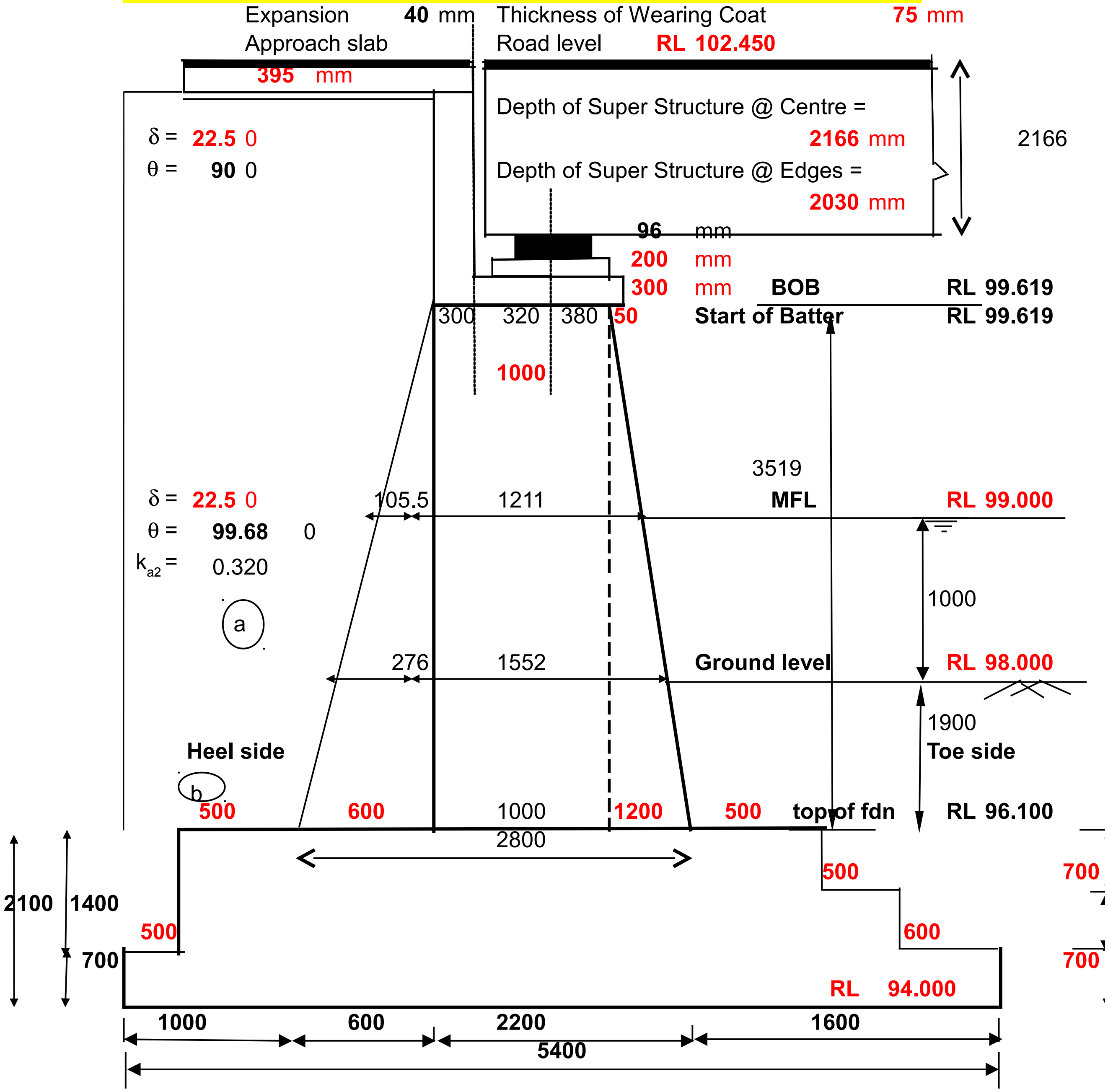
DESIGN OF PCC ABUTMENT - OPEN FOUNDATION

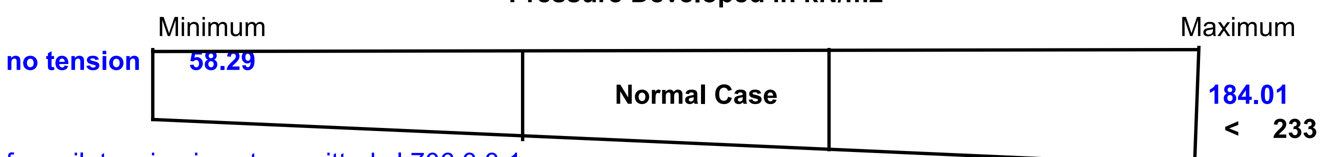
For "T beam cum slab " super structure with four beams& with footpath on both sides

Name of Work: Reconstruction of Bridge

ALL CELLS IN RED COLOUR ARE MEANT FOR DATA INPUT

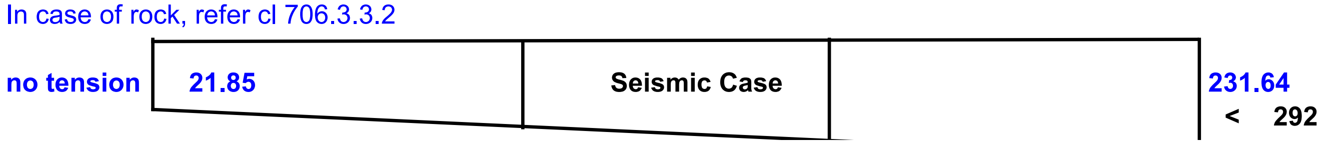


Pressure Developed in kN/m2



for soil, tension is not permitted,cl.706.3.3.1

In case of rock, refer cl 706.3.3.2



DESIGN OF PCC ABUTMENT

General Data:

Roadway of the bridge		=	**12.00**	m
Overall Length of span		=	**21.56**	m
Width of abutment in roadway direction		=	**12.00**	m
Width of bearing		=	**400**	mm
Length of bearing		=	**500**	mm
Thickness of bearing		=	**96**	mm
Thickness of steel plate		=	**4**	mm
No. of steel plate layers		=	**4**	
No of bearings in Abutment		=	**4**	
Intensity of footway loading (Vide Cl 209.1 IRC:6-2000)		=	**400**	kg/m^2
Width of footpath		=	**1.5**	
Longitudinal Gradient (only in case of ROB)		=	**0**	
camber in carriage way		=	**0.025**	
Skew Angle		=	**0.0**	°
Corrected N value at bottom of foundation for soil		=	**28**	
SEISMIC DATA				
Zone as per Fig. 11- IS 1893 (Part I) 2002		=	**2**	
BACKFILL SOIL PROPERTIES				
Unit wt of soil	γ	=	**18**	kN/m^2
Angle of internal friction	ϕ	=	**35**	0
Angle of surcharge	α	=	**0**	0
Slope of earth fill	i	=	**0**	0
Coeff of friction between Concrete and Founding Soil/rock		=	**0.5**	Cl.706.3.4 of IRC 78-20
Equivalent height of surcharge		=	**1.20**	m
MATERIAL DATA				
Grade of concrete		=	**M30**	kN/m^3
Dead load (total dead load of 1 span)		=	**4950**	kN
Unit weight of RCC, γ_2		=	25	kN/m^3
Unit weight of PCC, γ_1		=	22	kN/m^2
Maximum Live load reaction+ footpath live load		=	**837.2**	kN
Maximum Live load coming over the span		=	**1000.0**	kN
Derived / Known Data				
Carriageway of the bridge		=	7.50	m
No of lanes		=	2	
Intensity of live load on footpath for effective span of m		=	3.4	kN/m^2
Effective span of super structure		=	21.00	m
Thickness of wearing coat (ave)		=	75	mm
Depth of Superstructure at centre		=	2.166	m
Thickness of Superstructure at edges		=	2.030	m
Thickness of expansion gap		=	40	mm
Effective thickness of bearing		=	72	mm
Pedestal height		=	200	mm
Road level at centre		=	RL102.450	
Bottom of Deck Slab		=	RL100.209	
level at top of fdn		=	RL96.100	

Bottom of Foundation Level	=	RL94.000
Length of abutment at top of foundation level	=	12.000 m
Length of abutment at foundation level	=	16.060 m
Front Batter	=	1.20 m
Rear Batter	=	0.60 m
Backwall portion	=	0.30 m
Bearing portion	=	0.70 m
Bed block height	=	0.30 m

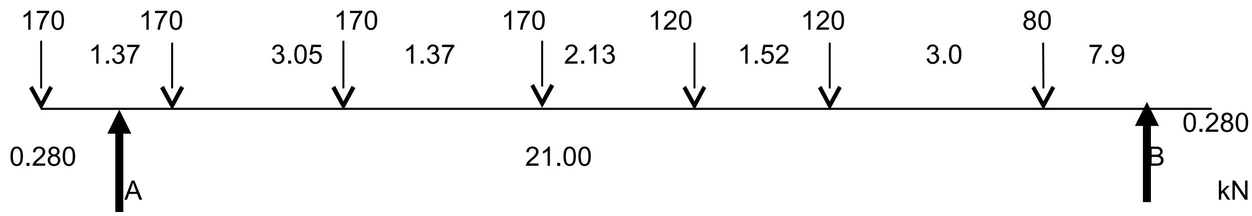
PERMISSIBLE STRESSES

Permissible tensile stress in concrete σ_{cbc} = **-0.67** N/mm^2

If surface reinforcement is not provided, permissible stress = **-0.603** N/mm2

Calculation of Live load Reaction

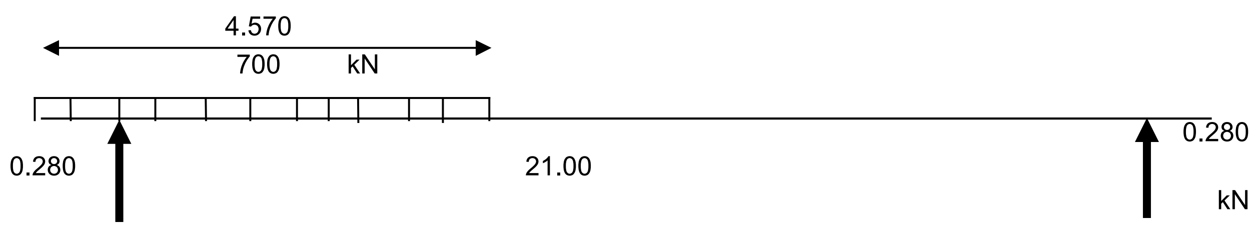
Class 70R wheeled loading - One lane



R_A = **727.29** kN RB = **272.7**

Total Load on Span = 1000.00 kN

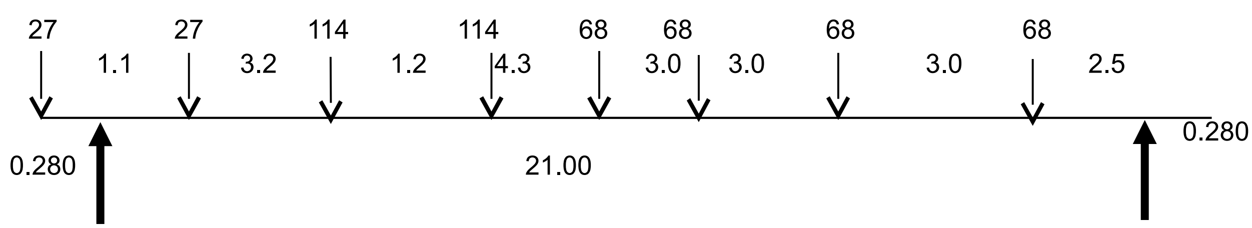
Class 70R tracked loading - One lane



R_A = **633.17** kN RB = **66.83**

Total Load on Span = 700.00 kN

Class A wheeled loading - one lane



R_A = **321.55** kN for one lane RB = **232.4** kN

Total Load on Span = **1108.00** kN

Class A wheeled loading - Two lane = 643.107 kN

Summary of Live load

Vehicle type	Reaction without impact	Impt. factor	Impact factor at bottom of fdn	Rn with impact at bottom of foundation	Imp. factor at top of fdn	Rn with impact at top of foundation	Rn with impact at top of bedblock
		%	%	kN	kN	kN	kN
Class 70R Wheeled	727.29	16.67	0.000	727.3	0.000	727.3	848.52
Class 70R Tracked	633.17	10.00	0.000	633.2	0.000	633.2	696.48
Class A wheeled - 2 lane	643.11	16.67	0.000	643.1	0.000	643.1	750.31

Combination of Live load considered

Combination	Vehicles considerd	No of lanes	Reaction	Total load	load on span
1	**Class 70RW - 1 Lane**	**1**	727.29	727.29	**1000.00**
	Footpath		3.4x21.56x1x1.5	109.96	
				837.24	
2	**Class 70RT-1 Lane**	**1**	633.17	**633.17**	**700.00**
	Footpath		3.4x21.56x1x1.5	109.96	
				743.12	
3	**Class A wheeled**	**2**	321.55	643.11	**1108.00**
	Footpath		3.4x21.56x1x1.5	109.96	
				753.06	

Max vertical reaction + footpath liveload	=	837.24	kN
Load on span for the above max reaction	=	1000	kN
Max load on span	=	1108	kN
Vertical reaction for max load on span	=	643.1	kN

Combination 1 is considered

ABUTMENT PRESSURE CALCULATIONS AT SILL LEVEL

Straight length of Abutment at top = 12.00 m

Effective length of Abutment at sill level = 12.00 + 2 x (1.20) x sec(0)

= 14.40 m

Dead Load reaction = 2475.000 kN

Live load reaction at sill = 727.286 kN

foot path liveload = 109.96 kN

Pressure Calculation at Sill level

Stress due to Active Earth pressure

Coefficient of earth pressure K_a = $\dfrac{\sin^2(\psi-\phi) \times 1}{\sin^2(\psi) \times \sin(\psi+\delta) \times (1+K^2)}$

$$K = \sqrt{\frac{\sin(\phi+\delta) \times \sin(\phi-\zeta)}{\sin(\psi+\delta) \times \sin(\psi-\zeta)}}$$

ϕ 35 °

ψ = 90 + α where,

α = $\tan^{-1}$(batter width/batter height)

= $\tan^{-1}\left(\dfrac{0.60}{3.519}\right)$

= 9.7 °

ψ = 99.68 °

δ = 22.5 °

ζ 0.0 °

$$K = \sqrt{\frac{\sin(35+22.5) \times \sin(35-0)}{\sin(99.68+22.5) \times \sin(99.68-0)}}$$

$$= \sqrt{\frac{0.48}{0.83}}$$

= 0.76

$$K_a = \frac{\sin2(99.68-35) \times 1}{\sin2(99.68) \times \sin(99.68+22.5) \times (1+0.76)^2}$$

$$= \frac{0.817}{2.552}$$

= 0.32

Active earth pressure

Earth pressure = 1/2 x x h^2 x K_a

K_a = 0.5x18x6.35x6.35x0.32

= **116.13** KN

K_{ah} = 0.32 x cos(9.68+22.5) = 0.271

Lever arm for pressure P_2 = 0.42 x 6.35

= **2.67** m from sill

a)Horizontal component of earth pressure P_H = 116.13 x cos(9.68+22.5)

= **98.29** kN

Modulus of section Z= $\frac{b \times d^2}{6}$ where d = 1.2+0.6+0.3+0.7 = 2.80 m

= $\frac{1.00 \times (2.8)^2}{6}$

= 1.31 m^3

Moment = 98.293x0.42x6.35

= **262.15** KN-M

Stress = $\pm$ **M/Z** = $\pm \frac{262.1}{1.31}$

= $\pm$ 201 kN/m^2

Stress due to Horizontal Earth Pressure at Heel = **-200.6** kN/m^2

Stress due to Horizontal Earth Pressure at Toe = **200.6** kN/m^2

Stress due to Live Load surcharge

Earth pressure due to a fill of 1.2m = 0.32x18x1.2 x cos(9.68+22.5)

= 5.85 KN/M^2

Horizontal force due to live load surcharge = 5.85x6.35

= 37.15 KN/M

Moment due to this force = 37.15x0.5x6.35

= 117.95 KN-M

Modulus of section Z = = $\frac{1 \times 2.8^2}{6}$ m

= 1.3067 m^3

Stress = $\pm$ **M/Z** = $\pm \frac{117.952}{1.307}$

= $\pm$ 90.2693 kN/m^2

Stress due to Earth Pressure at Heel = -90.27 kN/m²

Stress due to Earth Pressure at Toe = 90.27 kN/m²

Stress due to Dead Load reaction

Total Dead load reaction from abutment = 2475.000 kN

Intensity of the Dead load = $\frac{2475.000}{14.40}$

= 171.88 kN/m

Eccentricity = $\frac{2.80}{2}$ -(0.6+0.3+0.04+0.28)

= 0.180 m

Stress due to Dead load reaction

$\frac{P \times 1}{A}\left[1 \pm \frac{6e}{d}\right]$ = $\frac{171.88}{2.80}$ **x (** $1 \pm 6 \times \left(\frac{0.18}{2.80}\right)$ **)**

Stress due to Dead load reaction at Heel = 85.06 kN/m²

Stress due to Dead load reaction at Toe = 37.71 kN/m²

Stress due to Live load reaction

Maximum Live load reaction from abutment = 837.2 kN

Intensity of the Dead load = 837.2 / 14.40

= 58.142 kN/m

Eccentricity = 0.180 m

Stress due to Live load reaction $\frac{P \times 1}{A}\left[1 \pm \frac{6e}{d}\right]$ = $\frac{58.142}{2.80}$ **x (** 1±6x($\frac{0.18}{2.80}$) **)**

Stress due to Live load reaction at Heel **=** **28.77** **kN/m²**

Stress due to Live load reaction at Toe **=** **12.76** **kN/m²**

Stress due to Self weight

No.	L x B x unit weight							Wt/m	Lever arm	Moment About Heel
1	0.30	x	2.537	x			25	19.03	0.75	14.271
2	1.025	x	0.30	x			25	7.69	1.1125	8.552
3	0.5	x	0.60	x	3.519	x	22	23.2	0.4	9.290
4	0.30	x	3.519	x			22	23.2	0.75	17.419
5	0.70	x	3.519	x			22	54.2	1.25	67.741
6	0.5	x	1.20	x	3.519	x	22	46.45	2.00	92.902
							Total	173.8		210.175

C.G. from Heel = 210.2 / 173.8 = 1.2092 m

Eccentricity = 2.80 / 2 - 1.2092

= 0.191 m

Stress due to Self weight $\frac{P \times 1}{A}\left[1 \pm \frac{6e}{d}\right]$ = $\frac{173.8}{2.80}$ **x (** 1±6x($\frac{0.19}{2.800}$) **)**

Stress due to Self weight at Heel **=** **87.45** **kN/m²**

Stress due to Self weight at Toe **=** **36.70** **kN/m²**

Stress due to Longitudinal Force due to Braking effect

Maximum Load coming over the span = 1000.000 kN

Braking force (20 % of the load on span) = 200.000 kN

This force acts at 1.20m above road level

Vertical reaction due to Braking = 200x(1.2+2.241) / (21.0 x 14.40)

= 2.29 kN

Eccentricity = 0.180 m

Stress due to Braking effect $\frac{P \times 1}{A}\left[1 \pm \frac{6e}{d}\right]$ = $\frac{2.29}{2.80}$ **x (** 1±6x($\frac{0.18}{2.800}$) **)**

Stress due to Braking effect at Heel **=** **1.13** **kN/m²**

Stress due to Braking effect at Toe **=** **0.50** **kN/m²**

Stress due to Longitudinal force **(Cl.214.5.1.4 - IRC :6 - 2000)**

Longitudinal force = $F_h/2$ + $V_r\ l_{tc}$

Where F_h = Applied horizontal force.

V_r = Shear rating of elastic bearing

l_{tc} = Movement of deck above bearing other than that due to applied force

Strain due to shrinkage E_s = 2.00E-04 (Cl.220.3 -IRC:6 -2000)

Temperature variation = 17.0 deg

Coefficient of expansion a = 1.17E-05 (Cl.218.4 -IRC:6 -2000)

Strain due to Temperature variation E_t = 1.99E-04 (1 x a x t)

Total strain Es + Et = 2.00E-04 + 1.99E-04

= 3.99E-04

Horizontal deformation due to above strain = 0.0003989x21.56x10^3/2

= 4.30E+00 mm

Total thickness of bearing = 96 mm

Effective thickness of bearing = 96 - (4x4) = 80

Shear strain = 4.3/80 = 5.38E-02

Considering 10% variation in the efficiency of the bearing force developed

1.1 x 0.9 x 5E-02 x400x500x4x0.001

= 42.570 KN

Total longitudinal force = 200/2+42.57

= 142.57 KN at bearing level

Intensity of the force per metre run = 142.57/14.4

= 9.9007 KN

Moment due to this force = 9.9007 x 4.109

= 40.682 KN-M

Modulus of section Z= $\frac{b \times d^2}{6}$ = $\frac{1 \times 2.8^{\mathbf{2}}}{6}$

= 1.3067 m³

Stress due to long. force at Heel **-M/Z** = $\frac{40.682}{1.3067}$ = **31.13** **kN/m²**

Stress due to long force at Toe **+M/Z** = $\frac{40.682}{1.3067}$ = **31.13** **kN/m²**

b)Without liveload

Total longitudinal force = 42.570 KN acts at bearing level

Intensity of the force per metre run = 2.57/14.4 = 2.9563 KN

Moment due to this force = 2.9563 x 4.109 = 12.147 kN-m

Modulus of section Z= $\frac{b \times d^2}{6}$ = $\frac{1 \times 2.8^{\mathbf{2}}}{6}$ = 1.3067 m³

Stress due to longitudinal force at Heel **-M/Z** = $\frac{12.147}{1.3067}$

= 9.2964 **kN/m²**

Stress due to longitudinal force at Toe **+M/Z** = $\frac{12.1472}{}$

	1.3067	
=	9.2964	**kN/m²**

ABSTRACT OF STRESSES AT SILL LEVEL AT RL **98.000**

Without seismic (with live load condition)

No.	Stress due to	Dry condition Mpa	
		At Heel	At Toe
1	Active Earth pressure	-0.20062	0.20062
2	Live load surcharge	0.00000	0.00000
3	Dead load	0.08506	0.03771
4	Live load	0.02877	0.01276
5	Self weight	0.08745	0.03670
6	Braking effect	0.00113	0.00050
7	Longitudinal force	-0.03113	0.03113
	Net Stress with Earth Pressure	**-0.02934**	**0.31942**

Permissible Tensile stress for M30 grade of concrete is **-0.603** Mpa

The stresses are within the permissible limits.Hence the section is safe

Without seismic (without live load condition)

No.	Stress due to	Dry condition Mpa	
		At Heel	At Toe
1	Active Earth pressure	-0.20062	0.20062
2	Live load surcharge	-0.09027	0.09027
3	Dead load	0.08506	0.03771
4	Live load	0.00000	0.00000
5	Self weight	0.08745	0.03670
6	Braking effect	0.00000	0.00000
7	Longitudinal force	-0.00930	0.00930
	Net Stress with Earth Pressure	**-0.12768**	**0.37459**

Permissible Tensile stress for M30 grade of concrete is **-0.603** Mpa

The stresses are within the permissible limits.Hence the section is safe

With seismic (with live load condition)

No.	Stress due to	Dry condition Mpa	
		At Heel	At Toe
1	Active Earth pressure	-0.20062	0.20062
2	Live load surcharge	0.00000	0.00000
3	Dead load	0.08506	0.03771
4	Live load	0.01439	0.00638
5	Self weight	0.08745	0.03670
6	Braking effect	0.00057	0.00025
7	Longitudinal force	-0.02022	0.02022
8	Seismic force	-0.15817	0.15817
	Net Stress with Earth Pressure	**-0.19154**	**0.46004**

Permissible Tensile stress for M30 grade of concrete is **-0.905** Mpa

The stresses are within the permissible limits.Hence the section is safe

With seismic (without live load condition)

No.	Stress due to	Dry condition Mpa	
		At Heel	**At Toe**
1	Active Earth pressure	-0.20062	0.20062
2	Live load surcharge	-0.04513	0.04513
3	Dead load	0.08506	0.03771
4	Live load	0.00000	0.00000
5	Self weight	0.08745	0.03670
6	Braking effect	0.00000	0.00000
7	Longitudinal force	-0.00930	0.00930
8	Seismic force	-0.14998	0.14998
	Net Stress with Earth Pressure	**-0.23252**	**0.47944**

Permissible Tensile stress for M30 grade of concrete is **-0.905** Mpa

The stresses are within the permissible limits.Hence the section is safe

ABUTMENT PRESSURE CALCULATIONS AT THE BOTTOM OF FOUNDATION

Corrected N value = 28

Overburden pressure = 64.00 kN/m²

Footing No.1

Front offset	=	0.600	m
Rear offset	=	0.500	m
Height	=	0.700	m

Footing No.2

Front offset	=	0.500	m
Rear offset	=	0.000	m
Height	=	0.700	m

Footing No.3

Front offset	=	0.500	m
Rear offset	=	0.500	m
Height	=	0.700	m

Bottom of Foundation level = RL94.000

Width of foundation = 2.8 + 0.6 + 0.5 + 0.5 + 0 + 0.5 + 0.5

= 5.400 m

SBC of actual width of foundation = $3.5x(N-3)x\left[\frac{B+0.3}{2xB}\right]^2 x R_w x F_d$ +overburdenpr

R_w water reduction factor = 0.50

F_d Depth factor (1+D/B) = 1+(2.1 / 5.4) = 1.4

= $3.5x(28-3)x\left[\frac{5.4+0.3}{2x5.4}\right]^2 x0.5x1.389x10$ +64

= 233.257 kN/m²

Length of abutment at foundation level = 12+(2x(1.2+0.6+0.5+ 0.5) x sec

= 17.60 m

Stress due to Dead load

Dead load reaction = 2475.000 kN

Intensity of the Dead load = $\frac{2475.000}{17.60}$

= 140.625 kN/m

Eccentricity from Heel = $\frac{5.40}{2}$ - (0.6 + 0.3 + 0.04 + + 0.28 + 0.5 + 0.000 + 0.50)

= 0.480 m

Stress $\frac{P}{A} x \left[1 \pm \frac{6e}{d}\right]$ = $\frac{140.625}{5.400}$ x (1±6x($\frac{0.480}{5.400}$

Stress due to DL reaction at Heel = 39.9306 kN/m²

Stress due to DL reaction at Toe = 12.1528 kN/m²

Stress due to Live load reaction

Maximum Live load reaction from abutment = 837.242 kN

Intensity of the Live load = $\frac{837.242}{17.60}$

= 47.5706 kN/m

Eccentricity = 0.480 m

Stress due to Live load reaction $\frac{P}{A} x \left[1 \pm \frac{6e}{d}\right]$ = $\frac{47.5706}{5.40}$ **x (** 1±6x($\frac{0.480}{5.40}$

Stress due to LL reaction at Heel		**=**	**13.5077**	**kN/m²**
Stress due to LL reaction at Toe		**=**	**4.1110**	**kN/m²**

Stress due to Earth pressure

Live load surcharge height = 1.20 m

K_{ah} = 0.271

Active earth pressure

Active earth pressure P = $1/2 \times K_a \times g \times h^2$

= 0.5x0.271x18x8.45x8.45

= 174.15

= 174.15 KN

This force acts at 0.42H from sill level

Moment due to this force M = P x 0.42h

= 174.151x0.42x8.45

= 618.06 KN-M

Modulus of section Z = = $\frac{1 \times 5.4}{6}$ **2** m

= 4.860 m³

Stress = ± **M/Z** = + $\frac{618.062}{4.860}$

= + **127.17** kN/m²

Live load surcharge

Earth pressure due to a fill of 1.2m = 0.271x18x1.2

= 5.85 KN/M²

Horizontal force due to live load surcharge = 5.854x8.45

= 49.47

= 49.47 KN

Moment due to this force = 49.47x0.5x8.45

= 209.00 KN-M

Modulus of section Z = = $\frac{1 \times 5.4}{6}$ **2** m

= 4.860 m³

Stress = ± **M/Z** = + $\frac{208.995}{4.860}$

= + 43.0031 kN/m²

Stress due to Earth Pressure at Heel	**=**	**-43.00**	**kN/m²**
Stress due to Earth Pressure at Toe	**=**	**43.00**	**kN/m²**

Stress due to Longitudinal Force due to Braking effect

Maximum Load coming over the span = 1000.000 kN

Braking force (20 % of the load on span) = 200.000 kN

This force acts at 1.20m above road level

Vertical reaction due to Braking = $\frac{200\times(1.2+2.241)}{21.00 \times 17.6}$

= 1.872 kN

Eccentricity = 0.480 m

Stress due to Braking effect $\frac{P}{A} \times \left[1 \pm \frac{6e}{d}\right]$ = $\frac{1.87}{5.40} \times \left(1 \pm 6\times\left(\frac{0.480}{5.40}\right)\right)$

Stress due to Braking effect at Heel **=** **-0.5316** **kN/m²**

Stress due to Braking effect at Toe	**=**	**-0.1618**	**kN/m²**

Stress due to Longitudinal force **(Cl.214.5.1.4 - IRC :6 - 2000)**

Longitudinal force = $F_h/2$ + $V_r\ I_{tc}$

Where F_h = Applied horizontal force.

V_r = Shear rating of elastic bearing

I_{tc} = Movement of deck above bearing other than that due to applied force

Strain due to shrinkage E_s = 2.00E-04
(Cl.220.3 - IRC:6 - 2000)

Temperature variation = 25.0 deg

Coefficient of expansion a = 1.1700E-05
(Cl.218.4 - IRC:6 - 2000)

Strain due to Temperature variation E_t = 2.93E-04 (1 x a x t)

Total strain Es + Et = 2.00E-04 + 2.93E-04
= 4.93E-04

Horizontal deformation due to above strain = 4.93E-04 x 21.6 x10^3/2
= 5.31E+00 mm

Total thickness of bearing = 96 mm

Effective thickness of bearing = 96 - (4x3)
= 80 mm

Shear strain = 5.30915/80
= 6.64E-02

Considering 10% variation in the efficiency of the bearing, force developed =
= 1.1 x 0.9 x 0.07 x400x500x4x0.001
= 52.561 KN

Total longitudinal force = 200/2+52.561
= 152.561 KN

Intensity of the force per metre run = 152.561/12
= 12.7 KN

Moment due to this force = 12.7 x 6.209
= 78.9 KN-M

Modulus of section Z= $\frac{b \times d^2}{6}$ = $\frac{1 \times 5.4^{2}}{6}$
= 4.8600 m³

Stress due to longitudinal force at Toe **+M/Z =** $\frac{78.938}{4.860}$
= **16.2423** **kN/m²**

Stress due to longitudinal force at Heel **-M/Z=** **-16.2423** **kN/m²**

Without live load

Total longitudinal force **=** 52.561 KN at bearing level

Intensity of the force per metre run = 52.561/12
= 4.38 KN

Moment due to this force = 4.38 x 6.209
= 27.2 KN-M

Modulus of section Z= $\frac{b \times d^2}{6}$ = $\frac{1 \times 5.4^{2}}{6}$
= 4.860 m³

Stress due to longitudinal force at Toe **+M/Z =** $\frac{27.196}{4.860}$
= **5.5959** **kN/m²**

Stress due to longitudinal force at Heel	**-M/Z=**	**-5.5959**	**kN/m³**

Stress due to Bouyancy

Width of abutment at MFL level = 1.32 m

Bouyant force due to submerged vol of stem = (1.317+2.8)/2 x 1 x 10

= 21 kN

Bouyant force due to submerged volumeof footing1

= 3.90 x 0.70 x 1 x 10

= 27.3 kN

Bouyant force due to submerged volumeof footing2

= 4.40 x 0.70 x 1 x 10

= 30.8 kN

Bouyant force due to submerged volumeof footing3

= 5.40 x 0.70 x 1 x 10

= 37.8 kN

Total Bouyant force = 21 + 27.3 + 30.800

+ 37.80

= 116.483 kN

Bouyant effect (as per IRC:6-2000 is 15 % of full bouyancy)

= 0.15 x 116.483

= 17.472 kN

Stress $\frac{P}{A}$ = $\frac{17.472}{5.40}$

Stress due to Bouyancy at Heel = -3.2356 kN/m²

Stress due to Bouyancy at Toe = -3.2356 kN/m²

Stress due to Self weight

No.	L x B x unit weight						Wt/m	Lever arm	Moment About Heel
1	0.30	x	2.54	x			25	19.0	1.75	33.3
2	1.03	x	0.30	x			25	7.7	2.11	16.2
3	0.50	x	0.60	x	3.519	x	22	23.2	1.40	32.5
4	0.30	x	3.52	x			22	23.2	1.75	40.6
5	0.70	x	3.52	x			22	54.2	2.25	121.9
6	0.50	x	1.20	x	3.519	x	22	46.5	3.00	139.4
7	3.90	x	0.70	x			22	60.1	2.45	147.1
8	4.40	x	0.70	x			22	67.8	2.70	183.0
9	5.40	x	0.70	x			22	83.2	2.70	224.5
10	0.50	x	0.60	x	3.519	x	18	19.0	1.20	22.8
11	0.60	x	2.83	x			18	30.6	1.30	39.7
12	0.50	x	6.35	x			18	57.2	0.75	42.9
13	0.00	x	7.05	x			18	0.0	0.50	0.0
14	0.50	x	7.75	x			18	69.8	0.25	17.4
							Total	561.3		1061.5

C.G. from Heel = $\frac{1061.465}{561.267}$ = 1.891 m

Eccentricity = $\frac{5.40}{2}$ - 1.891

= 0.809 m

Stress due to Self weight $\frac{P}{A} \times \left[1 \pm \frac{6e}{d}\right]$ = $\frac{561}{5.4}$ x (1±6x($\frac{0.809))}{5.400}$

Stress due to Self weight at Heel = 197.3672 kN/m²

Stress due to Self weight at Toe = **10.5093** **kN/m²**

ABSTRACT OF STRESSES AT FOUNDATION LEVEL AT RL 94

CASE-1 **Without seismic (with live load condition)**

No.	Stress due to	Dry condition Mpa	
		At Heel	At Toe
1	Active earth pressure	-0.1272	0.1272
2	Live load surcharge	0.0000	0.0000
3	Dead load	0.0399	0.0122
4	Live load	0.0135	0.0041
5	Self weight	0.1974	0.0105
6	Braking effect	-0.0005	-0.0002
7	Seismic force	0.0000	0.0000
8	Longitudinal force	-0.0162	0.0162
9	Buoyancy	-0.0032	-0.0032
	Net Stress	**0.10362**	**0.16679**

Safe Bearing Capacity **0.233 Mpa**

Stresses within permissible limits.

CASE-2 **Without seismic (without live load condition)**

No.	Stress due to	Dry condition Mpa	
		At Heel	At Toe
1	Active earth pressure	-0.1272	0.1272
2	Live load surcharge	-0.0430	0.0430
3	Dead load	0.0399	0.0122
4	Live load	0.0000	0.0000
5	Self weight	0.1974	0.0105
6	Braking effect	0.0000	0.0000
7	Seismic force	0.0000	0.0000
8	Longitudinal force	-0.0056	-0.0056
9	Buoyancy	-0.0032	-0.0032
	Net Stress	**0.05829**	**0.18401**

Safe Bearing Capacity **0.233** Mpa

Stresses within permissible limits

CASE-3 **With seismic (with live load condition)**

No.	Stress due to	Dry condition Mpa	
		At Heel	At Toe
1	Active earth pressure	-0.1272	0.1272
2	Live load surcharge	0.0000	0.0000
3	Dead load	0.0399	0.0122
4	Live load	0.0068	0.0021
5	Self weight	0.1974	0.0105
6	Braking effect	-0.0003	-0.0001
7	Seismic force	-0.0610	0.0610
8	Longitudinal force	-0.0109	0.0053
9	Buoyancy	-0.0032	-0.0032
	Net Stress	**0.0414**	**0.21494**

Safe Bearing Capacity **0.292** Mpa

Stresses within permissible limits.

CASE-4 **With seismic (without live load condition)**

No.	Stress due to	Dry condition Mpa	
		At Heel	At Toe
1	Active earth pressure	-0.1272	0.1272
2	Live load surcharge	-0.0215	0.0215
3	Dead load	0.0399	0.0122
4	Live load	0.0000	0.0000
5	Self weight	0.1974	0.0105
6	Braking effect	0.0000	0.0000
7	Seismic force	-0.0579	0.0579
8	Longitudinal force	-0.0056	0.0056

9	Buoyancy	-0.0032 **0.0218**	-0.0032 **0.23164**	**Safe Bearing Capacity** **0.292** Mpa **Stresses are within permissible limits.**

Check for stability in loaded condition

Check for overturning

Resisting moment

Dead load moment	=	140.63	x (	5.400 / 2	+	0.480	)
	=	447.188	kNm				
Live load moment	=	47.57	x (	5.400 / 2	+	0.480	)
	=	151.274	kNm				
Vertical Reaction due braking	=	1.87	x (	5.400 / 2	+	0.480	)
	=	6	kNm				
Self weight moment	=	561	x (	5.400 / 2	+	0.809	)
	=	1969	kNm				

Over turning moment

Active earth pressure	=	618.06	kNm
Live load surcharge	=	208.995	kNm
Longitudinal moment	=	78.938	kNm
Seismic moment (with live load) =		301	kNm
(without live load)=		282	kNm

Factor of saftty against overturning without seismic

(I) Without seismic (with live load)

= (447 + 151.27 + 5.9539 + 1969.48) / (618 + 0.000 + 78.94)

= 3.69 > 2 **Hence safe.**

(II) Without seismic (without live load)

= (447.19 + 0.000 + 1969.48 + 0) / (618.1 + 209.00 + 0.00)

= 2.92 > 2 **Hence safe.**

Factor of safety against overturning with seismic

(I) With seismic (with live load)

= (447.2 + 75.637 + 2.9769 + 1969.48 + 0) / (618.1 + 0.000 + 78.94 + 301.383)

= 2.5 > 1.5 **Hence safe.**

(II) With seismic (without live load)

= (447.2 + 0.000 + 0 + 1969.48 + 0) / (618.1 + 104.498 + 0.00 + 281.62)

= 2.41 > 1.5 **Hence safe.**

Check for Sliding without seismic (without liveload)

Total horizontal force = Act.ear.pressure+LLsurcharge+Long.force
= 174.15 + 49.47 + 4.380
= 228.0 kN

Total resisting force = 0.5 x (DL + Self weight)
=0.5x(140.625 + 561)
= 350.946 kN

Factor of safety against sliding = 350.946 / 227.997
= **1.54 > 1.5 Hence safe.**

Check for Sliding with seismic (without liveload)

Total horizontal force = Act.ear.pressure+LLsurcharge+Long.force+ Seismic force
= 174.15 + 24.733 + 4.380 + 50.0
= 253.2 kN

Total resisting force = 0.5 x (DL + LL + Self weight)
=0.5x(140.625 + 0 + 561
= 350.946 kN

Factor of safety against sliding = 350.946 / 253.221 **Hence safe.**

The section is safe against sliding = 1.39 > 1.25

Check for Stability in Span Dislodged Condition

Check for Overturning

Resisting Moment

Dead load moment	=	0.00	kNm
Live load moment	=	0.00	kNm
Vertical moment	=	0.00	kNm
Selfweight moment	=	1969.484	kNm
Passive earth pressure moment	=	0.00	kNm
Total restraining moment	=	1969.484	kNm

Overturning moment

Active earth pressure	=	618.062	kNm
Live load surcharge	=	0.000	kNm
Longitudinal moment	=	0.00	kNm
Seismic moment	=	0.00	kNm
Total overturning moment	=	618.062	kNm

Factor of safety against overturning = 1969.484 kNm / 618.062

The section is safe against overturning = 3.19 > 1.5

Check for Sliding

Total horizontal force = Act.ear.pressure+LLsurcharge+Long.force Seismic force
= 174.15 + 0 + 0.00 + 0.00
= 174.2 kN

Total horizontal resisting force = 0.50 x (DL + LL + Self weight)
=0.5x(0.00 + 0.00 + 561
= 280.633 kN

Factor of safety against sliding = 280.633 /

174.151

The section is safe against sliding = **1.61** **>** **1.25**

CALCULATION OF SEISMIC FORCES

a_h = Horizontal seismic coefficient

= $\frac{(z/2)\ (S_a/g)}{(R/I)}$

z = Zone factor for zone **2** = **0.1**

I = Importance factor = **1.2**

R = Response reduction factor = **1**

S_a/g = Average response acceleration coeffici = **2.5**

= $\frac{(0.1/2) \times 2.5}{(1/1.2)}$ = 0.15

a_v = Vertical seismic coefficien = 0 for zone 2 & 3

AT SILL LEVEL

1. Self weight

No.	L x B x unit weight							Wt/m	Lever arm	Moment About Heel
1	0.3	x	2.537	x	25			19.0	5.09	96.802
2	1.03	x	0.30	x	25			7.7	3.67	28.205
3	0.5	x	0.28	x	1.619	x	22	4.9	2.44	11.994
4	0.3	x	1.62	x	22			10.7	2.71	28.952
5	0.7	x	1.62	x	22			24.9	2.71	67.555
6	0.5	x	0.55	x	1.619	x	22	9.8	2.44	23.983
7	0.50	x	0.28	x	1.619		18	4.0	2.98	11.984
8	0.28	x	2.83	x			18	14.1	3.32	46.638
9	0.82	x	4.45	x			18	66.0	4.13	272.245
							Total	161		588.400

Horizontal force = 161.2x0.15

= 24.18 Kn

Horizontal moment = 588.4x0.15

= 88.26 Knm

Stress at Toe = + 67.546 kN/m2

Stress at Heel = - 67.546 kN/m²

2.Deadload

Total Dead load from Superstructure = 4950.000 kN

Seismic coefficient ah = 0.150

Seismic force F' = 4950x0.15

= 742.5 KN

F1 = 742.5/2

= 371.25 kN

Seismic force perRM = 371.25/14.4

= 25.781 KN/m

Eccentricity of the above force e = $\frac{2.166+0.075}{2}$

= 1.121 m from top of bearing.

Moment due to seismic force F' = 832 KN-m at bearing level

Change in vertical reaction = 831.97125/21

= 39.62 kN at one support

Change in reaction per RM = 39.62/14.4 ↓↑

= 2.75 KN/M

Moment at sill level = 25.781x4.109

= 106 KN-m

Stress at Toe = + 81.073 kN/m2

Stress at Heel = - 81.073 kN/m²

b) Change in vertical reaction of Deadload

Change in reaction per RM = 2.751 **kN**

e = 0.18

M = 0.495 KN-m

Stress = P/A + or - M/Z

= $\frac{2.751}{2.80} \pm \frac{0.495}{1.307}$

Stress at heel = 1.362 kN/m²

Stress at toe = 0.604 kN/m²

3.Stress due to live load

Maximum Live load coming over the span = 1000.000 KN

Seismic force F' per span = 1000x0.15

= 150.0 kN

Seismic force F' per support = 150/2

= 75.000 KN

lever arm for seismic force from bearing level = $\frac{2.166+0.075+1.2}{2}$ = 1.721 m

Moment due to seismic force(at bearing level) = 129.038 KN-m

Seismic force at bearing level = 75.000 kN

Moment due to seismic force(at sill level) = 308.175 KN-m

Moment due to seismic at sill level/RM = 308.175000000001/1 = 21.401 KN-m

Stress at Toe = + 16.38 kN/m2

Stress at Heel = - 16.38 kN/m²

With live load on span

Total stress = 67.546+81.073+1.362+0.5x16.378

= 158 kN/m²

Without live load on span

Total stress = 67.546+81.073+1.362

= 150 kN/m²

AT FOUNDATION LEVEL

1. Self weight

No.	L x B x unit weight							Wt/m	Lever arm	Mom. About B.O.F
1	0.3	x	2.537	x	25			19.0	7.19	136.760
2	1.03	x	0.30	x	25			7.7	5.769	44.349
3	0.5	x	0.28	x	1.619	x	22	4.9	4.81	23.662
4	0.3	x	1.619	x	22			10.7	4.81	51.391
5	0.7	x	1.62	x	22			24.9	4.81	119.913
6	0.5	x	0.55	x	1.619	x	22	9.8	4.54	44.628
7	0.5	x	0.28	x	1.619		18	4.0	5.08	20.430
8	0.3	x	2.83	x			18	14.1	4.94	69.541
9	0.82	x	4.45				18	66.0	4.54	299.613
							Total	161		810.290

Horizontal force = 161.167x0.15
= 24.18 Kn

Horizontal moment = 810.29x0.15
= 122 Knm

Stress at Toe = **+** 121.544/4.86 = **25 kN/m2**

Stress at Heel = **-** = **25 kN/m²**

2.Deadload

Total Dead load from Superstructure = 4950.000

Seismic coefficient ah = 0.150

Seismic force F' = 4950x0.15
= 742.5 kN

F1 = 742.5/2
= 371.25 kN per support

Seismic force perRM = 371.25/14.4
= 25.781 kN/m

Eccentricity of the above force e = $\frac{2.166+0.075}{2}$
= 1.121 m from top of bearing.

Moment due to seismic force F' = 832 kN-m

Change in reaction = 831.97125/21
= 39.62 kN

Change in reaction per RM = 39.62/14.4
= 2.751 kN/m

Moment at foundation level = 25.78x (6.209)
= 160.08 kN-m

Stress at Toe = **+** **32.94** **kN/m2**

Stress at Heel	=	**-**	**32.94**	**kN/m²**

b) Change in vertical reaction of Deadload

Change in reaction per RM		**=**	2.751	kN
	e	=	1.30666667	m
	M	=	3.595	kN-m

Stress = P/A + or - M/Z

$= \frac{2.751}{5.40} \pm \frac{3.595}{4.86}$

Stress at heel	**=**	**1.249**	**kN/m²**
Stress at toe	**=**	**-0.23**	**kN/m²**

3.Stress due to live load

Maximum Live load coming over the span	=	1000.000	kN	
Seismic force per span	=	150.000	kN	
Seismic force F'	=	1000x0.15/ 2 x 14.4		
	=	5.2	kN/m	per support
Moment due to seismic at foundation level	=	5.208x(4.109+2.09999999999999)		
	=	32.336	KN-m	

Stress at Toe	=	**+**	**6.654**	**kN/m2**
Stress at Heel	=	**-**	**6.654**	**kN/m²**

With live load condition

Total seismic moment	=	121.544+160.076+3.595+0.5x32.336
	=	301 KN-M
Total horizontal force	=	24.175+25.781++0.5x5.208
	=	52.56 KN

Without live load condition

Total seismic moment	=	121.544+160.076+3.595
	=	281.62 kN-m
Total horizontal force	=	24.175+25.781
	=	49.956 kN-m

With live load

Total stress	=	25.009+32.937+0.5x6.654	
	=	**61.04**	**kN/m2**

Without live load

Total stress	=	25.009+32.937
	=	**57.95 kN/m2**