARY SECANT PILE

7.1 Geometry

The temporary secant pile with waler has been provided to start the construction activity and has been designed as per the forces given in "Geotechnical Report [1]" for shaft, cut & cover and ramp portion, as given in the **Figure 8** . The secant pile has been designed for 1.0m diameter (for shaft and C&C section) and 0.8m diameter (for ramp portion), for detailed design refer **Annexure 5** (Shaft and C&C) and **Annexure 6** (Ramp Portion).

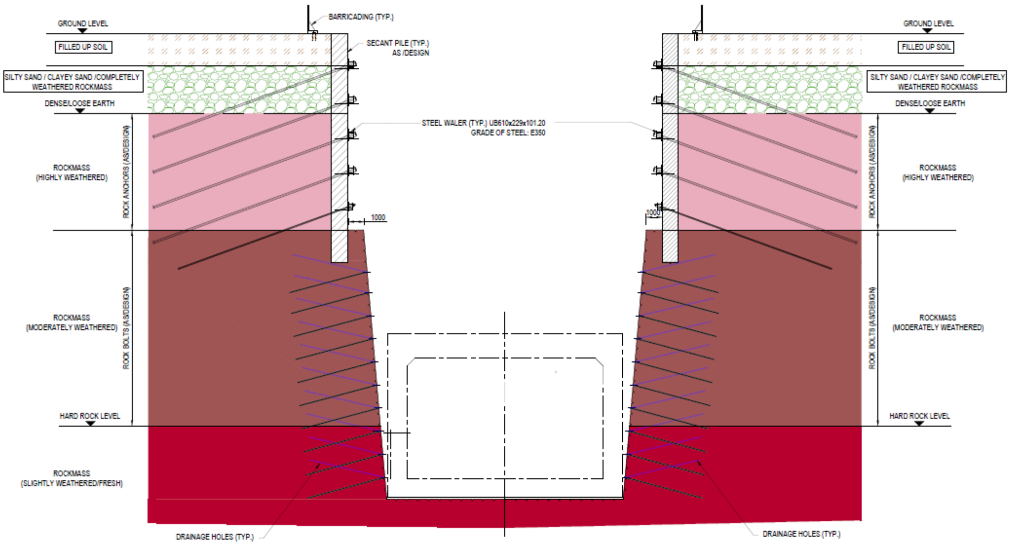

Figure 8: Typical Section of C&C & Ramp with Secant Pile

CHAPTER 8
LIST OF ANNEXURES

CHAPTER 8: LIST OF ANNEXURE

ANNEXURE - 1 - PRE-CAST TUNNEL SEGMENT

ANNEXURE - 2 - NATM SECTION

ANNEXURE - 3 - CUT & COVER BOX

ANNEXURE - 4 - RAMP PORTION

ANNEXURE - 5 - TEMPORARY SECANT PILE & STEEL, WALER FOR SHAFT & C&C

ANNEXURE - 6 - TEMPORARY SECANT PILE & STEEL, WALER FOR RAMP PORTION

ANNEXURES

ANNEXURE - 1
PRE-CAST TUNNEL SEGMENT

GEOCONSULT India Pvt Ltd	ANNEXURE -1	
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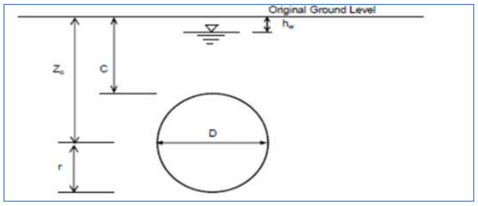
Project:	**DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction**
Calculation for	**Ground Force Calculation by- Muir Wood (1975) and Curtis (1976) & Segment Design**

TUNNEL LINNING DESIGN
[Based on Muir Wood (1975) and Curtis (1976)]
Soil Formation : SM[A]

From Ch	11196.935
To Ch	12704.714
Design Ch	11220
GL	898.33
RL	873.609
Centerline	876.43
Zo	21.90
Bottom Invert	869.68
Invert from GL	28.65
Cover	14.60



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
Ref 5 Outline Design Specification : MRTS Project at Kanpur, Uttar Pradesh, India KNPCC-06

Load Combination as per ODS

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	-

Notations

Symbol		Description
C	=	Cover to tunnel crown
Z_o	=	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 initia 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

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	

1) Load case 1: Groundwater table at the ground surface with a uniform surcharge of 50 kN/m².

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

3) Load case 3: No groundwater with a uniform surcharge of 50 kN/m² (with and without seismic action).

4) Load case 4: No groundwater with no surcharge (with seismic action).

5) Load case 5*: Groundwater table at extreme water level with no surcharge.

* Extreme water load is taken as 1m above the ground surface

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	
Track level	=	873.61	m	
Track 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 inetia 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)			
		N (kN)	U (mm)	M (kNm)	N (kN)	U (mm)	M (kNm)	V (kN)
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

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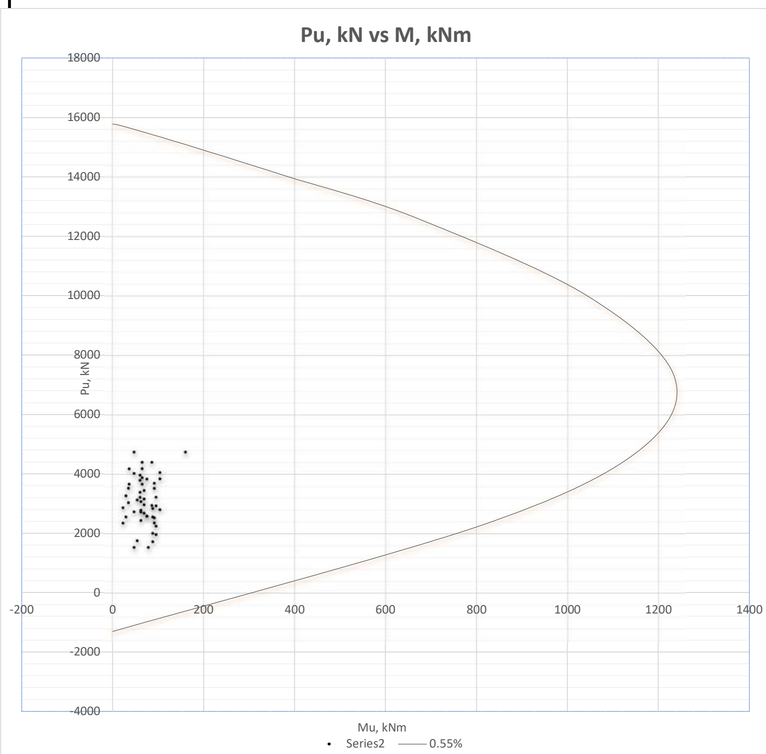
Project:	DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction		
Calculation for	Ground Force Calculation by- Muir Wood (1975) and Curtis (1976) & Segment Design		

Section Verification - Axial & Bending Moment

Interaction charts As per IS 456 :2000

DATA INPUT :

Concrete		*Steel*		*Section*		
Characteristic Strength fck,N/mm2	60	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	550	
Modulus of Elasticity Concrete Ec, N/mm2	38730	Modulus of Elasticity of Steel Es,N/mm2	200000	Clear cover, mm	45	
Strain at Yeild Point Concrete = ecy	0.0020			Reinforcement	Nos	Dia, mm
Ultimate Strain in concrete = ecu	0.0035			Top	7.50	16.00
C1	0.67			Middle		
				Bot	7.50	16.00



MAXIMA FOR DIFFERENT LOAD COMBINATIONS

LOAD CASE	CONDITION	Pu/kN	Mu, kNm
At Axis of Tunnel (per m run)	ULS CASE-LC 1-Static	4756.46	47.41
	ULS CASE-LC 2-Static	4193.63	36.71
	ULS CASE-LC 3-Static	4412.72	86.45
	ULS CASE-LC 3A-Dynamic ODE FS	3533.77	91.96
	ULS CASE-LC 3B-Dynamic ODE NS	3706.46	91.96
	ULS CASE-LC 3C-Dynamic MCE FS	2947.81	95.64
	ULS CASE-LC 3D-Dynamic MCE NS	3235.63	95.64
	ULS CASE-LC 4A-Dynamic ODE FS	3854.39	104.26
	ULS CASE-LC 4B-Dynamic ODE NS	4070.25	104.26
	ULS CASE-LC 4C-Dynamic MCE FS	2572.60	88.50
	ULS CASE-LC 4D-Dynamic MCE NS	2860.41	88.50
	ULS CASE-LC 5-Static	3540.65	34.93
	SLS CASE-LC 6-Static	3288.45	29.73
	SLS CASE-LC 7-Static	2880.35	23.12
	SLS CASE-LC 8-Static	3143.80	54.41
	SLS CASE-LC 9-Static	2749.42	47.58
At Crown of Tunnel (per m run)	ULS CASE-LC 1-Static	4037.07	47.41
	ULS CASE-LC 2-Static	3674.89	36.71
	ULS CASE-LC 3-Static	2961.00	86.45
	ULS CASE-LC 3A-Dynamic ODE FS	2372.40	91.96
	ULS CASE-LC 3B-Dynamic ODE NS	2545.09	91.96
	ULS CASE-LC 3C-Dynamic MCE FS	1980.00	95.64
	ULS CASE-LC 3D-Dynamic MCE NS	2267.81	95.64
	ULS CASE-LC 4A-Dynamic ODE FS	2603.32	75.76
	ULS CASE-LC 4B-Dynamic ODE NS	2819.18	104.26
	ULS CASE-LC 4C-Dynamic MCE FS	1738.54	88.50
	ULS CASE-LC 4D-Dynamic MCE NS	2026.36	88.50
	ULS CASE-LC 5-Static	3055.34	34.93
	SLS CASE-LC 6-Static	2573.91	29.73
	SLS CASE-LC 7-Static	2365.33	23.12
	SLS CASE-LC 8-Static	1772.01	54.41
	SLS CASE-LC 9-Static	1549.72	47.58
Considering Additional moment trasfer between segments at axis		4756.46	160.34
Considering Additional moment trasfer between segments at crown		1549.72	78.58

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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) & Segment Design**

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
Track Level:	RL	=	873.609	m
Tunnel invert to Track 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	r_o	=	7.300	m
Distance between tunnel axis to rail level		=	2.8210	m
Depth to Tunnel Axis	Zo	=	21.900	m

$$\sigma'_h = K\sigma'_v \qquad p_0 = \sigma'_v - \sigma'_h$$

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	σv'	=	388.94	kN/m^2
k value	K	=	0.479	
Factored horizontal stress, σh' = kσv'	σh'	=	186.3	kN/m^2
Po = σv' - σh'	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

$$p_a = \frac{q_1 + Kq_1}{2} \qquad \tau = c' + p_a \tan\phi'$$

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

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4 \qquad \tau = c' + p_a \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING

Young's modulus of ground	Ec	=	195865.385	kN/m^2
Poisson's ratio of ground	ν	=	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_1	=	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, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.002739	m^4

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

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

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}, \ if\ S_t < \tau \qquad S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2+(4-6\nu)\}\tau}{4Q_2+5-6\nu}, \ if\ S_t > \tau$$

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

where S_n and St are normal and shear stresses repectively

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

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

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

$$U = -\frac{r_0^4}{18EI}(2S_n+S_t)\cos 2\theta + U_w + U_u \qquad U_w = -\frac{p_w r_0^2}{EA} \qquad U_u = -\frac{N_0 r_0}{EA}$$

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-73.08
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-45.7
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	151
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-47
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-47
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	4037
Nd = -ro/3*(Sn + 2St)	Nd	=	-359.69
No=σ_{v*}(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	1998.72
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-2
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	0.01
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	12.988

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	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

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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) & Segment Design

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	=	898.33	m
Track Level:	RL	=	873.609	m
Tunnel Axis to Track Level	d	=	3.929	m

2. TUNNEL GEOMETRY

Excavated Diameter of Tunnel	D	=	14.6	m
Internal radius of tunnel	ri	=	6.75	m
Radius of lining centroid	r_o	=	7.025	m
Radius to extrados of lining	re	=	7.3	m
Distance between tunnel axis to rail level		=	2.821	m
Depth to Tunnel Axis	Zo	=	21.9	m

$$\sigma'_h = K\sigma'_v \qquad p_0 = \sigma'_v - \sigma'_h$$

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		21.9	m
Effective overburden pressure	q1	=	199.3	kN/m^2
Surcharge	q2	=	0	kN/m^2
Load factor for Overburden Load	FS1	=	1.5	
Load factor for Surcharge	FS2	=	1.5	
Factored vertical stress	σv'	=	298.94	kN/m^2
k value	K	=	0.4790	
Factored horizontal stress, σh' = kσv'	σh'	=	143.2	kN/m^2
Po = σv' - σh'	Po	=	155.7	kN/m^2
Load factor for Water	Fsw	=	1.5	
Hydrostatic water pressure	psw	=	328.50	kN/m^2

$$p_u = \frac{q_1 + Kq_1}{2} \qquad \tau = c' + p_u \tan\phi'$$

Unfactored load at tunnel crown	=	132.86	kN/m^2
Unfactored load at tunnel axis	=	199.29	kN/m^2

4. SHEAR STRENGTH OF SOIL

Uniform loading, Pu = (q1+ kq1) / 2	Pu	=	114.16	kN/m^2
Maximum shear strength of ground, τ = c' + Pu tanΦ	τ	=	69.68	kN/m^2

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4 \qquad \tau = c' + p_u \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING

Young's modulus of ground	Ec	=	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,(τ = c' + Pu tanΦ)	τ	=	69.683	kN/m^2
Young's modulus of lining	E_1	=	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	=	0.013864583	m^4
Total no. of segments	n=	=	9	
Reduced Lining, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.002738683	m^4

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

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

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}\ , \ if\ S_t < \tau \qquad S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5 - 6\nu}\ , \ if\ S_t > \tau$$

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

where S_n and St are normal and shear stresses repectively

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

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

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

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_u \qquad U_w = -\frac{p_w r_0^2}{EA} \qquad U_u = -\frac{N_0 r_0}{EA}$$

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-56.17
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-32.77
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	116
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-37
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-37
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	3675
Nd = -ro/3*(Sn + 2St)	Nd	=	-259.37
No=σ_{v*}(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	1536.21
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-1
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	6.01
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	10.058

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	Uw (mm)	Uu(mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	70	70	-32.8	2398	1536.21	0.00	0.00	-259	6.01	-36.7
										Vd (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 A company of the GEOCONSULT group	**ANNEXURE -1**	
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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) & Segment Design

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
Track Level:	RL	=	873.61	m
Tunnel Axis to Track Level	d	=	3.9290	m
2. TUNNEL GEOMETRY				
Excavated Diameter of Tunnel	D	=	14.600	m
Internal radius of tunnel	ri	=	6.750	m
Radius of lining centroid	r_o	=	7.025	m
Radius to extrados of lining	re	=	7.300	m
Distance between tunnel axis to rail level		=	2.821	m
Depth to Tunnel Axis	Zo	=	21.900	m

$$\sigma'_h = K\sigma'_v \qquad p_0 = \sigma'_v - \sigma'_h$$

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	=	21.9	m
Height of Water Table considered in design	h_w		2.4869E-14	m
Effective overburden pressure	q1	=	418.3	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	σv'	=	717.44	kN/m^2
k value	K	=	0.4790	
Factored horizontal stress, σh' = kσv'	σh'	=	343.6	kN/m^2
Po = σv' - σh'	Po	=	373.8	kN/m^2
Load factor for Water	Fsw	=	1.5	
Hydrostatic water pressure	psw	=	0.00	kN/m^2
Unfactored load at tunnel crown		=	411.86	kN/m^2
Unfactored load at tunnel axis		=	478.29	kN/m^2

$$p_u = \frac{q_1 + Kq_1}{2} \qquad \tau = c' + p_u \tan\phi'$$

4. SHEAR STRENGTH OF SOIL				
Uniform loading, Pu = (q1+ kq1) / 2	Pu	=	320.48	kN/m^2
[illegible]	τ	=	195.62	kN/m^2

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4 \qquad \tau = c' + p_u \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING				
Young's modulus of ground	Ec	=	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,(τ = c' + Pu tanΦ)	τ	=	195.621	kN/m^2
Young's modulus of lining	E_1	=	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, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.0027	m^4

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

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

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

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

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

where S_n and St are normal and shear stresses repectively

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

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

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

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

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

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

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

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

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

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-134.81
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-92.94
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	279
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-86
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-86
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	2961
Nd = -ro/3*(Sn + 2St)	Nd	=	-725.86
No=σ_{v*}(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	3686.86
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-3
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	0.01
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	23.686

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	Uw (mm)	Uu(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**

GC GROUP	**GEOCONSULT India Pvt Ltd**	**ANNEXURE -1**	
	A company of the GEOCONSULT group	**Job no:**	**I40172**
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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) & Segment Design**		

LOAD COMBINATION 4

* 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
Track Level:	RL	=	873.609	m
Tunnel Axis to Track 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	r_o	=	7.025	m
Radius to extrados of lining	re	=	7.3	m
Distance between tunnel axis to rail level		=	2.821	m
Depth to Tunnel Axis	Zo	=	21.900	m

$$\sigma'_h = K\sigma'_v \qquad p_0 = \sigma'_v - \sigma'_h$$

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	=	21.9	m
Height of Water Table considered in design	h_w		2.4869E-14	m
Effective overburden pressure	q1	=	418.3	kN/m^2
Surcharge	q2	=	0	kN/m^2
Load factor for Overburden Load	FS1	=	1.5	
Load factor for Surcharge	FS2	=	1.5	
Factored vertical stress	σv'	=	627.44	kN/m^2
k value	K	=	0.4790	
Factored horizontal stress, σh' = kσv'	σh'	=	300.5	kN/m^2
Po = σv' - σh'	Po	=	326.9	kN/m^2
Load factor for Water	Fsw	=	1.5	
Hydrostatic water pressure	psw	=	0.00	kN/m^2

$$p_u = \frac{q_1 + Kq_1}{2} \qquad \tau = c' + p_u \tan\phi'$$

Unfactored load at tunnel crown	=	351.86	kN/m^2
Unfactored load at tunnel axis	=	418.29	kN/m^2

4. SHEAR STRENGTH OF SOIL				
Uniform loading, Pu = (q1+ kq1) / 2	Pu	=	276.11	kN/m^2
[illegible]	τ	=	168.54	kN/m^2

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4 \qquad \tau = c' + p_u \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING				
Young's modulus of ground	Ec	=	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,(τ = c' + Pu tanΦ)	τ	=	168.537	kN/m^2
Young's modulus of lining	E_1	=	38730	N/mm^2
Poisson's ratio of lining	ν_1	=	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	=	0.013864583	m^4
Total no. of segments	n=	=	9	
Reduced Lining, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.002738683	m^4

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

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

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]},\ if\ S_t < \tau \qquad S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5 - 6\nu},\ if\ S_t > \tau$$

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

where S_n and St are normal and shear stresses repectively

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

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

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

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_u \qquad U_w = -\frac{p_w r_0^2}{EA} \qquad U_u = -\frac{N_0 r_0}{EA}$$

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-117.90
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-80.00
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	244
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-76
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-76
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	2599
Nd = -ro/3*(Sn + 2St)	Nd	=	-625.54
No=σ_{v}'(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	3224.35
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-3
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	0.01
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	20.755

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	Uw (mm)	Uu(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**

	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) & Segment Design**		

LOAD COMBINATION 5

* 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
Track Level:	RL	=	873.609	m
Tunnel Axis to Track Level	d	=	3.93	m

2. TUNNEL GEOMETRY

Excavated Diameter of Tunnel	D	=	14.6	m
Internal radius of tunnel	ri	=	6.750	m
Radius of lining centroid	r_o	=	7.025	m
Radius to extrados of lining	re	=	7.3	m
Distance between tunnel axis to rail level		=	2.82	m
Depth to Tunnel Axis	Zo	=	21.900	m

$$\sigma'_h = K\sigma'_v \qquad p_0 = \sigma'_v - \sigma'_h$$

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	=	-1	m
Height of Water Table considered in design	h_w		22.9	m
Effective overburden pressure	q1	=	189.3	kN/m^2
Surcharge	q2	=	0	kN/m^2
Load factor for Overburden Load	FS1	=	1.5	
Load factor for Surcharge	FS2	=	1.5	
Factored vertical stress	σv'	=	283.94	kN/m^2
k value	K	=	0.479	
Factored horizontal stress, σh' = kσv'	σh'	=	136.0	kN/m^2
Po = σv' - σh'	Po	=	147.9	kN/m^2
Load factor for Water	Fsw	=	1.1	
Hydrostatic water pressure	psw	=	251.90	kN/m^2
Unfactored load at tunnel crown		=	122.86	kN/m^2
Unfactored load at tunnel axis		=	189.29	kN/m^2

$$p_u = \frac{q_1 + Kq_1}{2} \qquad \tau = c' + p_u \tan\phi'$$

4. SHEAR STRENGTH OF SOIL

Uniform loading, Pu = (q1+ kq1) / 2	Pu	=	106.76	kN/m^2
M	τ	=	65.17	kN/m^2

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4 \qquad \tau = c' + p_u \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING

Young's modulus of ground	Ec	=	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,(τ = c' + Pu tanΦ)	τ	=	65.169	kN/m^2
Young's modulus of lining	E_1	=	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	=	0.013864583	m^4
Total no. of segments	n=	=	9	
Reduced Lining, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.002738683	m^4

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

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

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}, \; if \; S_t < \tau \qquad S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2+5-6\nu}, \; if \; S_t > \tau$$

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

where S_n and St are normal and shear stresses repectively

$$M = -\frac{r_0^2}{6}(2S_n+S_t)\cos 2\theta \qquad M_d = -\frac{r_0^2}{6}(2S_n+S_t), \; hogging \; moment \; positive$$

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

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

$$U = -\frac{r_0^4}{18EI}(2S_n+S_t)\cos 2\theta + U_w + U_u \qquad U_w = -\frac{p_w r_0^2}{EA} \qquad U_u = -\frac{N_0 r_0}{EA}$$

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-53.35
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-30.62
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	110
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-35
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-35
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	3055
Nd = -ro/3*(Sn + 2St)	Nd	=	-242.65
No=σ_v-(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	1459.13
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-1
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	0.01
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	9.569

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	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**

GC GROUP	**GEOCONSULT India Pvt Ltd**	**ANNEXURE -1**	
	A company of the GEOCONSULT group	**Job no:**	**I40172**
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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) & Segment Design**		

LOAD COMBINATION 7

* 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
Track Level:	RL	=	873.609	m
Tunnel Axis to Track 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	r_o	=	7.025	m
Radius to extrados of lining	re	=	7.30	m
Distance between tunnel axis to rail level		=	2.8210	m
Depth to Tunnel Axis	Zo	=	21.900	m

$$\sigma'_h = K\sigma'_v \qquad p_0 = \sigma'_v - \sigma'_h$$

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		21.9	m
Effective overburden pressure	q1	=	199.3	kN/m^2
Surcharge	q2	=	60	kN/m^2
Load factor for Overburden Load	FS1	=	1	
Load factor for Surcharge	FS2	=	1	
Factored vertical stress	σv'	=	259.29	kN/m^2
k value	K	=	0.48	
Factored horizontal stress, σh' = kσv'	σh'	=	124.2	kN/m^2
Po = σv' - σh'	Po	=	135.1	kN/m^2
Load factor for Water	Fsw	=	1	
Hydrostatic water pressure	psw	=	219.00	kN/m^2

$$p_u = \frac{q_1 + Kq_1}{2} \qquad \tau = c' + p_u \tan\phi'$$

Unfactored load at tunnel crown		=	192.86	kN/m^2
Unfactored load at tunnel axis		=	259.29	kN/m^2

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

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4 \qquad \tau = c' + p_u \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING

Young's modulus of ground	Ec	=	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,(τ = c' + Pu tanΦ)	τ	=	96.766	kN/m^2
Young's modulus of lining	E_1	=	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, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.002739	m^4

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

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

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}, \; if \; S_t < \tau \qquad S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2+(4-6\nu)\}\tau}{4Q_2+5-6\nu}, \; if \; S_t > \tau$$

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

where S_n and St are normal and shear stresses repectively

$$M = -\frac{r_0^2}{6}(2S_n+S_t)\cos 2\theta \qquad M_d = -\frac{r_0^2}{6}(2S_n+S_t), \; hogging \; moment \; positive$$

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

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

$$U = -\frac{r_0^4}{18EI}(2S_n+S_t)\cos 2\theta + U_w + U_u \qquad U_w = -\frac{p_w r_0^2}{EA} \qquad U_u = -\frac{N_0 r_0}{EA}$$

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-48.72
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-46.71
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	101
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-30
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-30
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	2574
Nd = -ro/3*(Sn + 2St)	Nd	=	-357.27
No=$\sigma_{v'}$(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	1332.48
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-1
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	0.00
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	8.145

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	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**

	GEOCONSULT India Pvt Ltd	ANNEXURE -1	
GC GROUP	A company of the GEOCONSULT group	Job no:	I40172
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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) & Segment Design		

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
Track Level:	RL	=	873.609	m
Tunnel Axis to Track 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	r_o	=	7.025	m
Radius to extrados of lining	re	=	7.30	m
Distance between tunnel axis to rail 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	=	0.00	m
Height of Water Table considered in design	h_w		21.9	m
Effective overburden pressure	q1	=	199.3	kN/m^2
Surcharge	q2	=	0.00	kN/m^2
Load factor for Overburden Load	FS1	=	1.00	
Load factor for Surcharge	FS2	=	1.00	
Factored vertical stress	σv'	=	199.29	kN/m^2
k value	K	=	0.48	
Factored horizontal stress, σh' = kσv'	σh'	=	95.5	kN/m^2
Po = σv' - σh'	Po	=	103.8	kN/m^2
Load factor for Water	Fsw	=	1.00	
Hydrostatic water pressure	psw	=	219.00	kN/m^2
Unfactored load at tunnel crown		=	132.86	kN/m^2
Unfactored load at tunnel axis		=	199.29	kN/m^2

$$p_u = \frac{q_1 + Kq_1}{2}$$ $$\tau = c' + p_u \tan\phi'$$

4. SHEAR STRENGTH OF SOIL

Uniform loading, Pu = (q1+ kq1) / 2	Pu	=	114.16	kN/m^2
Maximum shear strength of ground, τ = c' + Pu tanΦ	τ	=	69.68	kN/m^2

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4$$ $$\tau = c' + p_u \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING

Young's modulus of ground	Ec	=	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,(τ = c' + Pu tanΦ)	τ	=	69.683	kN/m^2
Young's modulus of lining	E_1	=	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, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.002739	m^4

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

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

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}, \; if \; S_t < \tau \qquad S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2 + 5 - 6\nu}, \; if \; S_t > \tau$$

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

where S_n and St are normal and shear stresses repectively

$$M = -\frac{r_0^2}{6}(2S_n + S_t)\cos 2\theta \qquad M_d = -\frac{r_0^2}{6}(2S_n + S_t), \; hogging \; moment \; positive$$

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

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

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_u \qquad U_w = -\frac{p_w r_0^2}{EA} \qquad U_u = -\frac{N_0 r_0}{EA}$$

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-37.45
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-33.54
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	77
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-23
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-23
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	2365
Nd = -ro/3*(Sn + 2St)	Nd	=	-257.51
No=σ_v-(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	1024.14
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-1
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	0.00
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	6.335

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	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	
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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) & Segment Design

LOAD COMBINATION 9

* 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
Track Level:	RL	=	873.609	m
Tunnel Axis to Track 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	r_o	=	7.025	m
Radius to extrados of lining	re	=	7.30	m
Distance between tunnel axis to rail level		=	2.8210	m
Depth to Tunnel Axis	Zo	=	21.900	m

$$\sigma'_h = K\sigma'_v \qquad p_0 = \sigma'_v - \sigma'_h$$

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	=	21.90	m
Height of Water Table considered in design	h_w		2.4869E-14	m
Effective overburden pressure	q1	=	418.3	kN/m^2
Surcharge	q2	=	60.00	kN/m^2
Load factor for Overburden Load	FS1	=	1.00	
Load factor for Surcharge	FS2	=	1.00	
Factored vertical stress	σv'	=	478.29	kN/m^2
k value	K	=	0.48	
Factored horizontal stress, σh' = kσv'	σh'	=	229.1	kN/m^2
Po = σv' - σh'	Po	=	249.2	kN/m^2
Load factor for Water	Fsw	=	1.00	
Hydrostatic water pressure	psw	=	0.00	kN/m^2

$$p_u = \frac{q_1 + Kq_1}{2} \qquad \tau = c' + p_u \tan\phi'$$

Unfactored load at tunnel crown	=	411.86	kN/m^2
Unfactored load at tunnel axis	=	478.29	kN/m^2

4. SHEAR STRENGTH OF SOIL

Uniform loading, Pu = (q1+ kq1) / 2	Pu	=	320.48	kN/m^2
Maximum shear strength of ground, τ = c' + Pu tanΦ	τ	=	195.62	kN/m^2

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4 \qquad \tau = c' + p_u \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING

Young's modulus of ground	Ec	=	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,(τ = c' + Pu tanΦ)	τ	=	195.621	kN/m^2
Young's modulus of lining	E_1	=	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, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.002739	m^4

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

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

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}\ , \ if\ S_t < \tau \qquad S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2+5-6\nu}\ , \ if\ S_t > \tau$$

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

where S_n and St are normal and shear stresses repectively

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

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

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

$$U = -\frac{r_0^4}{18EI}(2S_n+S_t)\cos 2\theta + U_w + U_u \qquad U_w = -\frac{p_w r_0^2}{EA} \qquad U_u = -\frac{N_0 r_0}{EA}$$

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-89.87
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-94.78
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	186
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-54
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-54
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	1772
Nd = -ro/3*(Sn + 2St)	Nd	=	-685.89
No=σ_v'(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	2457.91
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-2
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	0.01
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	14.907

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	Uw (mm)	Uu(mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	196	186	-89.9	0	2457.91	0.00	0.00	-686	0.01	-54.4
										Vd (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**

GEOCONSULT India Pvt Ltd		ANNEXURE -1	
A company of the GEOCONSULT group		Job no:	I40172
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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) & Segment Design

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
Track Level:	RL	=	873.609	m
Tunnel Axis to Track 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	r_o	=	7.025	m
Radius to extrados of lining	re	=	7.30	m
Distance between tunnel axis to rail level		=	2.8210	m
Depth to Tunnel Axis	Zo	=	21.900	m

$$\sigma'_h = K\sigma'_v \qquad p_0 = \sigma'_v - \sigma'_h$$

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	=	21.90	m
Height of Water Table considered in design	h_w		2.4869E-14	m
Effective overburden pressure	q1	=	418.3	kN/m^2
Surcharge	q2	=	0.00	kN/m^2
Load factor for Overburden Load	FS1	=	1.00	
Load factor for Surcharge	FS2	=	1.00	
Factored vertical stress	σv'	=	418.29	kN/m^2
k value	K	=	0.48	
Factored horizontal stress, σh' = kσv'	σh'	=	200.4	kN/m^2
Po = σv' - σh'	Po	=	217.9	kN/m^2
Load factor for Water	Fsw	=	1.00	
Hydrostatic water pressure	psw	=	0.00	kN/m^2

$$p_u = \frac{q_1 + Kq_1}{2} \qquad \tau = c' + p_u \tan\phi'$$

Unfactored load at tunnel crown	=	351.86	kN/m^2
Unfactored load at tunnel axis	=	418.29	kN/m^2

4. SHEAR STRENGTH OF SOIL

Uniform loading, Pu = (q1+ kq1) / 2	Pu	=	276.11	kN/m^2
Maximum shear strength of ground τ = c' + Pu tanΦ	τ	=	168.54	kN/m^2

$$I_e = I_j + \left(\frac{4}{n}\right)^2 I, \quad n > 4 \qquad \tau = c' + p_u \tan\phi'$$

5. PROPERTIES OF GROUND AND LINING

Young's modulus of ground	Ec	=	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,(τ = c' + Pu tanΦ)	τ	=	168.537	kN/m^2
Young's modulus of lining	E_1	=	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, Ie = Ij +(4/n)^2, (n>4)	Ie =	=	0.002739	m^4

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

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

$$S_n = \frac{(1-Q_2)p_0}{2\left[1+Q_2\left(\frac{3-2\nu}{3-4\nu}\right)\right]}, \ if \ S_t < \tau \qquad S_n = \frac{3(3-4\nu)\frac{p_0}{2} - \{2Q_2 + (4-6\nu)\}\tau}{4Q_2+5-6\nu}, \ if \ S_t > \tau$$

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

where S_n and St are normal and shear stresses repectively

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

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

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

$$U = -\frac{r_0^4}{18EI}(2S_n + S_t)\cos 2\theta + U_w + U_u \qquad U_w = -\frac{p_w r_0^2}{EA} \qquad U_u = -\frac{N_0 r_0}{EA}$$

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

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

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

Q2 = Ee* r0^3 / 12EI(I+v)	Q2	=	45.012
Sn =(1-Q2)po/2 * [I+Q2(3-2v/3-4v)] (ifSt,<τ)	Sn	=	-78.60
Sn=(3*(3-4v)*(p0/2)-(2Q2+(4-6v))t)/4Q2+5-6v , (if St>τ)	Sn	=	-81.61
St= (1+2Q2)Po/2[1+Q2(3-2v/3-4v)]	St	=	163
M = -ro^2/6*(2Sn + St)*cos2θ	M	=	-48
Md = -ro^2 /6 *(2Sn + St)	M_d	=	-48
N = -ro/3*(Sn +2St)cos2θ+Pw* r0+ No	N	=	1550
Nd = -ro/3*(Sn + 2St)	Nd	=	-599.85
No=σ_{v*}(1+k)*ro/2+[2Ec*ro/Et*(1+v)]	No	=	2149.57
Uw = -pw*ro^2/E*A	Uw	=	0.00
Uu =-No*ro/E*A	Uu	=	0.0
U=-ro^4/18EI*(2Sn+St)*cos2q+Uw+Uu	U	=	-2
Ud=-r0^4/(18E*I)*(2*Sn+St)	Ud	=	0.01
x=rq dx/dq=r			
V=r0/3*(2Sn+St)*sin2q	V	=	0
Vd=ro/3*(2Sn+St)	Vd	=	13.037

Q2	τ	St (<=τ)	Sn	$p_w r_e$	N_o	Uw (mm)	Uu(mm)	Nd (kN)	Ud (mm)	Md (kNm)
45.0123	169	163	-78.6	0	2149.57	0.00	0.00	-600	0.01	-47.6
										Vd (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 — Cl 40.2.2, IS 456

$$\delta = 1+3P_u/A_g f_{ck}$$

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

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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+((x-d'))/x (α-1) A_sc f_c-((d-x))/x α·A_st f_c]

M=[bx/2 f_c·(h/2-x/3)+((x-d'))/x (α-1) A_sc f_c·(h/2-d')-((d-x))/x α·A_st f_c·(h/2-d')]

ε≈((h-x))/((d-x))·f_s/E_s -(b(h-x)^2)/(3E_s A_s (d-x))

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

$$w_{cr} = \frac{3a_{cr}\varepsilon_m}{1+2\left(\frac{a_{cr}-c_{min}}{h-x}\right)} \quad \text{where} \quad a_{cr} = \sqrt{c_{min}^2 + \left(\frac{s}{2}\right)^2} - \frac{d_b}{2}$$

Concrete:			Steel:		
E_C	38,730	N/mm²	E_S	205,000	N/mm²
f_{CU}	60.0	N/mm²	f_y	500.0	N/mm²
b	1,000	mm	c_{MIN}	40.0	mm
f_{CT}	0.55	N/mm²	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 **0.3**

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]	**$a_{c,r}$** [mm]	**N** [kN]	**M** [kNm]	**x** [mm]	**f_C** [N/mm²]	**f_S** [N/mm²]	**ε** [*1000]	**W_{CR}** [mm]		**f_S'** [N/mm²]	**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

GEOCONSULT India Pvt Ltd	ANNEXURE-1C	
A company of the GEOCONSULT group	Page No.:	2

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

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

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

$$f_s=\frac{(d-x)}{x}\alpha f_c \qquad \varepsilon\approx\frac{h-x}{d-x}\cdot\frac{f_s}{E_s}-\frac{b(h-x)^2}{3E_s A_s (d-x)}$$

$$w_{cr}=\frac{3a_{cr}\varepsilon_m}{1+2\left(\frac{a_{cr}-c_{min}}{h-x}\right)} \quad \text{where} \quad a_{cr}=\sqrt{c_{min}^2+\left(\frac{s}{2}\right)^2}-\frac{d_b}{2}$$

Concrete:			Steel:		
E_C	38,730	N/mm²	E_S	205,000	N/mm²
f_{CU}	60.0	N/mm²	f_y	500.0	N/mm²
b	1,000	mm	c_{MIN}	50.0	mm
f_{CT}	0.55	N/mm²	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 CASE	2 h [mm]	3 d [mm]	4 d' [mm]	5 $A_{S,C}$ [mm²]	6 $A_{S,T}$ [mm²]	7 s [mm]	8 $a_{c,r}$ [mm]	9 N [kN]	10 M [kNm]	11 x [mm]	12 f_C [N/mm²]	13 f_S [N/mm²]	14 ε [*1000]	15 W_{CR} [mm]	16	17 f_S' [N/mm²]	18 N_i [kN]	19 M_i [kNm]	20 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 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 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+Ʋ))	1 /10 x 146.709470175082 x 146.709470175082	=	56	MPa
Dynamic Young;s Modulus of Soil	E_m	$2G_m$(1+Ʋ)	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^3F	0.05/146.71*sin45*Π/180*cos45*Π/180+(0.06*9.81*7.3)/0.0456^2*cos³*45*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_l			=	38,730	MPa
Concrete Poisson´s ratio	n_l			=	0.15	
Area of the tunnel lining per unit width	A_l			=	0.550	m²/m
Ij at a joint of lining	Ij			=	0.000000	
Reduced Moment of inertia of the tunnel lining per unit width	Ir	Ir =Ij+ (4/n)^2*I	(0) + ((4/9)^2) * 0.55^3 *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 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_l*I*(5-6*n))/((2r)³*G*(1-n_l²))	(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-v)/(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 circunferential thrust in tunnel lining	T(p/4)	(12*E_l*1000*I*Dd^n_{lining}*cos2(θ+p/4))/((2*r)³*(1-n_l²))	(12*38730*1000*0.003*0.007*cos2(θ+Π/4))/(2*7.3)^3*(1-0.15^2)	=	3.000	KN
Maximum circunferential bending moment in tunnel lining	M(p/4)	(6*E_l*1000*I*Dd^n_{lining}*cos2(θ+p/4))/((2*r)²*(1-n_l²))	(6*38729.834*1000*0.003*0.007*cos2(θ+Π/4))/((2*7.3)^2*(1-0.15^2)	=	19.000	KNm
Maximum Shear in tunnel lining	V(0)	(24*E_l*1000*I*Dd^n_{lining}*sin2(θ+p/4))/((2*r)³*(1-n_l²))	(24*38730*1000*0.003*0.007*sin2(θ+Π/4))/(2*7.3)^3*(1-0.15^2)	=	6.000	KN
Combined stress from thrust and bending moment due to earthquake	s_e	(T(p/4)/A_l+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	$(E*(1-n_l^2)*r^3) / (6*E_l*I*(1+n))$	(145.5*(1-0.15^2)*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)	=	3	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)	=	19	KNm
Combined stress from thrust and bending moment due to earthquake	s_e	$(T_{max}/A_l+M_{max}*(t/2)/I)/1000$	(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 compresive 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, $f_{cd} = \alpha_{cc} * f_{ck} / Y_c$			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						
$f_{ctd} > \sigma_e$					**safe**	

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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/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	$\rho_m c_m^2$	1 /10 x 146.709470175082 x 146.709470175082	56	MPa
Dynamic Young;s Modulus of Soil	E_m	$2G_m(1+\upsilon)$	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*П/180*cos45*П/180+(0.12*9.81*7.3)/0.0912^2*cos³*45*П/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_l			=	38,730	MPa
Concrete Poisson´s ratio	n_l			=	0.15	
Area of the tunnel lining per unit width	A_l			=	0.550	m²/m
Reduced Moment of inertia of the tunnel lining per unit width	Ir	Ir =Ij+ (4/n)^2*I	(0) + ((4/9)^2) * 0.55^3 *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 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_l*I*(5-6*n))/((2r)³*G*(1-n_l²))	(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-v)/(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	=	0.012	
Maximum circumferential thrust in tunnel lining	T(p/4)	(12*E_l*1000*I*Dd^n_{lining}*cos2(θ+p/4))/((2*r)³*(1-n_l²)	(12*38730*1000*0.003*0.013*cos2(θ+П/4))/(2*7.3)^3*(1-0.15^2)	=	6.000	KN
Maximum circumferential bending moment in tunnel lining	M(p/4)	(6*E_l*1000*I*Dd^n_{lining}*cos2(θ+p/4))/((2*r)²*(1-n_l²)	(6*38729.834*1000*0.003*0.013*cos2(θ+П/4))/((2*7.3)^2*(1-0.15^2)	=	38.000	KNm
Maximum Shear in tunnel lining	V(0)	(24*E_l*1000*I*Dd^n_{lining}*sin2(θ+p/4))/((2*r)³*(1-n_l²)	(24*38730*1000*0.003*0.013*sin2(θ+П/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_l+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	$(E*(1-n_l^2)*r^3) / (6*E_l*I*(1+n))$	(145.5*(1-0.15^2)*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	$(T_{max}/A_l+M_{max}*(t/2)/I)/1000$	(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 compresive 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, $f_{cd} = \alpha_{cc} *f_{ck} / Y_c$			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**			

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				0.30	
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	$\rho^2 C_m^2$	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^3F	0.05/146.71*sin45*Π/180*cos45*Π/180+(0.06*9.81*7.3)/0.0456^2*cos³*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_l			=	38,730	MPa
Concrete Poisson´s ratio	n_l			=	0.15	
Area of the tunnel lining per unit width	A_l			=	0.550	m²/m
Reduced Moment of inertia of the tunnel lining per unit width	Ir	Ir =Ij+ (4/n)^2*I	(0) + ((4/9)^2) * 0.55^3 *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	0.05/146.71	=	0.00031	
Coefficient to calculate R^n	a	(24*E_l*I*(3-4*n))/((2r)³*G*(1-n_l²))	(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*0.01*2*7.3/2	=	0.006	
Maximum circunferential thrust in tunnel lining	T(p/4)	(24*E_l*1000*I*Dd^n_{lining}*cos2(θ+p/4))/((2*r)³*(1-n_l²)	(24*38730*1000*0.003*0.007*cos2(θ+Π/4))/(2*7.3)^3*(1-0.15^2)	=	6.000	KN
Maximum circunferential bending moment in tunnel lining	M(p/4)	(6*E_l*1000*I*Dd^n_{lining}*cos2(θ+p/4)) /((2*r)²*(1-n_l²)	(6*38729.834*1000*0.003*0.007*cos2(θ+Π/4))/((2*7.3)^2*(1-0.15^2)	=	19.000	KNm
Maximum Shear in tunnel lining	V(0)	(24*E_l*1000*I*Dd^n_{lining}*sin2(θ+p/4))/((2*r)³*(1-n_l²)	(24*38730*1000*0.003*0.007*sin2(θ+Π/4))/(2*7.3)^3*(1-0.15^2)	=	6.000	KN
Combined stress from thrust and bending moment due to earthquake	s_e	(T(p/4)/A_l+M(p/4)*(t/2)/I)/1000	(6/0.55+19*(0.55/2)/0.003)/1000	=	1.919	MPa

Use formulations of Wang (1993) assuming no slip condition						
Flexibility ratio of tunnel lining	F	$(E*(1-n_l^2)*r^3) / (6*E_l*I*(1+n))$	(145.5*(1-0.15^2)*7.3^3)/(6*38729.834*1*(1+0.3)	=	66.875	
Compressibility Ratioof tunnel Lining	C	$(E*(1-n_l^2)*r) / (E_l*t*(1+n)(1-2n)$	(145.5*(1-0.15^2)*7.338729.834*0.55*(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)*0.094]+0.094[(5/2)-8*0.3+6*0.3^2]+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)	=	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 isconsidered		=	19	KNm
Combined stress from thrust and bending moment due to earthquake	s_e	$(T_{max}/A_l+M_{max}*(t/2)/I)/1000$	(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 compresive 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, $f_{cd} = \alpha_{cc} *f_{ck} / Y_c$			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						
$f_{ctd}>\sigma_e$						**safe**

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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	$\rho_m c_m^2$	1 /10 x 146.709470175082 x 146.709470175082	56	MPa
Dynamic Young;s Modulus of Soil	E_m	$2G_m(1+\upsilon)$	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*cos³*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_l			=	38,730	MPa
Concrete Poisson´s ratio	n_l			=	0.15	
Area of the tunnel lining per unit width	A_l			=	0.550	m²/m
Reduced Moment of inertia of the tunnel lining per unit width	Ir	Ir =Ij+ (4/n)^2*I	(0) + ((4/9)^2) * 0.55^3 *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_l*I*(3-4*n))/((2r)³*G*(1-n_l²))	(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*0.01*2*7.3/2	=	0.012	
Maximum circunferential thrust in tunnel lining	T(p/4)	(24*E_l*1000*I*Dd^n_{lining}*cos2(θ+p/4))/((2*r)³*(1-n_l²)	(24*38730*1000*0.003*0.013*cos2(θ+Π/4))/(2*7.3)^3*(1-0.15^2)	=	11.000	KN
Maximum circunferential bending moment in tunnel lining	M(p/4)	(6*E_l*1000*I*Dd^n_{lining}*cos2(θ+p/4))/((2*r)²*(1-n_l²)	(6*38729.834*1000*0.003*0.013*cos2(θ+Π/4))/((2*7.3)^2*(1-0.15^2)	=	38.000	KNm
Maximum Shear in tunnel lining	V(0)	(24*E_l*1000*I*Dd^n_{lining}*sin2(θ+p/4))/((2*r)³*(1-n_l²)	(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_l+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_l²)*r³) / (6*E_l*I*(1+n))	(145.5*(1-0.15^2)*7.3^3)/(6*38729.834*1*(1+0.3)	=	66.875	
Compressibility Ratioof tunnel Lining	C	(E*(1-n_l²)*r) / (E_l*t*(1+n)(1-2n)	(145.5*(1-0.15^2)*7.338729.834*0.00273868312757202*(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)*0.094]+0.094[(5/2)-8*0.3+6*0.3^2]+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 isconsidered		=	38	KNm
Combined stress from thrust and bending moment due to earthquake	s_e	$(T_{max}/A_l+M_{max}*(t/2)/I)/1000$	(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 compresive 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, $f_{cd} = \alpha_{cc} *f_{ck} / Y_c$			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

GEOCONSULT India Pvt Ltd			
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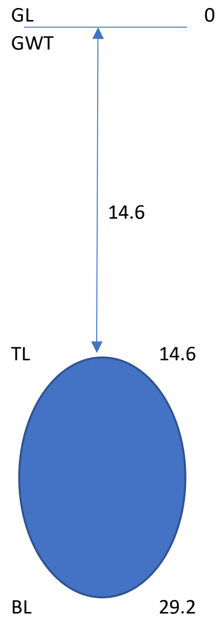
		Page No.:	3

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
overburden pressure at invert	(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

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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	
Poission'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	3.700	
Arc subtended by the beam element	**Φ** =	Radian	0.13514	
Radial Spring Stiffness, (E/(1+ μ)R)	Kr(max)	kN/m	**15125**	
Tangential Spring 0.5*Ks/(1+v)	Kt	kN/m	**5817**	

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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	
Poission'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+ μ)R)	Kr(max)	kN/m	**7562**	
Tangential Spring 0.5*Ks/(1+v)	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	
Poission'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+ μ)R)	Kr(max)	kN/m	**14349**	
Tangential Spring 0.5*Ks/(1+v)	Kt	kN/m	**5519**	

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

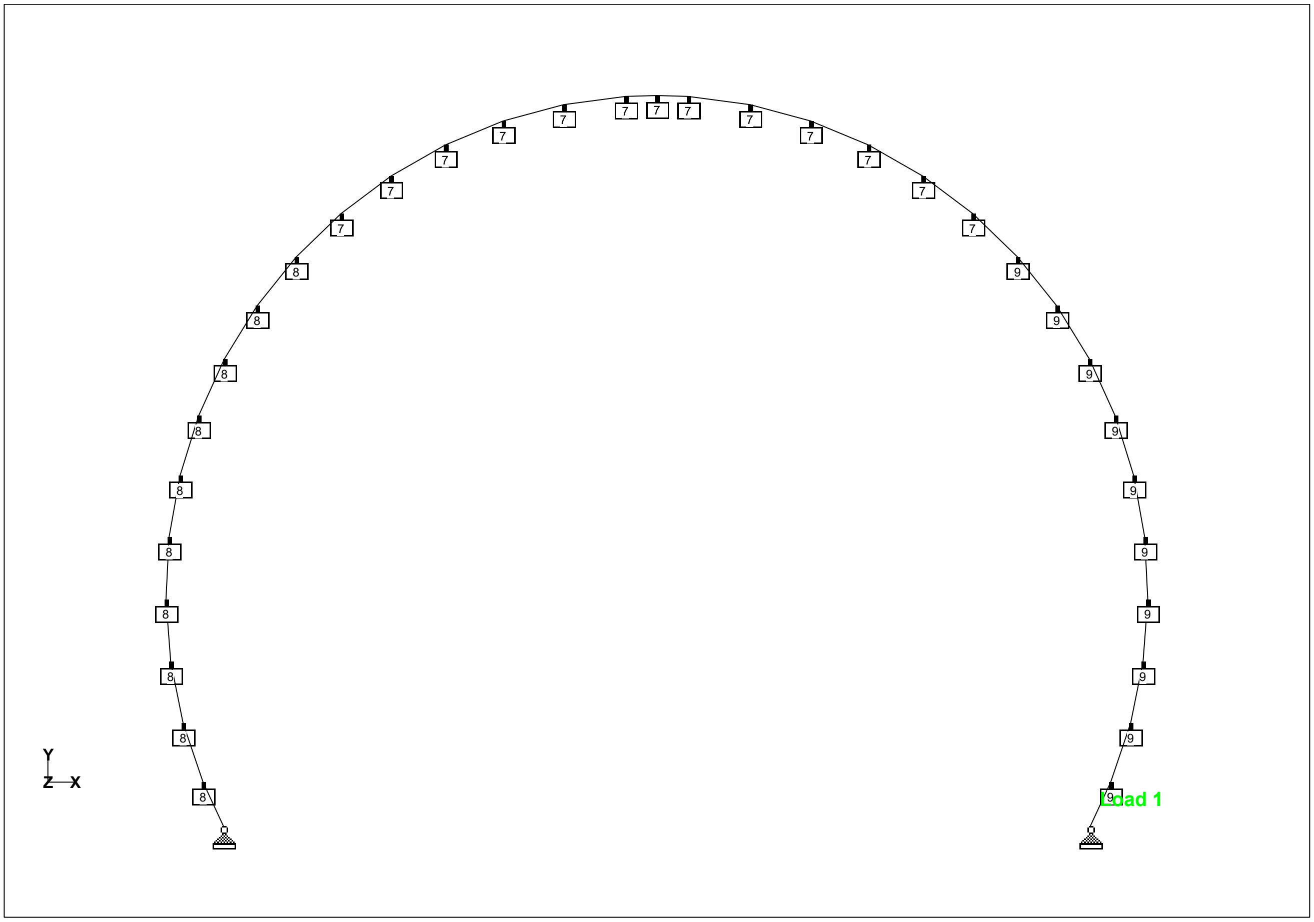
Included in this printout are data for:

All	The Whole Structure

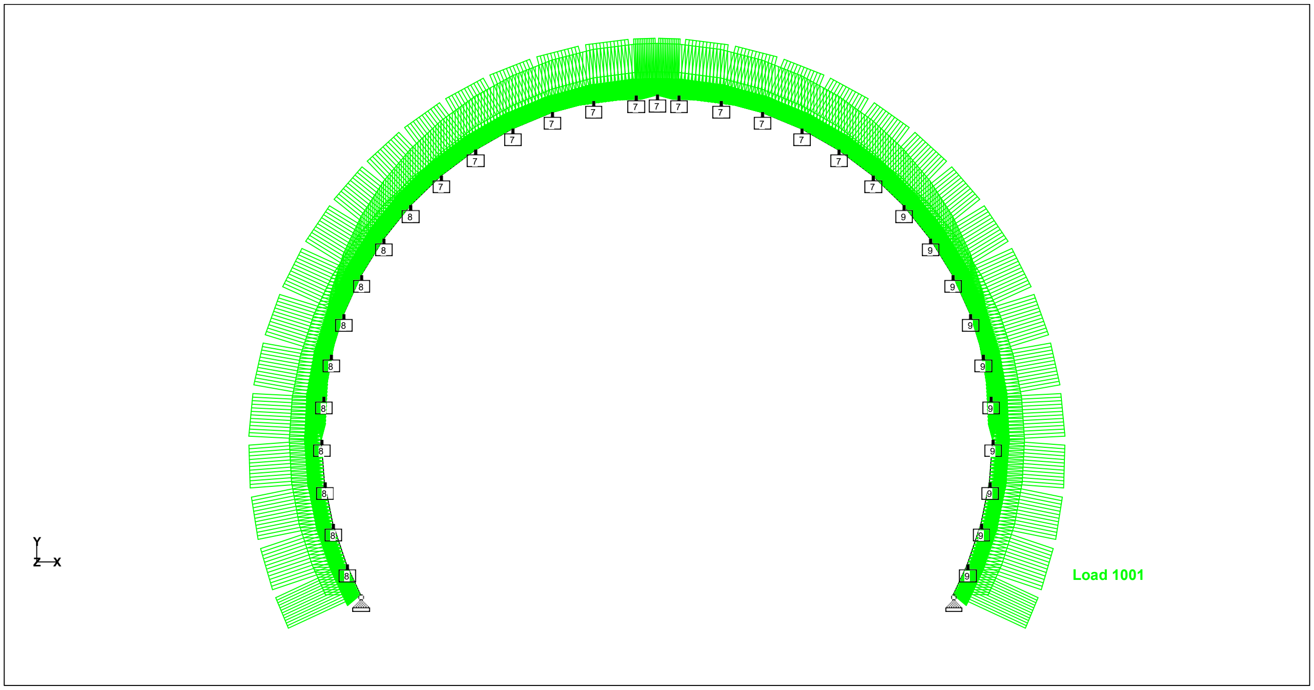
Included in this printout are results for load cases:

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

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



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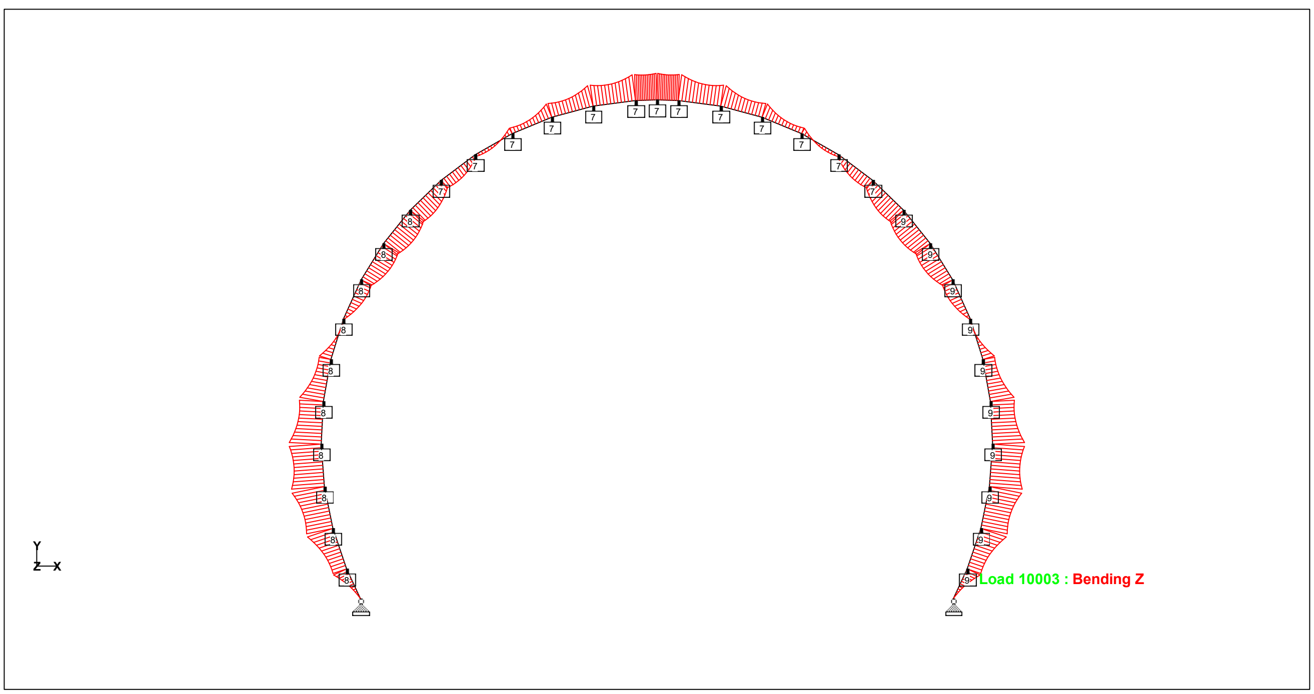

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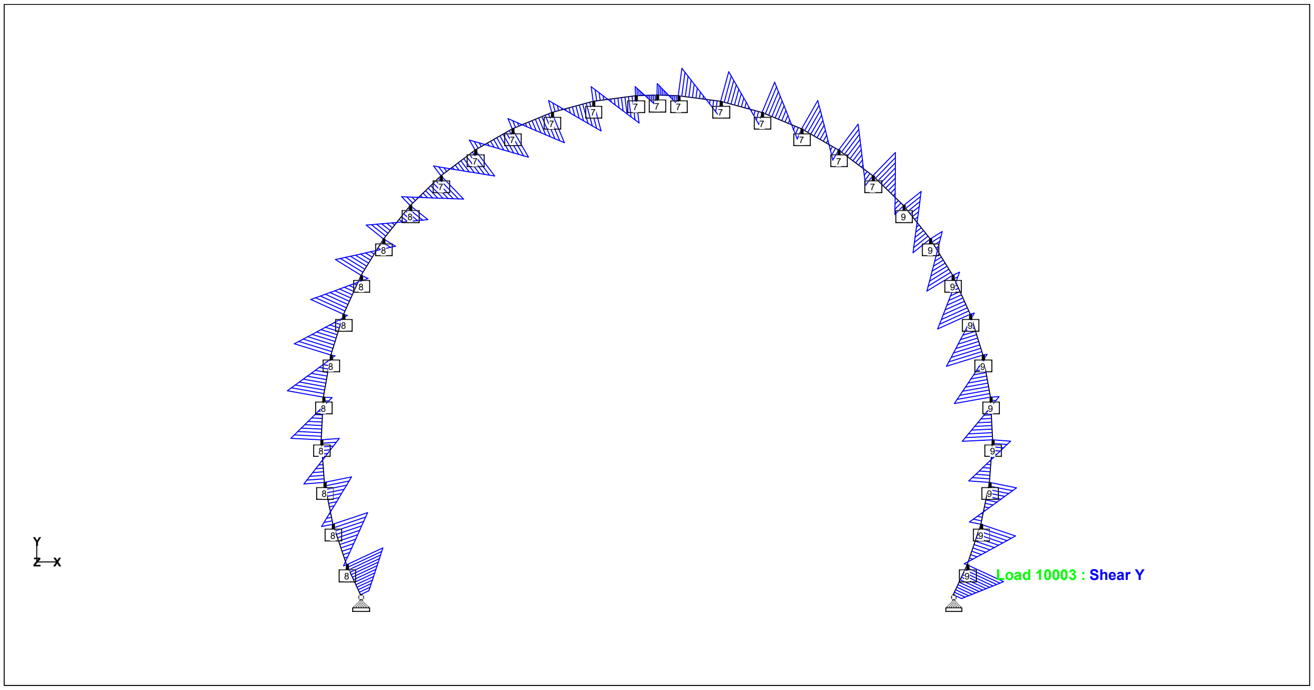

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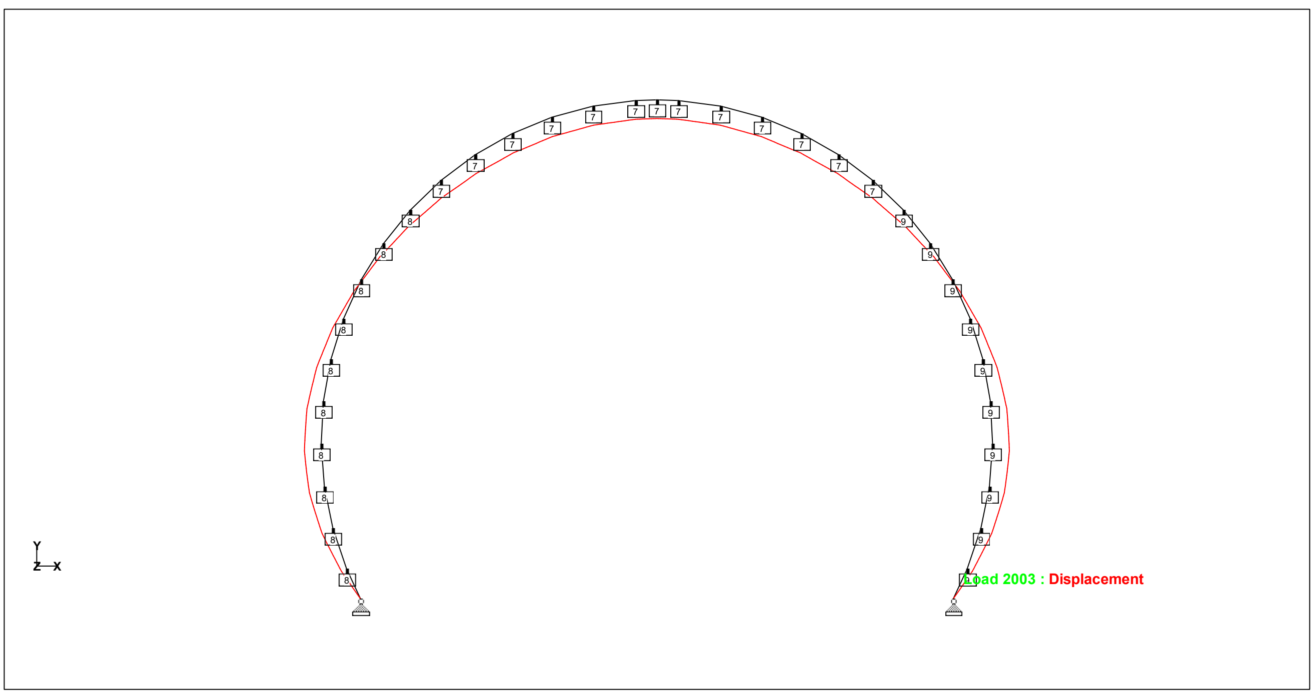

Deflection

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.

				Axial	Shear		Torsion	Bending	
	Beam	L/C	d (m)	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**

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	Page No.:	-

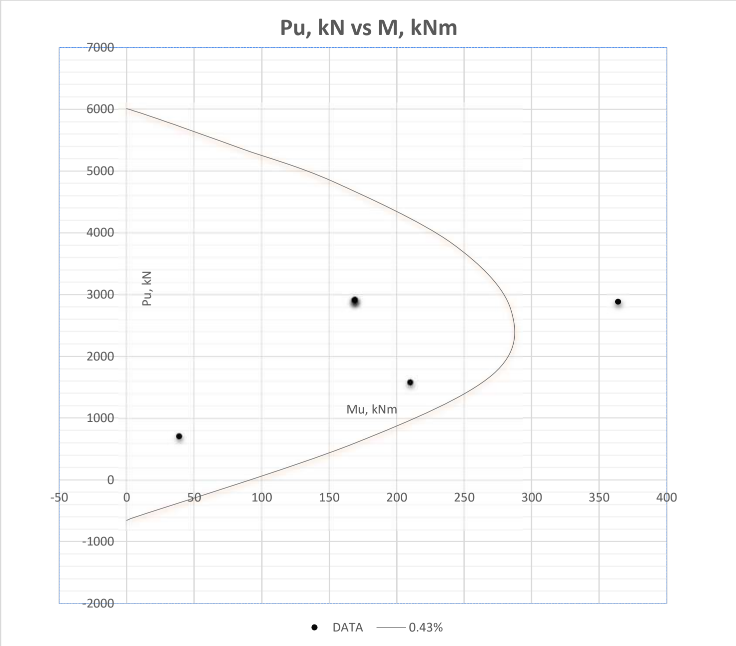
Project:	**Project: DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction**
Calculation for	**OVERT**

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 (ϒc)	1.5	Material Factor of Safety Steel e (ϒs)	1.15	Depth of Member D, mm	350	
Modulus of Elasticity Concrete Ec, N/mm2	29580	Modulus of Elasticity of Steel Es,N/mm2	200000	Clear cover, mm	60	
Strain at Yeild Point Concrete = ecy	0.0020			Reinforcement	Nos	Dia, mm
Ultimate Strain in concrete = ecu	0.0035			Top	6.7	12
C1	0.67			Middle	0.0	0
				Bot	6.7	12



MAXIMA FOR DIFFERENT LOAD COMBINATIONS			
LOAD CASE	CONDITION	Pu/kN	Mu, kNm
	outer	2913	169
	outer	2913	169
	outer	2913	169
	outer	2913	169
	outer	2883	364
	inner	711	39
	inner	1583	210

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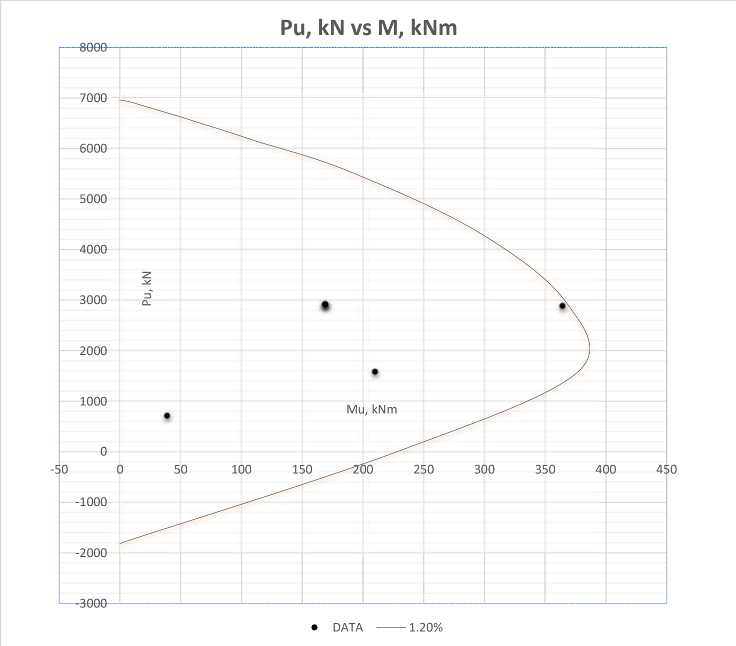
		Page No.:	-
Project:	**Project: DPR for the Work of Construction of Underground Vehicular tunnel from Hebbal Esteem Mall Junction to Silkboard KSRP Junction**		
Calculation for	**KIKER**		

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	350	
Modulus of Elasticity Concrete Ec, N/mm2	29580	Modulus of Elasticity of Steel Es,N/mm2	200000	Clear cover, mm	60	
Strain at Yeild Point Concrete = ecy	0.0020			Reinforcement	Nos	Dia, mm
Ultimate Strain in concrete = ecu	0.0035			Top	6.7	20
C1	0.67			Middle	0.0	0
				Bot	6.7	20



MAXIMA FOR DIFFERENT LOAD COMBINATIONS			
LOAD CASE	**CONDITION**	**Pu/kN**	**Mu, kNm**
	outer	2913	169
	outer	2913	169
	outer	2913	169
	outer	2913	169
	outer	2883	364
	inner	711	39
	inner	1583	210

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	
	100Ast/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 > τ_c = 0.57

SHEAR REINFORCED REQUIRED

Stirrups as transverse reinforcement is already provided

As per Clause 40.4, IS 456

Shear to be resisted by stirrups	$= V_U - \tau_c bd$ =	188829.81	N
Dia	=	8	mm
Spacing In Transverse Direction	=	150.00	
Area	=	50.27	mm^2
Spacing provided	=	150.00	mm

Shear resisted by vertical stirrpus

V_{US} = 0.87fyAsvd/sv

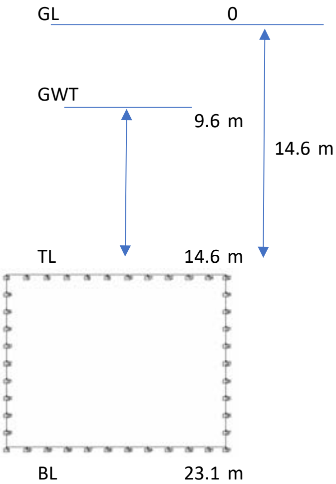
= 222619.8 N

Vus 222.6 kN > 188.8 kN Hence safe

ANNEXURE – 3
CUT & COVER BOX

ANNEXURE 3 (Case 1 - Water level at 5m below ground level)

Ground level at C&C location	0	m	
Top level at C&C loacation	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	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/m3	
K0	0.43		
poisson ratio	0.3		



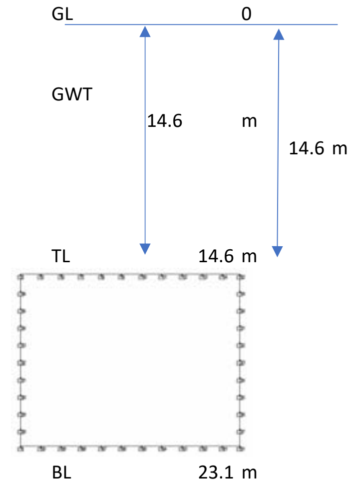
OVERBURDEN PRESSURE (SUBMERGED)		
overburden pressure at top slab	(unit weight of rock - unit weight of water) x overburden height	182.86
side earth pressure at wall top	k0 x overburden pressure at wall top	78.6298
side earth pressure at wall bottom	k0 x overburden pressure at Invert	111.8903

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 loacation	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				

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 SYYM
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) + 1.5SUI
Combination	105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.!
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) + 1.0SUI
Combination	205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.(

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

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

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)	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	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
32	-	-	-	-	-	-
33	-	-	-	-	-	-
34	-	-	-	-	-	-
35	-	-	-	-	-	-
36	-	-	-	-	-	-

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 SYYM	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 SYYM	1.50
104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SUI	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT 5MBGL)	1.50
		4	HYDROSTRATIC (5MBGL)	1.50

Combination Load Cases Cont...

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
		7	SURCHARGE SYYM	1.50
105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.!	1	DL (SELF WEIGHT)	1.50
		3	EARTH PRESSURE (WT AT GROUND)	1.50
		5	HYDROSTRATIC (WT AT GROUND)	1.50
		7	SURCHARGE SYYM	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 SYYM	1.00
204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SUI	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT 5MBGL)	1.00
		4	HYDROSTRATIC (5MBGL)	1.00
		7	SURCHARGE SYYM	1.00
205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.(	1	DL (SELF WEIGHT)	1.00
		3	EARTH PRESSURE (WT AT GROUND)	1.00
		5	HYDROSTRATIC (WT AT GROUND)	1.00
		7	SURCHARGE SYYM	1.00

Load Generators

There is no data of this type.

1 DL (SELF WEIGHT) : Selfweight

Direction	Factor	Assigned Geometry
Y	-1.000	ALL

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	-	-

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	-	-

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	-	-	-	-

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	-	-	-	-
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	-	-	-	-

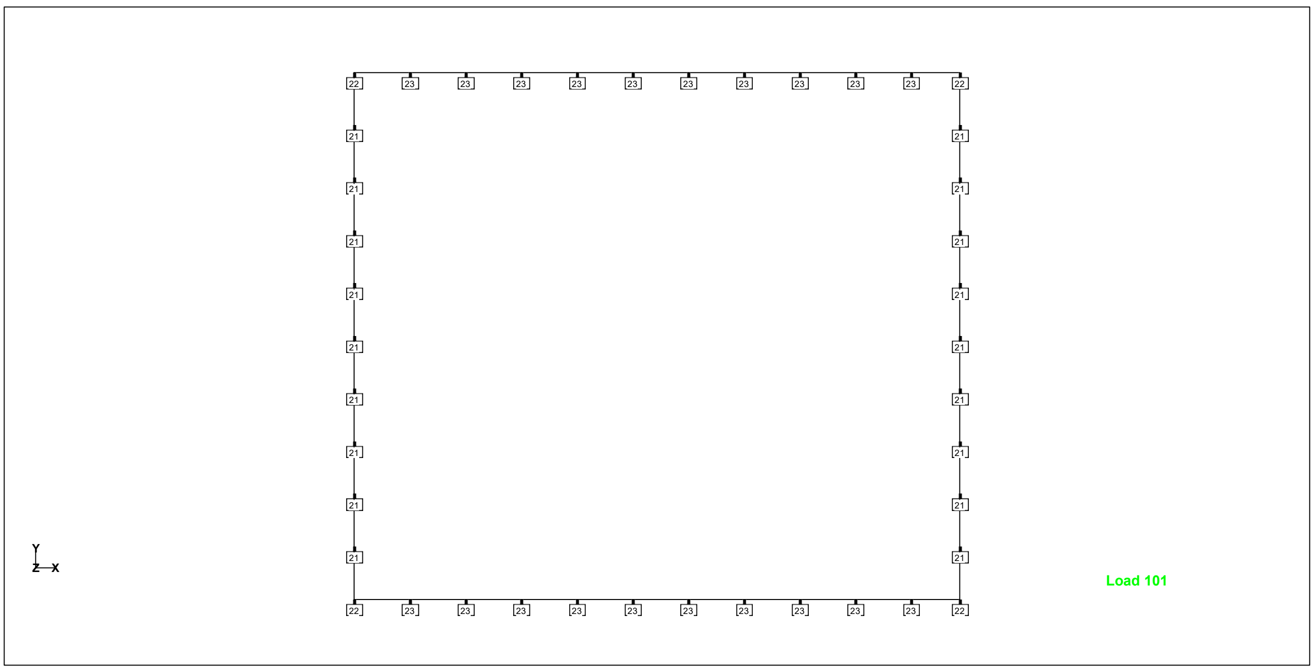
6 EARTH PRESSURE (DRY) : Beam Loads

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	-	-

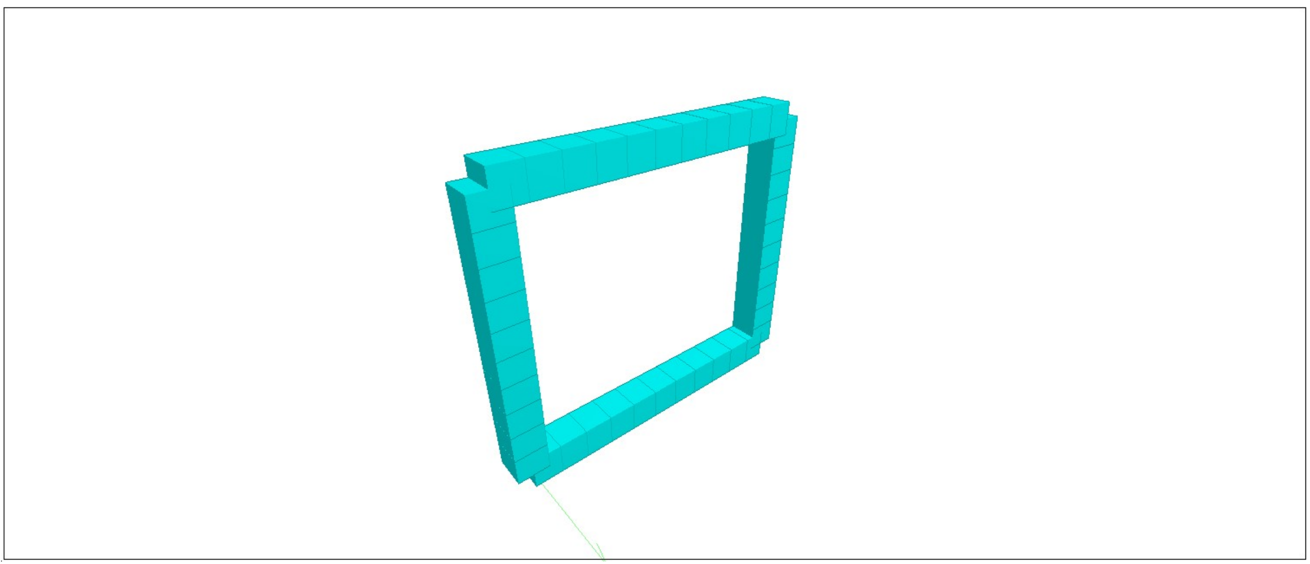
7 SURCHARGE SYYM : Beam Loads

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	-	-	-	-

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	

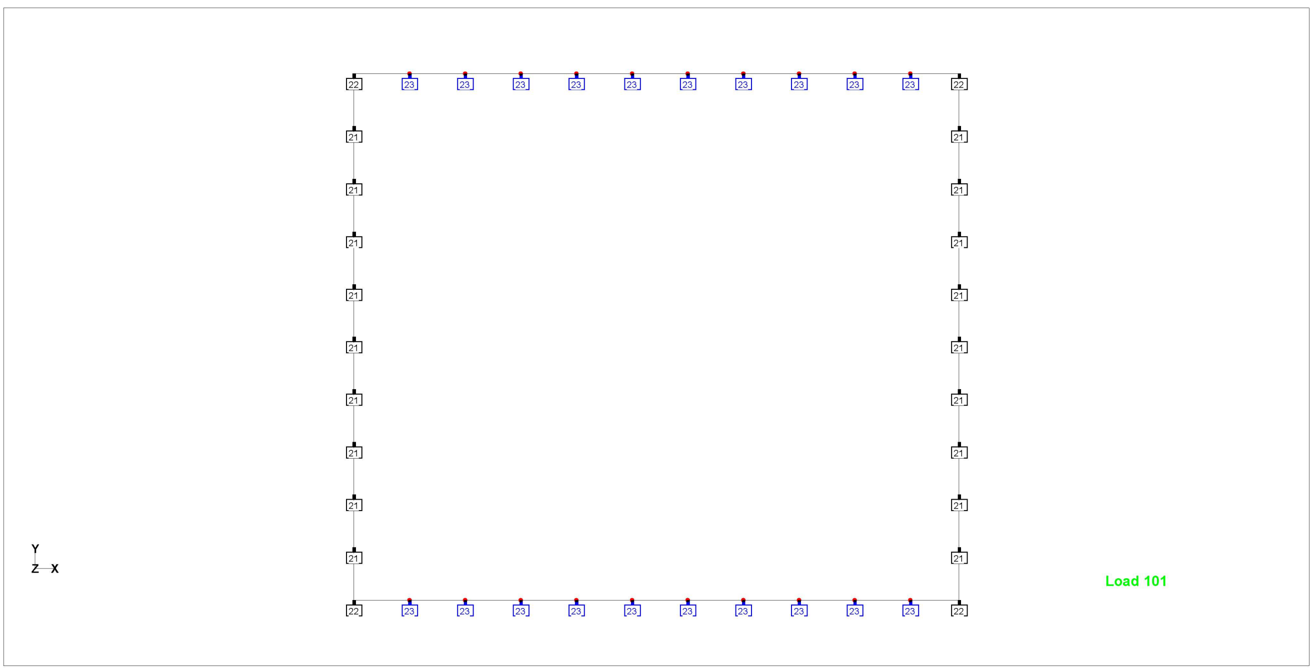


Whole Structure



3D Rendered View

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 la	Date/Time 11-Sep-2024 12:17	



SUPPORTS

Software licensed to	Job No	Sheet No **16**	Rev A
	Part		
Job Title I40172_C&C (2 lane)	Ref		
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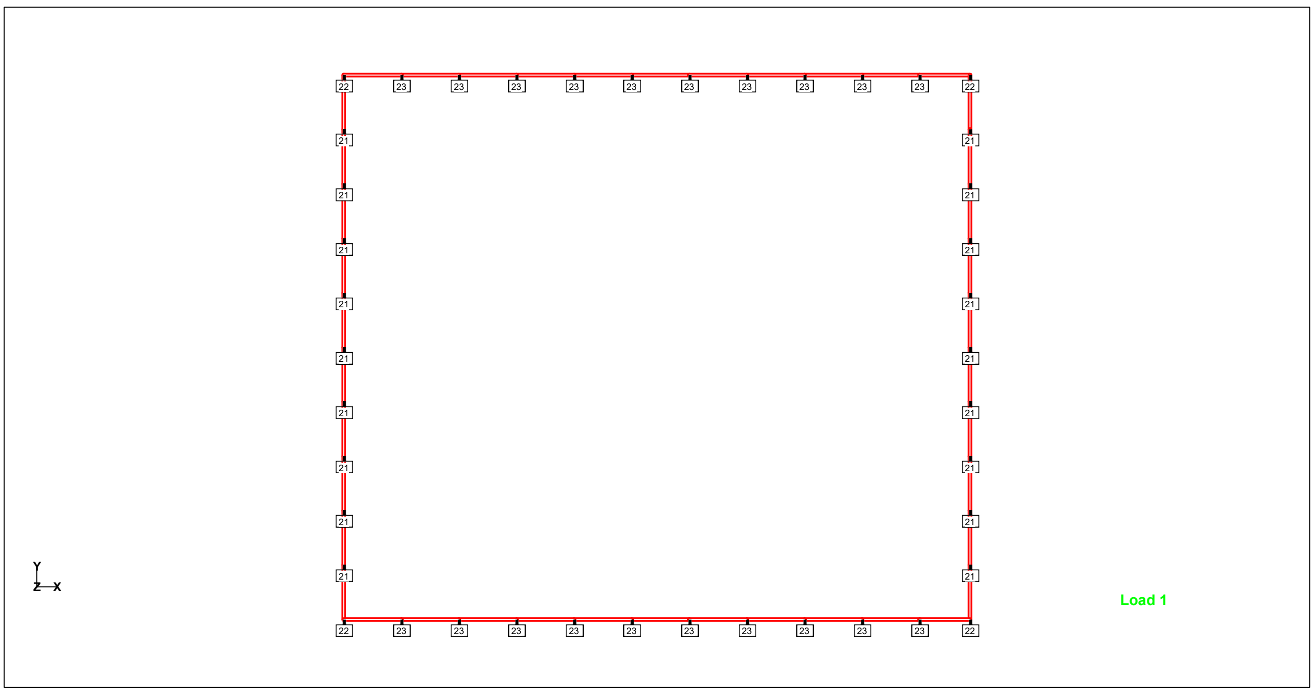
Client	File I40172_C&C section (2 la	Date/Time 11-Sep-2024 12:17	



DL

Software licensed to	Job No	Sheet No 17	Rev A
	Part		
Job Title I40172_C&C (2 lane)	Ref		
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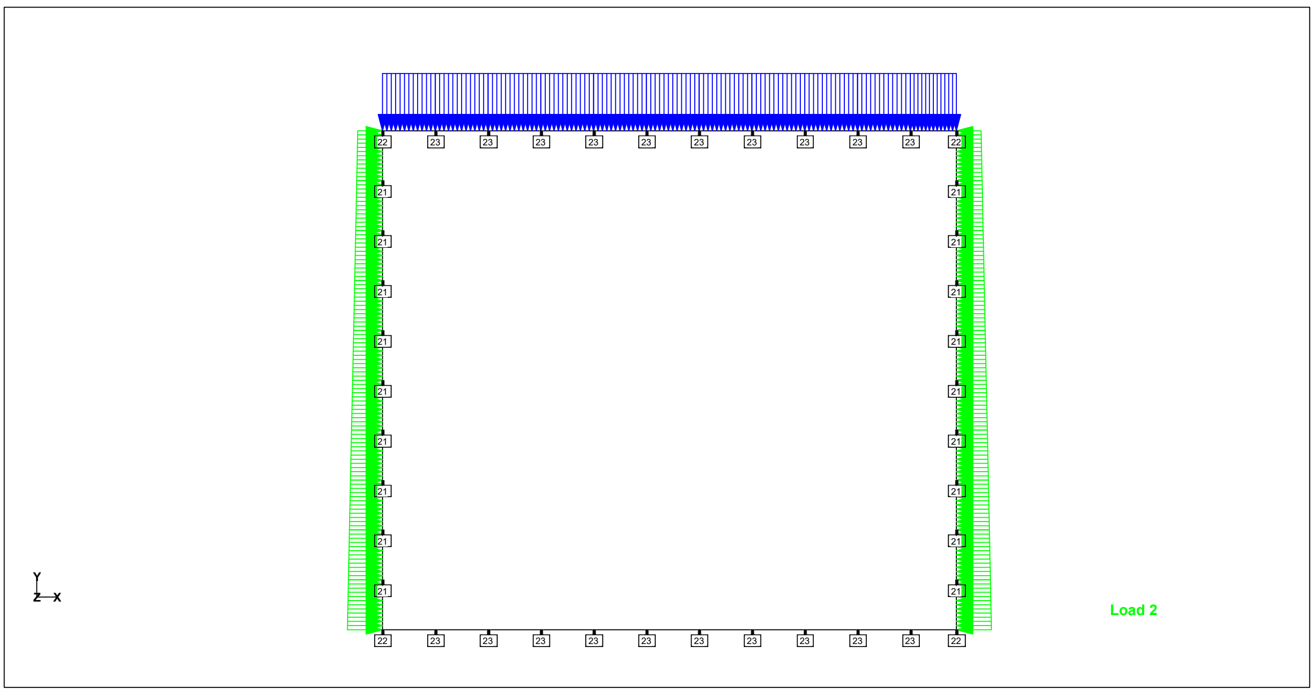
Client	File I40172_C&C section (2 la	Date/Time 11-Sep-2024 12:17	



EP(5MBGL)

Software licensed to	Job No	Sheet No 18	Rev A
	Part		
Job Title I40172_C&C (2 lane)	Ref		
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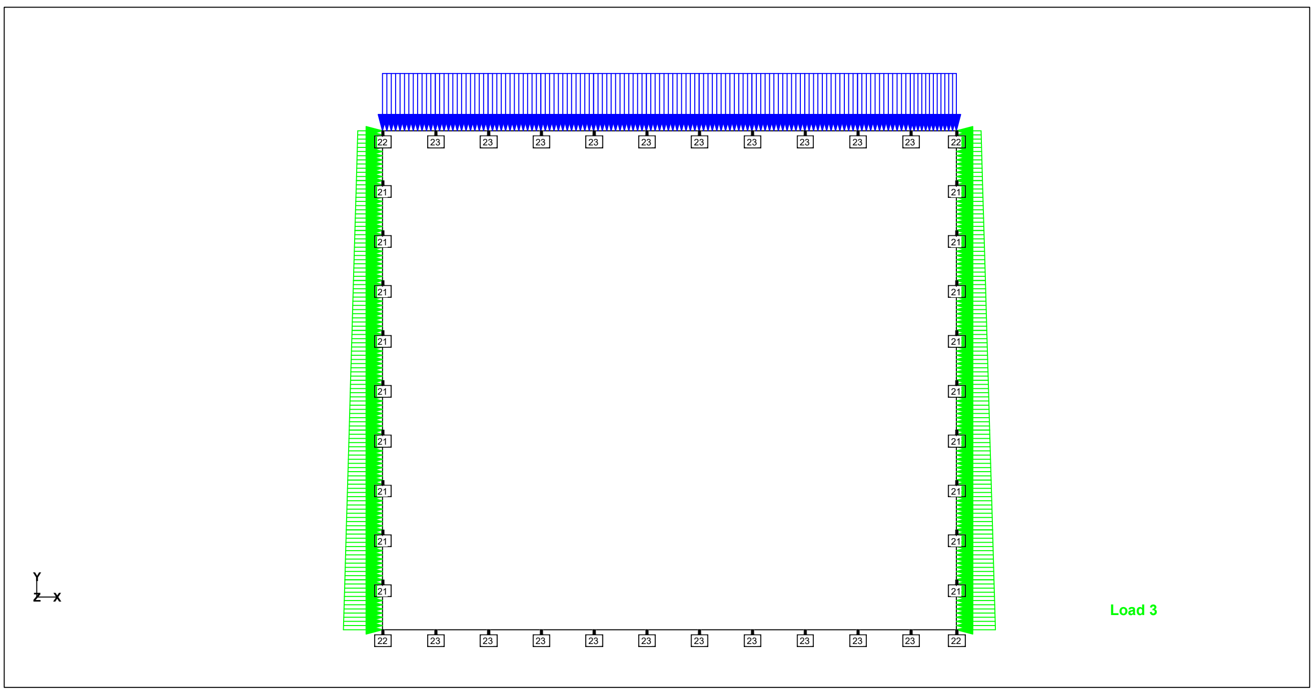
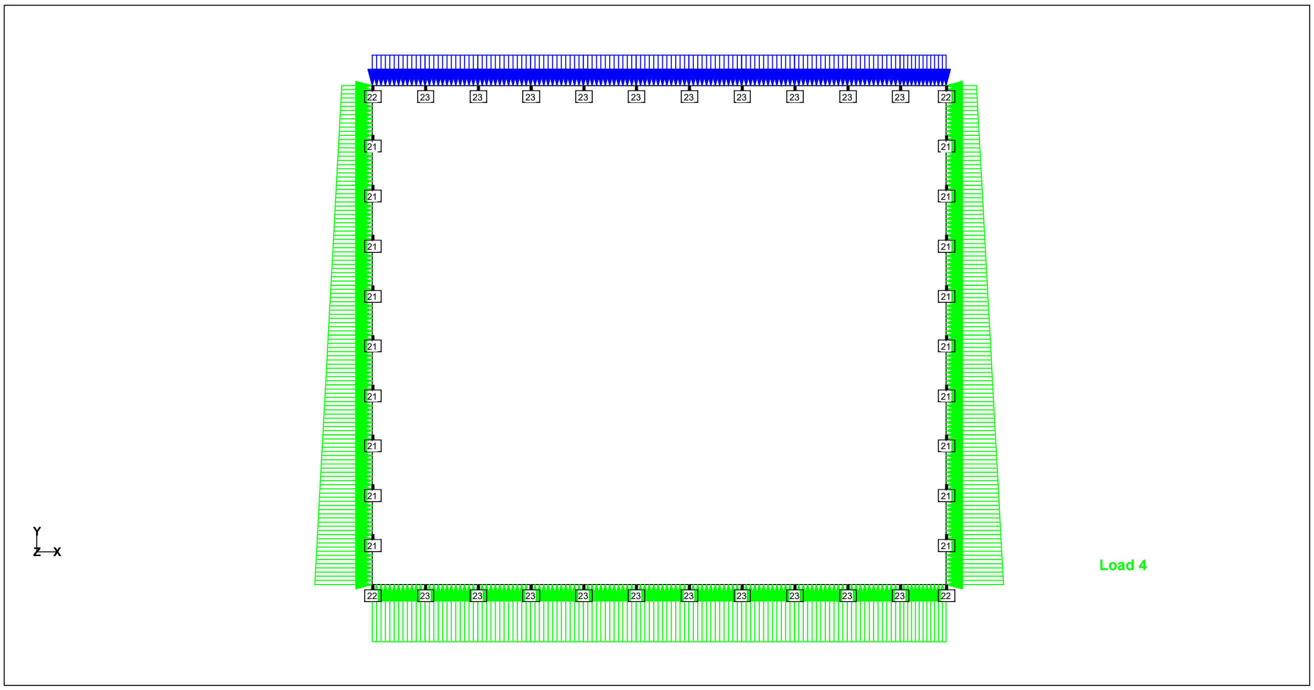
Client	File I40172_C&C section (2 la	Date/Time 11-Sep-2024 12:17	



EP(WT AT GROUND)

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	



WATER(5MBGL)

Software licensed to	Job No	Sheet No **20**	Rev A
	Part		
Job Title I40172_C&C (2 lane)	Ref		
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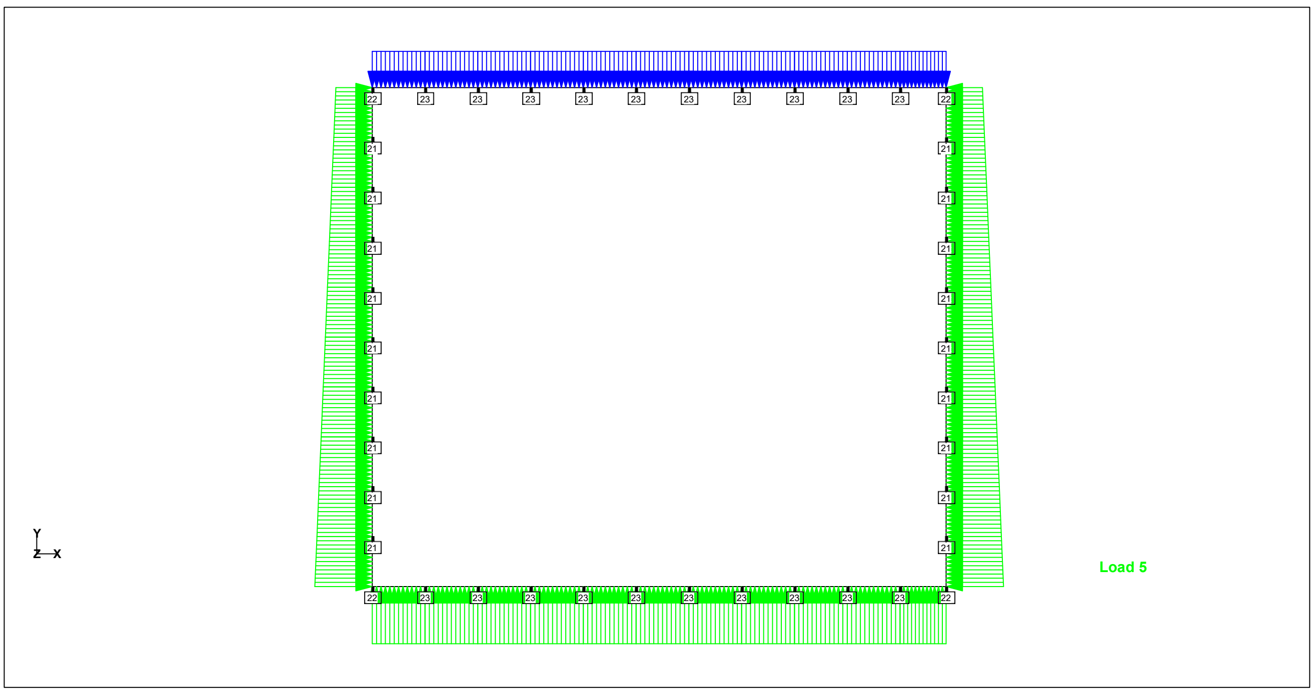
Client	File I40172_C&C section (2 la	Date/Time 11-Sep-2024 12:17	



WATER(WT AT GROUND)

Software licensed to	Job No	Sheet No 21	Rev A
	Part		
Job Title I40172_C&C (2 lane)	Ref		
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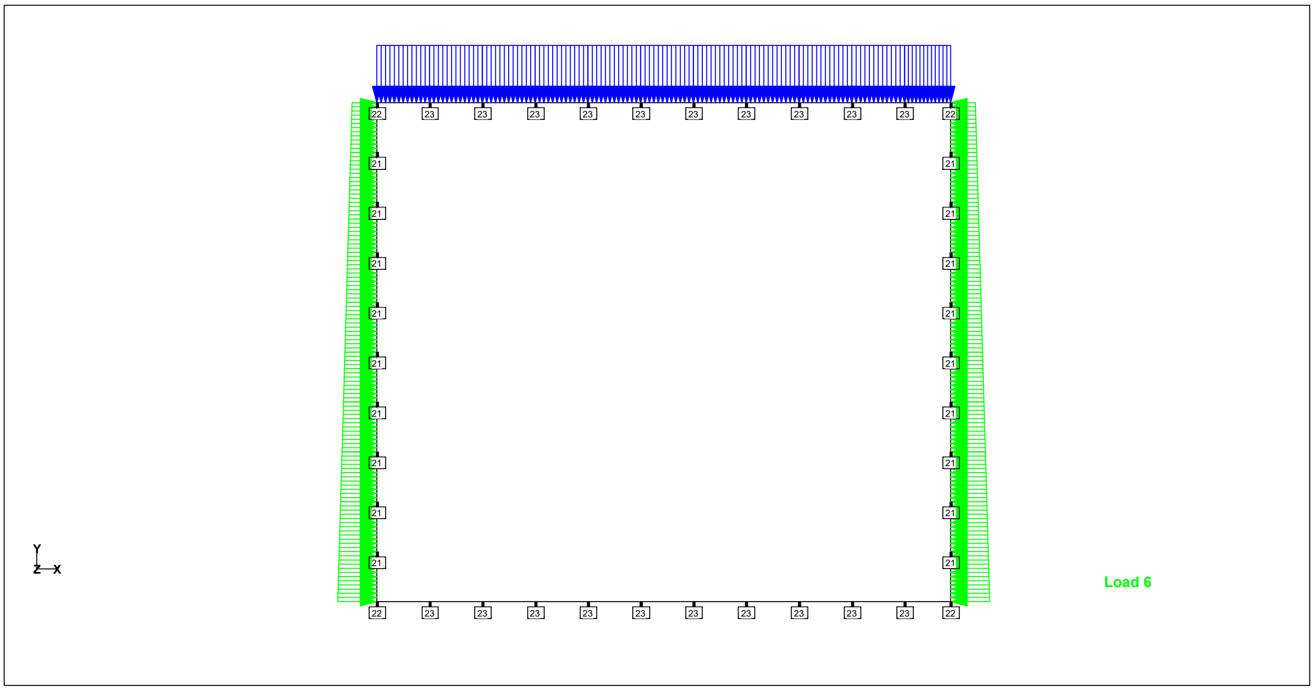
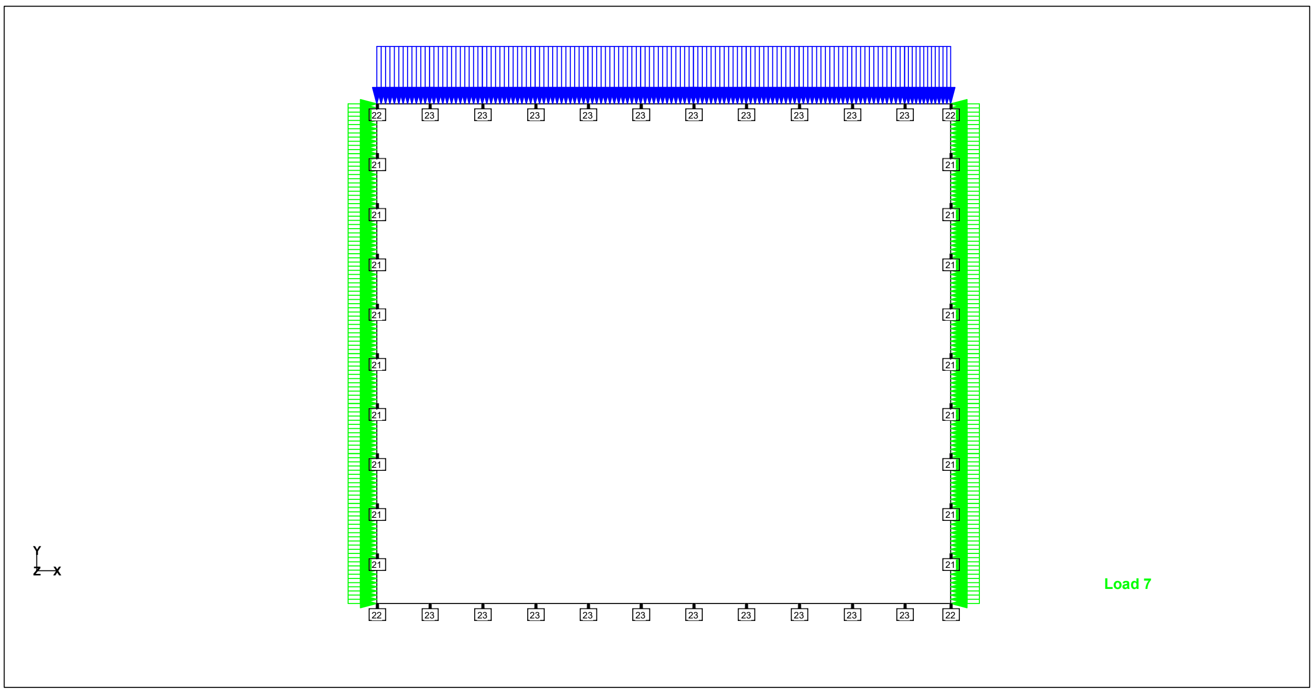
Client	File I40172_C&C section (2 la	Date/Time 11-Sep-2024 12:17	



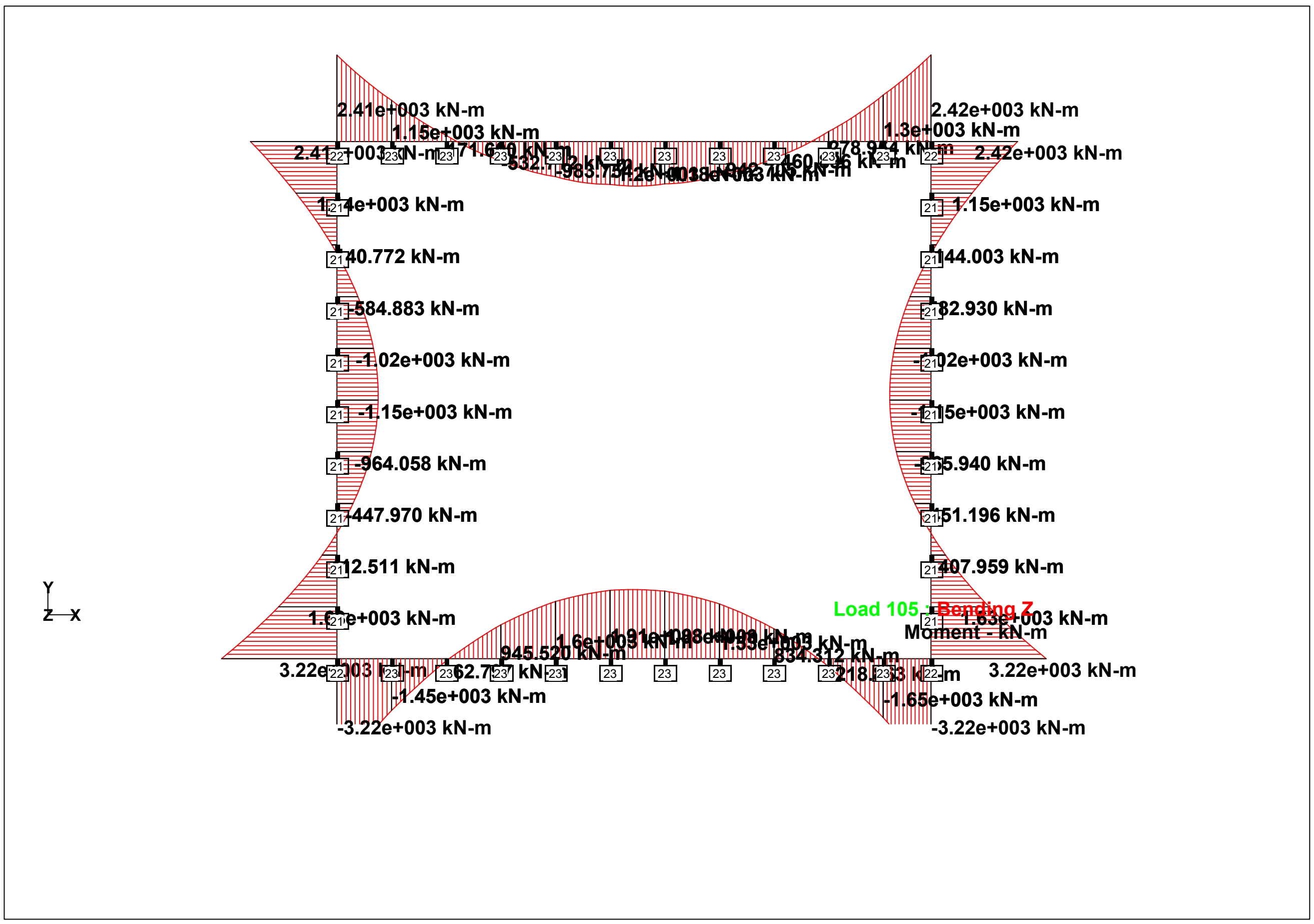
EP(DRY)

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	



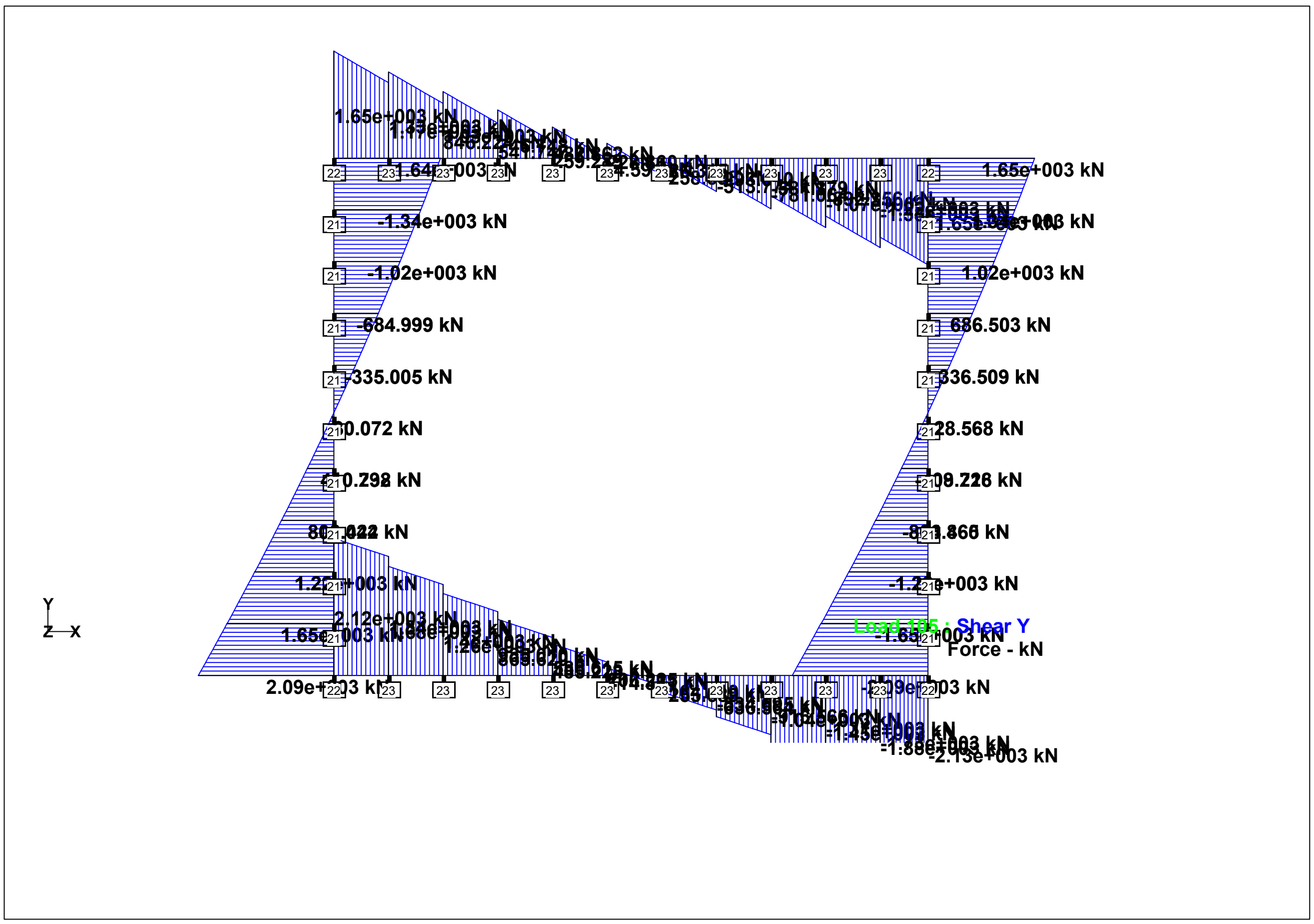
SURCHARGE

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

Software licensed to	Job No	Sheet No 24	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	



SHEAR

Software licensed to	Job No	Sheet No **25**		Rev A
	Part			
Job Title I40172_C&C (2 lane)	Ref			
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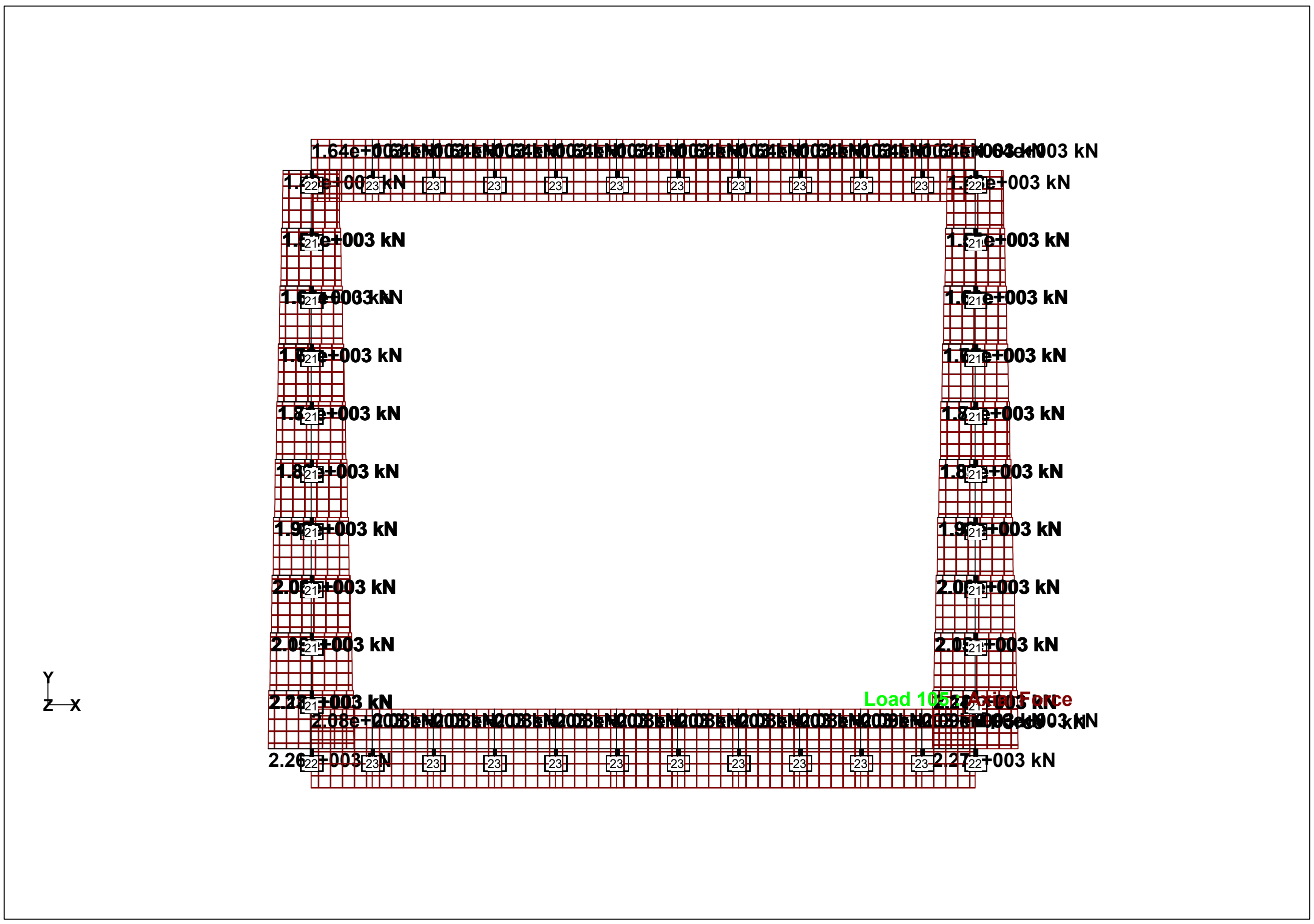
Client	File I40172_C&C section (2 la	Date/Time 11-Sep-2024 12:17		



AXIAL

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	HYDROSTRATIC (5MBGL)
Primary	5	HYDROSTRATIC (WT AT GROUND)
Primary	6	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYYM
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) + 1.5SUI
Combination	105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.!
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) + 1.0SUI
Combination	205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.(

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

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

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	-	-	-	-	-	-

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.

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 SYYM	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 SYYM	1.50
104	1.5DL + 1.5EP(5M) + 1.5WL(5M) + 1.5SUI	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT 5MBGL)	1.50
		4	HYDROSTRATIC (5MBGL)	1.50
		7	SURCHARGE SYYM	1.50
105	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.!	1	DL (SELF WEIGHT)	1.50
		3	EARTH PRESSURE (WT AT GROUND)	1.50
		5	HYDROSTRATIC (WT AT GROUND)	1.50
		7	SURCHARGE SYYM	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 SYYM	1.00
204	1.0DL + 1.0EP(5M) + 1.0WL(5M) + 1.0SUI	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT 5MBGL)	1.00
		4	HYDROSTRATIC (5MBGL)	1.00
		7	SURCHARGE SYYM	1.00
205	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.(	1	DL (SELF WEIGHT)	1.00
		3	EARTH PRESSURE (WT AT GROUND)	1.00
		5	HYDROSTRATIC (WT AT GROUND)	1.00
		7	SURCHARGE SYYM	1.00

Load Generators

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	-	-	-	-

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	-	-	-	-
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	-	-	-	-

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	-	-	-	-

5 HYDROSTRATIC (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	-	-

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	-	-	-	-

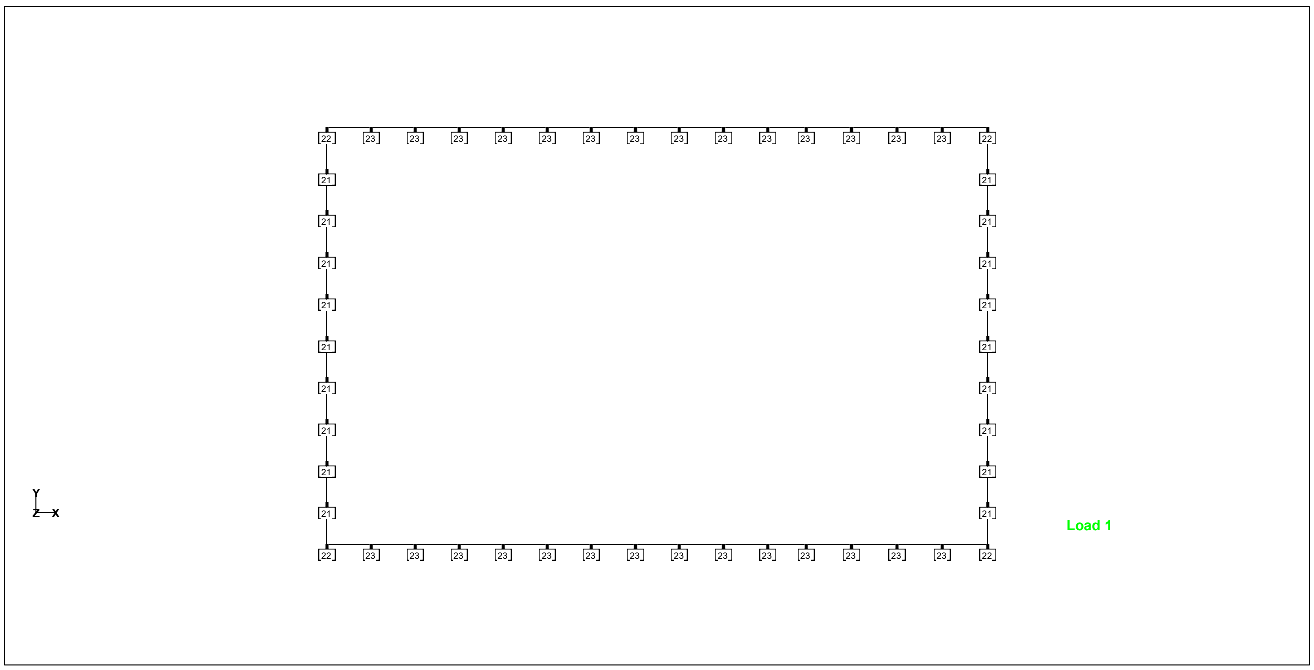
7 SURCHARGE SYYM : Beam Loads

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	-	-	-	-

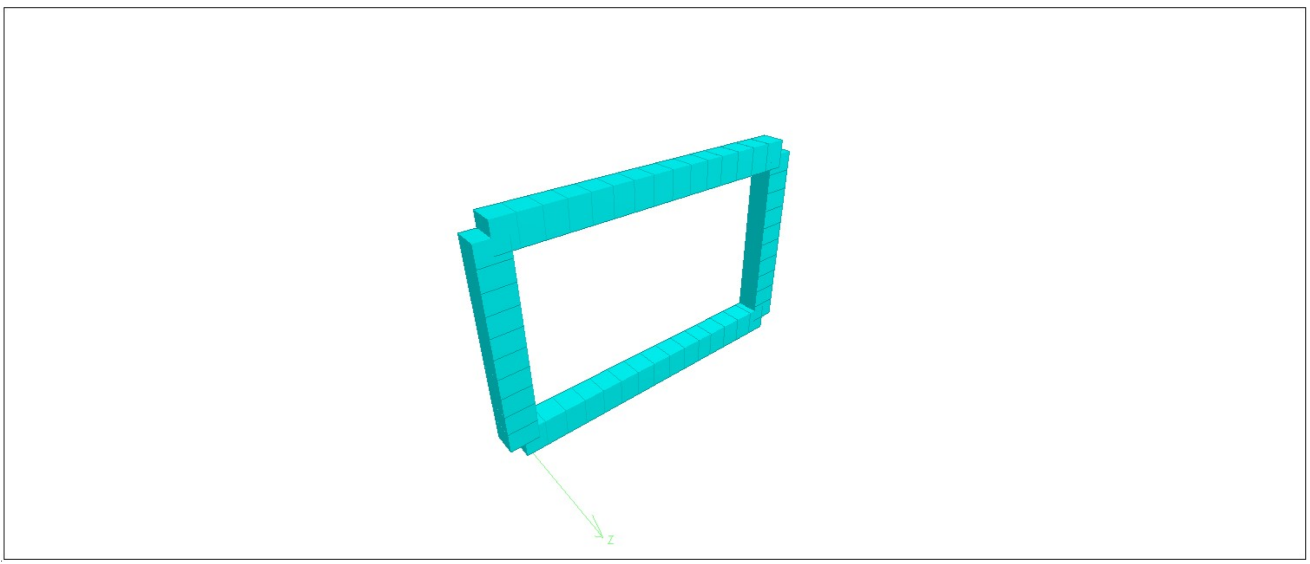
7 SURCHARGE SYYM : Beam Loads Cont...

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
55	UNI	kN/m	GY	-60.000	-	-	-	-

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	

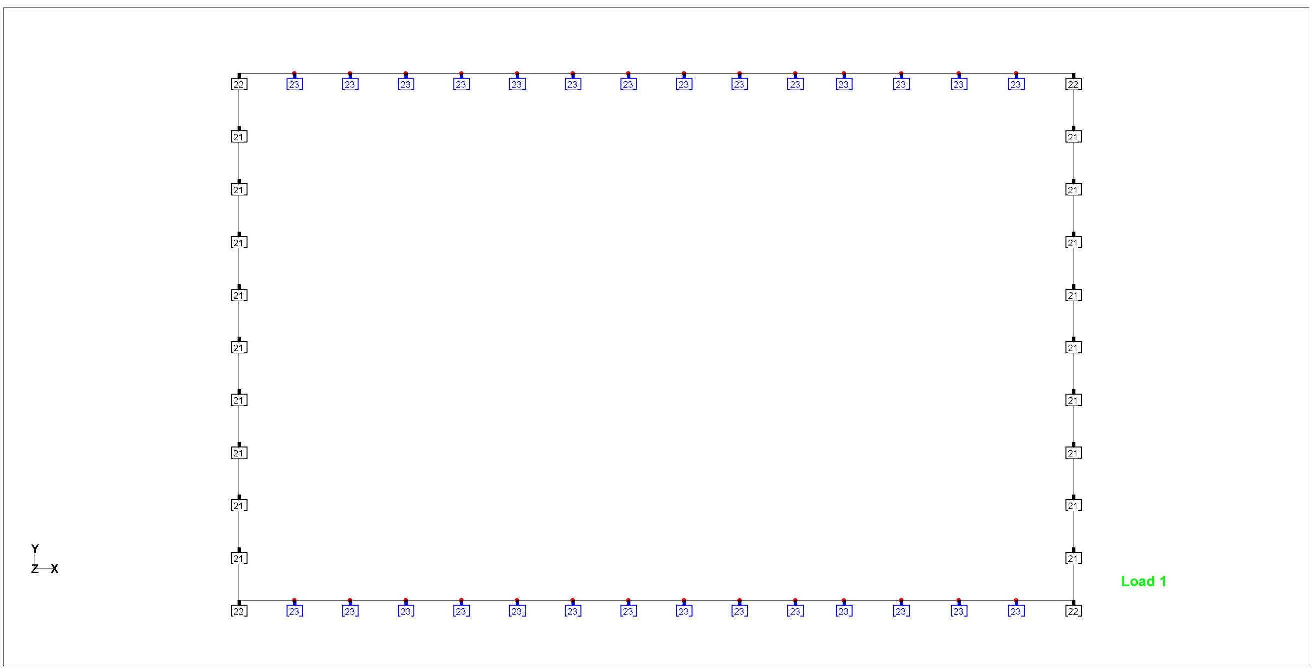


Whole Structure



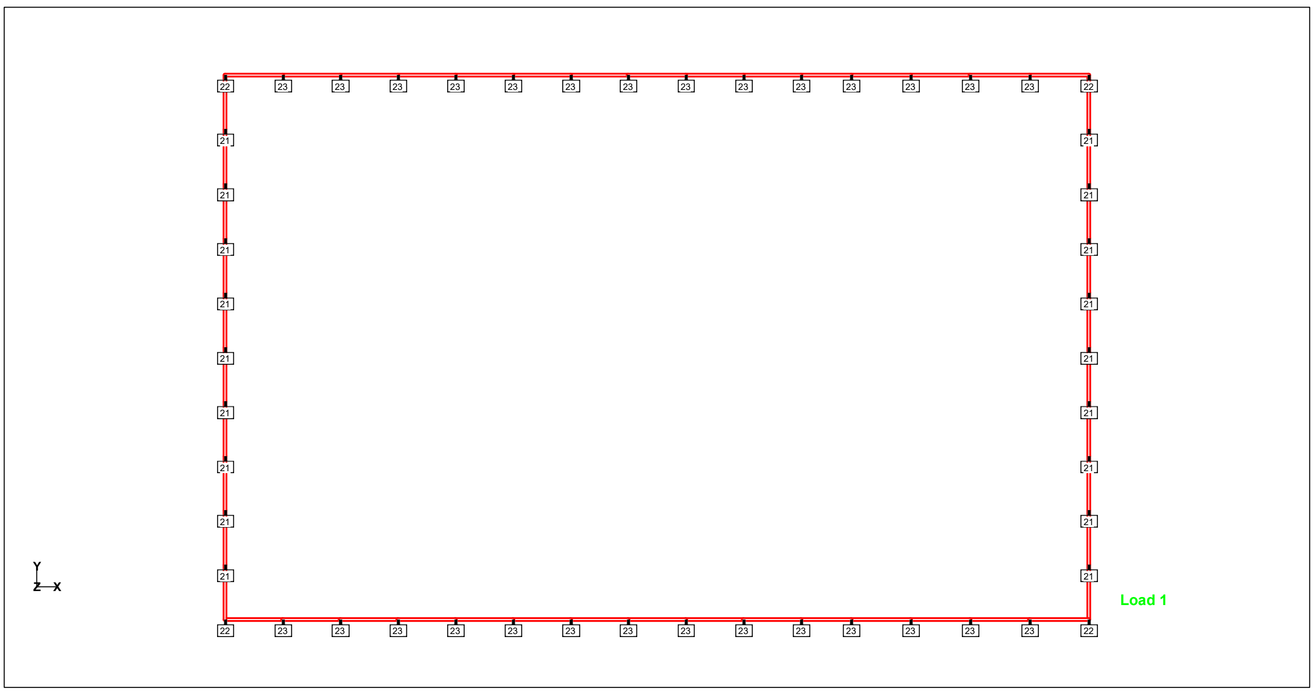
3D Rendered View

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 la	Date/Time 05-Sep-2024 19:38	



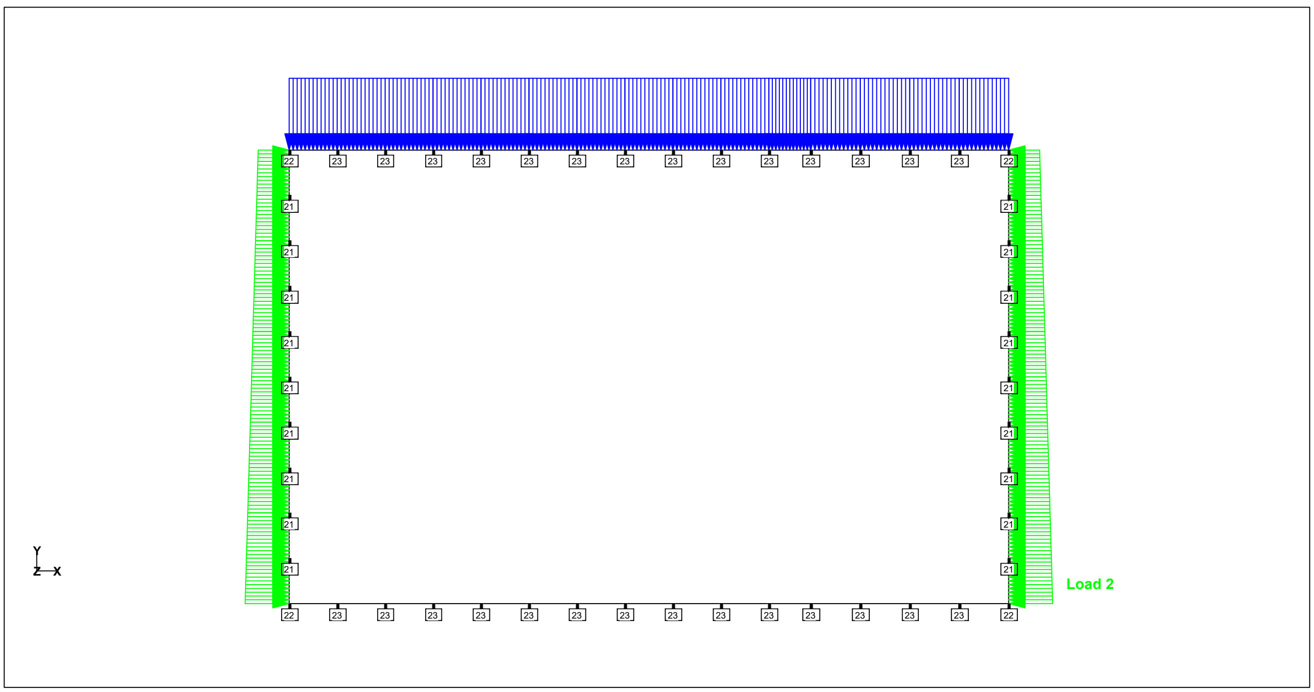
SUPPORTS

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	



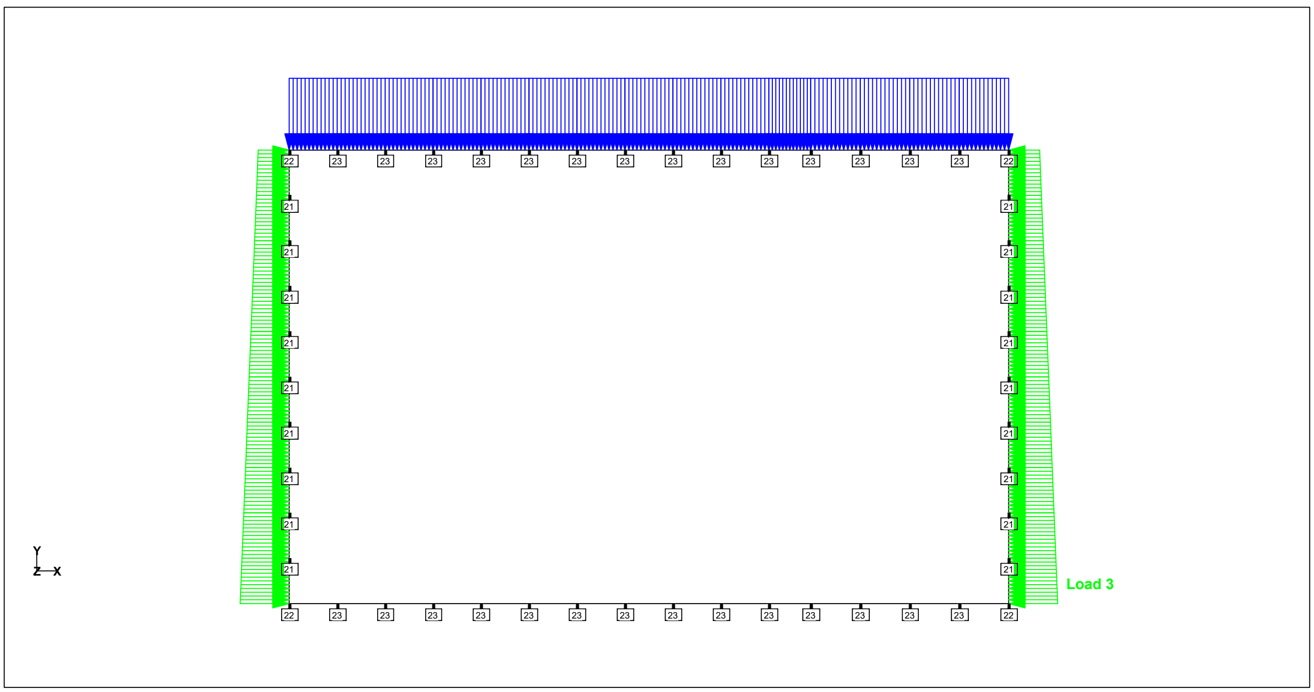
DL

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	

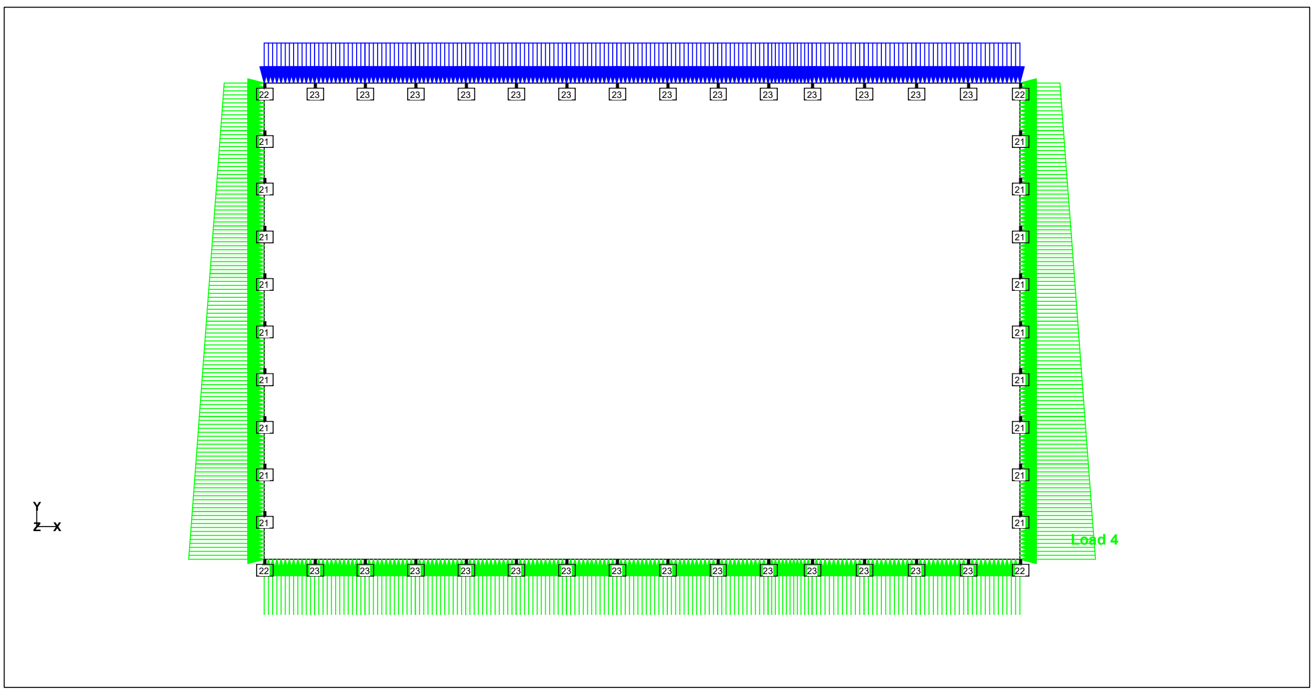


EP(WT 5MBGL)

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	

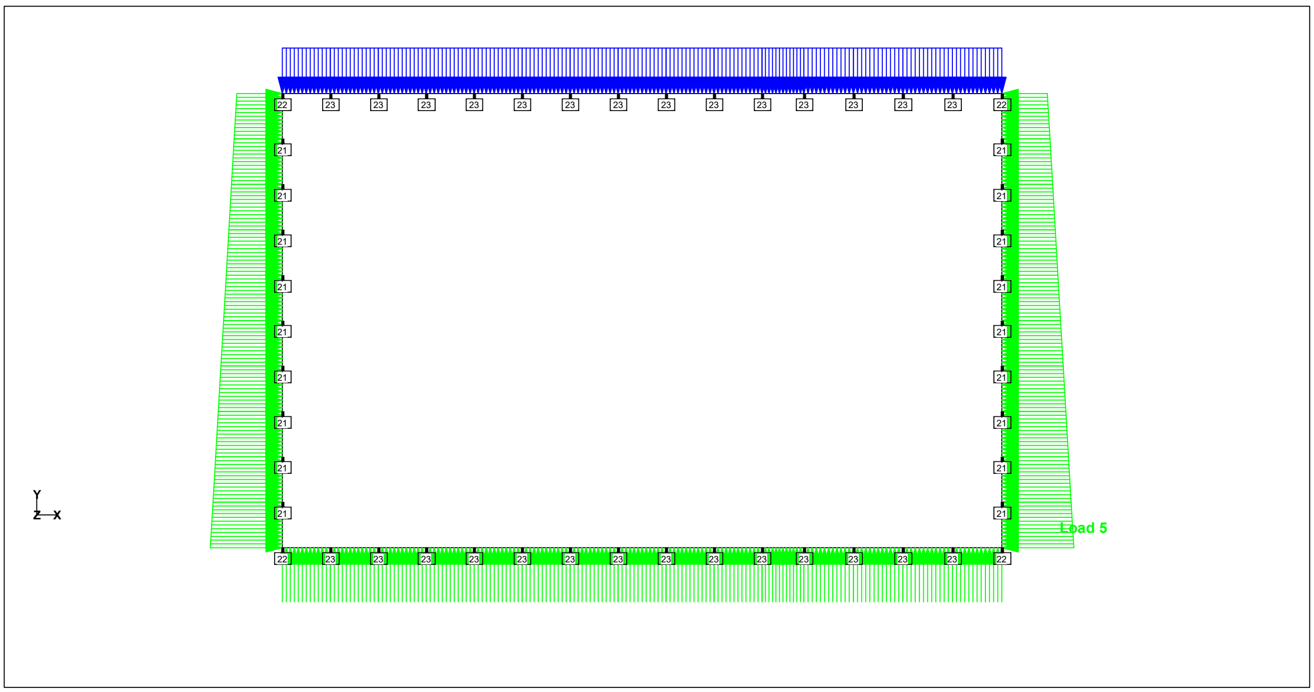


EP(WT AT GROUND)



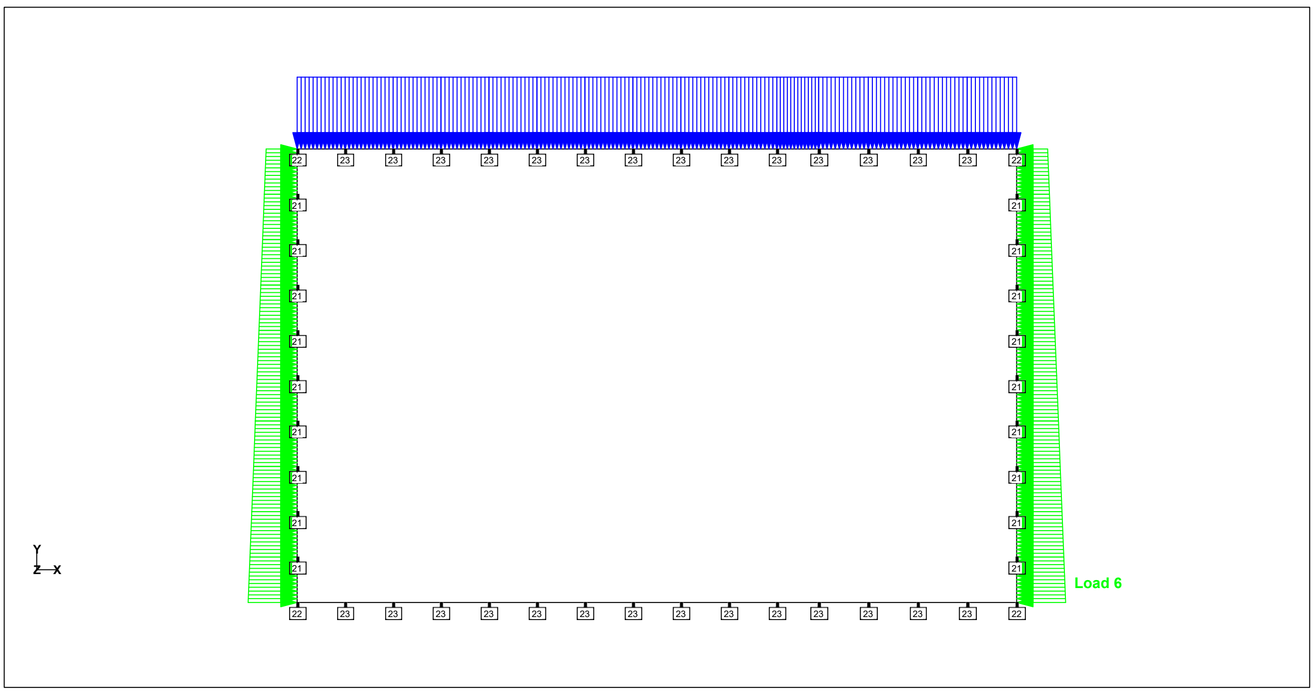
WATER(5MBGL)

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	



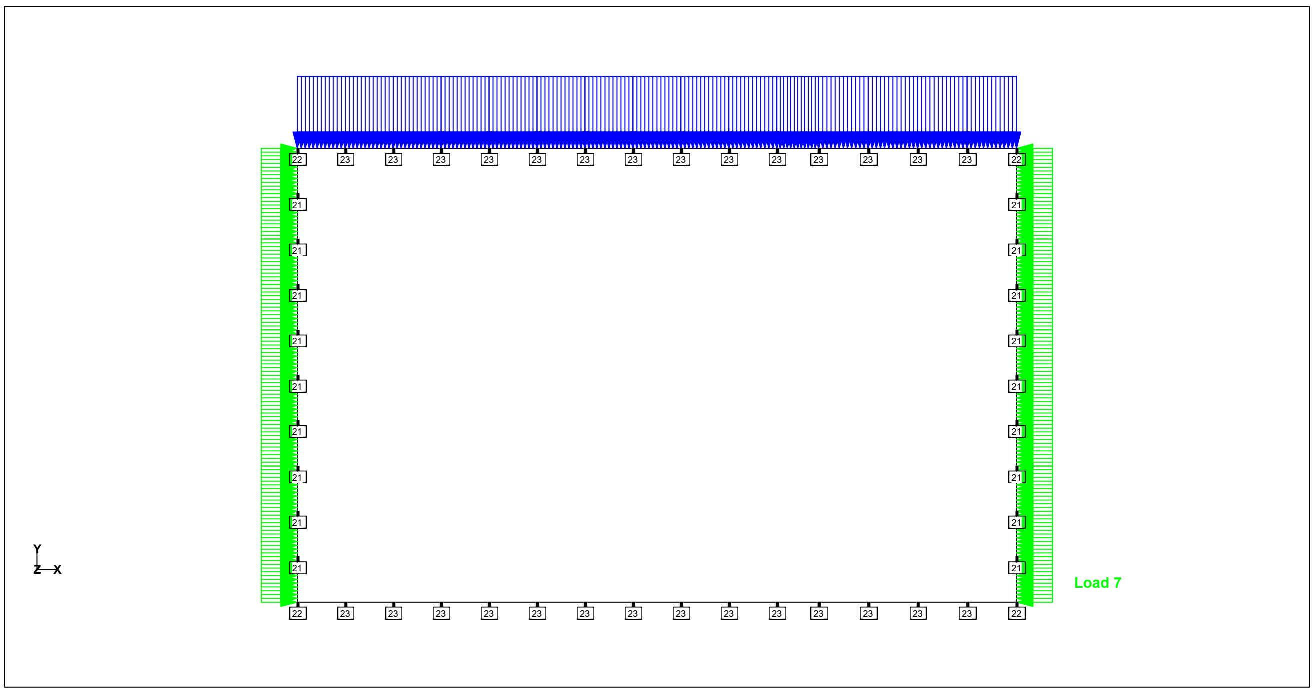
WATER(WT AT GROUND)

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	



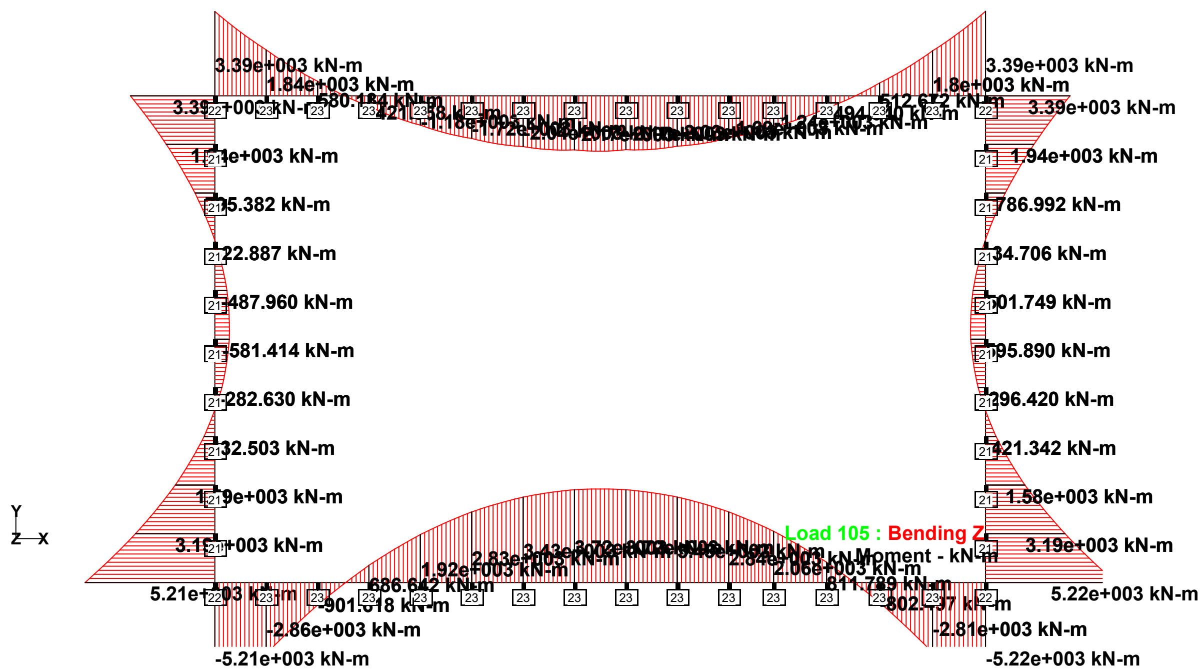
EP(DRY)

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	



SURCHARGE

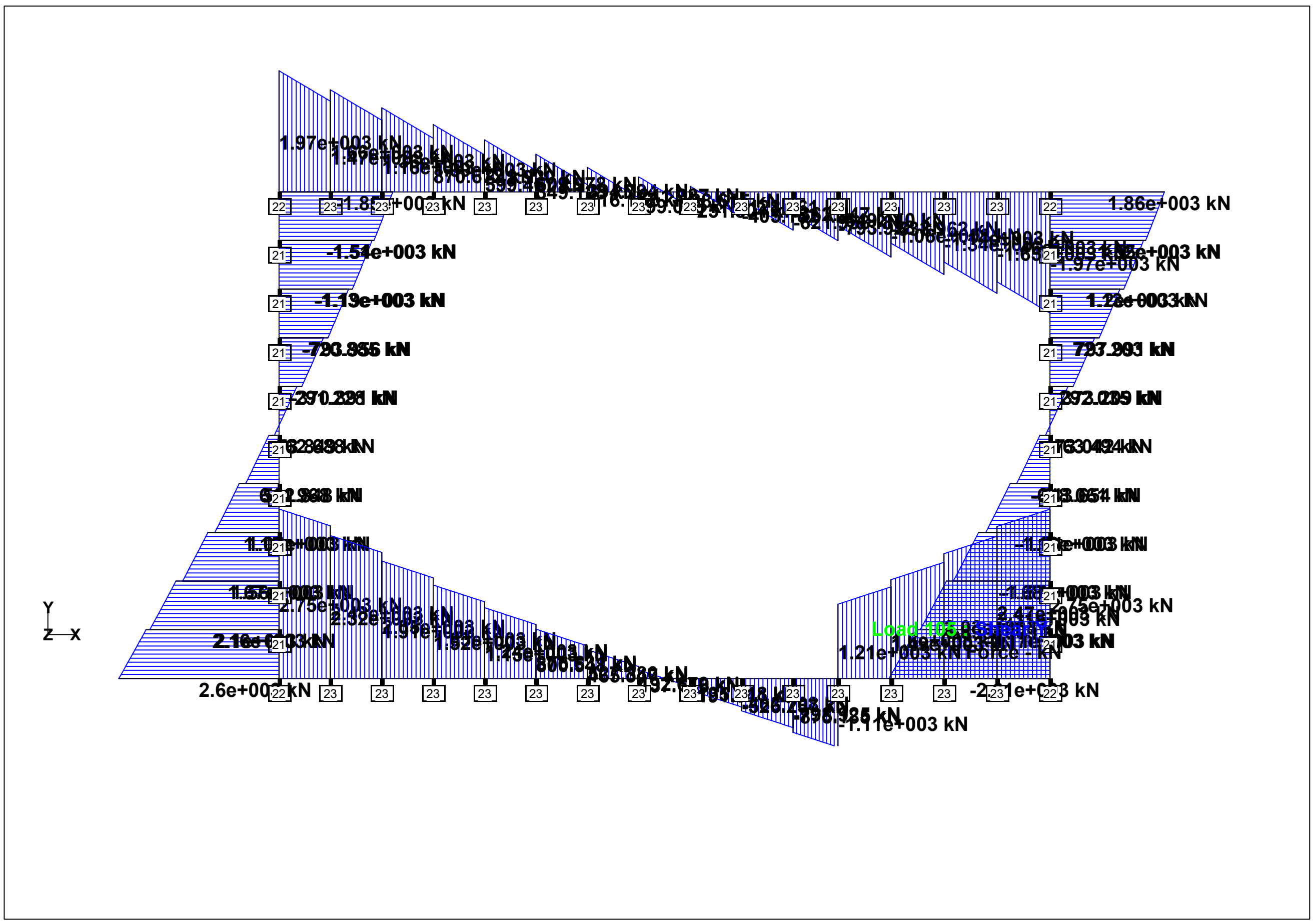
Software licensed to	Job No	Sheet No **23**	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
	By KCh	Date 03-Sep-24	Chd CSa
Client	File I40172_C&C section (3 la	Date/Time 05-Sep-2024 19:38	



BENDING(Mz)

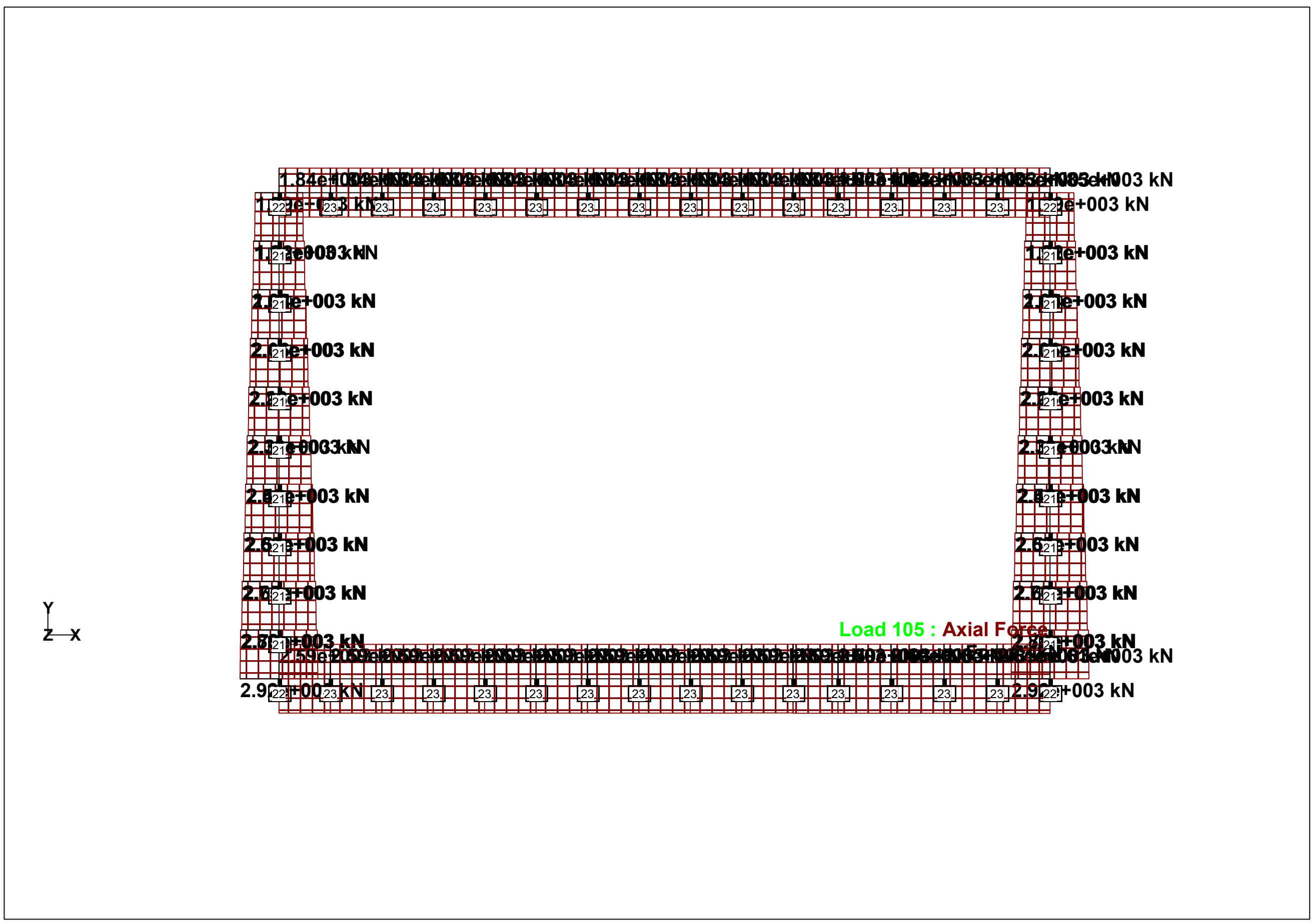
Software licensed to

Job Title I40172_C&C (3 lane)	Job No	Sheet No **24**	Rev A
	Part		
	Ref		
	By KCh	Date 03-Sep-24	Chd CSa
Client	File I40172_C&C section (3 la	Date/Time 05-Sep-2024 19:38	



shear

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

GC GEOCONSULT	**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/bd2		=	2.772	
Mulim		=	3762.18	kNm
Mulim/bd2		=	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 ±√(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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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 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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 5256.98 mm^2

Minimum area of steel required (0.12% on each face in one direction)	=	1090.80 mm^2
Required area of steel	=	5256.98 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 Longitudianl Bar

Longituanal Bar shall be Maxima of

0.12 % of Cross Sectional Area	=	1078.8 mm^2
0.2 Times of Main Bar	=	1608 mm^2
Longitunal 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

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 agianst 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	**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

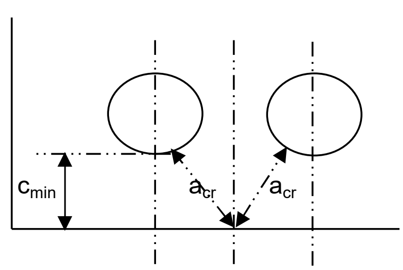
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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) =	1493333333		
Axial Force (P) (N) =	2089000		
Tension R/F=	32T	100c/c	(1st Layer)
	T	85c/c	(2nd Layer)
	T	85c/c	(3rd Layer)
Diameter of Spacer Bar=	T	mm	
Dia of Link Bar=	10	mm	

d (mm) =	883
Ast (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)

a'(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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00015

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00116

Average strain e_m = 0.000989572

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm

crack width (mm) w = 0.178 < 0.2 mm

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) = 45 mm

crack width (mm) w = 0.1336 < 0.2 mm

OK

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/bd2		=	2.227	
Mulim		=	3762.18	kNm
Mulim/bd2		=	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 ±√(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

2m+0.5m away from the support

Effective Thickness = 909 mm

Area of steel required = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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 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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 3312.37 mm^2

Minimum area of steel required (0.12% on each face in one direction) = 1095.00 mm^2

Required area of steel = 3312.37 mm^2

Required spacing of bars = 125 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

5)Design for Longitudianl Bar

Longituanal Bar shall be Maxima of

0.12 % of Cross Sectional Area = 1078.8 mm^2

0.2 Times of Main Bar = 982 mm^2

Longitunal 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 agianst 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

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

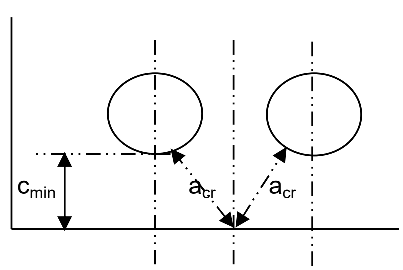
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(1st Layer)
	T	85c/c	(2nd Layer)
	T	85c/c	(3rd Layer)
Diameter of Spacer Bar=	T	mm	
Dia of Link Bar=	10	mm	

d (mm) =	883
Ast (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)

a'(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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00012

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00094

Average strain e_m = 0.000763887

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm

crack width (mm) w = 0.137 < 0.2 mm

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) = 45 mm

crack width (mm) w = 0.1031 < 0.2 mm

OK

GEOCONSULT	**GEOCONSULT India Pvt Ltd**	**APPENDIX-3**	
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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

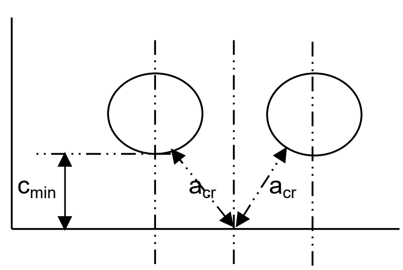
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(1st Layer)
	T	85c/c	(2nd Layer)
	T	85c/c	(3rd Layer)
Diameter of Spacer Bar=	T	mm	
Dia of Link Bar=	10	mm	

d (mm) =	890
Ast (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)

a'(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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00009

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00105

Average strain e_m = 0.000754368

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm

crack width (mm) w = 0.138 < 0.2 mm

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) = 45 mm

crack width (mm) w = 0.1018 < 0.2 mm

OK

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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

	=	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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

	=	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 = $\frac{0.5 \times fck \times b \times d \times \{1-[1-4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

	=	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 Longitudianl 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
Longitunal 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 agianst 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 .

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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

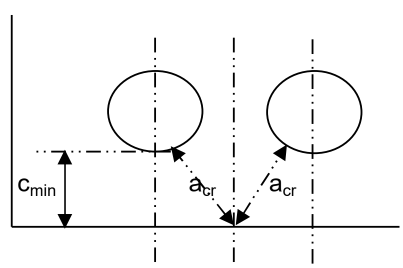
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(1st Layer)
	T	85c/c	(2nd Layer)
	T	85c/c	(3rd Layer)
Diameter of Spacer Bar=	T	mm	
Dia of Link Bar=	10	mm	

d (mm) =	883
Ast (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)

a'(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, e2 = ((P/b*h) / Eeff)

e_2 =	0.00016

Net effective Strain e'1 = e1 - e2

e'_1 =	0.00123

Average strain e_m = 0.001061229

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm			
crack width (mm) w =	0.191	<	0.2 mm	
	OK			

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45 mm			
crack width (mm) w =	0.1433	<	0.2 mm	
	OK			

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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

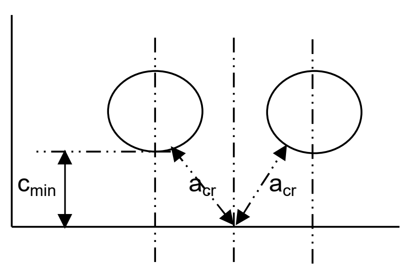
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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) =	766666666.7		
Axial Force (P) (N) =	1839000		
Tension R/F=	20T	100c/c	(1st Layer)
	T	85c/c	(2nd Layer)
	T	85c/c	(3rd Layer)
Diameter of Spacer Bar=	T	mm	
Dia of Link Bar=	10	mm	

d (mm) =	895
Ast (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)

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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00013

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00146

Average strain e_m = 0.000982178

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm

crack width (mm) w = 0.181 < 0.2 mm

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) = 45 mm

crack width (mm) w = 0.1326 < 0.2 mm

OK

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/bd2		=	3.312	
Mulim		=	5622.31	kNm
Mulim/bd2		=	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
2m+0.5m away from the support
Effective Thickness = 1109 mm

Area of steel required = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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 Longitudianl Bar

Longituanal Bar shall be Maxima of
0.12 % of Cross Sectional Area = 1318.8 mm^2
0.2 Times of Main Bar = 3217 mm^2
Longitunal 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

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 agianst 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

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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

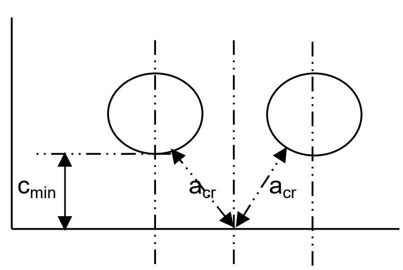
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(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 = 0.000897301

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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00014

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00090

Average strain e_m = 0.000800976

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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	mm		
crack width (mm) w =	0.145	<	0.2	mm
	OK			

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45	mm		
crack width (mm) w =	0.1081	<	0.2	mm
	OK			

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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

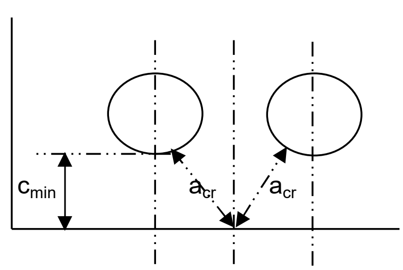
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(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 = 0.000842117

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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00014

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00084

Average strain e_m = 0.000736925

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm

crack width (mm) w = 0.133 < 0.2 mm

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) = 45 mm

crack width (mm) w = 0.0995 < 0.2 mm

OK

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/bd2		=	2.133
Mulim		=	5622.31 kNm
Mulim/bd2		=	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 ±√(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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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) = **2226** kNm

Effective Thickness = 1109 mm

Area of steel required = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 4929.63 mm^2

Minimum area of steel required (0.12% on each face in one direction) = 1330.80 mm^2
Required area of steel = 4929.63 mm^2
Required spacing of bars = 150 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

5)Design for Longitudianl Bar

Longituanal Bar shall be Maxima of
0.12 % of Cross Sectional Area = 1318.8 mm^2
0.2 Times of Main Bar = 1608 mm^2
Longitunal 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

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 agianst 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

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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

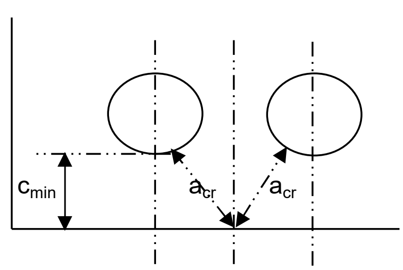
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(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) =	1083
Ast (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)

a'(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, e2 = ((P/b*h) / Eeff)

e_2 =	0.00011

Net effective Strain e'1 = e1 - e2

e'_1 =	0.00108

Average strain	e_m =	0.000875701	$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$
	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	mm		
crack width (mm) w =	0.159		<	0.2 mm
OK				

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45	mm		
crack width (mm) w =	0.1182		<	0.2 mm
OK				

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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

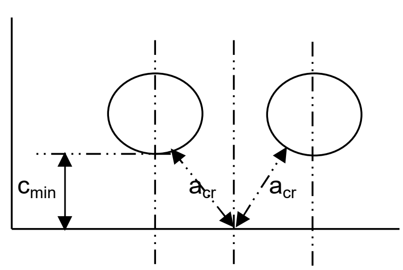
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(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) =	1083
Ast (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)

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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00011

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00092

Average strain e_m = 0.000714181

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm		
crack width (mm) w =	0.130	<	0.2 mm
	OK		

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45 mm		
crack width (mm) w =	0.0964	<	0.2 mm
	OK		

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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

	=	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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

	=	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 = $\dfrac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

	=	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 Longitudianl 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
Longitunal 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 agianst 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 .

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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

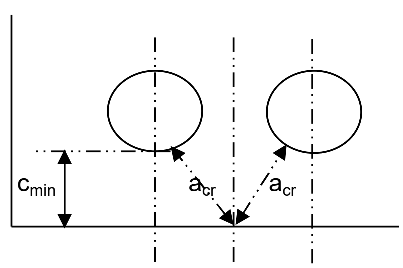
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(1st Layer)
	32T	85c/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) =	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)

a'(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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00018

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00084

Average strain e_m = 0.000747889

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm		
crack width (mm) w =	0.135	<	0.2 mm
	OK		

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45 mm		
crack width (mm) w =	0.1010	<	0.2 mm
	OK		

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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

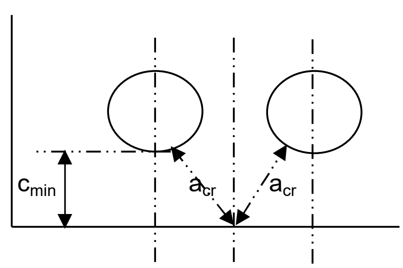
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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) =	651333333.3		
Axial Force (P) (N) =	925000		
Tension R/F=	20T	100c/c	(1st Layer)
	T	85c/c	(2nd Layer)
	T	85c/c	(3rd Layer)
Diameter of Spacer Bar=	T	mm	
Dia of Link Bar=	10	mm	

d (mm) =	1095
Ast (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

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, e2 = ((P/b*h) / Eeff)

e_2 =	0.00005

Net effective Strain e'1 = e1 - e2

e'_1 =	0.00102

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

Average strain e_m =	0.000453185		
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	mm		
crack width (mm) w =	0.084		<	0.2 mm
	OK			

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45	mm		
crack width (mm) w =	0.0612		<	0.2 mm
	OK			

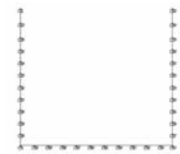
ANNEXURE – 4
RAMP PORTION

ANNEXURE 4

Ground level at C&C location	0	m	
Top level at C&C loacation	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		

GL 0

GWT TL 0 m



9.7

BL 9.7 m

OVERBURDEN PRESSURE (SUBMERGED)

side earth pressure at wall top	k0 x overburden pressure at wall top	0	
side earth pressure at wall bottom	k0 x overburden pressure at Invert	37.9561	88.27

HYDROSTATIC PRESSURE

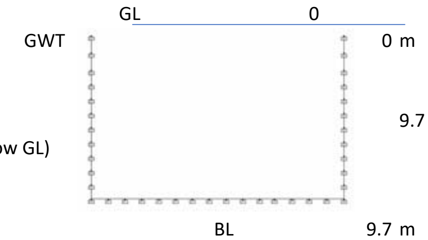
Hydrostratic pressure at top slab	height of water table above top slab x unit weight of water	0
bottom	height of water table at Invert x unit weight of water	97

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 loacation	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	k0 x overburden pressure at wall top	0
side earth pressure at wall bottom	k0 x 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		

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	HYDROSTRATIC (WT AT GROUND)
Primary	4	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYYM
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.!
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.(

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

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

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

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	-	-	-	-	-	-
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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.

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT AT GROUND)	Live
3	HYDROSTRATIC (WT AT GROUND)	Live
4	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYYM	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	HYDROSTRATIC (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 SYYM	1.50
103	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.!	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT AT GROUND)	1.50
		3	HYDROSTRATIC (WT AT GROUND)	1.50
		7	SURCHARGE SYYM	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	HYDROSTRATIC (WT AT GROUND)	1.00
202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	1	DL (SELF WEIGHT)	1.00
		7	SURCHARGE SYYM	1.00
		4	EARTH PRESSURE (DRY)	1.00
203	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.(	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT AT GROUND)	1.00
		7	SURCHARGE SYYM	1.00
		3	HYDROSTRATIC (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

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	-	-

3 HYDROSTRATIC (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

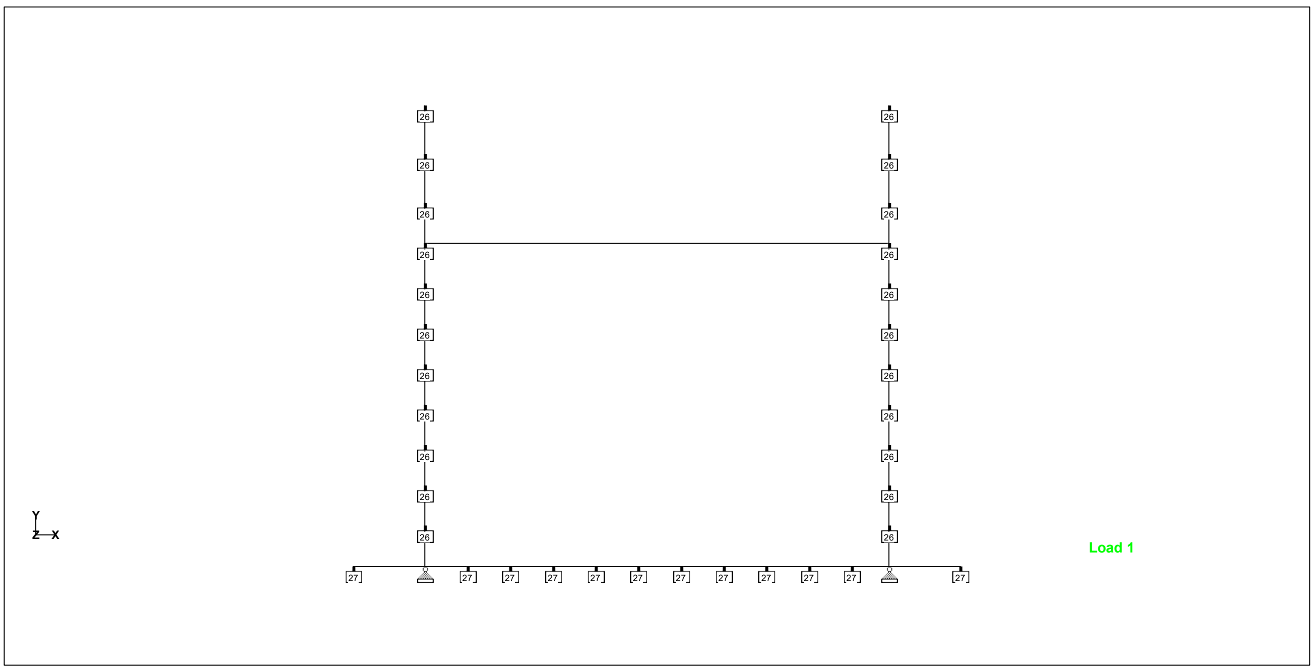
Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
2	TRAP	kN/m	GX	0.000	-	-8.454	-	-
4	TRAP	kN/m	GX	80.000	-	72.990	-	-
19	TRAP	kN/m	GX	-16.907	-	-23.917	-	-
20	TRAP	kN/m	GX	-23.917	-	-30.928	-	-
21	TRAP	kN/m	GX	-30.928	-	-37.938	-	-
22	TRAP	kN/m	GX	-37.938	-	-44.949	-	-
23	TRAP	kN/m	GX	-44.949	-	-51.959	-	-
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	-	-	-	-

4 EARTH PRESSURE (DRY) : Beam Loads Cont...

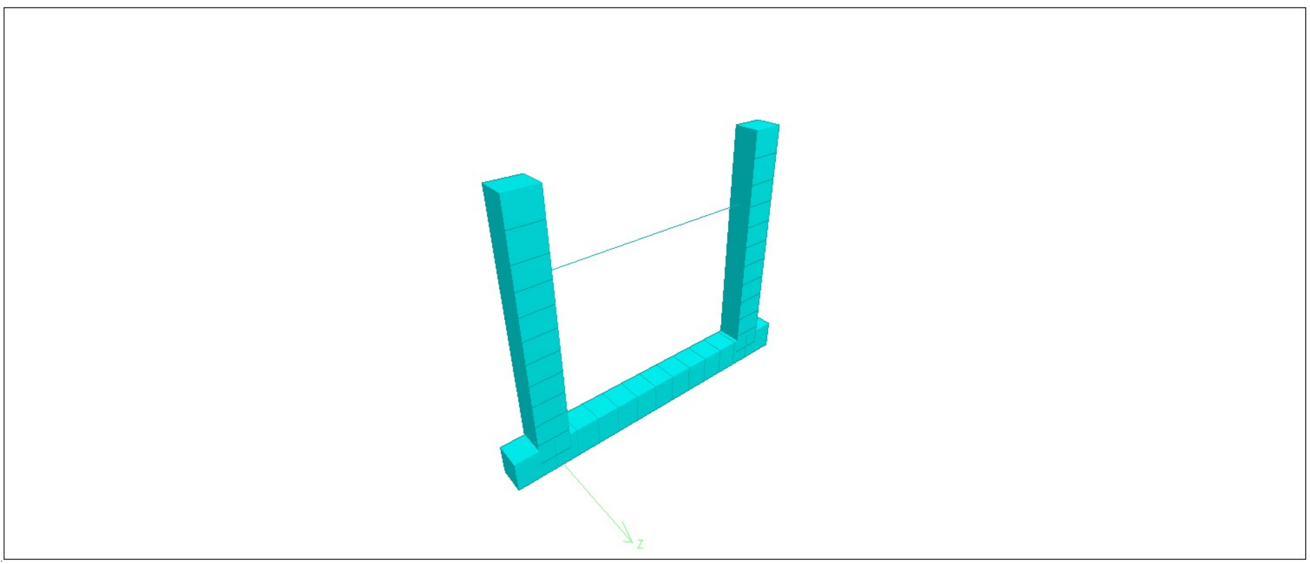
Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
55	UNI	kN/m	GY	-185.000	-	-	-	-

7 SURCHARGE SYYM : 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	-	-	-	-

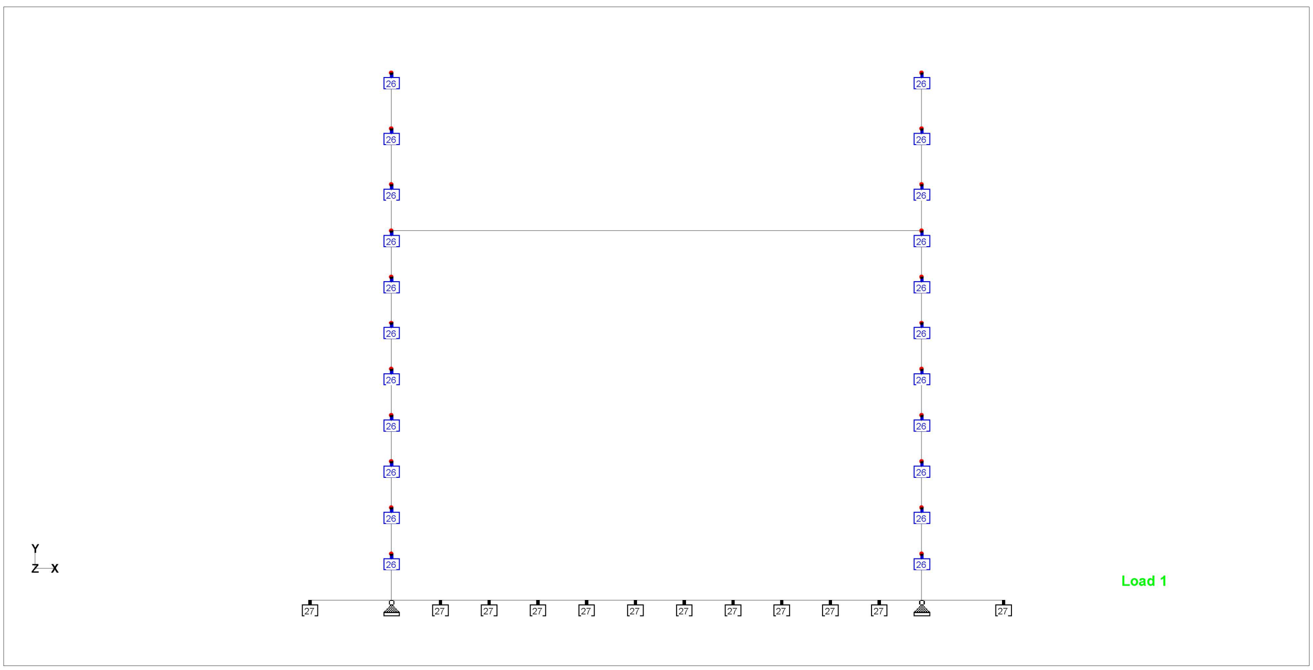


Whole Structure



3D Rendered View

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	



SUPPORTS

Software licensed to	Job No	Sheet No **12**		Rev A
	Part			
Job Title I40172_C&C (3 lane)	Ref			
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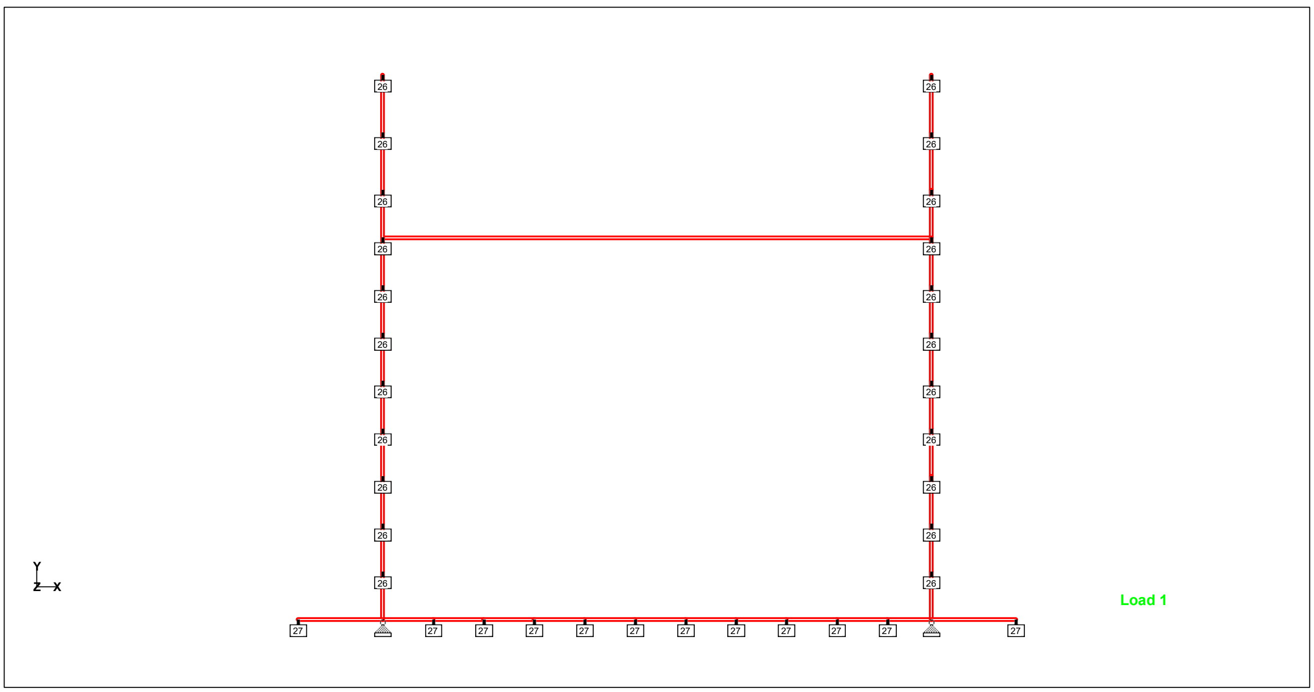

DL(SELF WEIGHT)

Software licensed to	Job No	Sheet No **13**	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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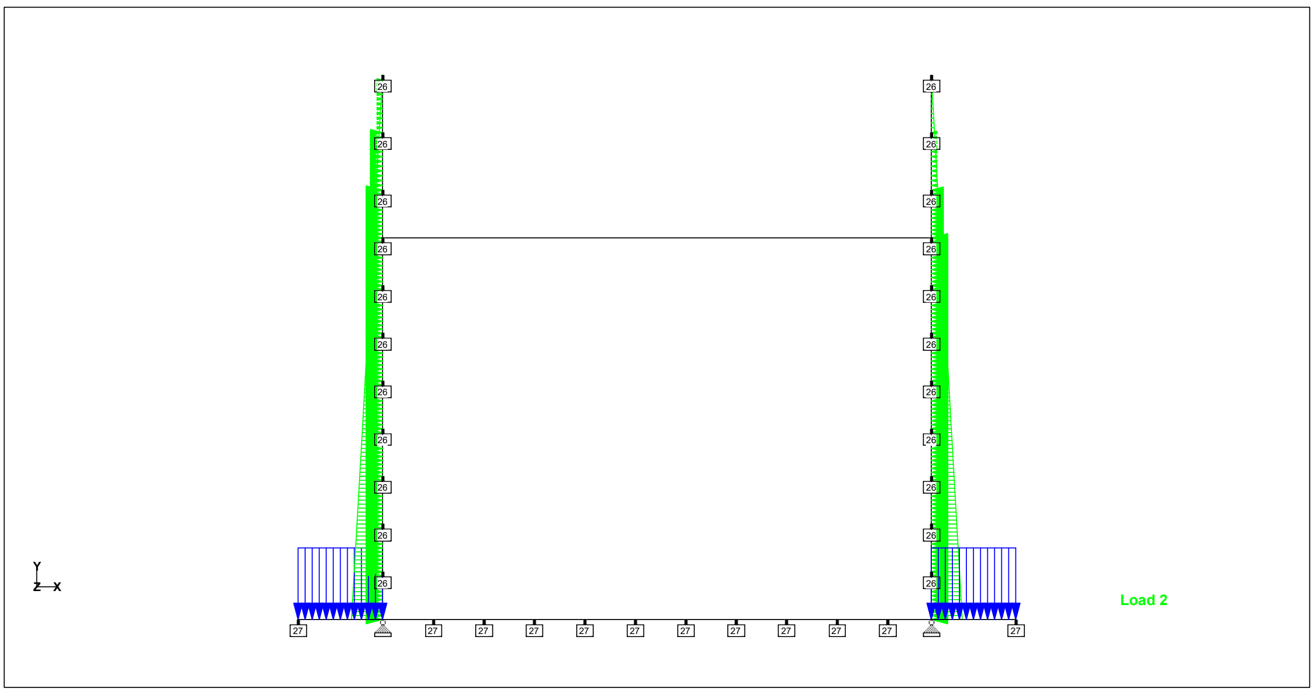

EP(WT AT GROUND)

Software licensed to	Job No	Sheet No 14	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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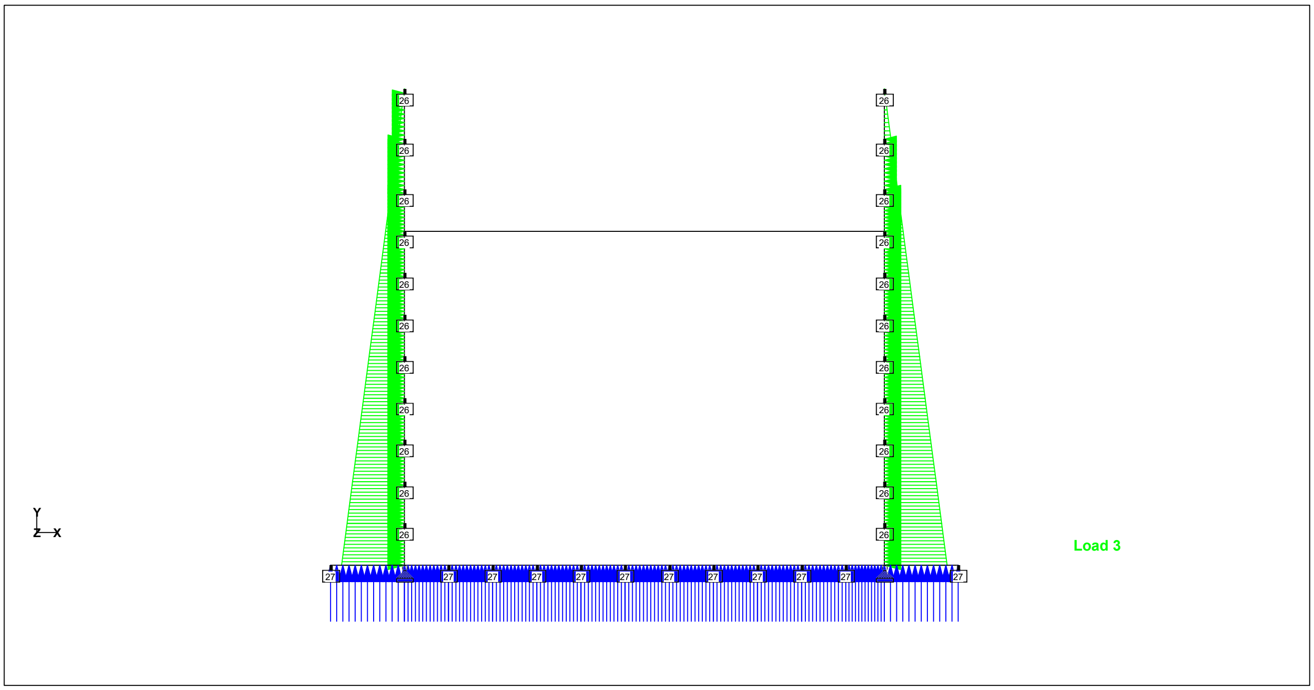
Client	File I40172_RAMP (2 lane) wi	Date/Time 11-Sep-2024 12:53	



WATER(WT AT GROUND)

Software licensed to	Job No	Sheet No 15	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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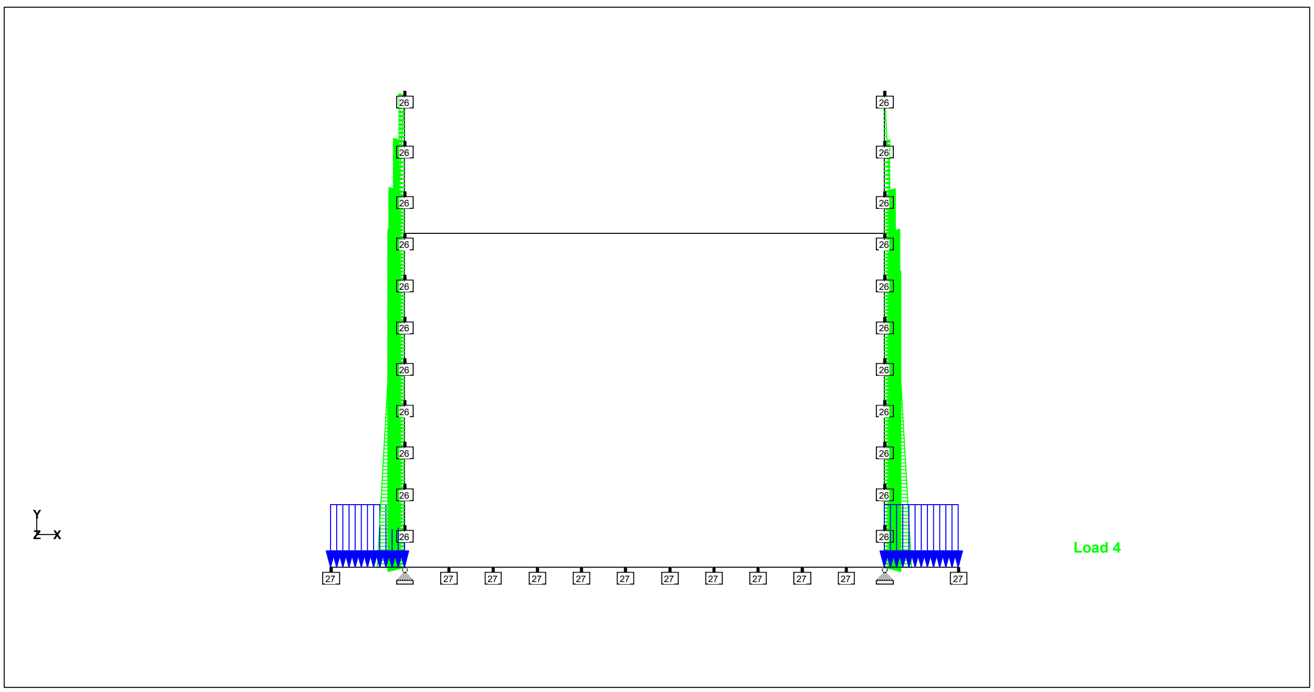

EP(DRY)

Software licensed to	Job No	Sheet No **16**	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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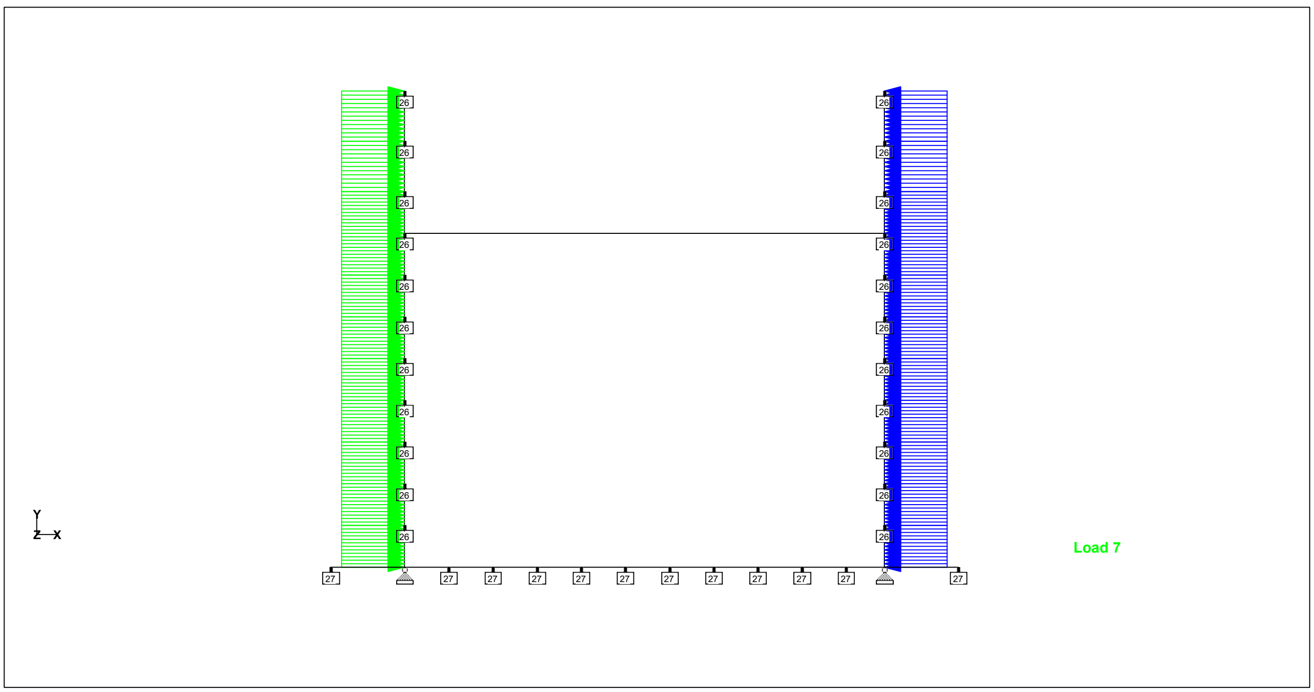

SURCHARGE

Software licensed to	Job No	Sheet No **17**	Rev A
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Job Title I40172_C&C (3 lane)	Ref		
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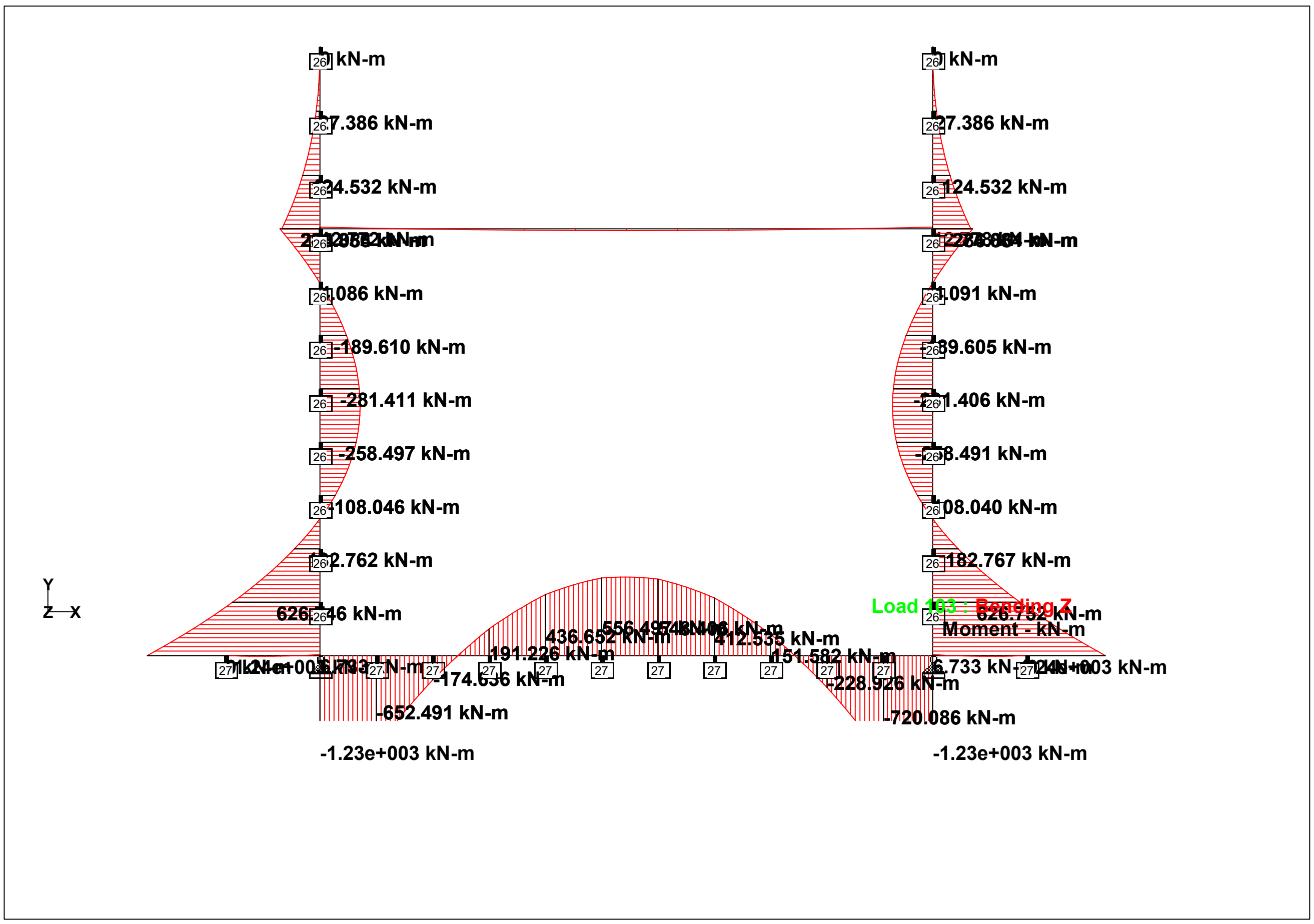

Mz

Software licensed to	Job No	Sheet No **18**	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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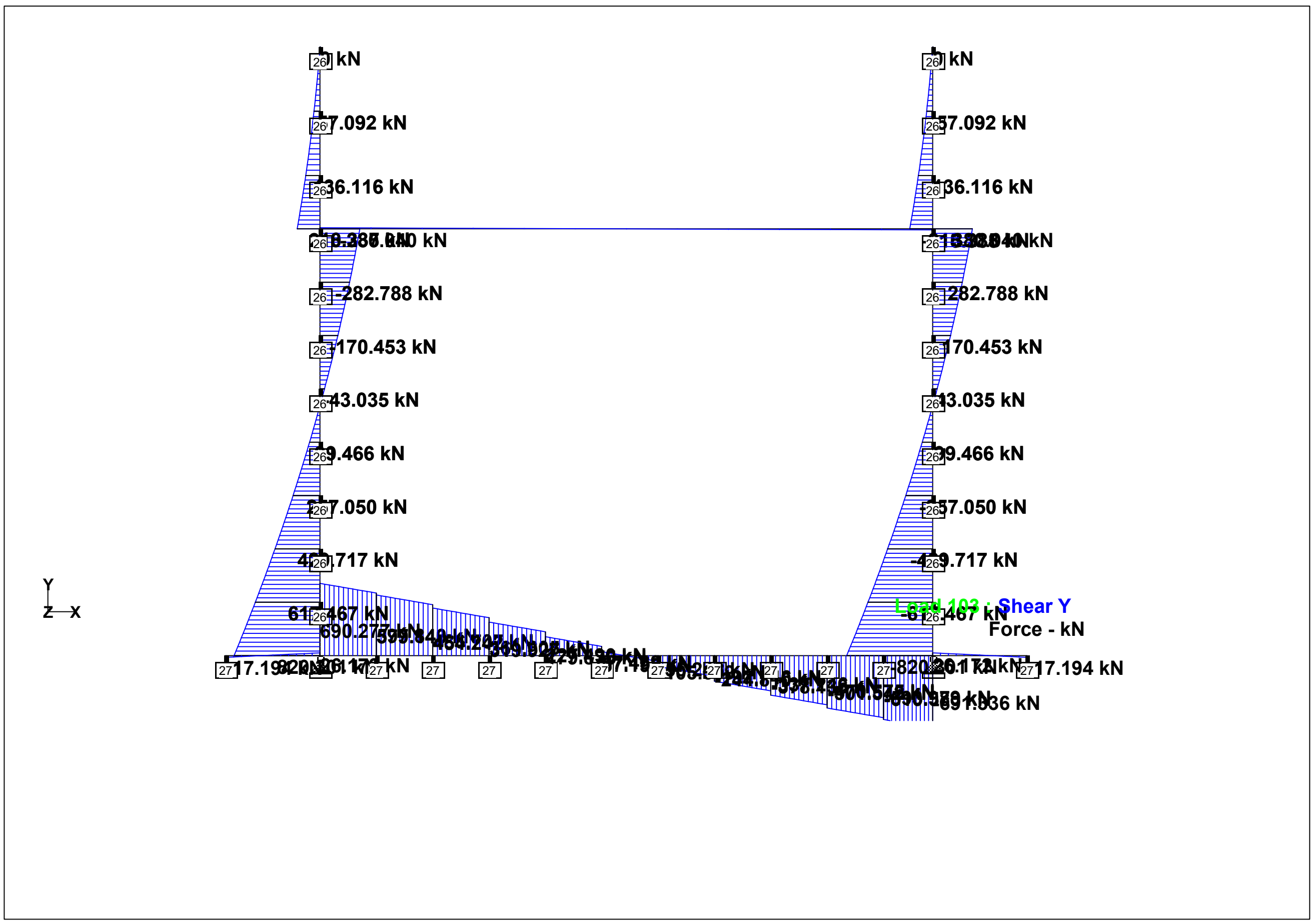

SHEAR

Software licensed to	Job No	Sheet No 19	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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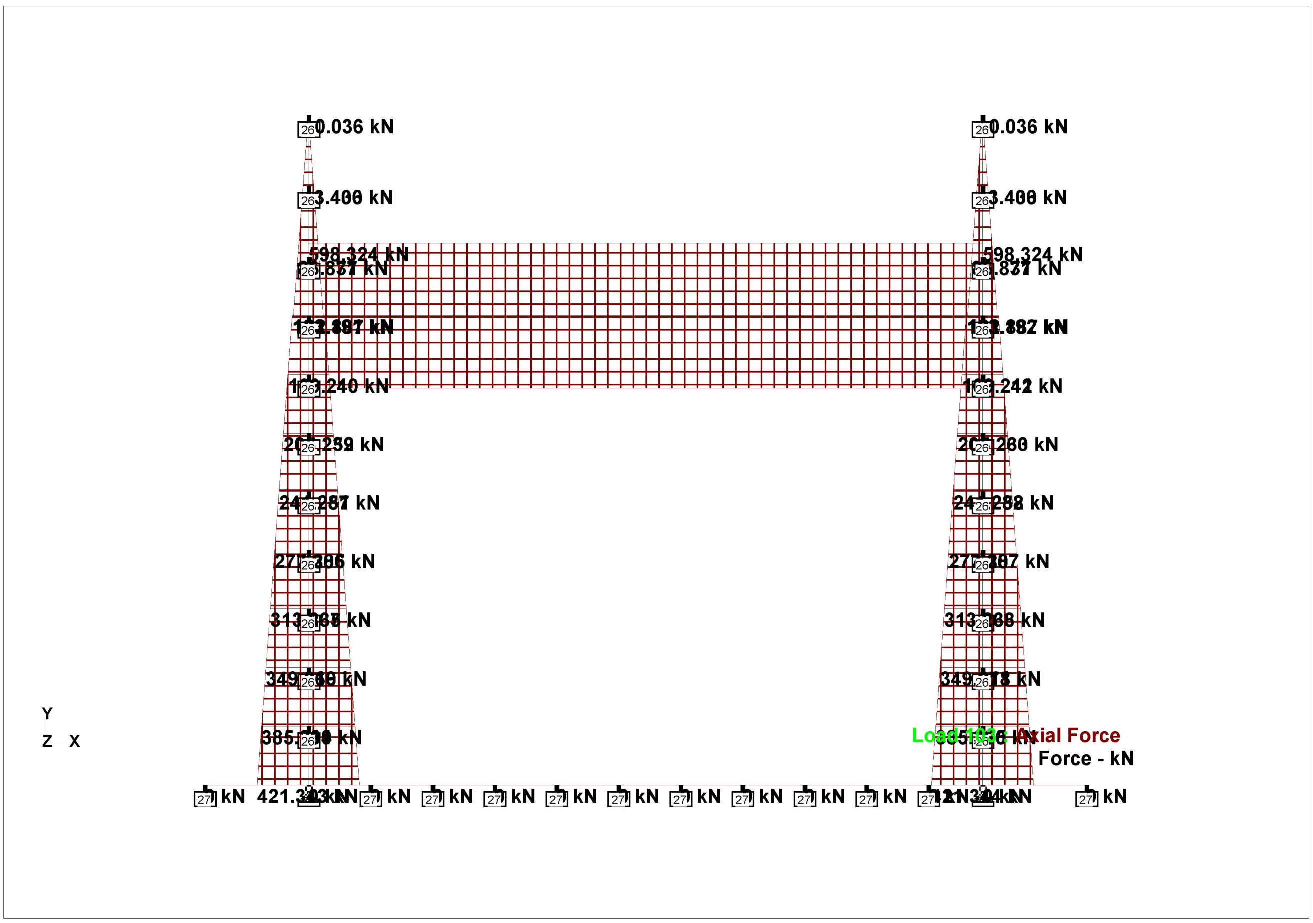


AXIAL

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	HYDROSTRATIC (WT AT GROUND)
Primary	4	EARTH PRESSURE (DRY)
Primary	7	SURCHARGE SYYM
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.!
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.(

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

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

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

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.

Primary Load Cases

Number	Name	Type
1	DL (SELF WEIGHT)	Dead
2	EARTH PRESSURE (WT AT GROUND)	Live
3	HYDROSTRATIC (WT AT GROUND)	Live
4	EARTH PRESSURE (DRY)	Live
7	SURCHARGE SYYM	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	HYDROSTRATIC (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 SYYM	1.50
103	1.5DL + 1.5EP(GWT) + 1.5WL(GWT) + 1.!	1	DL (SELF WEIGHT)	1.50
		2	EARTH PRESSURE (WT AT GROUND)	1.50
		3	HYDROSTRATIC (WT AT GROUND)	1.50
		7	SURCHARGE SYYM	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	HYDROSTRATIC (WT AT GROUND)	1.00
202	1.0DL + 1.0EP(DRY) + 1.0SURCHARGE	1	DL (SELF WEIGHT)	1.00
		7	SURCHARGE SYYM	1.00
		4	EARTH PRESSURE (DRY)	1.00
203	1.0DL + 1.0EP(GWT) + 1.0WL(GWT) + 1.(	1	DL (SELF WEIGHT)	1.00
		2	EARTH PRESSURE (WT AT GROUND)	1.00
		7	SURCHARGE SYYM	1.00
		3	HYDROSTRATIC (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

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 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	-	-

3 HYDROSTRATIC (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	-	-

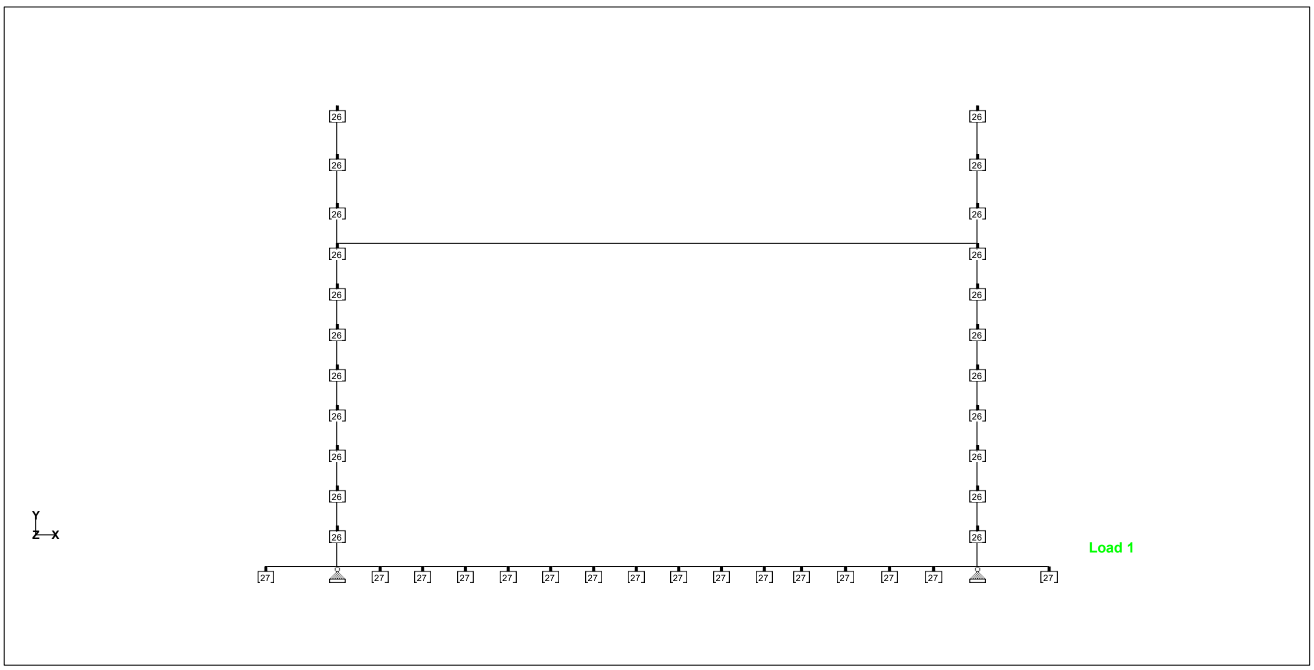
4 EARTH PRESSURE (DRY) : Beam Loads Cont...

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	-	-	-	-

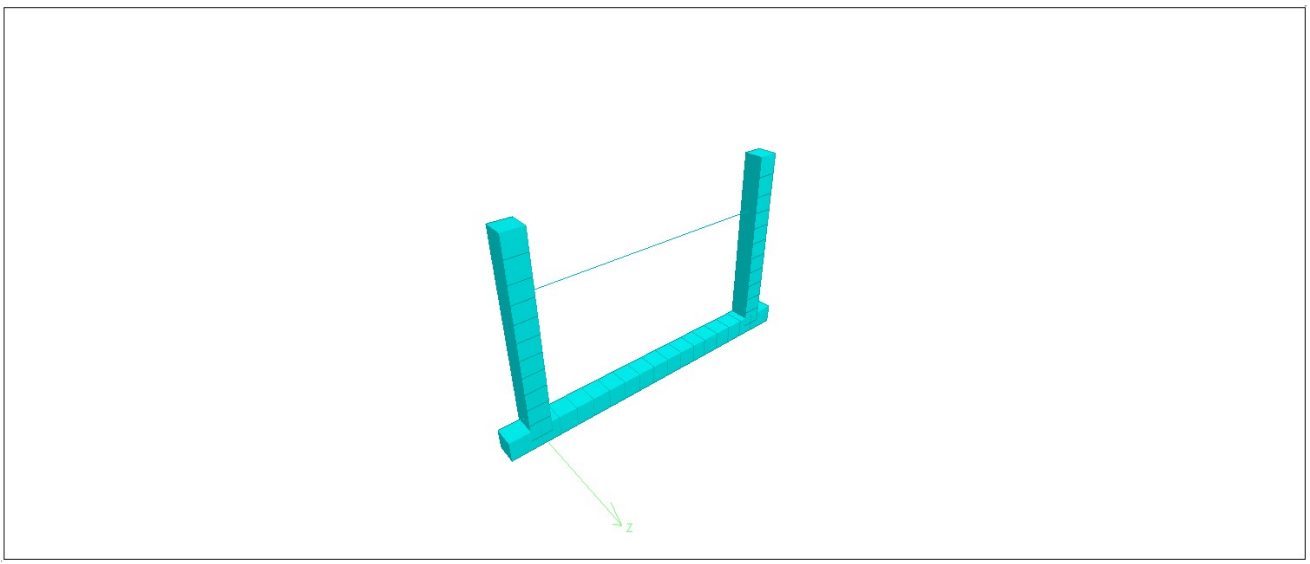
7 SURCHARGE SYYM : Beam Loads

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	-	-	-	-

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	



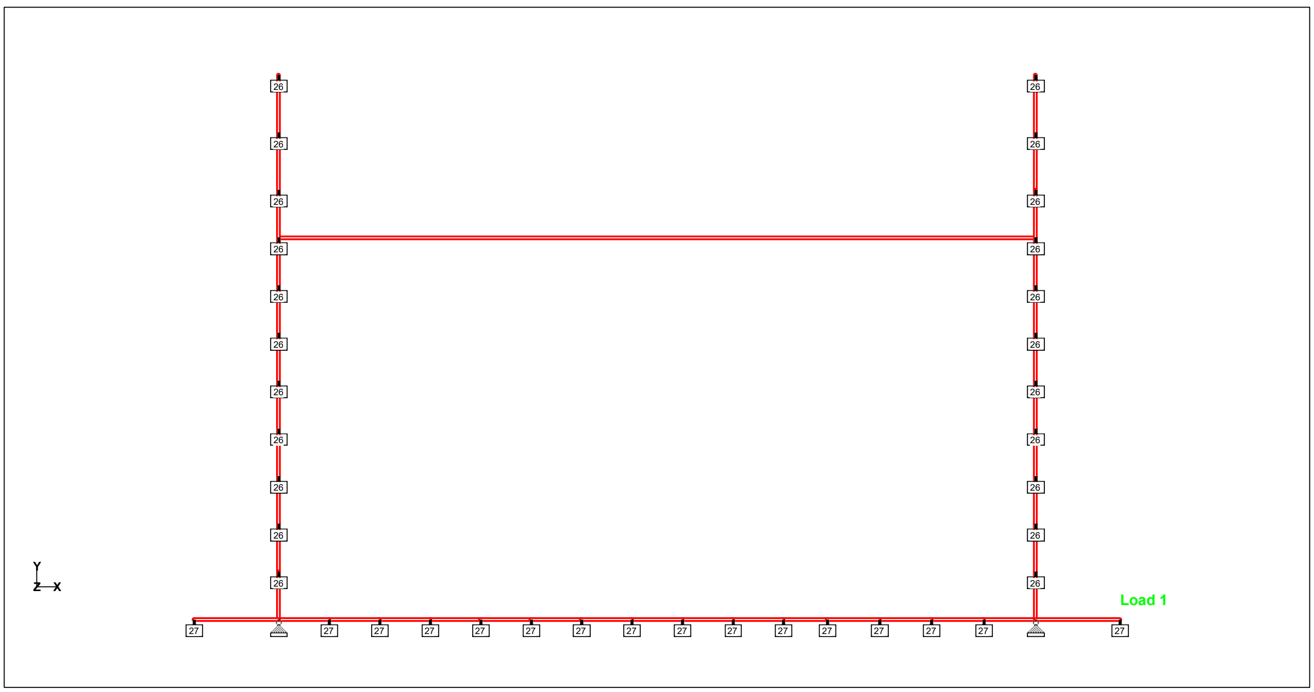
Whole Structure (Input data was modified after picture taken)



3D Rendered View (Input data was modified after picture taken)

SUPPORTS (Input data was modified after picture taken)

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	



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Software licensed to	Job No	Sheet No 13	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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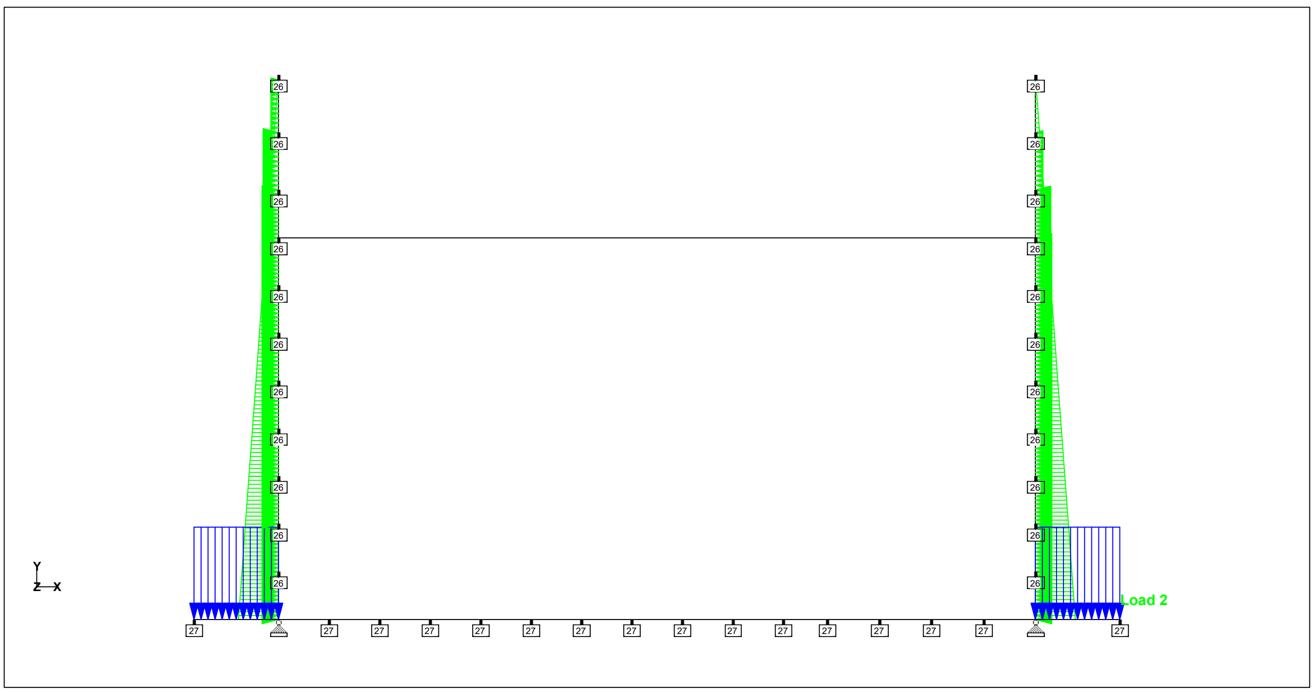
Client	File I40172_RAMP section (3	Date/Time 11-Sep-2024 16:02	



EP (Input data was modified after picture taken)

Software licensed to	Job No	Sheet No 14	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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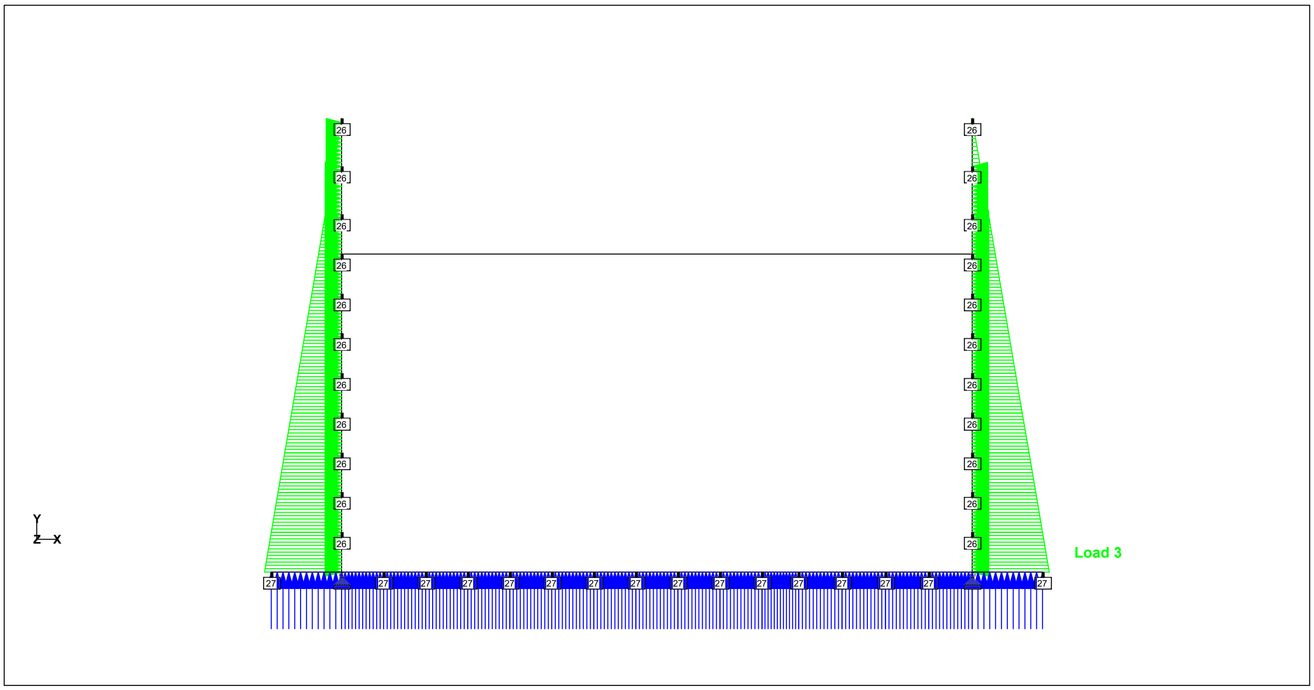

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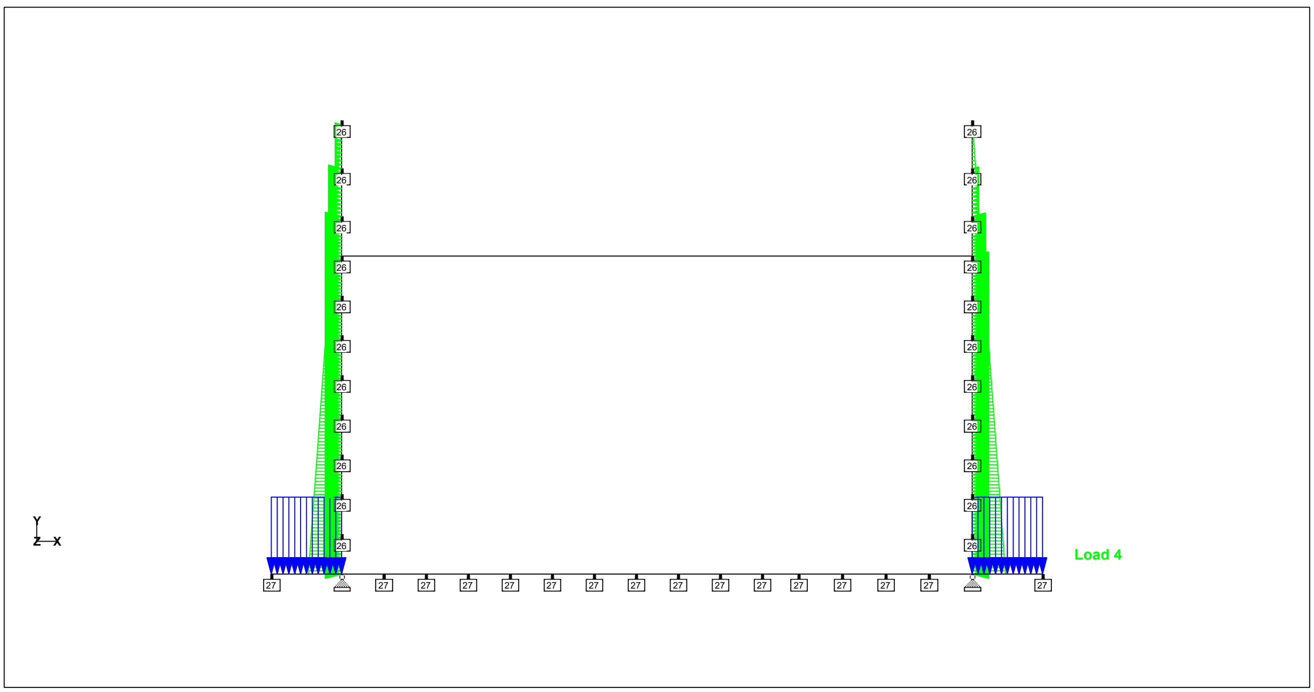

EP(DRY) (Input data was modified after picture taken)

Software licensed to	Job No	Sheet No **16**	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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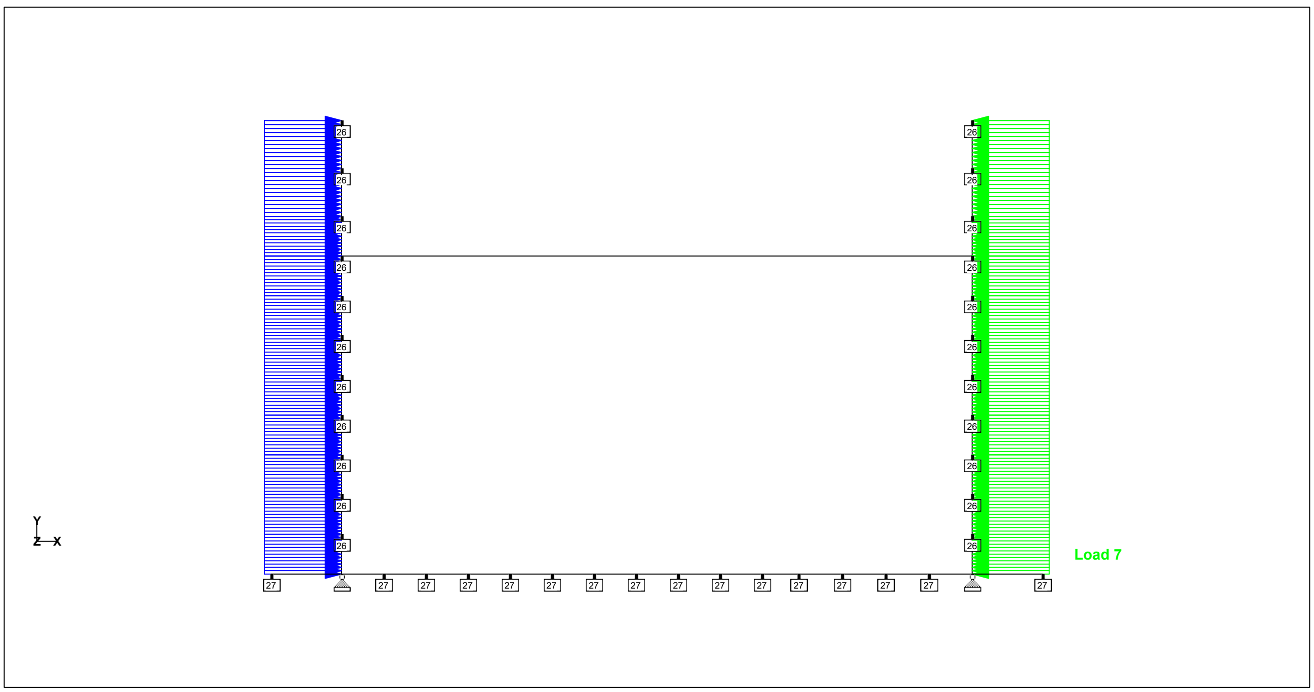
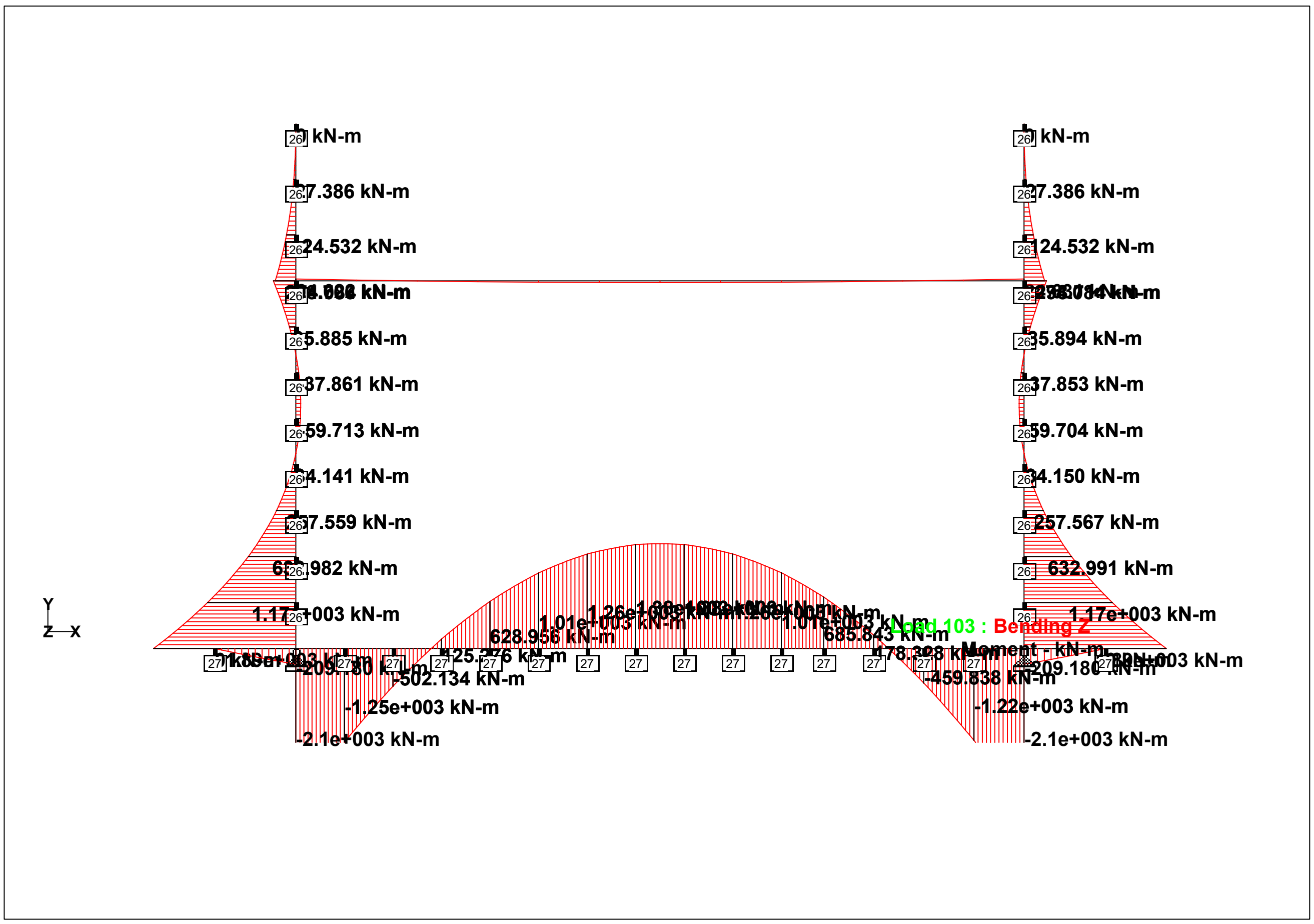


SURCHARGE (Input data was modified after picture taken)

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_RAMP section (3	Date/Time 11-Sep-2024 16:02	



Mz (Input data was modified after picture taken)

Software licensed to	Job No	Sheet No 18	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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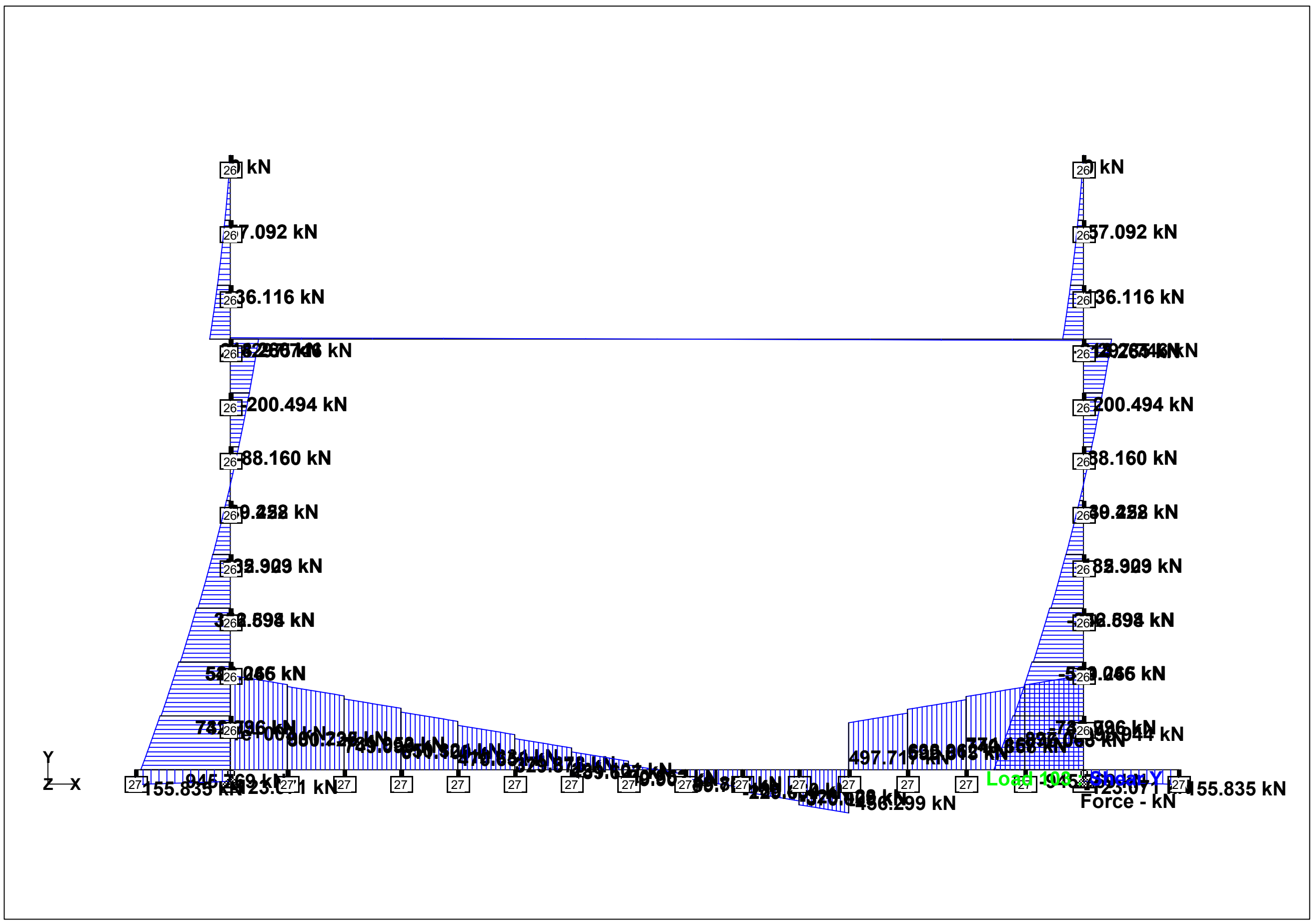
Client	File I40172_RAMP section (3	Date/Time 11-Sep-2024 16:02	



SHEAR

Software licensed to	Job No	Sheet No 19	Rev A
	Part		
Job Title I40172_C&C (3 lane)	Ref		
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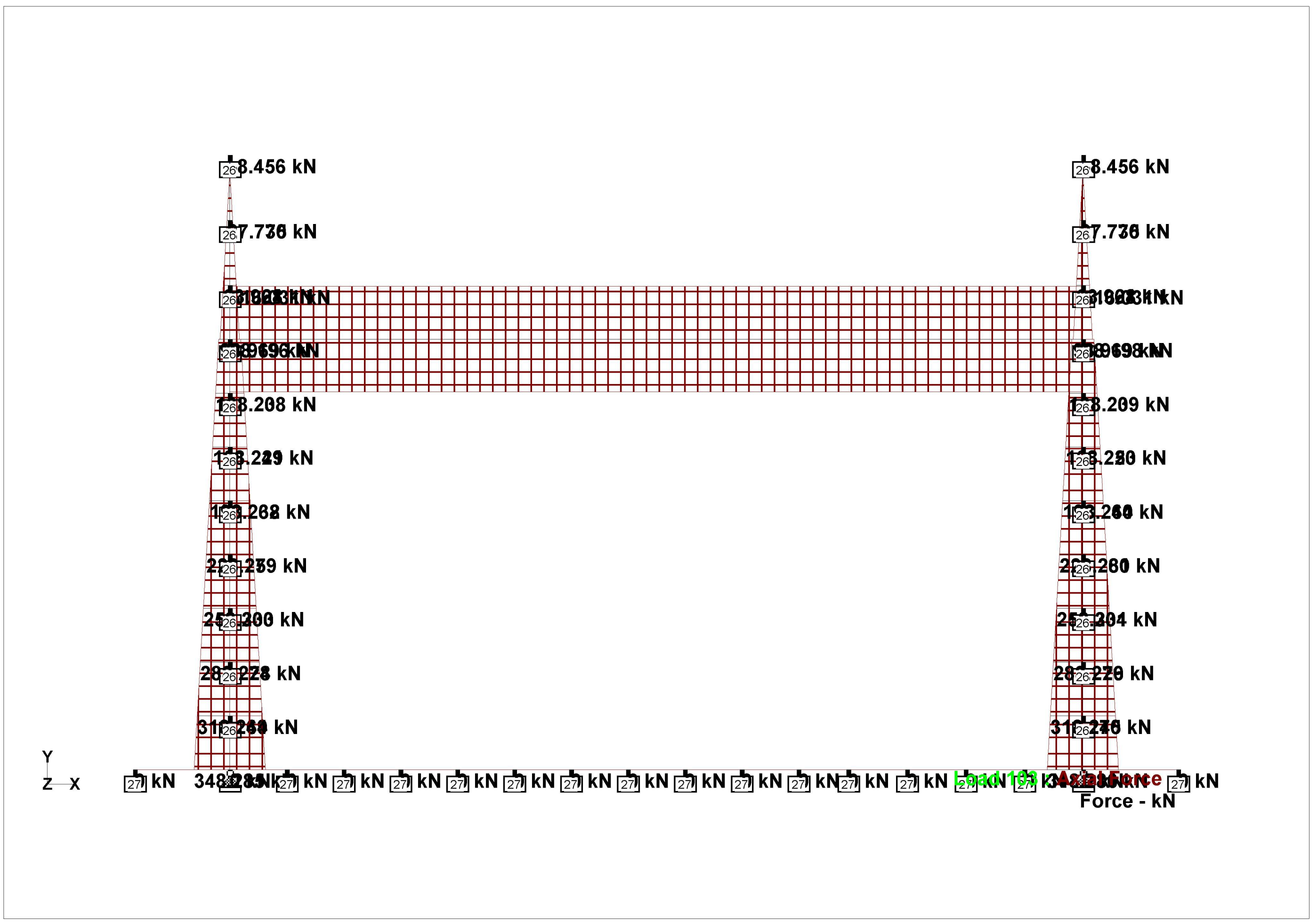
Client	File I40172_RAMP section (3	Date/Time 11-Sep-2024 16:02	



AXIAL

GC GEOCONSULT	**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/bd2		=	1.012	
Mulim		=	5658.18	kNm
Mulim/bd2		=	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 ±√(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

2m+0.5m away from the support

Effective Thickness	=	913 mm

Area of steel required = $\dfrac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

	=	0.00 mm^2
Minimum area of steel required (0.12% on each face in one direction)	=	1095.00 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 = $\dfrac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

	=	1452.08 mm^2
Minimum area of steel required (0.12% on each face in one direction)	=	1095.00 mm^2
Required area of steel	=	1452.08 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 Longitudianl Bar

Longituanal Bar shall be Maxima of

0.12 % of Cross Sectional Area	=	1323	mm^2
0.2 Times of Main Bar	=	982	mm^2
Longitunal 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 agianst 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	**GEOCONSULT India Pvt Ltd**	**APPENDIX-2**	
	A company of the GEOCONSULT group	Job no:	I40172
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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

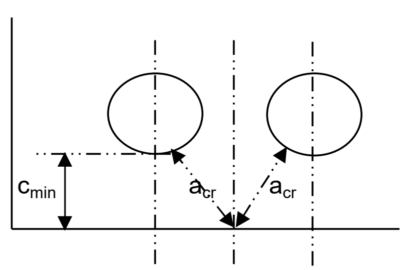
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(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) =	890
Ast (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)

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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00010

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00102

Average strain e_m = 0.000726461

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm		
crack width (mm) w =	0.133	<	0.2 mm
	OK		

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45 mm		
crack width (mm) w =	0.0981	<	0.2 mm
	OK		

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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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5} \}}{fy}$

	=	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 Longitudianl 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
Longitunal 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 agianst 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 .

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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

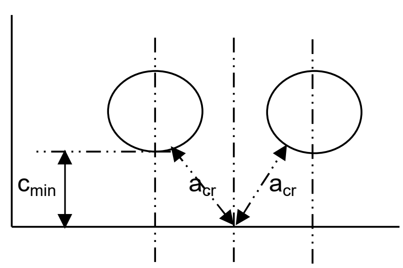
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(1st Layer)
	T	85c/c	(2nd Layer)
	T	85c/c	(3rd Layer)
Diameter of Spacer Bar=	T	mm	
Dia of Link Bar=	10	mm	

d (mm) =	890
Ast (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)

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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00021

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00092

Average strain e_m = 0.000622973

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm

crack width (mm) w = 0.114 < 0.2 mm

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) = 45 mm

crack width (mm) w = 0.0841 < 0.2 mm

OK

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/bd2		=	2.597	
Mulim		=	3762.18	kNm
Mulim/bd2		=	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 ±√(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 = $\dfrac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 M_z/(f_{ck} b d^2)]^{0.5}\}}{f_y}$

	=	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	=	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 = $\dfrac{0.5 \times f_{ck} \times b \times d \times \{1 - [1 - 4.6 M_z/(f_{ck} b d^2)]^{0.5}\}}{f_y}$

	=	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 Longitudianl Bar

Longituanal Bar shall be Maxima of

0.12 % of Cross Sectional Area	=	1078.8	mm^2
0.2 Times of Main Bar	=	982	mm^2
Longitunal 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	=	**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 agianst 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

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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

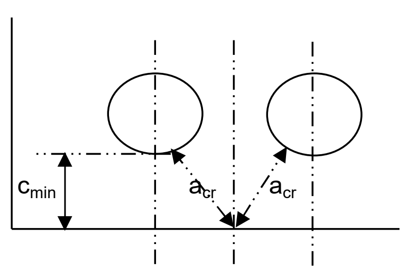
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(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) =	883
Ast (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)

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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00010

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00113

Average strain e_m = 0.000952965

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm

crack width (mm) w = 0.171 < 0.2 mm

OK

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) = 45 mm

crack width (mm) w = 0.1287 < 0.2 mm

OK

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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

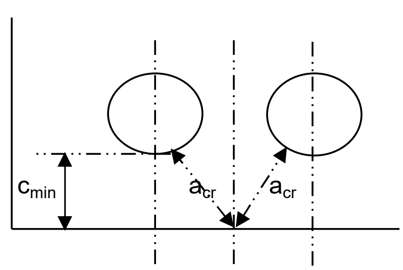
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(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) =	890
Ast (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)

a'(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, e2 = ((P/b*h) / Eeff)

e_2 = 0.00007

Net effective Strain e'1 = e1 - e2

e'_1 = 0.00120

Average strain e_m = 0.000908933

$$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$$

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 mm		
crack width (mm) w =	0.166	<	0.2 mm
	OK		

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45 mm		
crack width (mm) w =	0.1227	<	0.2 mm
	OK		

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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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 = $\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$

= 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 =
$$\frac{0.5 \times fck \times b \times d \times \{1- [1 - 4.6xM_z/(f_{ck}xbd^2)]^{0.5}\}}{fy}$$

	=	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 Longitudianl 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
Longitunal 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 agianst 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 .

GC GEOCONSULT	**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

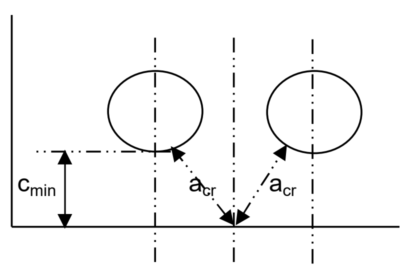
a_{cr} = distance from the point considered to the surface of the nearest longitudinal bar.

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	(1st Layer)
	T	85c/c	(2nd Layer)
	T	85c/c	(3rd Layer)
Diameter of Spacer Bar=	T	mm	
Dia of Link Bar=	10	mm	

d (mm) =	883
Ast (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)

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, e2 = ((P/b*h) / Eeff)

e_2 =	0.00021			

Net effective Strain e'1 = e1 - e2

e'_1 =	0.00089			
Average strain e_m =	0.000721041		$e_m = e_1 - \frac{b*(D - x)*(a' - x)}{3*Es*Ast*(d - x)}$	
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 mm			
crack width (mm) w =	0.130	<	0.2 mm	
	OK			

Width of crack directly under a bar on tension face of concrete (fig. 1)

a_{cr} (mm) =	45 mm			
crack width (mm) w =	0.0973	<	0.2 mm	
	OK			

ANNEXURE – 5
TEMPORARY SECANT PILE & STEEL, WALER FOR SHAFT & C&C

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/mm2

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				

$$\frac{d'}{D} = 0.104$$

$$\frac{pu}{fck\ D^2} = 0.03 \quad , \quad \frac{Mu}{fck\ \ D^3} = 0.054$$

From Sp 16,Chart 60	Pt/fck	=	0.042	, Ptc	=	1.47

Minimum Steel Required as per IS 2911-2010, Ptm = 0.4 %

Design reinforcement, Pt = **1.5** %

Reinforcement to be provided = 11545 mm^2

Using 25 mm tor steel = 490.87 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 mm^2 (Pt = 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	kN
Effective Shear Area of secant pile	=	1130973	mm^2
Shear Stress in secant Pile	=	0.64	N/mm^2
Allowable Shear Stress	=	0.75	N/mm^2
Shear force agianst which stirrups required	=	-85	KN
Considering 10 mm Dia stirrups		**10**	mm
Spacing of stirrups	=	-665	mm
Provide shear reinforcement at	=	180	mm

1.3 Transverse Reinforcement:

Spacing of transverse steel shall be least of

a) Least dimension of compression member (80%0f pile Dia)	=	800.0	mm
b) Sixteen times the smallest dia of longitudinal bar (16d)	=	400.0	mm
c) Minimum of 300 mm	=	300.0	mm
d) Fourty eight times the smallest dia of transverse bar (48dt)	=	480.0	mm

Using 10 mm tor diameter steel ties at 180.0 mm **OK**

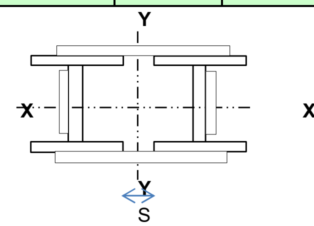
Properties of Waler WB (Shaft & C&C)

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 **x 128.9** **+ 0.0 x 2** + 0 x2

= **128.9** cm^2



Say "S" = **0** mm

Moment of Inertia of Combined Section (I_{yy})	=	**0.00** cm^4
Radius of Gyration of Combined Section (r_{yy})	=	**0.00** cm
Radius of Gyration of Combined Section (rxx)	=	**0.00**
Moment of Inertia of Combined Section (I_{xx})	=	**75780.00** cm^4

0 wide & 0 thk web plate

Properties of **UB 610 229 101.20** **with 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**

Design of Waler WB (Shaft & C&C)

(Normal Case)

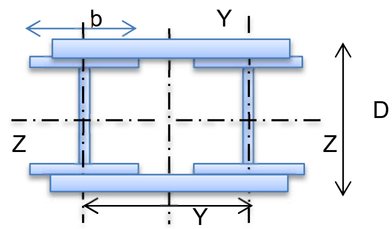
Summary of Forces

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 N/mm^2 γ_{m0} = 1.1 (Refer Table 5 of IS 800:2007)

Properties of Section ***UB*** ***610*** ***229***

with web Plate 0 mm 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	mm^2
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	mm^4
Moment of Inertia about minor axis I_{yy} =	2.92E+07	mm^4
Elastic section modulus (Z_{ez}) =	2.48E+06	mm^3
Elastic section modulus (Z_{ey}) =	2.56E+05	mm^3
Plastic section modulus (Z_{pz}) =	2.89E+06	mm^3
Plastic section modulus (Z_{py}) =	4.01E+05	mm^3

c = 0.23 m

Section Classification (Refer Table 2 page No. 18 of IS:800-2007)

ε = $\sqrt{(250/f_y)}$ =	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)*
KLy/ry	1.00	67.29
	67.29	

(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

Dessign 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

Dessign 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

(As per Cl. 8.4 of IS 800: 2007)

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) $0.6*V_d$ = 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)

β_b = 1.00 for a Plastic and Compact section

So $M_d = Z_p \times f_{bd}$ (putting the value of β_b)

for h_f / t_f = 39.2

From Table 14 page No. 57 of IS:800-2007

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

From Table 13(a) page No. 55 of IS:800-2007 — for f_y = 350 MPa and α_{LT} = 0.21 (for rolled section)

Critical Stress ($f_{cr,b}$)	f_{bd}
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)

$K_z = \{1 + (\lambda_z - 0.2) n_z\} \leq \{1 + 0.8 n_z\}$

$K_{LT} = \{1 - (0.1 \lambda_{LT} n_y)/(C_{mLT} - 0.25)\} \geq \{1 - (0.1 n_y)/(C_{mLT} - 0.25)\}$

$n_z = (P / P_{dz})$ = 0.074

$n_y = (P / P_{dy})$ = 0.110

$f_{cr,z} = (\pi^2 E) / (KL / r_z)^2$ = 11332.65 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** ≤ **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 ≥ 0.4

Equivalent Uniform Moment Factor for Lateral torsion (C_{mLT}) = 0.92

K_{LT} = **0.998** ≥ **0.98**

Check with Interaction Relationship

$P/P_{dy} + (K_{LT} M_z) / M_{dz}$ = **0.362** ≤ **1.0**

$P/P_{dz} + (K_z C_{mz} M_z) / M_{dz}$ = **0.339** ≤ **1.0**

Section is Safe

ANNEXURE – 6
TEMPORARY SECANT PILE & STEEL, WALER FOR RAMP PORTION

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/mm2

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				

$$\frac{d'}{D} = 0.122$$

$$\frac{pu}{fck\ D^2} = 0.03 \quad , \quad \frac{Mu}{fck\ \ D^3} = 0.059$$

From Sp 16,Chart 60	Pt/fck	=	0.055	,	Ptc	=	1.925	
Minimum Steel Required as per IS 2911-2010,			Ptm	=	0.4	%		
Design reinforcement,			Pt	=	**1.9**	%		
Reinforcement to be provided	=	9676.1	mm^2					
Using 25 mm tor steel	=	490.87	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	mm^2	(Pt = 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	kN
Effective Shear Area of secant pile	=	1130973	mm^2
Shear Stress in secant Pile	=	0.43	N/mm^2
Allowable Shear Stress	=	0.81	N/mm^2
Shear force agianst which stirrups required	=	-190	KN
Considering 10 mm Dia stirrups		**10**	mm
Spacing of stirrups	=	-298	mm
Provide shear reinforcement at	=	180	mm

1.3 Transverse Reinforcement:

Spacing of transverse steel shall be least of

a) Least dimension of compression member (80%0f pile Dia)	=	640.0	mm
b) Sixteen times the smallest dia of longitudinal bar (16d)	=	400.0	mm
c) Minimum of 300 mm	=	300.0	mm
d) Fourty eight times the smallest dia of transverse bar (48dt)	=	480.0	mm

Using 10 mm tor diameter steel ties at 180.0 mm **OK**

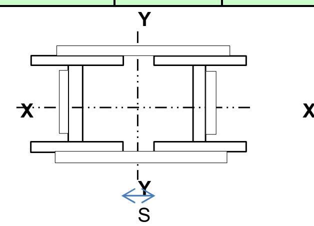
Properties of Waler WB (Ramp Portion)

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 **x 128.9** **+ 0.0 x 2** + 0 x2

= **128.9** cm^2



Say "S" = **0** mm

Moment of Inertia of Combined Section (I_{yy}) = **0.00** cm^4

Radius of Gyration of Combined Section (r_{yy}) = **0.00** cm

Radius of Gyration of Combined Section (rxx) = **0.00**

Moment of Inertia of Combined Section (I_{xx}) = **75780.00** cm^4

					0 wide &	0 thk web plate	
Properties of	**UB**	**610**	**229**	**101.20**	**with** **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**

Design of Waler WB (Ramp Portion)

(Normal Case)

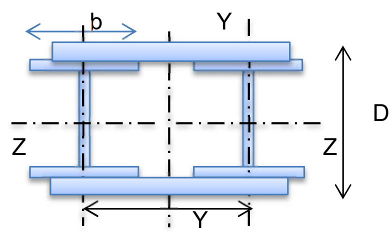
Summary of Forces

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 N/mm^2 γ_{m0} = 1.1 (Refer Table 5 of IS 800:2007)

Properties of Section ***UB*** ***610*** ***229***

with web Plate 0 mm 0 mm



c = 0.23 m

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	mm^2
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	mm^4
Moment of Inertia about minor axis I_{yy} =	2.92E+07	mm^4
Elastic section modulus (Z_{ez}) =	2.48E+06	mm^3
Elastic section modulus (Z_{ey}) =	2.56E+05	mm^3
Plastic section modulus (Z_{pz}) =	2.89E+06	mm^3
Plastic section modulus (Z_{py}) =	4.01E+05	mm^3

Section Classification

(Refer Table 2 page No. 18 of IS:800-2007)

ε =	$\sqrt{(250/f_y)}$ =	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)*
KLy/ry	1.00	54.67	
	54.67		

(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

Dessign 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

Dessign 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 (As per Cl. 8.4 of IS 800: 2007)

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^*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)

β_b = 1.00 for a Plastic and Compact section

So $M_d = Z_p \times f_{bd}$ (putting the value of β_b)

for h_f / t_f = 39.2

From Table 14 page No. 57 of IS:800-2007

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 α_{LT} = 0.21

(for rolled section)

Critical Stress ($f_{cr,b}$)	f_{bd}
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 x f_{bd}

= **920.5** kN-m **>** **142.8** kN-m

0.16 Section is safe

Member Buckling Resistance in Combined Bending & Axial Compression

$P/P_{dy} + (K_{LT} M_z) / M_{dz}$ ≤ **1.0** (As per clause: 9.3.2.2 of IS:800-2007)

and $P/P_{dz} + (K_z C_{mz} M_z) / M_{dz}$ ≤ **1.0** (As per clause: 9.3.2.2 of IS:800-2007)

$K_z = \{1+ (\lambda_z-0.2)n_z\} \leq \{1+0.8n_z\}$

$K_{LT} = \{1-(0.1\lambda_{LT} n_y)/(C_{mLT} - 0.25)\} \geq \{1-(0.1n_y)/(C_{mLT}-0.25)\}$

$n_z = (P / P_{dz})$ = 0.067

$n_y = (P / P_{dy})$ = 0.087

$f_{cr,z}=(\pi^2 E) / (KL / r_z)^2$ = 17166.62 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** ≤ **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 ≥ 0.4

Equivalent Uniform Moment Factor for Lateral torsion (C_{mLT}) = 0.92

K_{LT} = **0.998** ≥ **0.99**

Check with Interaction Relationship

$P/P_{dy} + (K_{LT} M_z) / M_{dz}$ = **0.222** ≤ **1.0**

$P/P_{dz} + (K_z C_{mz} M_z) / M_{dz}$ = **0.210** ≤ **1.0**

Section is Safe

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