राष्ट्रीय राजमार्ग एवं अवसंरचना विकास निगम लिमिटेड

BUILDING INFRASTRUCTURE - BUILDING THE NATION

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

FINAL DETAILED PROJECT REPORT

April 2020

CONSULTANCY SERVICES FOR PREPERATION OF DETAILED PROJECT REPORT AND PROVIDING PRE-CONSTRUCTION ACTIVITIES IN RESPECT OF THE FOLLOWING STRETCH ON NH-244 (OLD NH-1B) IN THE STATE OF JAMMU AND KASHMIR.

(1) SUDHMAHADEV- DRANGA TUNNEL OF APPROX. LENGTH 4.5 KM AND ITS APPROACH ROAD ON CHENANI - SUDHMAHADEV-GOHA ROAD PORTION.

(2) VAILOO TUNNEL OF APPROX. LENGTH 10.0 KM UNDER SINTHAN PASS AND ITS APPROACH ROAD ON GOHA-KHELLANI- KHANABAL ROAD PORTION.

(3) ROAD PORTION FROM 82.675 TO 82.925 AT KM 83 ON BATOTE-KISHTWAR ROAD SECTION OF NH-244.

(4) EXTENDED ROAD SECTION FROM GOHA TO KHELLANI OF 30 KM LENGTH

KHELLANI TUNNEL & ITS APPROACH ROAD PACKAGE - II (KM 29.030 to KM 31.449)

VOLUME - II - DESIGN REPORT (STRUCTURE)

getinsa-euroestudios

tpf INGENIERÍA

IN ASSOCIATION WITH

Rodic

TPF GETINSA EUROESTUDIOS S.L.
Unit 305, Suncity Business Tower, Golf Course Road,Sector 54 Gurgram Haryana - 122002 India
Email : indiacentral@tpfingeneria.com

RODIC CONSULTANTS PRIVATE LIMITED
1, Jai Singh Marg (First Floor), YMCA Cultural Centre Building, New Delhi – 110001 (INDIA)
Email :contact@rodicconsultants.com

DESIGN OF COUNTER FORT TYPE ABUTMENT (A2) WITH OPEN FOUNDATION

FOR MAJOR BRIDGE AT CH:- 31+158

Details of Superstructure:

Skew Angle of Bridge	=	0	Degree	=	0.000 Radians	COS θ =	1.000
						SIN θ =	0.000

Radius of Curvature of Superstructure	=	0	m
Design speed of vehicle	=	50	kmph

		Right Dimensions	**Skew Dimensions**
Span -c/c of Brg.	=	23.250m	23.250m
Thickness of Expansion Joint	=	0.050m	0.050m
Slab projection Beyond C/L of Bearing (Back Side)	=	0.850m	0.850m
Slab projection Beyond C/L of Bearing (Span Side)	=	0.850m	0.850m
Span -c/c of E.J.	=	25.000m	25.000m
Type of Superstructure	=	Steel Girder	
Width of Crash barrier (Both Side)	=	0.450m	
Width of Carriageway	=	9.000m	
Projection beyond RCC Railing	=	0.050m	
Thickness of Wearing coat	=	0.065m	
Length of Approach Slab (Right)	=	3.500m	3.500m
Width of Footpath on one side	=	0.000m	
Railing/kerb on footpath edge	=	0.000m	
Total Width of Superstructure	=	10.000m	
Median Width minus 20mm gap	=	0.000m	
Increase in length due to curvature effect	=	0 in skew	

Bearings

No of Bearings	=	4	
Type of Bearing	=	Spherical Bearing	
Coeff. Of Friction for POT-PTFE Bearing	=	0.05	
C/C Distance of Bearing in Transverse Direction	=	2.500m (Right)	2.500 (Skew)

Type of Soil	=	2	Medium Soil Strata	
NBC of soil -Normal Case	=	350	kN/m^2	As per Geo tech Report
SBC of soil-Normal Case	=	498	kN/m^2	
SBC of soil-Seismic Case	=	622	kN/m^2	
Coeff. of friction between concrete and soil	=	0.7	for cohesive/cohesionless soil	
Permissible FOS against Sliding	=	1.5	Normal Case	
	=	1.25	Seismic Case	
Permissible FOS against Overturning	=	2	Normal Case	
	=	1.5	Seismic Case	

Dirt Wall		**Right Dimensions**	**Skew Dimensions**
Width of Dirt wall at Top	=	0.300m	0.300m
Width of Dirt wall at Bottom	=	0.300m	0.300m
Height of Uniform portion	=	2.473m	
Height of Tapering portion	=	0.000m	
Length of Dirt Wall at top (Uniform portion)	=	10.000m	10.000m
Length of Dirt Wall at bottom (Tapering Portion)	=	10.000m	10.000m

Abutment Cap

Width of Abutment cap of Uniform portion	=	2.120m	2.120m
Width of Abutmentcap at bottom of Tapering Portion	=	2.120m	2.120m
Projection of Abutment Cap (Span Side)	=	0.495m	0.495m
Projection of Abutment Cap Back Side	=	0.825m	0.825m
Abutment cap thickness (Uniform portion)	=	0.300m	
Abutment cap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	10.000m	10.000m
Length of Abutment Cap at bottom (Tapering Portion)	=	10.000m	10.000m

Abutment- Counter Fort Wall Type

Thickness of Abutment	=	0.800m	
Width of abutment shaft	=	10.000m	10.000m
Thickness of Abutment shaft at Top	=	0.800m	0.800m
Thickness of Abutment shaft at HFL	=	0.800m	0.800m
Thickness of Abutment shaft at Bottom	=	0.800m	0.800m
Thickness of counterfort	=	0.800m	0.800m

Solid Return Wall & Counter Fort

Length of Return wall	=	10.200m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	1.500m
Length of counterfort @ bottom	=	10.200m
Length of counterfort @ top	=	0.825m
Thickness of counterfort	=	0.800m
No. of Counter Fort	=	2

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m
Height of wall at abutment	=	0.000m
Length of Return wall	=	0.000m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	1.500m

Foundation

Along Traffic Direction:

Total Width of Footing	=	16.000m
abutment pedestal width	=	0.800m
abutment pedestal Height	=	2.500m
Width of Toe Slab	=	5.000m
Width of Heel Slab	=	10.200m
Thickness of Toe slab at tip	=	1.000m
Thickness of Toe slab near shaft	=	2.500m
Thickness of heel slab at tip	=	1.000m
Thickness of heel slab near shaft	=	1.000m
Width of backfill on heel slab	=	10.200m
Thickness of heel slab at back fill edge	=	1.000m
Height of back fill at bottom edge of heel slab	=	15.853
Height of back fill at back fill edge of heel slab	=	15.853

Across Traffic Direction:

Width of foundation -Uniform portion	=	10.000m (skew dimension)
Width of foundation -Tapering portion	=	10.000m (skew dimension)

Levels

Deck Level at Median Edge=	**1121.011m**	Cross Slope (Bi-directional)	=	7.000%
Deck level at Outer Edge =	**1120.696m**	Height of Superstructure	=	1.470m
Deck level at center line =	**1121.011m**	Min. Height of Footpath Side Pedestal (1)	=	0.500m
Soffit Level at center of bridge =	1119.476m	Height of Pedestal (2)	=	0.675m

Abutment cap top level =	1118.539m	Height of Pedestal (3)	=	0.850m
Abutment cap bottom lvl (uniform portion ends)	1118.239m	Height of Pedestal (4)	=	1.025m
Abutment cap bottom lvl (corbel portion ends) =	1117.939m	Height of Pedestal (5)	=	0.000m
Abutment shaft top level =	1117.939m			
Ground level/LBL =	1116.293m	Distance of nearest girder to c.l. of deck	=	1.250m
Abutment shaft bottom level =	1106.500m	Height (Avg.) of Dirt Wall	=	2.473m
Foundation level =	1104.000m	Abutment shaft Above G.L	=	1.646m
HFL =	1105.000m	Abutment Shaft below G.L	=	9.793m
		Height of abutment shaft	=	11.439m
		MSL	=	1104.000m
		Wedge over girder flange	=	0.0700m

Material Specification

Concrete Grade	=	M 35		
Characteristic compressive strength of concrete,fck	=	35	MPa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63	MPa at 28 days	(0.67/1.5 * fck)
Tensile strength of concrete , fctm	=	2.77	MPa	
Strain at reaching Characteistic Strength, $\varepsilon c2$	=	0.002		
Ultimate Strain, $\varepsilon cu2$	=	0.0035		
Ecm	=	32308	MPa	
Steel Grade	=	Fe 500D	(HYSD Steel)	
Yield Strength of Reinforcement, fy or fyk	=	500	MPa	
Design Yield Strength of Reinforcement, fyd	=	435	MPa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000	MPa	
Dry weight of Concrete	=	25	kN/m^3	
Dry unit weight of soil	=	20	kN/m^3	
Permissible Crack Width	=	0.3	mm - For moderate Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck		
	=	16.8	N/mm^2	
Maximum tensile stress in steel under rare combination	=	300	N/mm^2	

Creep Coefficient

For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	40	mm

Seismic Data:

Seismic Zone		=	4	
Z	=Zone factor	=	0.24	
I	=Importance factor	=	1.2	
R	=Response Reduction factor	=	3	in Longitudinal direction
		=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	35
θ	=	90
β	=	0
δ	=	22.50

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	-0.025m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

			eT
DL Reaction on Bearing No.-1	=	271.42	3.750
DL Reaction on Bearing No.-2	=	271.42	1.250
DL Reaction on Bearing No.-3	=	271.42	-1.250
DL Reaction on Bearing No.-4	=	271.42	-3.750
DL Reaction on Bearing No.-5	=	0.00	0.000
		1085.68	0.000

Super Imposed Dead Load Reactions (Excluding Wearing Course)

SIDL Reaction on Bearing No.-1	=	159.835	3.75
SIDL Reaction on Bearing No.-2	=	-59.835	1.25
SIDL Reaction on Bearing No.-3	=	-59.835	-1.25
SIDL Reaction on Bearing No.-4	=	159.835	-3.75
SIDL Reaction on Bearing No.-5	=	0.000	0.00
		200.00	0.000

Reaction Due to Wearing Course only

SIDL Reaction on Bearing No.-1	=	68.613	3.75
SIDL Reaction on Bearing No.-2	=	68.613	1.25
SIDL Reaction on Bearing No.-3	=	68.613	-1.25
SIDL Reaction on Bearing No.-4	=	68.613	-3.75
SIDL Reaction on Bearing No.-5	=	0.000	0.00
		274.45	0.000

Carriageway Live Load Reactions

MAXIMUM REACTION CASE:

(1-70RW + 1-CLASS A) Reduction Factor = **0.9** (for 3 Lane)

max	=	1056.43	kN	Corr. Transve	=	209.890	kNm	ecc.	0.20
min	=	342.17	kN	Corr. Transve	=	417.910	kNm	ecc.	1.22

SV Loading

max	=	1592.52	kN	Corr. Transve	=	477.755	kNm	ecc.	0.30
min	=	1467.48	kN	Corr. Transve	=	440.245	kNm	ecc.	0.30

MAXIMUM TRANSVERSE MOMENT CASE:

(1-70RW) Reduction Factor = **1** (for 2 Lane)

max	=	774.00	kN	Corr. Transve	=	1554.824	kNm	ecc.	2.01
min	=	225.00	kN	Corr. Transve	=	350.176	kNm	ecc.	1.56

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.077
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for Cl A Wheeled loading

Impact Factor upto abut. cap	=	1.077
Impact Factor for Abut. Shaft Base	=	1.000

Bearing Pedestal

Right Span :

Pedestal 1	=	0.500 x	0.800 x	0.800 =	0.3200 m^3	3.750
Pedestal 2	=	0.675 x	0.800 x	0.800 =	0.4320 m^3	1.250

Pedestal 3	=	0.850 x	0.800 x	0.800 =	0.5440 m^3	-1.250
Pedestal 4	=	1.025 x	0.800 x	0.800 =	0.6560 m^3	-3.750
Pedestal 5	=	0.000 x	0.800 x	0.800 =	0.0000 m^3	0.000
					1.9520 m^3	-0.717

VOLUME CALCULATION

C.G. Of Footing	=	8.000 m
C.G. Of shaft from toe tip	=	5.400 m
Distance between c.g. of shaft and footing	=	2.600 m

Description		No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
			m	m	m	m^3	m	m	m	
Dirt Wal -Uniform portion		1	10.00	0.300	2.473	7.418	-1.075	1.525	-6.475	0.000
-Trapering portion		1	10.00	0.300	0.000	0.000	-1.075	1.525	-6.475	0.000
Bracket (Rectangle)		1	10.00	0.300	0.300	0.900	-1.375	1.225	-6.775	0.000
(Corbel)	0.5	1	10.00	0.300	0.300	0.450	-1.325	1.275	-6.725	0.000
Cap (uniform portion)		1	10.00	2.120	0.300	6.360	-0.165	2.435	-5.565	0.000
Cap (Corbel Portion)		1	10.00 10.00	2.120 2.120	0.300	6.360	-0.165	2.435	-5.565	0.000
Shaft above HFL		1	10.00	0.800	11.439	91.508	0.000	2.600	-5.400	0.000
Shaft below HFL		1	10.00	0.800	0.000	0.000	0.000	2.600	-5.400	0.000
Solid Return Wall		2	10.20	1.000	16.011	326.624	-5.500	-2.900	-10.900	0.000
Cantilever Return wall(Rectangular portion)		0	0.00	0.500	0.000	0.000	-0.400	2.200	-5.800	0.000
Cantilever Return wall(Traingular portion)		0	0.00	1.000	0.000	0.000	-0.400	2.200	-5.800	0.000
Counter fort wall		2	10.20	0.800	11.439	93.338	-3.800	-2.900	-10.900	0.000
Front Counter fort wall		0	5.00	0.800	2.500	0.000	2.067	5.441	-2.559	0.000
Footing										
Heel Slab		1	10.00	10.200	1.000	102.000		-2.900	-10.900	0.000
Toe Slab		1	10.00	5.000	1.750	87.500		5.143	-2.857	0.000
Portion between Heel and Toe		1	10.00	0.800	2.500	20.000		2.600	-5.400	0.000
Back filling above HFL over Heel Slab		1	10.00	10.200	16.011	1213.159		-2.900	-10.900	0.000
Back filling below HFL over Heel Slab		1	10.00	10.200	0.000	0.000		-2.900	-10.900	0.000
Backfill above Heel slab		1	10.00	10.200	15.853	1197.094		-2.900	-10.900	0.000
Front Filling over Toe Slab		1	10.00	5.000	10.543	527.150		5.441	-2.559	0.000
Front Filling over Toe Slab in HFL Case		1	10.00	5.000	-1.750	0.000		3.257	-4.743	0.000
Side filling between heel and toe		1	0.00	0.800	10.543	0.000		0.000	0.000	0.000
Aproach Slab		1	10.000	1.750	0.300	5.250	-1.375	1.225	-6.775	0.000
Back fill above HFL on flared portion of stem		1	10.00	0.000	16.011	0.000		0.000	0.000	0.000
Back fill below HFL on flared portion of stem		1	10.00	0.000	0.000	0.000		0.000	0.000	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barr	2	0 kN/m	1.750	0.00kN		-1.075	1.525	-6.475

SECTIONAL PROPERTIES

Width of Footing (B) = 16 m

Length of Footing (L) = 10.000 m

A = 16.000 x 10.000 = 160.000 m^2

ZL = 10.000 x 42.667 = 426.667 m^3

ZT = $\dfrac{\text{IT1} + \text{IT2}}{\text{distance of extreme point from centre}}$

IT1 = 16.000 x 83.333 = 1333.33 m^4

IT2 (moment of inertia of triangle) = 16.000 x 0.000 + 0.500 x 16.000 x 0.000 x 25.000

from centre of footing = 0.000 m^4

Moment of inertia of two triangle = 0.000 m^4

Total moment of inertia = 1333.33 m^4

Distance of extreme point from centre of footing = 5.000 + 0.000 = 5.000 m

Total Section modulus (ZT) = 266.667 m^3

Load Factors (As per IRC:6-2017)

Table B.1 Partial Safety Factor For Verification of Equilibrium

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Laod,SIDL & Backfill except wearing course	1.100	0.900	1.100	0.900
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	1.000	1.000	1.000
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table B.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table B.2 of IRC:6-2017

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table B.3 Partial Safety Factor For Verification of Servicibilty Limit State

-Refer Table B.3 of IRC:6-2017

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table B.4 Partial Safety Factor For Design of Foundation

-Refer Table B.4 of IRC:6-2017

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Seismic Coefficient Calculation

(As Per IRC:6-2017 , Clause 219)

F(Horizontal Seismic Force For Zone 4.0

Feq	=	Seismic forces to be resisted
Feq	=	Ah x (Dead load + Appropriate Live load)
Ah	=	horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \quad \frac{Sa}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.24	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \left(\frac{D}{1000F}\right)^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 15.038 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 16.687 m

Abutment Cap Top Level - Foundation Level
= 14.538 m

Dimensions of Abutment Shaft

Length	=	10.00	m
Width	=	0.80	m
Width of counter for @ top	=	0.83	m
Width of counter for @ Bottom		10.20	m
Height of Counter fort	=	11.44	m
Thk. Of counter fort	=	0.80	m
No. counter fort	=	2.00	m
Width of Solid Return Wall	=	10.20	m
Thk. of Return wall	=	1.00	m

Moment of Inertia , $I_{longitudinal}$	=	5148.176	m^4
Moment of Inertia , $I_{transverse}$	=	288.981	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction **Transverse Direction**

Force	=	77206.521	KN	Force	=	3730.504	KN
D	=	1560.13	KN	D	=	1839.853	KN
T	=	0.0090	sec	T	=	0.0444	sec

For Hard or Rocky Strata, with N>30

$\frac{Sa}{g}$ = 2.500 $\frac{Sa}{g}$ = 2.500

For Medium Strata, with N>10&N<30

$\frac{Sa}{g}$ = 2.500 $\frac{Sa}{g}$ = 2.500

For Soft Soil Strata, with N<10

$\frac{Sa}{g}$ = 2.5000 $\frac{Sa}{g}$ = 2.500

Medium Soil Strata

Sa/g = 2.50000 Sa/g = 2.500

Seismic Coeff. In Longitudinal Direction = 0.120

Seismic Coeff. In Transverse Direction = 0.360

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.120	In Longitudinal direction
Ah	=	0.360	In Transverse direction
Av	=	0.240	In Vertical direction

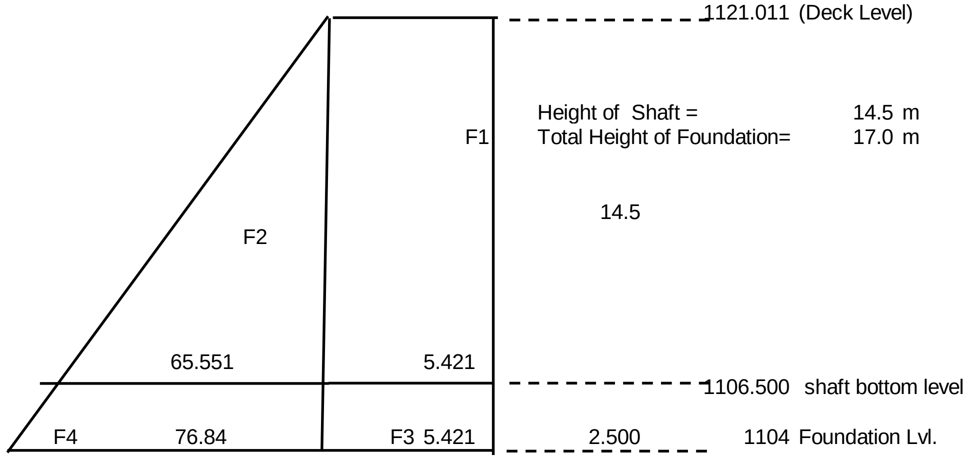
For Design of Foundation

Ah	=	0.162	In Longitudinal direction
Ah	=	0.360	In Transverse direction
Av	=	0.240	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0			
	ϕ	=	35	degree	0.611	radians
	θ	=	90.00	degree	1.571	radians
	$\theta 1$	=	90.00	degree	1.571	radians
	β	=	0		0	radians
	δ	=	22.5	degree	0.393	radians
	Kah	=	0.226	active component		
	Kph	=	5.249	Passive component		
	γ	=	20	kN/m^3		

Equivalent Live Load Surcharge height Assuming = 1.2 m



Earth Pressure Diagram

Horizontal Forces and Moments @ RL 1106.500 m (at Shaft Base)
@ RL 1104.000 m (at Foundation Level)

Due to Live Load Surcharge

Intensity for rectangular portion	=	0.226	x	20	x	1.2	=	5.421	kN/m^2
F1	=	5.421	x	14.511	x	5.400	=	**424.771**	**kN**
M1	=	424.77	x	7.26	=	**3081.927**	**kN.m**	**at Shaft Bottom**	
F3	=	5.421	x	17.011	x	5.400	=	**497.952**	**kN**
M3	=	497.952	x	8.505	=	**4235.331**	**kN.m**	**at Foundation**	

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

	=	0.226	x	20	x	14.511	=	65.551	kN/m^2
F2	=	0.5	x	65.55	x	14.511	x	5.40	
	=	**2568.273**	**kN**						

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2017)

M2	=	2568.27	x	6.09	=	**15652.646**	**kN.m**	**at Shaft Bottom**

Intensity for triangular portion (At Foundation level)

	=	0.226	x	20	x	17.011	=	76.844	kN/m^2
F4	=	0.5	x	76.84	x	17.011	x	5.40	
	=	**3529.443**	**kN**						

M4 = 3529.44 x 7.14 = **25216.527 kN.m** **at Foundation**

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m^3

Intensity for triangular portion (At Shaft bottom level)
= 4.800 x 14.511 = 69.653 kN/m^2

F = 0.5 x 69.653 x 14.511 x 5.400
= **2728.976 kN**

M = 2728.98 x 4.837 = **13200.056 kN.m** **at Shaft Bottom**

Intensity for triangular portion (At Foundation level)
= 4.800 x 17.011 = 81.65 kN/m^2

F = 0.5 x 81.653 x 17.01 x 5.400
= **3750.289 kN**

M = 3750.29 x 5.670 = **21265.387 kN.m** **at Foundation**

Intensity of Passive pressure
= 5.249 x 20 x 0.000 = 0.000 kN/m^2
Force due to passive @ Foundation, F
= 0.5 x 0.000 x 0.000 x 5.40
= **0.000 kN**

Moment due to passive @ Foundation, M
= 0.000 x 0.000 = **0.000 kN.m** **at Foundation**

Summary of Moment and Horizontal Force

	MOMENTS		**HORIZONTAL FORCE**	
	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl kN	At Foundation Lvl kN
Due to active Earth Pressure	15652.646	25216.527	2568.273	3529.443
Due to Minimum Fluid Pressure	13200.056	21265.387	2728.976	3750.289
Governing of Two	**15652.646**	**25216.527**	**2728.976**	**3750.289**
Due to Live Load Surcharge	**3081.927**	**4235.331**	**424.771**	**497.952**
Due to Passive pressure		**0.000**		**0.000**

Earth Pressure : Seismic Dry Case

As per Clause 219.5.4 , IRC:6-2017

Seismic Zone =	4.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha)\cos\delta \quad (1 \pm \alpha v)}{\cos^2\alpha \cos(\alpha + \delta + \lambda)\cos\lambda\,[1 + \mathrm{sqrt}(\sin(\phi + \delta)\sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda)\cos(\alpha - \beta)))]^2}$$

α h	=	0.120	
α v	=	0.240	
φ	=	35.00	0.611
δ	=	22.50	0.393
α	=	0.00	0.000
β	=	0.00	0.000

α h	=	HORIZONTAL SEISMIC COFFICIENT
α v	=	VERTICAL SEISMIC COFFICIENT
φ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$\lambda = \tan^{-1} \dfrac{\alpha h}{(1 \pm \alpha v)}$ = 0.096 / 0.157

		1	2
C_a	=	0.348	0.245

Ca	=	0.348		
Ka	=	**0.226**		
Dynamic Increment	=	0.348	-0.226	**0.122**

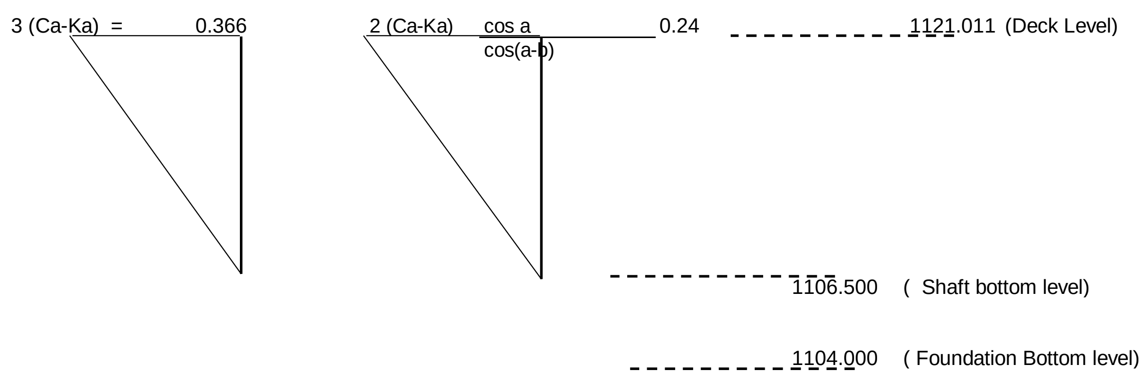
3 Earth Pressure : **DRY CASE (Seismic case)**

Equivalent Live Load Surcharge height = 1.2 m

Assuming γdry = 20 kN/m^3

γwater = 10.00 kN/m^3

Active Earth Pressure **Surcharge Earth Pressure**



Earth Pressure Diagram for Dynamic Increment

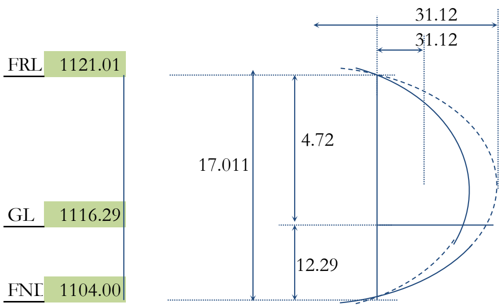
Due to Dynamic Live Load Surcharge

	=	0.244	x	20.00	x	1.2	=	5.853 kN/m^2
at Shaft Bottom Level								
E1	=	0.50 x		5.853	x	14.511	x	5.400
	=	**229.333** kN						
M1	=	229.333	x	9.722			=	**2229.7** kN.m
at Foundation Bottom Level								
E2	=	0.50	x	5.853	x	17.011	x	5.400

= **268.843** kN

M2 = 268.843 x 13.897 = **3736.2** kN.m

<u>Due to Dynamic Active Earth Pressure</u>



Dynamic Earth Pressure

Dyanmic Earth Pressure Calculation

Parabola above Water Level

p_mid_height = 31.12 t/m^2
h = 17.011 m
y = -3.7875 m
L = 5.400 m

Parabola below Water Level

p_mid_height = 31.12 t/m^2
h = 17.011 m
y = 3.7875 m
L = 5.400 m

Dyanmic Earth Pressure	Pa	ey
	T	m
Parabola above Water Level	358.4	14.0
Parabola below Water Level	1547.1	7.2
Total Dynamic Earth Pressure	**1905.5**	**8.5**

E3 = **1905.535** kN

E4 = **1905.535** kN

M3 = 1905.54 x 8.51 = **16207.5** kN.m **(Shaft bottom level)**

M4 = 1905.54 x 11.01 = **20971.4** kN.m **(Foundation Bottom level)**

Summary of Moment and Horizontal Force **Dry Seismic Case**

	MOMENTS		**HORIZONTAL FORCE**	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	15652.6	25216.527	2568.273	3529.443
Due to active Earth Pressure (dynamic Increment)	16207.5	20971.370	1905.535	1905.535
Total Earth Pressure	31860.2	46187.897	4473.808	5434.978
Due to Minimum Fluid Pressure	13200.1	21265.387	2728.976	3750.289
Governing of Two	**15652.6**	**46187.897**	**4473.808**	**5434.978**
Due to Live Load Surcharge (Static)	**3081.9**	**4235.331**	**424.771**	**497.952**
Due to Live Load Surcharge(Dynamic)	**2229.657**	**3736.208**	**229.333**	**268.843**

Due to Passive pressure		**0.000**		**0.000**

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - Spherical Brg

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1085.68	1.35	1.35	1465.67	1465.67	
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00	
WC	=	274.45	1.75	1.75	480.29	480.29	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	1056.43	1.5	0.20	1584.64	211.29	(1-70RW + 1-CLASS A)
CWLLmax-Reaction case	=	1592.52	1	0.20	1592.52	318.50	SV Loading
CWLLmin	=	342.17	1.5	0.20	513.26	68.43	(1-70RW + 1-CLASS A)
CWLLmin	=	1467.48	1	0.20	1467.48	293.50	SV Loading
CWLLmax-Transv. Moment Case		774.00	1.5	0.20	1161.00	154.80	(1-70RW)

Braking Force = 0.2 x 0 + 0.05 x 0

= 0 KN

Normal Case:

	Vertical Force (R)	Fh	µ R	Fh/2 +µ R	Fh-µ R	Governing Long. Force (kN)		
DL+SIDL	2215.96	0	110.798	110.798	-110.798	110.798		
DL+SIDL+LL-Max Reaction case	2729.21	0	136.461	136.461	-136.461	136.461	(1-70RW + 1-CLASS A)	Dry Case
	4196.70	0	209.835	209.835	-209.835	209.835	SV Loading	
DL+SIDL+LL-Min Reaction case	3800.60	0	190.030	190.030	-190.030	190.030	(1-70RW + 1-CLASS A)	HFL Case
	3808.48	0	190.424	190.424	-190.424	190.424	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	3376.96	0	168.848	168.848	-168.848	168.848		

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	µ R	Fh/2 +µ R	Fh-µ R	Governing Long. Force (kN)	
DL+SIDL	1560.13	2215.96	0.00	110.798	110.798	-110.798	110.798	
DL+SIDL+LL-Max Reaction case		2284.39	0.00	114.220	114.220	-114.220	114.220	Dry Case
DL+SIDL+LL-Min Reaction case		2427.25	0.00	121.362	121.362	-121.362	121.362	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2370.76	0.00	118.538	118.538	-118.538	118.538	

Transverse Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	µ R	Fh/2 +µ R	Fh-µ R	Governing Long. Force (kN)	
DL+SIDL	1560.13	2215.96	0.000	110.798	110.798	-110.798	110.798	
DL+SIDL+LL-Max Reaction case		2284.39	0.00	114.220	114.220	-114.220	114.220	Dry Case
DL+SIDL+LL-Min Reaction case		2427.25	0.00	121.362	121.362	-121.362	121.362	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2370.76	0.00	118.538	118.538	-118.538	118.538	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1085.68	1.35	1.35	1465.67	1465.67
SIDL except wc	=	200.00	1.35	1.35	270.00	270.00
WC	=	274.45	1.75	1.75	480.29	480.29
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	1056.43	1.5	0.75	1584.64	792.32
CWLLmax-Transv. Moment Case	=	774.00	1.5	0.75	1161.00	580.50
CWLLmin	=	342.17	1.5	0.75	513.26	256.63

Braking Force = 0 KN

Normal Case:

	Vertical Force (R)	Fh	µ R	Fh/2 +µ R	Fh-µ R	Governing Long. Force (kN)		
DL+SIDL	2215.96	0.000	110.798	110.798	-110.798	110.798		
DL+SIDL+LL-Max Reaction case	2729.21	0.000	136.461	136.461	-136.461	136.461	(1-70RW + 1-CLASS A)	Dry Case
	4196.70	0.000	209.835	209.835	-209.835	209.835	SV Loading	
DL+SIDL+LL-Min Reaction case	3800.60	0.000	190.030	190.030	-190.030	190.030	(1-70RW + 1-CLASS A)	HFL Case
	3808.48	0.000	190.424	190.424	-190.424	190.424	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	3376.96	0.000	168.848	168.848	-168.848	168.848		

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Vertical Force	Fh	µ R	Fh/2 +µ R	Fh-µ R	Governing Long. Force (kN)	
DL+SIDL	1560.13	2215.96	0.00	110.798	110.798	-110.798	110.798	
DL+SIDL+LL-Max Reaction case		2472.59	0.00	123.629	123.629	-123.629	123.629	Dry Case

DL+SIDL+LL-Min Reaction case		3008.28	0.00	150.414	150.414	-150.414	150.414	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2796.46	0.00	139.823	139.823	-139.823	139.823	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)	
DL+SIDL	1560.13	2215.96	0.000	110.798	110.798	-110.798	110.798	
DL+SIDL+LL-Max Reaction case		2472.59	0.000	123.629	123.629	-123.629	123.629	Dry Case
DL+SIDL+LL-Min Reaction case		3008.28	0.000	150.414	150.414	-150.414	150.414	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2796.46	0.000	139.823	139.823	-139.823	139.823	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1085.68	1	1.00	1085.68	1085.68
SIDL except wc	=	200.00	1	1.00	200.00	200.00
WC	=	274.45	1	1.00	274.45	274.45
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	1056.43	1	0.20	1056.43	211.29
CWLLmax-Transv. Moment Case		774.00	1	0.20	774.00	154.80
CWLLmin	=	342.17	1	0.20	342.17	68.43

Braking Force = 0 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)		
DL+SIDL	1560.13	0.000	78.007	78.007	-78.007	78.007		
DL+SIDL+LL-Max Reaction case	1902.30	0.000	95.115	95.115	-95.115	95.115	(1-70RW + 1-CLASS A)	Dry Case
	3027.62	0.000	151.381	151.381	-151.381	151.381	SV Loading	
DL+SIDL+LL-Min Reaction case	2616.56	0.000	130.828	130.828	-130.828	130.828	(1-70RW + 1-CLASS A)	HFL Case
	3152.65	0.000	157.632	157.632	-157.632	157.632	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2334.13	0.000	116.707	116.707	-116.707	116.707		

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)	
DL+SIDL	1560.13	0.000	78.007	78.007	-78.007	78.007	
DL+SIDL+LL-Max Reaction case	1628.57	0.000	81.428	81.428	-81.428	81.428	Dry Case
DL+SIDL+LL-Min Reaction case	1771.42	0.000	88.571	88.571	-88.571	88.571	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1714.93	0.000	85.747	85.747	-85.747	85.747	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)	
DL+SIDL	1560.13	0.000	78.007	78.007	-78.007	78.007	
DL+SIDL+LL-Max Reaction case	1628.57	0.000	81.428	81.428	-81.428	81.428	Dry Case
DL+SIDL+LL-Min Reaction case	1771.42	0.000	88.571	88.571	-88.571	88.571	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1714.93	0.000	85.747	85.747	-85.747	85.747	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2017)

Type of bearing - POT-PTFE

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1085.68	1.1	1.10	1194.25	1194.25
SIDL except wc	=	200.00	1.1	1.10	220.00	220.00
WC	=	274.45	1.35	1.35	370.51	370.51
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Reaction case	=	1056.43	1.5	0.00	1584.64	0.00
CWLLmax-Transv. Moment Case	=	774.00	1.5	0.00	1161.00	0.00
CWLLmin	=	342.17	1.5	0.00	513.26	0.00

Braking Force = 0 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)		
DL+SIDL	1784.76	0.000	89.238	89.238	-89.238	89.238		
DL+SIDL+LL-Max Reaction case	2298.01	0.000	114.901	114.901	-114.901	114.901	(1-70RW + 1-CLASS A)	Dry Case
	3252.24	0.000	162.612	162.612	-162.612	162.612	SV Loading	
DL+SIDL+LL-Min	3369.40	0.000	168.470	168.470	-168.470	168.470	(1-70RW + 1-CLASS A)	HFL Case

Reaction case	3377.27	0.000	168.864	168.864	-168.864	168.864	SV Loading
DL+SIDL+LL-Max Transv. Moment case	2945.76	0.000	147.288	147.288	-147.288	147.288	

Longitudinal Seismic Case: Seismic effect = 0.00

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)	
DL+SIDL	1560.13	1784.76	0.00	89.238	89.238	-89.238	89.238	
DL+SIDL+LL-Max Reaction case		1784.76	0.00	89.238	89.238	-89.238	89.238	Dry Case
DL+SIDL+LL-Min Reaction case		1784.76	0.00	89.238	89.238	-89.238	89.238	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1784.76	0.00	89.238	89.238	-89.238	89.238	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)	
DL+SIDL	1560.13	1784.76	0.000	89.238	89.238	-89.238	89.238	
DL+SIDL+LL-Max Reaction case		1784.76	0.000	89.238	89.238	-89.238	89.238	Dry Case
DL+SIDL+LL-Min Reaction case		1784.76	0.000	89.238	89.238	-89.238	89.238	HFL Case
DL+SIDL+LL-Max Transv. Moment case		1784.76	0.000	89.238	89.238	-89.238	89.238	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1085.68	1	1	1	1085.68	1085.68	1085.68
SIDL except wc	=	200.00	1	1	1	200.00	200.00	200.00
WC	=	274.45	1.20	1.20	1.20	329.34	329.34	329.34
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	1056.43	1	0.75	0	1056.43	792.32	0.00
CWLLmax-Transv. Moment Case	=	774.00	1	0.75	0	774.00	580.50	0.00
CWLLmin	=	342.17	1	0.75	0	342.17	256.63	0.00

Braking Force = 0 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)	
DL+SIDL	1615.02	0.000	80.751	80.751	-80.751	80.751	
DL+SIDL+LL-Max	1957.19	0.000	97.860	97.860	-97.860	97.860	(1-70RW + 1-CLASS A)

Dry Case

Reaction case	3082.51	0.000	154.125	154.125	-154.125	154.125	SV Loading	
DL+SIDL+LL-Min Reaction case	2671.45	0.000	133.573	133.573	-133.573	133.573	(1-70RW + 1-CLASS A)	HFL Case
	3207.54	0.000	160.377	160.377	-160.377	160.377	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2389.02	0.000	119.451	119.451	-119.451	119.451		

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)	
DL+SIDL	1615.02	0.000	80.751	80.751	-80.751	80.751	
DL+SIDL+LL-Max Reaction case	1871.65	0.000	93.583	93.583	-93.583	93.583	Dry Case
DL+SIDL+LL-Min Reaction case	2407.35	0.000	120.367	120.367	-120.367	120.367	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2195.52	0.000	109.776	109.776	-109.776	109.776	

Normal Case: Quasi Permenant Combination

	Vertical Force (R)	Fh	μ R	Fh/2 +μ R	Fh-μ R	Governing Long. Force (kN)	
DL+SIDL	1615.02	0.000	80.751	80.751	-80.751	80.751	
DL+SIDL+LL-Max Reaction case	1615.02	0.000	80.751	80.751	-80.751	80.751	Dry Case
DL+SIDL+LL-Min Reaction case	1615.02	0.000	80.751	80.751	-80.751	80.751	HFL Case
DL+SIDL+LL-Max Transv. Moment case	1615.02	0.000	80.751	80.751	-80.751	80.751	

Centrifugal Force Calculation

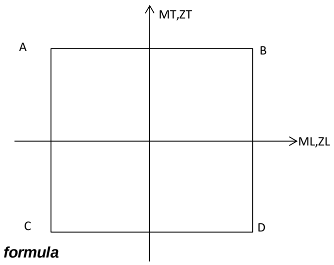
CENTRIFUGAL FORCE C = $\dfrac{\mathbf{W\,V^2}}{\mathbf{127\,R}}$

			Normal Case		Seismic Case	
Design Speed	V	=	50.00	kmph	50.00	kmph
Live Load	W	=	1056.43	kN	1056.43	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

SBC AND STABILITY CHECK OF FOUNDATION



Foundation Lvl = 1104.00 m

Properties of Footing Base:

A	=	160.00	m^2
ZL	=	426.67	m^3
ZT	=	266.67	m^3

For Skew bridges, Resolve the moment due to braking force,Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	**ML = ML Cos θ + MT Sin θ**
Moment along transverse axis	**MT = MT Cos θ - ML Sin θ**

Case 1 : DL+SIDL-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.00			1085.68	2.58	2795.63	0.00	0.00
SIDL except Wearing Course	1.00			200.00	2.58	515.00	0.00	0.00
Wearing Course	1.00			274.45	2.58	706.71	0.00	0.00
Bearing Pedestal	1.00	25.00	1.95	48.80	2.58	125.66	-0.72	-35.00
				1608.93		**4143.00**		**-35.00**
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1.00	25.00	7.42	185.44	1.53	282.79	0.00	0.00
Dirt Wall-Tapered portion	1.00	25.00	0.00	0.00	1.53	0.00	0.00	0.00
Bracket - Uniform portion	1.00	25.00	0.90	22.50	1.23	27.56	0.00	0.00
Bracket - Tapered portion	1.00	25.00	0.45	11.25	1.28	14.34	0.00	0.00
Cap - (uniform portion)	1.00	25.00	6.36	159.00	2.44	387.17	0.00	0.00
Cap - (corbel portion)	1.00	25.00	6.36	159.00	2.44	387.17	0.00	0.00
Cantilever Return Wall-Rectangle p	1.00	25.00	0.00	0.00	2.20	0.00	0.00	0.00
Cantilever Return Wall-Traingle port	1.00	25.00	0.00	0.00	2.20	0.00	0.00	0.00
RCC Railing or Crash Barrier	1.00			0.00	1.53	0.00	0.00	0.00
Aproach Slab	1.00	25.00	5.25	131.25	1.23	160.78	0.00	0.00
				668.44		**1259.81**		**0.00**
Substructure & Foundation -Portion 2								
Solid Return wall	1.00	25.00	326.62	8165.61	-2.90	-23680.27	0.00	0.00
Counterfort wall	1.00	5.00	93.34	466.69	-2.90	-1353.40		
Front Counterfort wall	1.00	5.00	0.00	0.00	5.44	0.00		
Abutment Shaft	1.00	25.00	91.51	2287.70	2.60	5948.02	0.00	0.00
Back filling over heel slab	1.00	20.00	1197.09	23941.89	-2.90	-69431.48	0.00	0.00
Front Filling over toe slab	1.00	20.00	527.15	10543.00	5.44	57361.50	0.00	0.00
Side filling between heel and toe	1.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
Heel slab	1.00	25.00	102.00	2550.00	-2.90	-7395.00	0.00	0.00
Toe slab	1.00	25.00	87.50	2187.50	5.14	11250.00	0.00	0.00
portion between heel & toe	1.00	25.00	20.00	500.00	2.60	1300.00	0.00	0.00
Vertical Components of active earth pressure	1.00			1553.42	-8.00	-12427.36	0.00	0.00
				52195.81		**-38427.99**		**0.00**
Total				**54473.18**		**-33025.18**		**-35.00**

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
Superstructure				
Dead Load	0.90	977.11	-5.43	-5300.85
SIDL except Wearing Course	0.90	180.00	-5.43	-976.50
Wearing Course	1.00	274.45	-5.43	-1488.89
Bearing Pedestal	0.90	43.92	-5.43	-238.27
		1475.48		**-8004.50**
Substructure & Foundation -Portion 1				
Dirt Wall-Uniform portion	0.90	166.89	-6.48	-1080.64
Dirt Wall-Tapered portion	0.90	0.00	-6.48	0.00
Bracket - Uniform portion	0.90	20.25	-6.78	-137.19
Bracket - Tapered portion	0.90	10.13	-6.73	-68.09
Cap - (uniform portion)	0.90	143.10	-5.57	-796.35
Cap - (corbel portion)	0.90	143.10	-5.57	-796.35
Cantilever Return Wall-Rectangle p	0.90	0.00	-5.80	0.00
Cantilever Return Wall-Traingle port	0.90	0.00	-5.80	0.00
RCC Railing or Crash Barrier	0.90	0.00	-6.48	0.00
Aproach Slab	0.90	118.13	-6.78	-800.30
		601.59		**-3678.92**
Substructure & Foundation -Portion 2				
Solid Return wall	0.90	7349.05	-10.90	-80104.63
Counterfort wall	0.90	420.02	-10.90	-4578.24
Front Counterfort wall	0.90	0.00	-2.56	0.00
Abutment Shaft	0.90	2058.93	-5.40	-11118.22
Back filling over heel slab	0.90	21547.70	-10.90	-234869.93
Front Filling over toe slab	0.90	9488.70	-2.56	-24284.25
Side filling between heel and toe	0.90	0.00	0.00	0.00
Heel slab	0.90	2295.00	-10.90	-25015.50
Toe slab	0.90	1968.75	-2.86	-5625.00
portion between heel & toe	0.90	450.00	-5.40	-2430.00
Vertical Components of active earth pressure	1.00	1553.42	-16.00	-24854.73
		47131.57		**-412880.50**
Total		**49208.65**		**-424563.92**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)	Forces along Long. Axis		Forces along Trans. Axis	
					FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ

due to Superstructure	1.00	78.01	1119.48	1207.23		78.01	1207.23	0.00	0.00
due to Earth pressure	1.00	3750.29		25216.53		3750.29	25216.53	0.00	0.00

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)	FL Cosθ (Forces along Long. Axis)	ML Cosθ (Forces along Long. Axis)	FL Sinθ (Forces along Trans. Axis)	ML Sin θ (Forces along Trans. Axis)
due to Superstructure		89.24	1119.48	1381.05	89.24	1381.05	0.00	0.00
due to Earth pressure	1.50	5625.43		37824.79	5625.43	37824.79	0.00	0.00

Summary of Forces For SBC		
P	54473.18	KN
ML	-6601.42	kNm
MT	-35.00	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		54473.18		-33025.18		-35.00
CWLL-Max. Reaction case	1.00	1056.43	2.58	2720.31	0.20	209.89
Vertical Components of LL Surcharge	1.00	206.26	-8.00	-1650.07	0.00	0.00
Total		**55735.87**		**-31954.94**		**174.89**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	49208.65		-424563.92
0.00		-5.43	0.00
1.00		-16.00	-3300.14
	49208.65		**-427864.06**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)	FL Cosθ (Forces along Long. Axis)	ML Cosθ (Forces along Long. Axis)	FL Sinθ (Forces along Trans. Axis)	ML Sin θ (Forces along Trans. Axis)
due to Superstructure	1.00	95.12	1119.48	1472.00	95.12	1472.00	0.00	0.00
due to Earth pressure	1.00	3750.29		25216.53	3750.29	25216.53	0.00	0.00
due to Live load surcharge	1.00	497.95		4235.33	497.95	4235.33	0.00	0.00
					4343.36	**30923.86**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)	FL Cosθ (Forces along Long. Axis)	ML Cosθ (Forces along Long. Axis)	FL Sinθ (Forces along Trans. Axis)	ML Sin θ (Forces along Trans. Axis)
due to Superstructure		114.90	1119.48	1778.20	114.90	1778.20	0.00	0.00
due to Earth pressure	1.50	5625.43		37824.79	5625.43	37824.79	0.00	0.00
due to Live load surcharge	1.20	597.54		5082.40	597.54	5082.40	0.00	0.00
		6337.88		**44685.39**	**6337.88**	**44685.39**	**0.00**	**0.00**

Summary of Forces For SBC		
P	55735.87	KN
ML	-1031.08	kNm
MT	174.89	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1.00	αh=	0.12	In Longitudinal direction
		αh=	0.36	In Transverse direction
		αv=	0.24	In Vertical direction

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1.00			1085.68		117.25	78.17	2.58	2795.63	201.29	1120.46		0.00	0.00	1929.53
SIDL except Wearing Course	1.00			200.00		21.60	14.40	2.58	515.00	37.08	1121.46		0.00	0.00	377.13
Wearing Course	1.00			274.45		29.64	19.76	2.58	706.71	50.88	1121.01		0.00	0.00	504.22
Bearing Pedestal	1.00	25.00	1.95	48.80		5.27	3.51	2.58	125.66	9.05			-0.72	-35.00	
				1608.93		**173.76**	**115.84**		**4143.00**	**298.30**				**-35.00**	**2810.88**
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1.00	25.00	7.42	185.44	22.25	20.03	13.35	1.53	282.79	20.36	1119.77	351.03	0.00	0.00	315.92
Dirt Wall-Tapered portion	1.00	25.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00	1118.54	0.00	0.00	0.00	0.00
Bracket - Uniform portion	1.00	25.00	0.90	22.50				1.23	27.56						
Bracket - Tapered portion	1.00	25.00	0.45	11.25				1.28	14.34						
Cap - (uniform portion)	1.00	25.00	6.36	159.00	19.08	17.17	11.45	2.44	387.17	27.88	1118.39	274.53	0.00	0.00	247.08
Cap - (corbel portion)	1.00	25.00	6.36	159.00	19.08	17.17	11.45	2.44	387.17	27.88	1118.09	268.81	0.00	0.00	241.93
Cantilever Return Wall-Rectangle p	1.00	25.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	1121.01	0.00	0.00	0.00	0.00
Cantilever Return Wall-Traingle port	1.00	25.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	1121.01	0.00	0.00	0.00	0.00
RCC Railing or Crash Barrier	1.00			0.00				1.53	0.00				0.00	0.00	
Aproach Slab	1.00	25.00	5.25	131.25				1.23	160.78				0.00	0.00	
				668.44	**60.41**	**54.37**	**36.25**		**1259.81**	**76.11**		**894.37**		**0.00**	**804.93**
Substructure & Foundation -Portion 2															
Solid Return wall	1.00	25.00	326.62	8165.61	979.87	881.89	587.92	-2.90	-23680.27	-1704.98	1113.08	8901.41	0.00	0.00	8011.27
0.00	1.00	5.00	93.34	466.69	56.00	50.40	33.60	-2.90	-1353.40	-97.45	1110.44	360.77	0.00	0.00	324.69
0.00	1.00	5.00	0.00	0.00	0.00	0.00	0.00	5.44	0.00	0.00	1107.33	0.00	0.00	0.00	0.00
Abutment Shaft	1.00	25.00	91.51	2287.70	274.52	247.07	164.71	2.60	5948.02	428.26	1117.12	3600.59	0.00	0.00	3240.53
Back filling over heel slab	1.00	20.00	1197.09	23941.89	0.00	0.00	0.00	-2.90	-69431.48	0.00	1113.08	0.00	0.00	0.00	0.00
Front Filling over toe	1.00	20.00	527.15	10543.00				5.44	57361.50				0.00	0.00	
Side filling between heel and toe	1.00	20.00	0.00	0.00				0.00	0.00				0.00	0.00	
Heel slab	1.00	25.00	102.00	2550.00	306.00	275.40	183.60	-2.90	-7395.00		1105.75	535.50	0.00	0.00	481.95
Toe slab	1.00	25.00	87.50	2187.50	262.50	236.25	157.50	5.14	11250.00		1105.75	459.38	0.00	0.00	413.44
portion between heel & toe	1.00	25.00	20.00	500.00	60.00	54.00	36.00	2.60	1300.00		1105.25	75.00	0.00	0.00	67.50
Vertical component of active earth pressure	1.00			1461.94				-8.00	-11695.54				0.00	0.00	
Vertical component of dynamic increment of earth pressure	1.00			789.30				-8.00	-6314.39				0.00	0.00	
				52893.63	**1938.90**	**1745.01**	**1163.34**		**-44010.56**	**-1374.17**		**13932.65**		**0.00**	**12539.38**
Total =				**55171.00**	**1999.31**	**1973.15**	**1315.43**		**-38607.75**	**-999.76**		**14827.02**		**-35.00**	**16155.19**
							-1315.43			999.76					

Vertical Forces For Restoring or Resisting Effect / **For Overturning or Sliding Effect**

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv	Load Factor	FL = αh x P (kN)	C.g. of Force (m)	MLs due to FL
Superstructure												
Dead Load	0.90			977.11	70.35	-5.43	-5300.85	-381.66				
SIDL except Wearing Course	0.90			180.00	12.96	-5.43	-976.50	-70.31				
Wearing Course	1.00			274.45	19.76	-5.43	-1488.89	-107.20				
Bearing Pedestal	0.90	25.00	1.95	43.92		-5.43	-238.27					
				1475.48	**103.07**		**-8004.50**	**-559.17**				
Substructure & Foundation -Portion 1												
Dirt Wall-Uniform portion	0.90	25.00	7.42	166.89	12.02	-6.48	-1080.64	-77.81	1.00	22.25	1119.77	351.03
Dirt Wall-Tapered portion	0.90	25.00	0.00	0.00	0.00	-6.48	0.00	0.00	1.00	0.00	1118.54	0.00
Bracket - Uniform portion	0.90	25.00	0.90	20.25								
Bracket - Tapered portion	0.90	25.00	0.45	10.13								
Cap - (uniform portion)	0.90	25.00	6.36	143.10	10.30	-5.57	-796.35	-57.34	1.00	19.08	1118.39	274.53
Cap - (corbel portion)	0.90	25.00	6.36	143.10	10.30	-5.57	-796.35	-57.34	1.00	19.08	1118.09	268.81
Cantilever Return Wall-Rectangle p	0.90	25.00	0.00	0.00	0.00	-5.80	0.00	0.00	1.00	0.00	1121.01	0.00
Cantilever Return Wall-Traingle port	0.90	25.00	0.00	0.00	0.00	-5.80	0.00	0.00	1.00	0.00	1121.01	0.00
RCC Railing or Crash Barrier	0.90			0.00		-6.48	0.00					

Aproach Slab	0.90	25.00	5.25	118.13		-6.78	-800.30					
				601.59	**32.62**		**-3473.64**	**-192.48**		**60.41**		**894.37**
Substructure & Foundation -Portion 2												
Abutment Shaft	0.90	25.00	91.51	2058.93	148.24	-5.40	-11118.22	-800.51	1.00	274.52	1117.12	3600.59
0.00	0.90	5.00	93.34	420.02	30.24	-10.90	-4578.24	-329.63	1.00	56.00	1110.44	360.77
0.00	0.90	5.00	0.00	0.00	0.00	-2.56	0.00	0.00	1.00	0.00	1107.33	0.00
Solid Return wall	0.90	25.00	326.62	7349.05	529.13	-10.90	-80104.63	-5767.53	1.00	979.87	1113.08	8901.41
Back filling over heel slab	0.90	20.00	1197.09	21547.70	0.00	-10.90	-234869.93	0.00	1.00	0.00	1113.08	0.00
Front Filling over toe	0.90	20.00	527.15	9488.70		-2.56	-24284.25					
Side filling between heel and toe	0.90	20.00	0.00	0.00		0.00	0.00					
Heel slab	0.90	25.00	102.00	2295.00		-10.90	-25015.50		1.00	306.00	1105.75	535.50
Toe slab	0.90	25.00	87.50	1968.75		-2.86	-5625.00		1.00	262.50	1105.75	459.38
portion between heel & toe	0.90	25.00	20.00	450.00		-5.40	-2430.00		1.00	60.00	1105.25	75.00
Vertical component of active earth pressure	1.00			1553.42		-16.00	-24854.73					
Vertical component of dynamic increment of earth pressure	1.00			789.30		-16.00	-12628.78					
				47920.87	**707.62**		**-425509.28**	**-6897.68**		**1938.90**		**13932.65**
Total =				**49997.95**	**843.31**		**-436987.42**	**-7649.33**		**1999.31**		**14827.02**
					-843.31			7649.33				

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1.00	78.01	173.76	1119.48	1207.23	2810.88
due to Substructure	1.00	1999.31	1799.38		14827.02	13344.31
due to Earth pressure	1.00	5434.98			46187.90	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
78.01	1207.23	0.00	0.00	0.00	0.00	173.76	2810.88
1999.31	14827.02	0.00	0.00	0.00	0.00	1799.38	13344.31
5434.98	46187.90						
7512.30	**62222.14**	**0.00**	**0.00**	**0.00**	**0.00**	**1973.15**	**16155.19**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		89.24	1119.48	1381.05
due to Substructure	1.50	2998.97		22240.52
due to Active Earth pressure	1.00	3529.44		25216.53
due to dynamic Earth pressure	1.00	1905.54		20971.37
		8523.18		**69809.47**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
89.24	1381.05	0.00	0.00
2998.97	22240.52	0.00	0.00
3529.44	25216.53	0.00	0.00
1905.54	20971.37	0.00	0.00
8523.18	**69809.47**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	56486.43	53855.57	KN
ML	22614.63	24614.15	kNm
MT	16120.19	16120.19	kNm

Summary of Restoring Forces

Vertical Load	49154.64	kN
Moment	-444636.74	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				1608.93		173.76	115.84		4143.00	298.30				-35.00	2810.88
Forces from Substructure				53562.07	1999.31	1799.38	1199.59		-42750.75	-1298.05		14827.02		0.00	13344.31
CWLL-Max. Reaction case	0.20			211.29		22.82	15.21	2.58	544.06	39.17	1122.21		0.20	41.98	415.55
Vertical component of LL Surcharge	0.20			41.25				-8.00	-330.01				0.00	0.00	

Vertical component of dynamic increment LL Surcharge	0.20			22.27				-8.00	-178.17				0.00	0.00	
Total =				**55445.81**	**1999.31**	**1995.96**	**1330.64**		**-38571.88**	**-960.59**		**14827.02**		**6.98**	**16570.75**
							-1330.64			960.59					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstucture				1475.48	103.07	0.00	-8004.50	-559.17
Forces from Substructure				48522.46	740.24	0.00	-428982.91	-7090.16
CWLL-Max. Reaction case	0.00			0.00	0.00	-5.43	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-16.00	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.00		-16.00	0.00	
Total =				**49997.95**	**843.31**		**-436987.42**	**-7649.33**
					-843.31			**7649.33**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1.00	81.43	196.58	1119.48	1260.19	3226.43
due to Substructure	1.00	1999.31	1799.38		14827.02	13344.31
due to Earth pressure	1.00	5434.98			46187.90	
due to Live load surcharge	0.20	153.36			1594.31	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
81.43	1260.19	0.00	0.00	0.00	0.00	196.58	3226.43
1999.31	14827.02	0.00	0.00	0.00	0.00	1799.38	13344.31
5434.98	46187.90						
153.36	1594.31						
7669.08	**63869.41**	**0.00**	**0.00**	**0.00**	**0.00**	**1995.96**	**16570.75**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		89.24	1119.48	1381.05
due to Substructure	1.50	2998.97		22240.52
due to Active Earth pressure	1.00	3529.44		25216.53
due to dynamic Earth pressure	1.00	1905.54		20971.37
due to Live load surcharge	0.00	0.00		0.00
due to dynamic increment of live load surcharge	0.00	0.00		0.00
		8523.18		**69809.47**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
89.24	1381.05	0.00	0.00
2998.97	22240.52	0.00	0.00
3529.44	25216.53		
1905.54	20971.37		
0.00	0.00		
0.00	0.00		
8523.18	**69809.47**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	56776.45	54115.17	KN
ML	24336.94	26258.11	kNm
MT	16577.72	16577.72	kNm

Summary of Restoring Forces

Vertical Load	49154.64	kN
Moment	-444636.74	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**1608.93**		**579.22**	**115.84**		**4143.00**	**298.30**				**-35.00**	**9369.59**
Substructure & Foundation -Portion 1				**668.44**	**18.12**	**181.24**	**36.25**		**1259.81**	**76.11**		**268.31**		**0.00**	**2683.11**

Substructure & Foundation -Portion 2				**52893.63**	**581.67**	**5816.70**	**1163.34**		**-44010.56**	**-1374.17**		**4179.79**		**0.00**	**41797.94**
Total =				**55171.00**	**599.79**	**6577.15**	**1315.43**		**-38607.75**	**-999.76**		**4448.10**		**-35.00**	**53850.64**
							-1315.43			999.76					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				**1475.48**	**103.07**		**-8004.50**	**-559.17**
Substructure & Foundation -Portion 1				**601.59**	**32.62**		**-3473.64**	**-192.48**
Substructure & Foundation -Portion 2				**47920.87**	**707.62**		**-425509.28**	**-6897.68**
Total =				**49997.95**	**843.31**		**-436987.42**	**-7649.33**
					-843.31			7649.33

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x αh x P (kN)	C.g. of Force (m)	MLs due to FL
	60.41		**894.37**
	1938.90		**13932.65**
	1999.31		**14827.02**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1.00	78.01	579.22	1119.48	1207.23	9369.59
due to Substructure	1.00	599.79	5997.94		4448.10	44481.05
due to Earth pressure	1.00	5434.98			46187.90	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
78.01	1207.23	0.00	0.00	0.00	0.00	579.22	9369.59
599.79	4448.10	0.00	0.00	0.00	0.00	5997.94	44481.05
5434.98	46187.90						
6112.78	**51843.23**	**0.00**	**0.00**	**0.00**	**0.00**	**6577.15**	**53850.64**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		89.24	1119.48	1381.05
due to Substructure	1.50	2998.97		22240.52
due to Active Earth pressure	1.00	3529.44		25216.53
due to dynamic Earth pressure	1.00	571.66		6291.41
		7189.31		**55129.51**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
89.24	1381.05	0.00	0.00
2998.97	22240.52	0.00	0.00
3529.44	25216.53		
571.66	6291.41		
7189.31	**55129.51**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	56486.43	53855.57	KN
ML	12235.72	14235.24	kNm
MT	53815.64	53815.64	kNm

Summary of Restoring Forces

Vertical Load	49154.64	kN
Moment	-444636.74	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	**55445.81**	**1330.64**	**-38571.88**	**-960.59**	**6.98**

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL2	MLs due to Fv
Total =	**49997.95**	**843.31**	**-436987.42**	**-7649.33**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1.00	81.43	655.28	1119.48	1260.19	10754.78
due to Substructure	1.00	599.79	5997.94		4448.10	44481.05
due to Earth pressure	1.00	5434.98			46187.90	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
81.43	1260.19	0.00	0.00	0.00	0.00	655.28	10754.78
599.79	4448.10	0.00	0.00	0.00	0.00	5997.94	44481.05
5434.98	46187.90						

due to Live load surcharge	0.20	153.36			1594.31			153.36	1594.31						
								6269.56	**53490.49**	**0.00**	**0.00**	**0.00**	**0.00**	**6653.22**	**55235.82**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)	Forces along Long. Axis FL Cosθ	ML Cosθ	Forces along Trans. Axis FL Sinθ	ML Sin θ
due to Superstructure		89.24	1119.48	1381.05	89.24	1381.05	0.00	0.00
due to Substructure	1.50	899.69		6672.16	899.69	6672.16	0.00	0.00
due to Active Earth pressure	1.00	3529.44		25216.53	3529.44	25216.53		
due to dynamic Earth pressure	1.00	571.66		6291.41	571.66	6291.41		
due to Live load surcharge	0.00	0.00		0.00	0.00	0.00		
due to dynamic increment of live load surcharge	0.00	0.00		0.00	0.00	0.00		
		5090.03		**39561.14**	**5090.03**	**39561.14**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	56776.45	54115.17	KN
ML	13958.03	15879.20	kNm
MT	55242.80	55242.80	kNm

Summary of Restoring Forces

Vertical Load	49154.64	kN
Moment	-444636.74	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.00 KN

Transverse Moment due to C.F. = 0.00 x (1122.21 - 1104.00) = 0.00 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00 = 0.00 KN

Transverse Moment due to C.F. = 0.00 x (1122.21 - 1104.00) = 0.00 kNm

	Forces along Long. Axis FT Cosθ	MT Cosθ	Forces along Trans. Axis FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT

Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

LOAD CASES	SAFE BEARING CAPACITY CHECK P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	SLIDING CHECK Sliding Force	Restoring Force= μP + c.A + Fp	FOS	OVERTURNING CHECK Overturning moment	Restoring Moment = ΣP.eToe+Mp	FOS
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	54473.18	-6601.42	-35.00	355.80	324.85	356.06	325.12	356.06	324.85	5714.67	34446.05	6.03	39205.84	424563.92	10.83
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	55735.87	-1031.08	174.89	351.42	346.59	350.11	345.28	351.42	345.28	6337.88	34446.05	5.43	44685.39	427864.06	9.58
								SAFE	**SAFE**			**SAFE**			**SAFE**
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	56486.43	24614.15	16120.19	355.80	471.18	234.90	350.28	471.18	234.90	8523.18	34408.25	4.04	69809.47	444636.74	6.37

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	56776.45	26258.11	16577.72	355.48	478.56	231.14	354.23	478.56	231.14	8523.18	34408.25	4.04	69809.47	444636.74	6.37
								SAFE	SAFE			SAFE			SAFE
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	56486.43	14235.24	53815.64	521.49	588.21	117.87	184.60	588.21	117.87	7189.31	34408.25	4.79	55129.51	444636.7	8.07
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	56776.45	15879.20	55242.80	524.80	599.23	110.48	184.91	599.23	110.48	5090.03	34408.25	6.76	39561.14	444636.7	11.24
								SAFE	SAFE			SAFE			SAFE

DESIGN OF FOUNDATION

Foundation Lvl = 1104.00 m

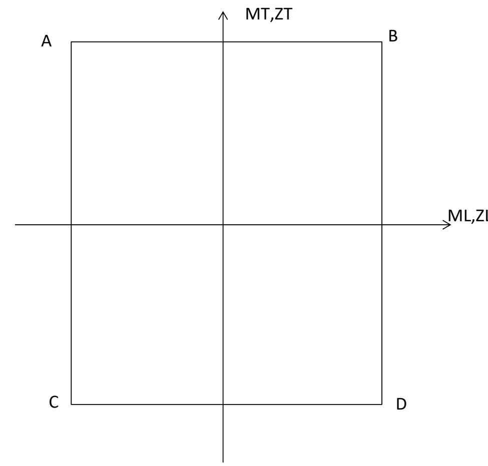
Properties of Footing Base:

A	=	160.00	m^2
ZL	=	426.67	m^3
ZT	=	266.67	m^3

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.35			1465.67	2.58	3774.10	0.00	0.00
SIDL except Wearing Course	1.35			270.00	2.58	695.25	0.00	0.00
Wearing Course	1.75			480.29	2.58	1236.74	0.00	0.00
Bearing Pedestal	1.35	25.00	1.95	65.88	2.58	169.64	-0.72	-47.25
				2281.84		**5875.74**		**-47.25**
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1.35	25.00	7.42	250.34	1.53	381.77	0.00	0.00
Dirt Wall-Tapered portion	1.35	25.00	0.00	0.00	1.53	0.00	0.00	0.00
Bracket - Uniform portion	1.35	25.00	0.90	30.38	1.23	37.21	0.00	0.00
Bracket - Tapered portion	1.35	25.00	0.45	15.19	1.28	19.36	0.00	0.00
Cap - (uniform portion)	1.35	25.00	6.36	214.65	2.44	522.67	0.00	0.00
Cap - (corbel portion)	1.35	25.00	6.36	214.65	2.44	522.67	0.00	0.00
Cantilever Return Wall-Rectangle p	1.35	25.00	0.00	0.00	2.20	0.00	0.00	0.00
Cantilever Return Wall-Traingle por	1.35	25.00	0.00	0.00	2.20	0.00	0.00	0.00
RCC Railing or Crash Barrier or Crash Barrier	1.35			0.00	1.53	0.00	0.00	0.00
Aproach Slab	1.35	25.00	5.25	177.19	1.23	217.05	0.00	0.00
				902.39		**1700.74**		**0.00**
Substructure & Foundation -Portion 2								
Solid Return wall	1.35	25.00	326.62	11023.57	-2.90	-31968.36	0.00	0.00
Counterfort wall	1.35	5.00	93.34	630.03	-2.90	-1827.09	0.00	0.00
Front Counterfort wall	1.35	5.00	0.00	0.00	5.44	0.00	0.00	0.00
Abutment Shaft	1.35	25.00	91.51	3088.39	2.60	8029.83	0.00	0.00
Back filling over heel slab	1.35	20.00	1197.09	32321.55	-2.90	-93732.49	0.00	0.00
Front Filling over toe slab	1.35	20.00	527.15	14233.05	5.44	77438.02	0.00	0.00
Side filling between heel and toe	1.35	20.00	0.00	0.00	0.00	0.00	0.00	0.00
Heel slab	1.35	25.00	102.00	3442.50	-2.90	-9983.25	0.00	0.00
Toe slab	1.35	25.00	87.50	2953.13	5.14	15187.50	0.00	0.00
portion between heel & toe	1.35	25.00	20.00	675.00	2.60	1755.00	0.00	0.00
Vertical Components of active earth pressure	1.50			2330.13	-8.00	-18641.04	0.00	0.00
				70697.36		**-53741.90**		**0.00**
Total				**73881.59**		**-46165.42**		**-47.25**



Summary of Forces About C.G. OF Footing

P	73881.59	KN
ML	-6625.92	kNm
MT	-47.25	kNm

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		110.80	1119.48	1714.71
due to Earth pressure	1.50	5625.43		37824.79

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
110.80	1714.71	0.00	0.00
5625.43	37824.79	0.00	0.00
5736.23	**39539.50**	**0.00**	**0.00**

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		73881.59		-46165.42		-47.25
CWLL-Max. Reaction case	1.50	1584.64	2.58	4080.46	0.20	314.83
Vertical Components of LL Surcharge	1.20	247.51	-8.00	-1980.08	0.00	0.00
Total		**75713.74**		**-44065.04**		**267.58**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		136.46	1119.48	2111.87
due to Earth pressure	1.50	5625.43		37824.79
due to Live load surcharge	1.20	597.54		5082.40
		6359.44		**45019.06**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
136.46	2111.87	0.00	0.00
5625.43	37824.79		
597.54	5082.40		
6359.44	**45019.06**	**0.00**	**0.00**

Summary of Forces About C.G. OF Footing

P	75713.74	KN
ML	954.02	kNm
MT	267.58	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1.50 αh= 0.16 In Longitudinal direction
αh= 0.36 In Transverse direction
αv= 0.24 In Vertical direction

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1.35			1465.67		175.88	117.25	2.58	3774.10	301.93	1120.46		0.00	0.00	2894.29
SIDL except Wearing Course	1.35			270.00		32.40	21.60	2.58	695.25	55.62	1121.46		0.00	0.00	565.70
Wearing Course	1.75			480.29		44.46	29.64	2.58	1236.74	76.32	1121.01		0.00	0.00	756.32
Bearing Pedestal	1.35	25.00	1.95	65.88		7.91	5.27	2.58	169.64	13.57			-0.72	-47.25	
				2281.84		**260.65**	**173.76**		**5875.74**	**447.44**				**-47.25**	**4216.32**
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1.35	25.00	7.42	250.34	45.06	30.04	20.03	1.53	381.77	30.54	1119.77	710.83	0.00	0.00	473.89
Dirt Wall-Tapered portion	1.35	25.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00	1118.54	0.00	0.00	0.00	0.00
Bracket - Uniform portion	1.35	25.00	0.90	30.38				1.23	37.21						
Bracket - Tapered portion	1.35	25.00	0.45	15.19				1.28	19.36						
Cap - (uniform portion)	1.35	25.00	6.36	214.65	38.64	25.76	17.17	2.44	522.67	41.81	1118.39	555.93	0.00	0.00	370.62
Cap - (corbel portion)	1.35	25.00	6.36	214.65	38.64	25.76	17.17	2.44	522.67	41.81	1118.09	544.34	0.00	0.00	362.89
Cantilever Return Wall-Rectangle p	1.35	25.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	1121.01	0.00	0.00	0.00	0.00
Cantilever Return Wall-Traingle por	1.35	25.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	1121.01	0.00	0.00	0.00	0.00
RCC Railing or Crash Barrier	1.35			0.00				1.53	0.00				0.00	0.00	
Aproach Slab	1.35	25.00	5.25	177.19				1.23	217.05				0.00	0.00	
				902.39	**122.34**	**81.56**	**54.37**		**1700.74**	**114.17**		**1811.10**		**0.00**	**1207.40**
Substructure & Foundation -Portion 2															
Solid Return wall	1.35	25.00	326.62	11023.57	1984.24	1322.83	881.89	-2.90	-31968.36	-2557.47	1113.08	18025.36	0.00	0.00	12016.91
Counterfort wall	1.35	5.00	93.34	630.03	113.41	75.60	50.40	-2.90	-1827.09	-146.17	1110.44	730.56	0.00	0.00	487.04
Front Counterfort wall	1.35	5.00	0.00	0.00	0.00	0.00	0.00	5.44	0.00	0.00	1107.33	0.00	0.00	0.00	0.00
Abutment Shaft	1.35	25.00	91.51	3088.39	555.91	370.61	247.07	2.60	8029.83	642.39	1117.12	7291.19	0.00	0.00	4860.79
Back filling over heel slab	1.35	20.00	1197.09	32321.55	0.00	0.00	0.00	-2.90	-93732.49	0.00	1113.08	0.00	0.00	0.00	0.00
Front Filling over Pile Cap	1.35	20.00	527.15	14233.05				5.44	77438.02				0.00	0.00	
Side filling between heel and toe	1.35	20.00	0.00	0.00				0.00	0.00				0.00	0.00	

Heel slab	1.35	25.00	102.00	3442.50	619.65	413.10	275.40	-2.90	-9983.25		1105.75	1084.39	0.00	0.00	722.93
Toe slab	1.35	25.00	87.50	2953.13	531.56	354.38	236.25	5.14	15187.50		1105.75	930.23	0.00	0.00	620.16
portion between heel & toe	1.35	25.00	20.00	675.00	121.50	81.00	54.00	2.60	1755.00		1105.25	151.88	0.00	0.00	101.25
Vertical component of active earth pressure	1.00			1461.94				-8.00	-11695.54						
Vertical component of dynamic increment of earth pressure	1.50			1183.95				-8.00	-9471.58						
				71013.12	3926.27	2617.52	1745.01		-56267.98	-2061.25		28213.61		0.00	18809.07
Total =				**74197.35**	**4048.61**	**2959.72**	**1973.15**		**-48691.50**	**-1499.64**		**30024.71**		**-47.25**	**24232.79**
							-1973.15			1499.64					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		110.80	260.65	1119.48	1714.71	4216.32
due to Substructure		4048.61	2699.07		30024.71	20016.47
due to Active Earth pressure	1.00	3529.44			25216.53	
due to dynamic increment of EP	1.50	2858.30			31457.05	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
110.80	1714.71	0.00	0.00	0.00	0.00	260.65	4216.32
4048.61	30024.71	0.00	0.00	0.00	0.00	2699.07	20016.47
3529.44	25216.53						
2858.30	31457.05						
10547.15	**88413.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2959.72**	**24232.79**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	76170.49	72224.20	KN
ML	38221.86	41221.14	kNm
MT	24185.54	24185.54	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				2281.84		260.65	173.76		5875.74	447.44				-47.25	4216.32
Forces from Substructure				71915.51	4048.61	2699.07	1799.38		-54567.23	-1947.08		30024.71		0.00	20016.47
CWLL-Max. Reaction case	0.75			792.32		128.36	85.57	2.58	2040.23	220.34	1122.21		0.20	157.42	2337.49
Vertical component of LL Surcharge	0.20			41.25				-8.00	-330.01						
Vertical component of dynamic increment LL Surcharge	0.20			22.27				-8.00	-178.17						
Total =				**75053.19**	**4048.61**	**3088.08**	**2058.72**		**-47159.46**	**-1279.29**		**30024.71**		**110.17**	**26570.28**
							-2058.72			1279.29					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		123.63	389.00	1119.48	1913.29	6553.81
due to Substructure		4048.61	2699.07		30024.71	20016.47
due to Active Earth pressure	1.00	3529.44			25216.53	
due to dynamic increment of EP	1.50	2858.30			31457.05	
due to Live load surcharge	0.20	99.59			847.07	
due to dynamic increment of Surcharge	0.20	53.77			747.24	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
123.63	1913.29	0.00	0.00	0.00	0.00	389.00	6553.81
4048.61	30024.71	0.00	0.00	0.00	0.00	2699.07	20016.47
3529.44	25216.53						
2858.30	31457.05						
99.59	847.07						
53.77	747.24						
10713.34	**90205.88**	**0.00**	**0.00**	**0.00**	**0.00**	**3088.08**	**26570.28**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	77111.91	72994.48	KN
ML	41767.14	44325.72	kNm
MT	26680.45	26680.45	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2281.84**		**868.82**	**173.76**		**5875.74**	**447.44**				**-47.25**	**14054.39**
Substructure & Foundation -Portion 1				**902.39**	**36.70**	**271.86**	**54.37**		**1700.74**	**114.17**		**543.33**		**0.00**	**4024.66**
Substructure & Foundation -Portion 2				**71013.12**	**1177.88**	**8725.05**	**1745.01**		**-56267.98**	**-2061.25**		**8464.08**		**0.00**	**62696.91**
Total =				**74197.35**	**1214.58**	**9865.73**	**1973.15**		**-48691.50**	**-1499.64**		**9007.41**		**-47.25**	**80775.96**
							-1973.15			1499.64					

Forces due to Horizontal Load

		FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		110.80	868.82	1119.48	1714.71	14054.39
due to Substructure		1214.58	8996.91		9007.41	66721.57
due to Active Earth pressure		3529.44			25216.53	
due to dynamic increment of EP		857.49			9437.12	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
110.80	1714.71	0.00	0.00	0.00	0.00	868.82	14054.39
1214.58	9007.41	0.00	0.00	0.00	0.00	8996.91	66721.57
3529.44	25216.53						
857.49	9437.12						
5712.31	**45375.77**	**0.00**	**0.00**	**0.00**	**0.00**	**9865.73**	**80775.96**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	76170.49	72224.20	KN
ML	-4815.37	-1816.10	kNm
MT	80728.71	80728.71	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**75053.19**	**2058.72**	**-47159.46**	**-1279.29**	**110.17**
					-2058.72		1279.29	

Forces due to Horizontal Load

		FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		123.63	1296.68	1119.48	1913.29	21846.04
due to Substructure		1214.58	8996.91		9007.41	66721.57
due to Earth pressure		3529.44			25216.53	
due to dynamic increment of EP		857.49			9437.12	
due to Live load surcharge		99.59			847.07	
due to dynamic increment of Surcharge		16.13			224.17	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
123.63	1913.29	0.00	0.00	0.00	0.00	1296.68	21846.04
1214.58	9007.41	0.00	0.00	0.00	0.00	8996.91	66721.57
3529.44	25216.53						
857.49	9437.12						
99.59	847.07						
16.13	224.17						

5840.87	46645.58	0.00	0.00	0.00	0.00	10293.58	88567.61

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	77111.91	72994.48	KN
ML	-1793.17	765.42	kNm
MT	88677.78	88677.78	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.50 x 0.00 = 0.00 KN

Transverse Moment due to C.F. = 0.00 x (1122.21 - 1104.00) = 0.00 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.75 x 0.00 = 0.00 KN

Transverse Moment due to C.F. = 0.00 x (1122.21 - 1104.00) = 0.00 kNm

	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

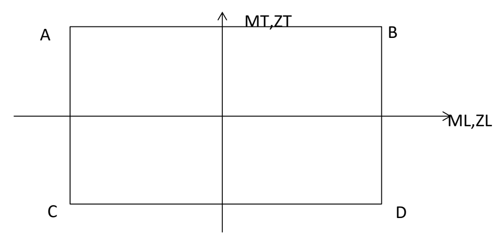
Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT

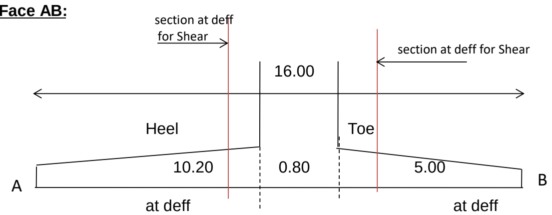
Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

Summary of Design Base Pressure

LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2
Case 1 : DL+SIDL-Normal Dry Case	73881.59	-6625.92	-47.25	477.11	446.05	477.47	446.41
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	75713.74	954.02	267.58	471.98	476.45	469.97	474.44
Longitudinal Seismic Dry Case							
Case 5 : DL+SIDL-Long. Seismic Dry Case	76170.49	41221.14	24185.54	470.15	663.37	288.76	481.98
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	77111.91	44325.72	26680.45	478.11	685.89	278.01	485.79
Transverse Seismic Dry Case							
Case 9 : DL+SIDL-Trans. Seismic Dry Case	76170.49	-1816.10	80728.71	783.05	774.54	177.59	169.08
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	77111.91	765.42	88677.78	812.70	816.29	147.61	151.20

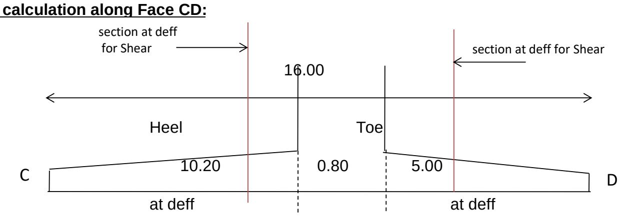


Pressure calculation along Face AB:



1.00	477.11	459.09	457.31	455.76	451.08	446.05
2.00	471.98	474.57	474.83	475.05	475.73	476.45

Pressure calculation along Face CD:



1.00	477.47	459.45	457.67	456.11	451.44	446.41
2.00	469.97	472.57	472.82	473.05	473.72	474.44

5.00	470.15	582.26	593.33	602.99	632.08	663.37	1.00	288.76	400.86	411.94	421.60	450.69	481.98
6.00	478.11	598.66	610.57	620.96	652.24	685.89	2.00	278.01	398.56	410.47	420.86	452.14	485.79
9.00	783.05	778.12	777.63	777.20	775.92	774.54	1.00	177.59	172.65	172.16	171.74	170.46	169.08
10.00	812.70	814.78	814.98	815.16	815.70	816.29	2.00	147.61	149.70	149.90	150.08	150.62	151.20

Average MAX Base Pressure for Design of Heel Slab-along Face AB = 813.84 kN/m^2
Average MIN Base Pressure for Design of Heel Slab-along Face AB = 467.21 kN/m^2
Average MAX Base Pressure for Design of Toe Slab-along Face AB = 815.72 kN/m^2
Max. Base Pressure at deff for Design of Toe Slab-along Face AB = 815.70 kN/m^2
Max. Base Pressure at deff for Design of Heel Slab-along Face AB = 814.78 kN/m^2

Average MAX Base Pressure for Design of Heel Slab-along Face CD = 471.40 kN/m^2
Average MIN Base Pressure for Design of Heel Slab-along Face CD = 148.76 kN/m^2
Average Base Pressure for Design of Toe Slab-along Face CD = 473.74 kN/m^2
Max. Base Pressure at deff for Design of Toe Slab-along Face CD = 473.72 kN/m^2
Max. Base Pressure at deff for Design of Heel Slab-along Face CD = 472.57 kN/m^2

Calculation of Moment and Shear Force Along Traffic Direction:

Case 1 : Maximum Base Pressure Case (Dry Case)
Heel Slab - Maximum Moment Calculation

Max Average Base Pressure for Design of Heel Slab = 148.76 kN/m^2
Net pressure = -336.66 kN/m^2 a 2.33
Dimension of heel between counterfort = 10.200 x 2.333 b 10.20
Thickness of heel slab = 1.00
section modulus of heel slab = 0.17
(σ b)max = -993.56 By Roark's formula
a/b = 0.229
$\beta 3$ = 0.028
Design moment = -165.59
Design moment/m = -165.59

Toe Slab - Moment Calculation

Maximum Average Base Pressure for Design of Toe Slab = 815.72 kN/m^2

Upward moment due to Base pressure = 10196.56 kNm/m

Downward moment due to self weight of Toe slab = 1.35 x 87.50 / 10.000 x 25.00 x 2.14
= 632.81 kNm/m

Net Moment at face of shaft = 10196.56 -632.81 = 9563.74 kNm/m **Tension at Bottom of Toe Slab**

Heel Slab - Shear Calculation

Net upward pressure = -336.662 kN/m^2
a/b = 0.23
$\gamma 2$ = 0.11
Shear force per unit length = -38.507 kN/m

Net Shear Force / unit meter = -38.507 KN/m

Toe Slab - Shear Calculation at deff from Face of Wall
For shear, critical section is assumed to be located at a distance equal to effective depth from face of wall

Depth of slab at critical section = 2.500 m
effective depth at critical section = 2.425 m
Base pressure at deff from face of wall = 815.704 kN/m^2
upward shear force due to base pressure = 815.995 x 5.000 x 10.000 = 40799.727 KN
C.g. Of base pressure = 2.143 m
moment due to upward pressure at critical section = 87427.987 kNm
tanβ = 0.300
reduction in shear force (V_{ccd}) = $\frac{M \tan\beta}{}$ = 0.000 KN

		d										
Downward force due to self weight of toe slab	=	1.35	x	1.750	x	2.59	x	10.000	x 25			
	=	1530.309	KN									
Net Shear Force at deff	=	21142	-	1530.309	-	0.000			=	19612.109	KN	
Net Shear Force / unit meter	=	19612.109	/	10.000					=	1961.211	KN/m	

Design Input :

Design length	=	1000	mm	
Clear Cover For Foundation	=	75	mm	
Grade of Concrete for Footing	=	M	35	
fck	=	35	N/mm^2	
fctm	=	2.77	N/mm^2	
Grade of Reinforcement Steel	=	Fe	500	(HYSD Bars)
fy or fyk	=	500	N/mm^2	
fyd	=	435	N/mm^2	(fy/1.15)
Es	=	200000	N/mm^2	

Flexural Reinforcement Calculation:

		Along Traffic Direction	
		Heel Slab	Toe Slab
Ultimate bending moment,Mu (kNm/m)	**=**	**165.59**	**9563.74**
Effective depth required (dreq) (mm)	=	168.32	1279.15
Effective depth provided (dpro) (mm)	=	917	2409
Check for provided depth	**=**	**SAFE**	**SAFE**
R = Mu/(b d2)	**=**	**0.20**	**1.65**
Total depth provided (mm)	=	1000	2500
Limiting depth of neutral axis (mm)	=	565.66	1486.01
Actual depth of neutral axis (mm)	=	54.20	370.02
Check for Neutral axis depth	**=**	**OK**	**OK**
Lever arm (z) , mm	=	895.32	2260.99
Moment of Resistance w.r.to steel	=	611.46	10541.43
Check for Moment Capacity	**=**	**SAFE**	**SAFE**
Ast reqd (mm^2 / m)	=	455.70	10048.84
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S,min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	=	1321.45	3471.51
Governing Ast (mm2 / m)	=	1321.45	10048.84
		Tension Reinforcement	
Dia (mm)	=	**16**	**32**
Spacing (mm)	=	**200**	**150**
+ Dia (mm)	=	**12**	**32**
Spacing (mm)	=	**200**	**150**
+ Dia (mm)	=	**0**	**0**
Spacing (mm)	=	**200**	**150**
Ast provided (mm2 / m)	=	1570.80	10723.30
Check for Ast provided	**=**	**OK**	**OK**

As per Clause 16.6.1.1. of IRC:112-2011 , Secondary Reinforcement shall be at least 20 % of the main reinforcement

Secondary Reinforcement (mm2/m)	=	314.16	2144.66
Dia (mm)	=	12	25
Spacing (mm)	=	150	150
Ast provided (mm2 /m)	=	753.98	3272.49
Check for Ast provided	**=**	**OK**	**OK**

Shear Reinforcement Calculation:

Along Traffic Direction	

		Heel Slab	Toe Slab	
Ultimate Shear Force (V_{Ed})	=	39	1961	kN/m
Ast provided	=	1571	10723	mm2/m
Depth of slab at critical section	=	1000	2500	mm
Effective depth at critical section	=	917	2409	mm
Percentage of steel provided (ρ1)	=	0	0	
cl. 10.3.1 of IRC :112-2011				
$\rho 1 = A_{sl}/(b_w\ d) <= 0.02$	=	OK	OK	
Actual shear stress=v_{ED} = (V_{Ed}/b*0.9d)	**=**	0.047	0.905	N/mm^2
Max shear capacity, 0.135 fck(1-fck/310)	=	4.19	4.19	N/mm^2
Depth Check for Shear Resistance	=	SAFE	SAFE	
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010				
K = 1+Sqrt(200/d) <= 2.0	=	1.47	1.29	
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010				
$v_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	=	0.326	0.268	N/mm^2
$0.12\ K\ (80\ \rho 1\ f_{ck})^{0.33}$	=	0.287	0.351	N/mm^2
$\sigma_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	=	0.000	0.000	N/mm^2
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2011				
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d$ subjected to minimum ($v_{min} + 0.15\ \sigma_{cp}$) b_w d	=	299	846	kN
Check for Shear Reinforcement		OK, No shear reinf. Req.	Provide Shear Reinf.	
Balance Shear Force= $V_{Rd,s} = V_{Ed} - V_{Rd,c}$	=	0	1115	KN/m
b	=	1.000	1.000	m
Total Shear Force	=	0	1115	kN
θ = 0.5 x sin^-1 [vEd / (0.18 fck (1- fck/250))]		0.25	4.81	
cot θ = (< 1 cotθ <2.5)	=	2.50	2.50	
fywd = 0.8 x fy/1.15	=	348	348	N/mm^2
Provide Shear Reinforcement				
Legged	=	5	2	
Dia	=	12	10	mm
Area of Shear Reinf, Asw	=	565	157	mm^2
z = 0.9 * d	=	825	2168	mm
Spacing of shear Reinforcement required				
S = Asw*z* fywd* cotθ / V_{Rd}	=	0	265	mm
As per Clause 10.3.3.5 of IRC:112-2011				
Asw/ (b S) = $\rho_{w,min} = (0.072\ f_{ck}^{0.5}) / f_{yk}$	=	0	0	
Spacing of shear Reinforcement required	=	664	184	mm
As per Clause 16.5.2 , eq. 16.6 of IRC:112-2011				
S_{max} = 0.75 d	=	688	1807	mm
Governing Spacing of Shear Reinf.	=	0	184	mm
Provided Spacing of Shear Reinf.	=	300	150	mm

SLS CHECK OF FOUNDATION

Foundation Lvl = 1104.000 m

Properties of Footing Base:

A	=	160.000	m^2
ZL	=	426.667	m^3
ZT	=	266.667	m^3

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.00			1085.683	2.575	2795.633	0.000	0.000
SIDL except Wearing Course	1.00			200.000	2.575	515.000	0.000	0.000
Wearing Course	1.20			329.340	2.575	848.051	0.000	0.000
Bearing Pedestal	1.00	25	1.952	48.800	2.575	125.660	-0.717	-35.000
				1663.823		**4284.344**		**-35.000**
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1.00	25	7.418	185.438	1.525	282.792	0.000	0.000
Dirt Wall-Tapered portion	1.00	25	0.000	0.000	1.525	0.000	0.000	0.000
Bracket - Uniform portion	1.00	25	0.900	22.500	1.225	27.563	0.000	0.000
Bracket - Tapered portion	1.00	25	0.450	11.250	1.275	14.344	0.000	0.000
Cap - (uniform portion)	1.00	25	6.360	159.000	2.435	387.165	0.000	0.000
Cap - (corbel portion)	1.00	25	6.360	159.000	2.435	387.165	0.000	0.000
Cantilever Return Wall-Rectangle portion	1.00	25	0.000	0.000	2.200	0.000	0.000	0.000
Cantilever Return Wall-Traingle portion	1.00	25	0.000	0.000	2.200	0.000	0.000	0.000
RCC Railing or Crash Barrier or Crash Barrier	1.00	25		0.000	1.525	0.000	0.000	0.000
Aproach Slab	1.00	25	5.250	131.250	1.225	160.781	0.000	0.000
				668.438		**1259.810**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.00	25	326.624	8165.610	-2.900	-23680.269	0.000	0.000
Counterfort wall	1.00	5.00	93.34	630.03	-2.90	-1827.094	0.00	0.00
Front Counterfort wall	1.00	5.00	0.00	0.00	5.44	0.000	0.00	0.00
Abutment Shaft	1.00	25	91.508	2287.700	2.600	5948.020	0.000	0.000
Back filling over heel slab	1.00	20	1197.094	23941.889	-2.900	-69431.478	0.000	0.000
Front Filling over toe slab	1.00	20	527.150	10543.000	5.441	57361.500	0.000	0.000
Side filling between heel and toe	1.00	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.00	25	102.000	2550.000	-2.900	-7395.000	0.000	0.000
Toe slab	1.00	25	87.500	2187.500	5.143	11250.000	0.000	0.000
portion between heel & toe	1.00	25	20.000	500.000	2.600	1300.000	0.000	0.000
Vertical Components of active earth pressure	1.00			1553.420	-8.000	-12427.363	0.000	0.000
				52359.152		**-38901.684**		**0.000**
Total				**54691.412**		**-33357.531**		**-35.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		80.751	1119.476	1249.705
due to Earth pressure	1.00	3750.289		25216.527

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
80.75	1249.70	0.00	0.00
3750.29	25216.53		
3831.040	**26466.232**	**0.000**	**0.000**

Summary of Forces

P	54691.412	KN
ML	-6891.299	kNm
MT	35.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		54691.412		-33357.531		-35.000
CWLL-Max. Reaction case	1.00	1056.430	2.575	2720.306	0.199	209.890
Vertical Components of LL Surcharge	0.80	165.007	-8.000	-1320.054	0.000	0.000
Total		**55912.849**		**-31957.279**		**174.890**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		97.860	1119.476	1514.476

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
97.86	1514.48	0.00	0.00

due to Earth pressure	1.00	3750.289		25216.527
due to Live load surcharge	0.80	398.362		3388.265

3750.29	25216.53		
398.36	3388.27		
4246.510	**30119.269**	**0.000**	**0.000**

Summary of Forces

P	55912.849	KN
ML	-1838.010	kNm
MT	174.890	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1122.211 - 1104.000)

= 0.000 kNm

Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

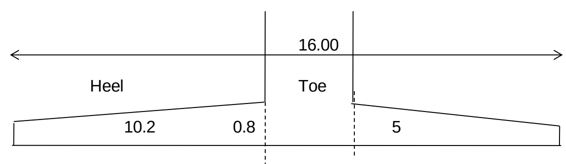
Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT

Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

	Design Base Pressure						
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2
Case 1 : DL+SIDL-Normal Dry Case	54691.412	-6891.299	35.000	358.104	325.801	357.842	325.539
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	55912.849	-1838.010	174.890	354.419	345.803	353.107	344.492
Normal HFLCase							
Case 3 : DL+SIDL-Normal HFL Case	2962.293	4966.76	35.000	7.005	30.286	6.742	30.024
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	3304.463	6665.32	382.910	6.467	37.711	3.595	34.839

Pressure calculation along Face AB:



Case 1 :	358.104	337.51	335.896	325.801
Case 2:	354.419	348.93	348.496	345.803
Case 4:	7.005	21.85	23.011	30.286
Case 5:	6.467	26.38	27.947	37.711

For Rare Combination

Average Base Pressure for Design of Heel Slab-along Face AB = 351.673 kN/m^2

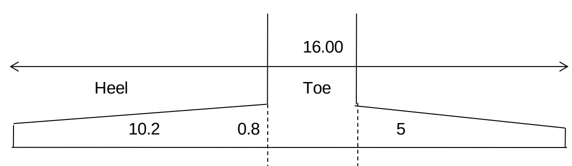
Average Base Pressure for Design of Toe Slab-along Face AB = 347.150 kN/m^2

For Quasi Permenant Combination

Average Base Pressure for Design of Heel Slab-along Face AB = 347.807 kN/m^2

Average Base Pressure for Design of Toe Slab-along Face AB = 330.848 kN/m^2

Pressure calculation along Face CD:



Case 1 :	357.842	337.25	335.633	325.539
Case 2:	353.107	347.61	347.184	344.492
Case 4:	6.742	21.58	22.748	30.024
Case 5:	3.595	23.51	25.075	34.839

For Rare Combination

Average Base Pressure for Design of Heel Slab-along Face CD = 350.361 kN/m^2

Average Base Pressure for Design of Toe Slab-along Face CD = 345.838 kN/m^2

For Quasi Permenant Combination

Average Base Pressure for Design of Heel Slab-along Face CD = 347.545 kN/m^2

Average Base Pressure for Design of Toe Slab-along Face CD = 330.586 kN/m^2

Moment Calculation

Rare Combination	Quasi-Parmenant

		Toe Slab		Toe Slab	
Max Average Base Pressure		347.15		330.85	kN/m^2
Max stress		53.61		51.10	
Upward moment due to Base pressure		4339.37		4135.61	kNm/m
Downward moment due to backfill		0.00		0.00	kNm/m
Downward moment due to self weight of slab		468.75		468.75	kNm/m
Net Moment		**3870.62**		**3666.86**	kNm/m
		Tension at Bottom of Toe Slab		**Tension at Bottom of Toe Slab**	

Check For Stresses in Rare and Quasi-Permanent Load Combination

Creep Coeff = 1.2

Ecm = 32308.25 N/mm^2

Es = 200000.00 N/mm^2

Eceff = $\frac{Ecm}{(1 + \phi)}$ = 1.47E+04

Modular Ratio (m) = Es/ Eceff = 13.62

		Rare Combination		Quasi Permanent Comb.		
			Toe Slab		**Toe Slab**	
Working bending moment, M	=		**3870.62**		**3666.86**	kNm/m
Dx	=		**1.00**			m
Dy	=		**2.50**			m
Section Modulus (ZL) of uncracked sec	=		**1.04**			m^3
Bending Stress (M/ZL)	=		3.716			N/mm^2
Tensile stress of concrete , fctm	=		2.771			N/mm^2
Cracked or Uncracked Section	**=**		**Cracked**			
Section properties of Cracked section:						
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.						
Clear Cover, c	=		75			mm
Maximum dia used, ϕ	=		32			mm
Effective Depth deff (dy)	=		2409			mm
Ast provided	=		10723.3			mm^2/m
Percentage of steel , pt	=		0.0045			
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=		0.293			
Depth of neutral axis from extreme Compression face (yc = k * dy)	=		705.396			mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=		1703.604			mm
Depth of neutral axis from c.g. Of tesnion steel (ys)	=		1612.604			mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2				
Icr	=		5.408E+11			mm^4
Maximum compressive stress in concrete	=		**5.048**	**0.000**	**4.783**	**< 16.8, SAFE**
Maximum Tensile stress in steel	=		**157.173**	**0.000**	**148.899**	**< 300, SAFE**

Check For Crack Width in Quasi-Permanent Load Combination

Crack width , Wk = **Sr max (εsm - εcm)**

Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+φ/2)

5*(c+φ/2)	=		455	mm
Provided Spacing	=		75	mm
Check for Applicability of Formula	=		OK	
Maximum crack spacing , $S_{r\ max}$	=		$\frac{0.425\ k1\ k2\ \varphi}{\rho_{\rho\ eff}}$	
K1	=		0.800	for deformed bars
K2	=		0.500	for bending
depth of neutral axis , yc	=		705	mm
$\rho_{\rho\ eff}$ = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.		
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=		228	mm
Ac, eff = Dx * hc,eff	=		227500	mm
$\rho_{\rho\ eff}$ = As/Ac eff	=		0.047	

Maximum crack spacing , $S_{r\ max}$	=		370.412	mm
(ε_{sm} - ε_{cm})	=		/ Es	
tensile stress in steel, ,σsc	=		148.899	N/mm^2
Kt	=		0.500	
Tensile strength of concrete = fct eff = fctm	=		2.771	N/mm^2
αe = Es/Ecm	=		6.190	
(εsm - εcm)	=		0.0006	
Crack width , Wk=Sr max (εsm - εcm)	**=**		**0.205**	mm
Check	**=**		**SAFE**	

CALCULATION OF ULS FORCES FOR DESIGN OF ABUTMENT SHAFT

Abutment shaft bottom lvl = 1106.500 m

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.35			1465.672	-0.025	-36.642	0.000	0.000
SIDL except Wearing Course	1.35			270.000	-0.025	-6.750	0.000	0.000
Wearing Course	1.75			480.288	-0.025	-12.007	0.000	0.000
Bearing Pedestal	1.35	25	1.952	65.880	-0.025	-1.647	-0.717	-47.250
				2281.839		**-57.046**		**-47.250**
Substructure-Portion 1								
Dirt Wall-Uniform portion	1.35	25	7.418	250.341	-1.075	-269.116	0.000	0.000
Dirt Wall-Tapered portion	1.35	25	0.000	0.000	-1.075	0.000	0.000	0.000
Bracket - Uniform portion	1.35	25	0.900	30.375	-1.375	-41.766	0.000	0.000
Bracket - Tapered portion	1.35	25	0.450	15.188	-1.325	-20.123	0.000	0.000
Cap - (uniform portion)	1.35	25	6.360	214.650	-0.165	-35.417	0.000	0.000
Cap - (corbel portion)	1.35	25	6.360	214.650	-0.165	-35.417	0.000	0.000
RCC Railing or Crash Barrier	1.35	25		0.000	-1.075	0.000	0.000	0.000
Aproach Slab	1.35	25	5.250	177.188	-1.375	-243.633	0.000	0.000
				902.391		**-645.473**		**0.000**
Substructure-Portion 2								
Abutment Shaft	1.35	25	91.508	3088.395	0.000	0.000	0.000	0.000
Total				**6272.625**		**-702.519**		**-47.250**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		110.798	1119.476	1437.714
due to Earth pressure	1.5	4093.464		23478.970

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
110.80	1437.71	0.00	0.00
4093.46	23478.97	0.00	0.00
4204.262	**24916.684**	**0.000**	**0.000**

Summary of Forces

P	6272.625	KN
ML	24214.165	kNm
MT	47.250	kNm
HL	4204.262	KN

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		6272.625		-702.519		-47.250
CWLL-Max. Reaction case	1.5	1584.645	-0.025	-39.616	0.199	314.834
Total		**7857.269**		**-742.135**		**267.584**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ

due to Superstructure		136.461	1119.476	1770.715
due to Earth pressure	1.5	4093.464		23478.970
due to Live load surcharge	1.2	509.725		3698.313

136.46	1770.71	0.00	0.00
4093.46	23478.97		
509.73	3698.31		
4739.650	**28947.997**	**0.000**	**0.000**

Summary of Forces

P	7857.269	KN
ML	28205.862	kNm
MT	267.584	kNm
HL	4739.650	KN

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1.50 αh= 0.120 In Longitudinal direction

αh= 0.360 In Transverse direction

αv= 0.240 In Vertical direction

Weight of shaft below Ground level = 0.0 KN

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1.35			1465.672		175.881	117.254	-0.025	-36.642	-2.931	1120.456		0.000	0.000	2454.590
SIDL except Wearing Course	1.35			270.000		32.400	21.600	-0.025	-6.750	-0.540	1121.460		0.000	0.000	484.701
Wearing Course	1.75			480.288		44.461	29.641	-0.025	-12.007	-0.741	1121.011		0.000	0.000	645.172
Bearing Pedestal	1.35	25	1.952	65.880		7.906	5.270	-0.025	-1.647	-0.132			-0.717	-47.250	
				2281.839		**260.647**	**173.765**		**-57.046**	**-4.344**				**-47.250**	**3584.463**
Substructure-Portion 1															
Dirt Wall-Uniform portion	1.35	25	7.418	250.341	33.379	30.041	20.027	-1.075	-269.116	-21.529	1119.775	443.095	0.000	0.000	398.785
Dirt Wall-Tapered portion	1.35	25	0.000	0.000	0.000	0.000	0.000	-1.075	0.000	0.000	1118.539	0.000	0.000	0.000	0.000
Bracket - Uniform portion	1.35	25	0.900	30.375				-1.375	-41.766						
Bracket - Tapered portion	1.35	25	0.450	15.188				-1.325	-20.123						
Cap - (uniform portion)	1.35	25	6.360	214.650	28.620	25.758	17.172	-0.165	-35.417	-2.833	1118.389	340.249	0.000	0.000	306.224
Cap - (corbel portion)	1.35	25	6.360	214.650	28.620	25.758	17.172	-0.165	-35.417	-2.833	1118.089	331.663	0.000	0.000	298.497
RCC Railing or Crash Barrier	1.35	25		0.000				-1.075	0.000				0.000		
Aproach Slab	1.35	25	5.250	177.188				-1.375	-243.633				0.000		
				902.391	**90.619**	**81.557**	**54.371**		**-645.473**	**-27.196**		**1115.006**		**0.000**	**1003.506**
Substructure-Portion 2															
Abutment Shaft	1.35	25	91.508	**3088.395**	**411.786**	**370.607**	**247.072**	**0.000**	**0.000**	**0.000**	**1117.116**	**4371.417**	**0.000**	**0.000**	**3934.276**
Total =				**6272.625**	**502.405**	**712.811**	**475.208**		**-702.519**	**-31.540**		**5486.424**		**-47.250**	**8522.244**
							-475.208			31.540					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		110.798	260.647	1119.476	1437.714	3584.463
due to Substructure		502.405	452.164		5486.424	4937.781
due to Active Earth pressure	1.00	2728.976			15652.646	
due to dynamic increment of EP	1.50	2858.303			24311.297	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
110.80	1437.71	0.00	0.00	0.00	0.00	260.65	3584.46
502.40	5486.42	0.00	0.00	0.00	0.00	452.16	4937.78
2728.98	15652.65						
2858.30	24311.30						
6200.48	**46888.08**	**0.00**	**0.00**	**0.00**	**0.00**	**712.81**	**8522.24**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6747.833	5797.417	KN
ML	46154.022	46217.103	kNm

MT	8474.994	8474.994	kNm
HL	6200.482	6200.482	KN

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				2281.839		260.647	173.765		-57.046	-4.344				-47.250	3584.463
Forces from Substructure				3990.786	502.405	452.164	301.443		-645.473	-27.196		5486.424		0.000	4937.781
CWLL-Max. Reaction case	0.20			211.29		34.228	22.819	-0.025	-5.282	-0.570	1122.211		0.199	41.978	537.761
Total =				**6483.911**	**502.405**	**747.040**	**498.026**		**-707.801**	**-32.111**		**5486.424**		**-5.272**	**9060.006**
							-498.026			32.111					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)	Forces along Long. Axis				Forces along Trans. Axis			
							FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
due to Superstructure		114.220	294.875	1119.476	1482.114	4122.224	114.22	1482.11	0.00	0.00	0.00	0.00	294.88	4122.22
due to Substructure		502.405	452.164		5486.424	4937.781	502.40	5486.42	0.00	0.00	0.00	0.00	452.16	4937.78
due to Active Earth pressure	1.00	2728.976			15652.646		2728.98	15652.65						
due to dynamic increment of EP	1.50	2858.303			24311.297		2858.30	24311.30						
due to Live load surcharge	0.20	84.954			616.385		84.95	616.39						
due to dynamic increment of Surcharge	0.20	45.867			445.931		45.87	445.93						
							6334.72	**47994.80**	**0.00**	**0.00**	**0.00**	**0.00**	**747.04**	**9060.01**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6981.937	5985.884	KN
ML	47254.887	47319.108	kNm
MT	9065.278	9065.278	kNm
HL	6334.724	6334.724	KN

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**6272.625**	**475.208**	**-702.519**	**-31.540**	**-47.250**
					-475.208		31.540	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)	Forces along Long. Axis				Forces along Trans. Axis			
							FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
due to Superstructure		110.798	868.82372	1119.476	1437.714	11948.2109	110.80	1437.71	0.00	0.00	0.00	0.00	868.82	11948.21
due to Substructure		150.721	1507.2143		1645.927	16459.2706	150.72	1645.93	0.00	0.00	0.00	0.00	1507.21	16459.27
due to Active Earth pressure	1.00	2728.976			15652.646		2728.98	15652.65						
due to dynamic increment of EP	1.50	857.491			7293.389		857.49	7293.39						
							3847.99	**26029.68**	**0.00**	**0.00**	**0.00**	**0.00**	**2376.04**	**28407.48**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6747.833	5797.417	KN
ML	25295.618	25358.698	kNm
MT	28454.732	28454.732	kNm
HL	3847.986	3847.986	KN

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**6483.911**	**498.026**	**-707.801**	**-32.111**	**-5.272**
					-498.026		32.111	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		114.220	982.91812	1119.476	1482.114	13740.7481
due to Substructure		150.721	1507.2143		1645.927	16459.271
due to Earth pressure	1.00	2728.976			15652.646	
due to dynamic increment of EP	1.50	857.491			7293.389	
due to Live load surcharge	0.20	84.954			616.385	
Surcharge	0.20	13.760			133.779	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
114.22	1482.11	0.00	0.00	0.00	0.00	982.92	13740.75
150.72	1645.93	0.00	0.00	0.00	0.00	1507.21	16459.27
2728.98	15652.65						
857.49	7293.39						
84.95	616.39						
13.76	133.78						
3950.12	**26824.24**	**0.00**	**0.00**	**0.00**	**0.00**	**2490.13**	**30200.02**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6981.937	5985.884	KN
ML	26084.330	26148.552	kNm
MT	30205.291	30205.291	kNm
HL	3950.122	3950.122	KN

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.50 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1122.211 - 1106.500) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1122.211 - 1106.500) = 0.000 kNm

	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Summary of ULS Forces for Design of Abutment Shaft

Total forces at bottom of abutment shaft

LOAD CASES		P	ML	MT	HL
Normal Dry Case		kN	kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case		6272.62	24214.17	47.25	4204.26
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case		7857.27	28205.86	267.58	4739.65
Longitudinal Seismic Dry Case					
Case 5 : DL+SIDL-Long. Seismic Dry Case	DN	6747.83	46154.02	8474.99	6200.48
	UP	5797.42	46217.10	8474.99	6200.48
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	DN	6981.94	47254.89	9065.28	6334.72
	UP	5985.88	47319.11	9065.28	6334.72
Transverse Seismic Dry Case					
Case 9 : DL+SIDL-Trans. Seismic Dry Case	DN	6747.83	25295.62	28454.73	3847.99
	UP	5797.42	25358.70	28454.73	3847.99
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	DN	6981.94	26084.33	30205.29	3950.12
	UP	5985.88	26148.55	30205.29	3950.12
	MAX =	**7857.27**	**47319.11**	**30205.29**	**6334.72**

Design of Counterfort

Material Property:

Grade of Concrete	=	M	35
fck	=	35	N/mm^2
fcd	=	15.633	N/mm^2
Grade of steel	=	Fe	500
fy	=	500	N/mm^2
fyd	=	435	N/mm^2
Es	=	200000	N/mm^2

Cross section

Thickness of Counter fort (B)	=	0.800	m			
Depth of counter fort (d)	=	7.889	m	39.34	DEG	
Area of Concrete (Ac)	=	6.311	m^2			
Clear Cover to earth faces	=	75	mm			
Clear Cover to non earth faces	=	40	mm			
Maximum Dia of Reinf.	=	32	mm			
Dia of Horizontal Reinf.	=	0	mm			
Ultimate Design bending moment (ML)	=	47319.11	kNm	=	4732	kNm/m
Ultimate Design Shear Force(Horizontal force	=	6334.72	KN	=	633	kN/m
max eff. Width of Counter Fort(c/c)	=	3.000	m			
Design B.M for counterfort	=	14196	kNm/m	Design SF =	1900.42	kN/m

Check For Depth of Wall :

Mult = 0.165 x fck x b x d^2

= 14195.73 kNm/m

b = 800 mm

Effective Depth Required (dreq) $= \text{SQRT}\left(\dfrac{14195.73 \times 1000000}{0.165 \times 35.00 \times 800}\right)$

(dreq) = 1753 mm

Total Depth Required (Dreq) = 1844 mm

Total Depth Provided (Dprov) = 7889 mm **OK**

Effective depth provided(deff) = 7702 mm

R= Mu/(b d^2) = **0.30**

Minimum Longitudinal Reinforcement in wall on each face

= $0.26 * f_{ctm} * b * d / f_y$ OR 0.0013 * b * d

Ast min = **8879.09** mm^2 8009.95

Area of Steel Required:

$\dfrac{pt}{100} = \dfrac{Ast_{req}}{b\,D} = \dfrac{fck \{ 1 - sqrt(1- 4.598 R/fck) \}}{2\,fy}$

= 0.0007

Ast_{req} = 4279.877 mm^2

Ast required = max(Astmin, Astreq) = **8879.09** mm^2

Total are of steel required in full length wall = **8879.09** mm^2

Provide	32	mm dia	@	4.00	no.	=	9649.34	mm^2/m	OK
Provide	32	mm dia	@	4.00	no.	=			
Provide	32	mm dia	@	4.00	no.	=			

Calculation of reinforcement in numbers

Provide	32	mm dia	-	4.00	nos	=	9649.34	mm^2	OK
Provide	32	mm dia	-	4.00	nos	=			
Provide	32	mm dia	-	4.00	nos	=			
Provide	0	mm dia	-	0.00	nos	=			
Provide	0	mm dia	-	0.00	nos	=			
Provide	0	mm dia	-	0.00	nos	=			

Percentage of steel = **0.153** %

Check for Moment of Resistance of Section due to Steel

Limiting Depth of Neutral Axis , Xm = $\dfrac{0.0035 \;.\; d}{(0.0035 + fyd/ Es)}$

= $\dfrac{0.0035 \quad x \quad 7701.88}{0.0035 \quad + \quad 0.0022}$

= 4750.97 mm

Depth of Neutral Axis , X = $\dfrac{fyd \;.\; Ast}{0.36 \;.\; fck \;.\; b}$

= $\dfrac{434.78 \quad x \quad 9649.34}{0.36 \quad x \quad 35.00 \quad x \quad 800.00}$

= 416.21 mm **OK**

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X
= 7701.88 - 173.14
= 7528.73 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 9649.34 x 7528.73

= 3.16E+10 Nmm /m

= 31585.80 kNm/m > 4731.91 kNm/m

Moment of Resistance of Counter Fort is More than Design Bending Moment , HENCE SAFE IN BENDING

Design of Horizontal Ties

Area of steel requirement by Shear Force

Vunet	=	Vu	-	Mu/d	tanQ
	=	1900.42	-	1799.46	0.82
	=	425.58	kN/m		
Case1					
Assuming	2.00	L	-	12.00	dia
Asv	=	226.19	mm2		
Spacing required	=	1823.02	mm		

Max spacing	=	300.00						
Provided spacing	=	200.00	mm					

Area of steel requirement by Direct Tension

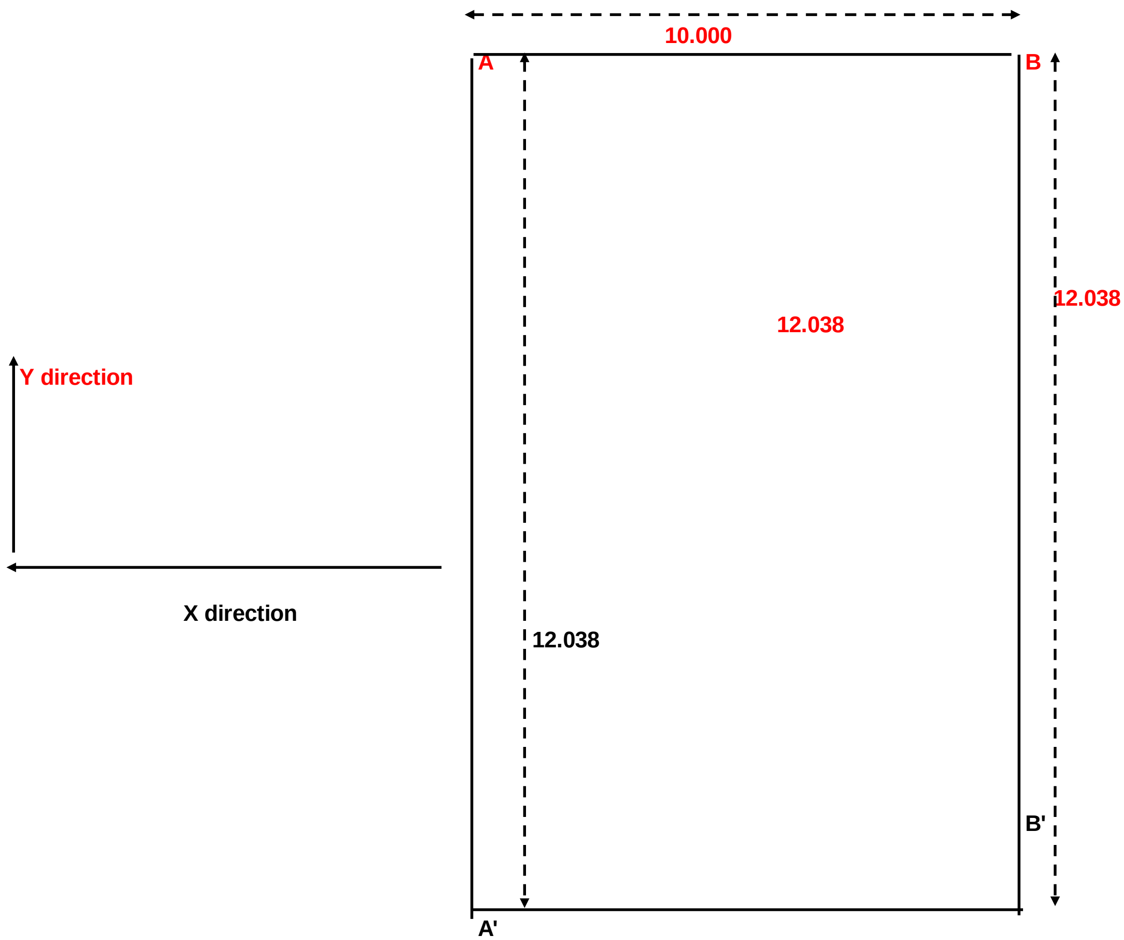
Assuming	2.00	L	-	12.00	dia			
Asv	=	226.19	mm2					
direct tension	**=**	978.83	mm2/m					
Spacing required		231.09	mm	**say**	**150.00**			

Design of Vertical Ties

Upward Base pressure	=	336.66	kN/m^2					
tensile force intensity	=	336.66	x	3.00	=	1009.99	kN/m	
Assuming		**2.00**	**leg**	**-**	**16.00**	**dia**		
Asv	=	402.12	mm2					
direct tension	=	2322.97	mm2/m					
Spacing required	=	173.11	mm	say	**150**			

Design of Solid Abutment shaft

Thickness of Shaft = 0.800 m



Effective Width of wall	a	=	2.333	m
Avg. Heigth of wall	b	=	12.038	m

a) Design of shaft

For design of return wall Load case 11.a & 11.d and their formulae given by Roark have been used.

Here, a/b = 0.194

a/b	=	0.2500	$\beta 1$ =	0.020	$\beta 2$ =	0.031
a/b	=	0.2500	$\beta 1$ =	0.020	$\beta 2$ =	0.031

For uniformly distributed load over entire plate

For, a/b = 0.194 $\beta 1$ = 0.020

$\beta 2$ = 0.031

Live Load Surcharge Intensity:

q = 0.2259 x 20.00 x 1.200 = 5.421 kN/m^2

Max. $.\sigma b = \dfrac{\beta 1 \times q \times b^2}{(t1)^2}$

	.σ a	=	β2	x	q	› b^2	
					(t2)^2		
	.σ b	=	0.020	x	5.421	x	144.925
					0.160		
At bottom edge		=	98.202 kN/m2		=	0.098 MPa	
For	1000 mm of width , Z			=	1000	x	640000
						6	
				=	1.07E+08 mm^3		

Hence Moment /m width along Y direction -

My /m width		=	0.098	x	1.067E+08		
		=	10474841 Nmm/m		=	**10.475 kN.m/m**	
	.σ a	=	0.031	x	5.421	x	144.925
					0.640		
		=	38	=	**0.0381 MPa**		
For	1000 mm of height , Z			=	1000	x	640000
						6	
				=	1.067E+08 mm^3		

Hence, Moment /m height along X direction -

Mx /m height		=	0.0381	x	1.067E+08	=	4.059E+06 Nmm/m
		=	**4.059 kN.m/m**				

For triangular loading due to Earth Pressure

Refer Load case No. 11 d

a/b =	0.250	β1 =	0.018	β2 =	0.019
a/b =	0.250	β1 =	0.018	β2 =	0.019

For,	a/b	=	0.194		β1	=	**0.018**
					β2	=	**0.019**
	q	=	0.226	x	20.00	x	12.04
		=	54.382 kN/m^2				
Max.	.σ b	=	β1	x	q	› b^2	
					(t1)^2		
	.σ a	=	β2	x	q	› b^2	
					(t2)^2		
	σ b	=	0.018	x	54.382	x	144.925
					0.16		
		=	886.65 kN/m^2				
		=	**0.887 MPa**				
For	1000 mm of width , Z			=	1000	x	640000
						6	
				=	1.067E+08 mm^3		

Hence Moment /m width along Y direction -

My /m width		=	0.887	x	1.067E+08

	=	94576028	Nmm/m	=	**94.576**	**kN.m/m**	
.σ a	=	0.019	x	54.382	x	144.925	
				0.64			
	=	234.0	kN/m^2	=	0.234	MPa	

For 1000 mm of height , Z = $\frac{1000 \times 640000}{6}$

= 1.067E+08 mm^3

Hence Moment /m height along X direction -

Mx /m height = 0.234 x 1.067E+08 = 2.496E+07 Nmm/m

= **24.958 kN.m/m**

Total Moment in Wall / m height = 29.017 kN.m/m

Total Moment in Wall / m width = 105.051 kN.m/m

Final Design Moments:

Load Factor for Earth pressure	=	1.50	
Load Factor for live load surcharge	=	1.20	
Total Moment(Mx) in Wall / m height =		42	kN.m/m
Total Moment(My) in Wall / m width =		154	kN.m/m

Material Property:

- Refer Table No 6.5 of IRC : 112-2011

Grade of Concrete	=	M 35	
Characteristic Strength of Concrete,fck	=	35.00 Mpa at 28 days	
Grade of Reinforcement	=	Fe 500	
Yield Strength of Reinforcement, fy or fyk	=	500.00 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000 Mpa	

1. Design For Mx/m Height

Moment in wall /m height

= **42.307 + 0.00**

= **42.31 kN.m / m**

Adopting clear cover on either face	=	75 mm		
Minimum Dia of Reinforcement	=	16 mm		
Maximum Spacing of Steel	=	150 mm		
Thickness of wall	=	0.800 m		
Available effective depth	=	800	-75	-8
	=	717 mm		

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 42.31 kNm/m

Effective Depth of Cap Required (dreq) = SQRT($\frac{42.31 \times 1000000}{0.165 \times 35.00 \times 1000}$)

Effective Depth of Cap Required (dreq) = 86 mm

Total Depth Required (Dreq) = 169 mm

Total Depth Provided (Dprov) = 800 mm **OK**

R= Mu/(b d^2) = 0.08

Area of Steel Required:

$$\frac{pt}{100} = \frac{Ast_{req}}{b\,d} = \frac{fck \{ 1 - \sqrt{1 - 4.598\, R/fck} \}}{2\, fy}$$

= 0.000

Ast_{req} = 136.023 mm^2/m

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011

= 960 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 960.000 mm^2/m

Provide 16 mm dia bar @ 150 mm c/c as Horizontal steel

Provide Ast= 1340 mm^2/m) OK

Percentage of Steel Provided = 0.187 %

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\frac{0.0035\ .\ d}{(0.0035 + fyd/Es)}$

= $\frac{0.0035 \times 717}{0.0035 + 0.00217}$

= 442.287 mm

Depth of Neutral Axis , X = $\frac{fyd\ .\ Ast}{0.36\ .\ fck\ .\ b}$

= $\frac{434.78 \times 1340}{0.36 \times 35.00 \times 1000}$

= 46.253 mm OK

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X

= 717 - 19.241

= 697.759 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 1340 x 697.759

= 4.07E+08 Nmm

= 406.646 kNm/m > 42.31 kNm/m

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

2. Design for My/m Width

Moment in Wall /m width = 154.43 kN.m / m

Adorting clear cover on either face = 75 mm
Minimum Dia of Reinforcement = 16 mm
Maximum Spacing of Steel = 150 mm
Thickness of wall = 0.800 m
Available effective depth = 800 -75 -16 -8
= 701 mm

Check for Depth:

Mult = $0.165 \times fck \times b \times d^2$ = 154.43 kNm/m

Effective Depth of Cap Required (dreq) = SQRT($\frac{154.43 \times 1000000}{0.165 \times 35.00 \times 1000}$)

Effective Depth of Cap Required (dreq) = 163.529 mm

Total Depth Required (Dreq) = 246.53 mm

Total Depth Provided (Dprov) = 800.00 mm **OK**

R= Mu/(b d^2) = 0.31

Area of Steel Required:

$\frac{pt}{100} = \frac{Ast_{req}}{b\,d} = \frac{fck}{2\,fy}\{1 - \text{sqrt}(1 - 4.598\,R/fck)\}$

= 0.001

Ast_{req} = 511.820 mm^2/m

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011

= 960 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 960 mm^2/m

Provide	**16**	**mm dia bar @**	**150**	**mm c/c as vertical steel at earth face.**

Provide Ast=	**1340**	**mm^2/m)**	**OK**

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\frac{0.0035\,.\,d}{(0.0035 + fyd/Es)}$

= $\frac{0.0035 \times 701}{0.0035 + 0.00217}$

= 432.42 mm

Depth of Neutral Axis , X = $\frac{fyd\,.\,Ast}{0.36\,.\,fck\,.\,b}$

= $\frac{434.78 \times 1340}{0.36 \times 35.00 \times 1000}$

= 46.253 mm OK

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X

= 701 - 19.241

= 681.76 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

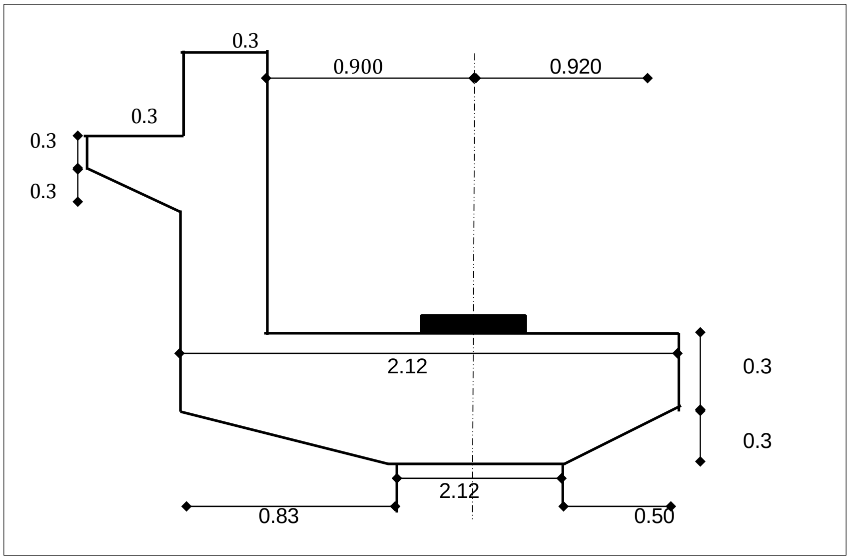
= 434.78 x 1340 x 681.759

= 3.97E+08 Nmm

= 397.321 kNm/m > 154.43 kNm/m

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

DESIGN OF ABUTMENT CAP



Thickness of Abutment Cap (uniform)	s	=	0.3	m	
Thickness of Abutment Cap (tapered)		=	0.3	m	
C.G. of dirt wall from face of abutment shaft (a)		=	0.675	m	
Overall depth of Abutment cap at face of abutment shaft		=	0.600	m	
Clear cover		=	40	mm	
Diameter of the main bar		=	16	mm	
Effective cover	d'	=	48	mm	
Effective depth of cap	d	=	0.552	m	

For the section to be designed as corbel " a / d " shall be less than 1.

Hence a / d = 0.675 / 0.55
= 1.223 **>1.0**

For the section to be designed as corbel " s / d " shall be greater than 0.5.

Hence s / d = 0.3 / 0.55
= 0.54 **> 0.5** **Proceed with the design**

Note: THE ABUTMENT CAP HAS BEEN DESIGNED AS CORBEL FOR DIRT WALL AND LIVE LOAD ON DIRT WALL

1. Dead Load

Self Weight of Dirt Wall	=	18.5438	kN		
Self Weight of Bracket	=	0.135	m^3/m	x	25
	=	3.375	kN		
Total Dead Load	=	21.9188	kN		
Load Factor	=	1.35			
Ultimate Dead Load	=	**29.5903**	kN		

2. Live Load

Assuming Class 70R Boggie load, One Axle is Directly over Dirt Wall

Vertical Load on Dirt Wall	=	200	kN
Load Factor	=	1.5	
Factored Live load	=	300	kN
Actual horizontal force in normal case	=	40.00	kN
Effective width for this load is considered as (b)	=	1000	mm

Vertical Load (V_u)

Total maximum Vertical Load " V_u "	329.59	kN

Horizontal Load (H_u)

H_u = 1.7 x actual horizontal force in working load condition
but not less than
= 0.2 * V_u

Total maximum Horizontal Load " H_u "	68.00	kN

Now the design for the corbel is carried out as per the following steps.

STEP I

Check for Nominal Shear Strength

Ensure $\mathbf{V_u / b\,d <= 0.15\, f_c'}$

where; V_u = 329.59 kN
= 329590.31 N

bd = 1000 x 552 sqmm
= 552000.00 mm^2

V_u / b d = 329590.32 / 552000

V_u / b d = **0.60** N / mm^2

f_c' = 28 - day standard cylinder strength of concrete used.
= 0.80 times the standard cube strength

Grade of Concrete M 35

0.15 f_c' = 0.15 x 0.8 x 35
= **4.20** N / mm^2 **Ensured**

Hence $\mathbf{V_u / b\,d <= 0.15\, f_c'}$ is **Ensured**

STEP II

Calculation of Shear Friction Reinforcement " A_{vf} "

$$A_{vf} = \frac{V_u}{0.87\, f_{sy}\, m}$$

where; f_{sy} = yeild stress value of the reinforcement used.
= 500.00 N/ mm^2

	Type of Surface	m
1	Concrete placed monolithically across interface.	1.40
2	Concrete placed against hardened concrete but with roughened surface	1.00
3	Concrete anchored to structural steel	0.70
4	Concrete placed against hardened concrete but surface not roughened	0.60

Type of Surface (1 / 2 / 3 / 4) ? = **1.00**

m = 1.40

(Note: Only monolithic construction is recommended)

$$A_{vf} = \frac{329.6 \times 1000}{0.87 \times 500 \times 1.4}\ mm^2$$

A_{vf} = **553.93** mm^2

STEP III

Calculation for Direct Tension Reinforcement " A_t ".

$$A_t = \frac{H_u}{0.87\ f_{sy}}$$

H_u = 68.00 kn

$$A_t = \frac{68 \times 1000}{0.87 \times 500}$$

= **156.32** mm^2

STEP IV

Calculation for Flexural Tension Reinforcement " A_f "

$$A_f = \frac{[\ V_u\ a + H_u\ (\ h - d'\ )\ ]}{0.87\ f_{sy}\ d}$$

$$= \frac{329.6 \times 1000 \times 675 + 68 \times 1000\ (\ 600 - 48\ )}{0.87 \times 500 \times 552}$$

= **1082.83** mm^2

STEP V

Total Primary Tensile Reinforcement " A_s "

A_s >= $(\ A_f + A_t\ )$

>= $(\ 2 / 3\ A_{vf} + A_t\ )$

>= $(\ 0.04\ f_c' / f_{sy}\ )\ b\ d$

Provide the largest of these three magnitudes as A_s.

$(\ A_f + A_t\ )$ = 1082.84 + 156.33 mm^2

= 1239.15 mm^2

$(\ 2 / 3\ A_{vf} + A_t\ )$ = 2 / 3 x 553.94 + 156.33 mm^2

= 525.61 mm^2

$(\ 0.04\ f_c' / f_{sy}\ )\ b\ d$ = 0.04 x 0.8 x 35 / 500 x 1000 x 552

= 1236.48 mm^2

Hence A_s = **1239.15** mm^2

STEP VI

The total sectional area of the stirrups is " A_h " (closed ties) to be provided horizontally, one below the other, and next to " A_s "

A_h >= 0.25 * A s

>= 0.333 * A_{vf}

Provide the largest of these two magnitudes as Ah.

0.25 * A s = 0.25 x 1239.16

= 541.42 mm^2

0.333*A_{vf} = 0.333 x 553.94

= 184.46 mm^2

Hence A_h = **541.42** mm^2

STEP VII

The total steel in vertical stirrups is " A_v "

V c = 10 bd in kgs ***where b & d are in cms***

= 10 x 100 x 55.2

	=	55200.00	kg
	=	552.00	kN
Pitch	=	200	mm

$$A_v = \frac{0.50 * (V_u - V_c) * p}{f_{sy}\, d}$$

$$= \frac{0.5 \times (329.6 - 552) \times 200 \times 1000}{500 \times 552}$$

A_v = **0.00** mm^2

Reinforcement Details

Total Primary Tensile Reinforcement " A_s "

A_s	=	**1239.15**	mm^2			
Diameter of Primary Steel	=	16	mm			
Area of one bar	=	201.06	mm^2			
Spacing of Bar	=	**150**	mm c/c			
$A_{s\ provided}$	=					
	=	1340.413	mm^2	>	A_s	R/F is adequate

provide	**150 mm c/c 16 mm diameter bars as main reinforcement**	

DESIGN OF DIRT WALL

Dirt wall will be designed as a vertical cantilever.

1.) NORMAL CASE

1a. Dead Load

Self Weight of Dirt Wall = 7.418 m^3 x 25.00 = 185.438 kN

Self Weight of Dirt Wall/ m = 185.438 / 10.00 = 18.544 kN

1b. Live Load

Assuming Class 70R Boggie load, One Axle is Directly over Dirt Wall

Vertical Load on Dirt Wall = 200 kN

Braking Load

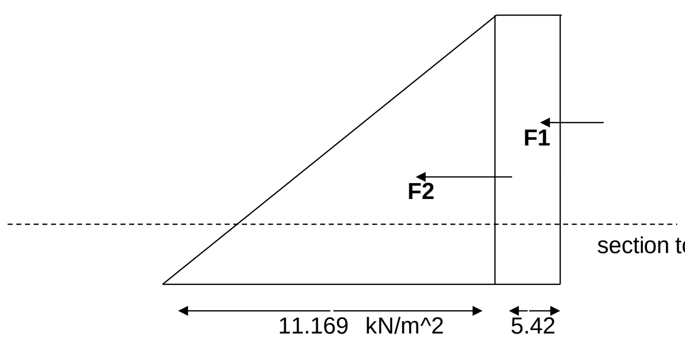
Assuming 20% braking Force i.e. 0.2 *200 = 40.000 kN acting at 1.2 m above deck

Effective Width = 2.79 m

Moment (due to Breaking) = $\frac{40.000 \times 3.673}{2.79}$ = 52.652 kNm/m

1c. EARTH PRESSURE

Height of dirt wall = 2.473 m



section to check Shear stress

Normal Earth Pressure

Earth Pressure Diagram

Intensity for rectangular portion = 0.226 x 20 x 1.2 = 5.421 kN/m^2

F1 = 5.421 x 2.47 x 1.00 = 13.403 kN/m

Intensity for triangular portion = 0.2259 x 20 x 2.473 = 11.169 kN/m^2

F2 = 0.50 x 11.17 x 2.473 x 1.00 = 13.808 kN/m

Moment @ RL **1118.54** m (at dirt wall base)

M1 = 13.403 x 1.236 = 16.569 kN.m/m

(Centre of pressure considered at an elevation of 0.42 x the height of the wall as per cl. 217.1 of IRC:6-2017)

M2 = 13.808 x 1.038 = 14.339 kN.m/m

Design Horizontal Forces (Normal Case):

Load Factor For Live Load Surcharge = 1.2

Ultimate Moment due to Live Load Surcharge	=	19.883	kN.m/m
Load Factor For Earth Pressure	=	1.5	
Ultimate Moment due to Earth Pressure	=	21.508	kN.m/m
Load Factor For Braking Force	=	1.5	
Ultimate Moment due to Braking Force	=	78.978	kN.m/m
Total Ultimate Moment	**=**	**120.370**	**kN.m/m**

Material Property:

Grade of Concrete	=	M	35
Characteristic Strength of Concrete,fck	=	35.00	Mpa at 28 days
Grade of Reinforcement	=	Fe	500
Yield Strength of Reinforcement, fy or fyk	=	500	N/mm^2
Design Yield Strength of Reinforcement, fyd	=	434.783	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2

(a) Vertical steel on earth face As per Clause 16.3.1 of IRC:112-2011

Adorting clear cover on either face	=	40	mm
Minimum Dia of Reinforcement	=	16	mm
Maximum Spacing of Steel	=	150	mm
Thickness of dirtwall	=	0.300	m

Available effective depth = 300 -40 -8 = 252 mm

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 120.37 kNm/m

Effective Depth of Cap Required (dreq) $= SQRT\left(\dfrac{120.37 \times 1000000}{0.165 \times 35.00 \times 1000}\right)$ = 144.372 mm

Total Depth Required (Dreq) = 192.37 mm

Total Depth Provided (Dprov) = 300.00 mm **OK**

R= Mu/(b d^2) = 1.895

Area of Steel Required:

$\dfrac{pt}{100} = \dfrac{Ast_{req}}{b\ d} = \dfrac{fck \{ 1 - sqrt(1- 4.598\ R/fck) \}}{2\ fy}$ = 0.005

Ast_{req} = 1176.619 mm^2/m

As per Clause 16.3.1 of IRC:112-2011

Minimum Reinforcement = 0.12/100 b x D = 360 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 1176.619 mm^2/m

Provide 16 mm dia bar @ 150 mm c/c as vertical steel at earth face.

Provide Ast = 1340 mm^2/m) OK

Percentage of Steel Provided = 0.532 %

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm $= \dfrac{0.0035\ .\ d}{(0.0035 + fyd/ Es)} = \dfrac{0.0035 \times 252}{0.0035 + 0.00217}$

= 155.4483 mm

Depth of Neutral Axis , $= \dfrac{fyd\ .\ Ast}{0.36\ .\ fck\ .\ b}$

$= \dfrac{435 \times 1340}{}$ = 46.276 mm

0.36 x 35.00 x 1000 **OK**

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z	=	d	-	0.416 . X	=	252	- 19.251
	=	232.749	mm				

Moment of Resistance of Section w.r.t. Steel (MR)

MR	=	fyd . Ast . z	=	434.78	x	1340 x	232.75
	=	1.4E+08 Nmm	=	135.643	kNm/m	>	120.37 kNm/m

SAFE

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

(b) Horizontal steel Refer Clause 16.3.2 of IRC:112-2011

Adopting distribution steel bars Dia.	=	12 mm
Minimum Area of Steel	=	0.001x 0.5 x b x D OR 25% of Ast on Vertical Face
0.001x0.5xbxD	=	150 mm^2/m OR 294.155 mm^2/m
Governing Ast	=	294.155 mm^2/m
Maximum Spacing of Bars	=	300 mm

Provide 12 mm dia bar @ 150 mm c/c horizontal steel at non earth face.

Provided Ast = **754 mm^2/m)** **OK**

(c) Vertical steel on other face

As per Clause 16.3.1 of IRC:112-2011

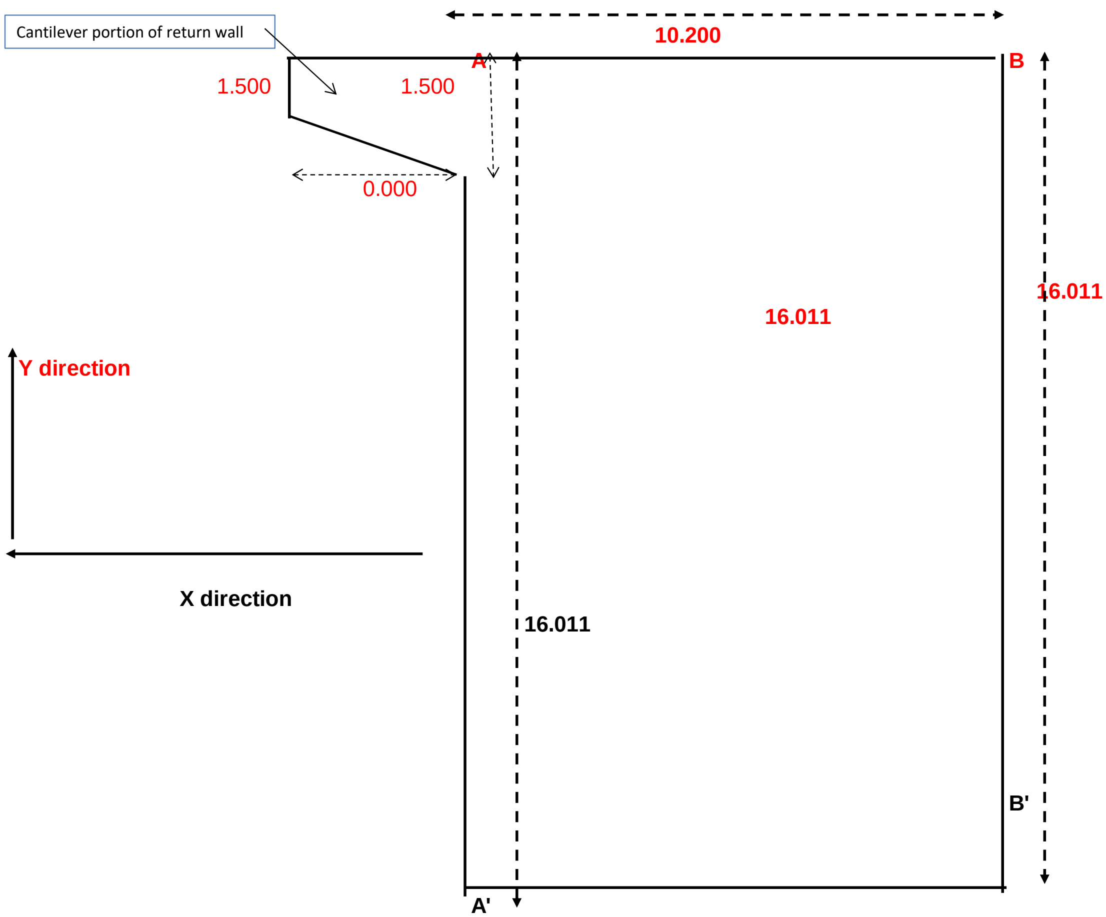
Minimum Reinforcement = 0.12/100 b x D = 360 mm^2/m

Provide 10 mm dia bar @ 150 mm c/c as vertical steel at earth face.

Provided Ast= 524 mm^2/m) **OK**

Design of Solid Return wall

THICKNESS OF SOLID RETURN WALL	=	1.500	m	at bottom
THICKNESS OF CANTILEVER RETURN WALL	=	1.500	m	for design



Width of Solid Return	a	=	10.20	m
Avg. Heigth of Solid Return	b	=	16.011	m

a) Design of Solid Return wall

For design of return wall Load case 11.a & 11.d and their formulae given by Roark have been used.

Here, a/b = 0.637

a/b	=	0.50	$\beta 1$ =	0.631	$\beta 2$ =	0.632
a/b	=	0.75	$\beta 1$ =	1.246	$\beta 2$ =	1.186

For uniformly distributed load over entire plate

For, a/b = 0.637 — $\beta 1$ = 0.968; $\beta 2$ = 0.936

Live Load Surcharge Intensity:

q = 0.2259 x 20.00 x 1.200 = 5.421 kN/m^2

Max. $.\sigma$ b = $\dfrac{\beta 1 \times q \times b^2}{(t1)^2}$

$.\sigma$ a = $\beta 2 \times q \times b^2$

(t2)^2

.σ b = $\dfrac{0.968 \times 5.421 \times 256.352}{2.250}$

At bottom edge = 597.959 kN/m2 = **0.598 MPa**

For 1000 mm of width , Z = $\dfrac{1000 \times 2250000}{6}$

= 3.75E+08 mm^3

Hence Moment /m width along Y direction -

My /m width = 0.598 x 3.750E+08

= 224234471 Nmm/m = **224.234 kN.m/m**

.σ a = $\dfrac{0.936 \times 5.421 \times 256.352}{2.250}$

= 578 = **0.5779 MPa**

For 1000 mm of height , Z = $\dfrac{1000 \times 2250000}{6}$

= 3.750E+08 mm^3

Hence, Moment /m height along X direction -

Mx /m height = 0.5779 x 3.750E+08 = 2.167E+08 Nmm/m

= **216.720 kN.m/m**

For triangular loading due to Earth Pressure

Refer Load case No. 11 d

a/b =	0.500	β1 =	0.328	β2 =	0.200
a/b =	0.75	β1 =	0.537	β2 =	0.276

For, a/b = 0.637 β1 = **0.443**

β2 = **0.242**

q = 0.226 x 20.00 x 16.01

= 72.327 kN/m^2

Max. .σ b = $\dfrac{\beta 1 \times q \times b^2}{(t1)^2}$

.σ a = $\dfrac{\beta 2 \times q \times b^2}{(t2)^2}$

σ b = $\dfrac{0.443 \times 72.327 \times 256.352}{2.25}$

= 3647.13 kN/m^2

= **3.647 MPa**

For 1000 mm of width , Z = $\dfrac{1000 \times 2250000}{6}$

= 3.750E+08 mm^3

Hence Moment /m width along Y direction -

My /m width = 3.647 x 3.750E+08

= 1367673321 Nmm/m = **1367.673 kN.m/m**

.σ a	=	0.242	x	72.327	x	256.352
				2.25		
	=	1991.5 kN/m^2		=	1.991 MPa	

For 1000 mm of height , Z = $\frac{1000 \times 2250000}{6}$

= 3.750E+08 mm^3

Hence Moment /m height along X direction -

Mx /m height = 1.991 x 3.750E+08 = 7.468E+08 Nmm/m

= **746.799 kN.m/m**

Total Moment in Solid Return Wall / m height = 963.520 kN.m/m

Total Moment in Solid Return Wall / m width = 1591.908 kN.m/m

Final Design Moments:

Load Factor for Earth pressure	=	1.50	
Load Factor for live load surcharge	=	1.20	
Total Moment(Mx) in Solid Return Wall / m height	=	1380	kN.m/m
Total Moment(My) in Solid Return Wall / m width	=	2321	kN.m/m

Material Property:

- Refer Table No 6.5 of IRC : 112-2011

Grade of Concrete	=	M	35	
Characteristic Strength of Concrete,fck	=	35.00	Mpa at 28 days	
Grade of Reinforcement	=	Fe	500	
Yield Strength of Reinforcement, fy or fyk	=	500	Mpa	
Design Yield Strength of Reinforcement, fyd	=	435	Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000	Mpa	

1. Design of Face BB'

Moment in Solid Return /m height (including cantilever moment) =

= **1380.263** **+** **0.00**

= **1380.26 kN.m / m**

Adopting clear cover on either face	=	75	mm		
Minimum Dia of Reinforcement	=	32	mm		
Maximum Spacing of Steel	=	150	mm		
Thickness of wall	=	1.500	m		
Available effective depth	=	1500		-75	-16
	=	1409	mm		

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 1380.26 kNm/m

Effective Depth of Cap Required (dreq) = SQRT($\frac{1380.26 \times 1000000}{0.165 \times 35.00 \times 1000}$)

Effective Depth of Cap Required (dreq) = 489 mm

Total Depth Required (Dreq) = 580 mm

Total Depth Provided (Dprov) = 1500 mm **OK**

R= Mu/(b d^2) = 0.70

Area of Steel Required:

$\frac{pt}{100} = \frac{Ast_{req}}{b\,d} = \frac{fck \{ 1 - sqrt(1- 4.598 R/fck) \}}{2\,fy}$

= 0.0016

Ast_{req}	=	2306.028	mm^2/m	
Minimum Reinforcement	=	0.12/100	b x D	As per Clause 16.3.1 of IRC:112-2011
	=	1800	mm^2/m	
Maximum (Ast_{req}, Ast_{min})	=	2306.028	mm^2/m	

Provide 32 mm dia bar @ 150 mm c/c as Horizontal steel at earth face.

Provide Ast= 5362 mm^2/m) OK

Percentage of Steel Provided = 0.381 %

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\frac{0.0035 \,.\, d}{(0.0035 + fyd/ Es)}$

= $\frac{0.0035 \times 1409}{0.0035 + 0.00217}$

= 869.153 mm

Depth of Neutral Axis , X = $\frac{fyd \,.\, Ast}{0.36 \,.\, fck \,.\, b}$

= $\frac{434.78 \times 5362}{0.36 \times 35.00 \times 1000}$

= 185.012 mm OK

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X
= 1409 - 76.965
= 1332.035 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 5362 x 1332.035

= 3.11E+09 Nmm

= 3105.177 kNm/m > 1380.26 kNm/m

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

Provide 16 mm dia bar @ 150 mm c/c as Horizontal steel at non earth face.

Provided Ast = **1340 mm^2/m)**

2. Design for Face A'B'

Moment in Solid Return /m width = 2320.59 kN.m / m

Adorting clear cover on either face	=	75	mm			
Minimum Dia of Reinforcement	=	25	mm			
Maximum Spacing of Steel	=	100	mm			
Thickness of wall	=	1.500	m			
Available effective depth	=	1500		-75	-32	-12.5
	=	1380.5	mm			

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 2320.59 kNm/m

Effective Depth of Cap Required (dreq) = SQRT($\frac{2320.59 \times 1000000}{0.165 \times 35.00 \times 1000}$)

Effective Depth of Cap Required (dreq) = 634 mm

Total Depth Required (Dreq) = 721 mm
Total Depth Provided (Dprov) = 1500 mm **OK**

R= Mu/(b d^2) = 1.22

Area of Steel Required:

$\frac{pt}{100} = \frac{Ast_{req}}{b\,d} = \frac{fck \{ 1 - sqrt(1- 4.598 R/fck) \}}{2\,fy}$

= 0.003

Ast_{req} = 4032.875 mm^2/m

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011
= 1800 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 4032.875 mm^2/m

Provide 25 mm dia bar @ 100 mm c/c as vertical steel at earth face.

Provide Ast= 4909 mm^2/m) OK

Percentage of Steel Provided = 0.3556 %

Provide 16 mm dia bar @ 100 mm c/c as Vertical steel at non earth face.

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\frac{0.0035\ .\ d}{(0.0035 + fyd/ Es)}$

= $\frac{0.0035 \times 1380.5}{0.0035 + 0.00217}$

= 851.57 mm

Depth of Neutral Axis , X = $\frac{fyd\ .\ Ast}{0.36\ .\ fck\ .\ b}$

= $\frac{434.78 \times 4909}{0.36 \times 35 \times 1000}$

= 169.384 mm OK

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X
= 1380.5 - 70.464
= 1310.04 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 4909 x 1310.036

= 2.80E+09 Nmm

= 2795.924 kNm/m > 2320.59 kNm/m

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

ANNEXURE-I (LOAD CALCULATION-DL & SIDL)

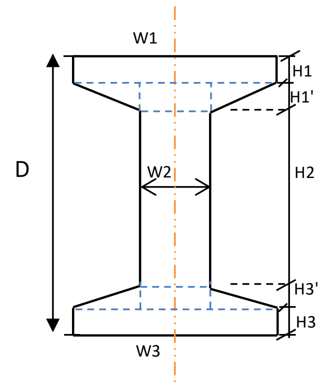
SECTIONAL PROPERTIES OF OUTER GIRDER & INNER GIRDER

1. SECTIONAL PROPERTIES OF GIRDERS -MID SPAN

(Dimension in mm)

D	=	1600
H1	=	150
H1'	=	100
H2	=	950
H3'	=	150
H3	=	250
W1	=	1000
W2	=	325
W3	=	625

Element	Width (mm)	Height (mm)	A (mm^2)
1 (Rect.)	1000	150	150000
1' (Tri.)	675	100	33750
1' (Rect.)	325	100	32500
2 (Rect.)	325	950	308750
3' (Tri.)	300	150	22500
3' (Rect.)	325	150	48750
3 (Rect.)	625	250	156250
			752500



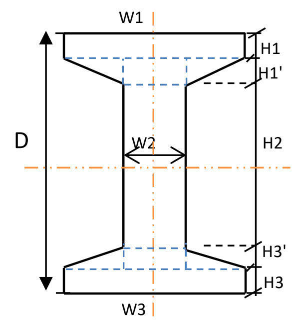
Total Area of Section A = 0.753 m^2

2. SECTIONAL PROPERTIES OF GIRDERS -VARRYING PORTION

(Dimension in mm)

D	=	1600
H1	=	150
H1'	=	78
H2	=	1122
H3'	=	0
H3	=	250
W1	=	1000
W2	=	475
W3	=	475

Element	Width (mm)	Height (mm)	A (mm^2)
1 (Rect.)	1000	150	150000
1' (Tri.)	525	78	20417
1' (Rect.)	475	78	36944
2 (Rect.)	475	1122	533056
3' (Tri.)	0	0	0
3' (Rect.)	475	0	0
3 (Rect.)	475	250	118750
			859167



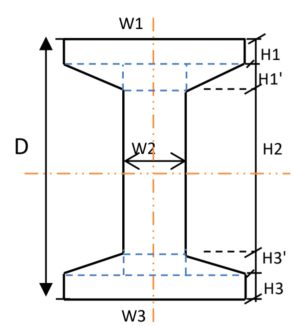
Total Area of Section A = 0.859 m^2

3. SECTIONAL PROPERTIES OF GIRDERS (AT SUPPORT)

(Dimension in mm)

D	=	1600
H1	=	150
H1'	=	56
H2	=	1394
H3'	=	0.00
H3	=	0.00
W1	=	1000
W2	=	625
W3	=	625

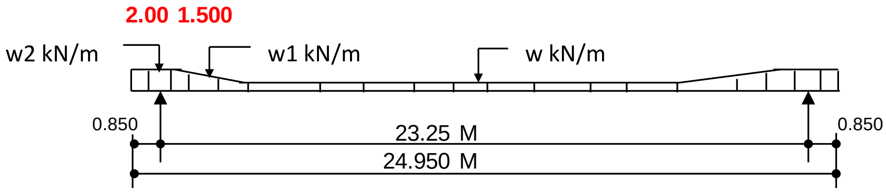
Element	Width (mm)	Height (mm)	A (mm^2)
1 (Rect.)	1000	150	150000
1' (Tri.)	375	56	10417
1' (Rect.)	625	56	34722
2 (Rect.)	625	1394	871528
3' (Tri.)	0	0	0
3' (Rect.)	625	0	0
3 (Rect.)	625	0	0
			1066667



Total Area of Section A = 1.067 m^2

1.0 Self weight of Inner Girder & Outer Girder

Length of the girder = 24.950 m



UDL , w	=	18.81	kN/m
Avg. , w_1	=	21.48	kN/m
UDL , w_2	=	26.67	kN/m
Supp. Reaction , R	=	**247.81**	KN

2.0 Weight of cast-in-situ deck slab

Effective Width of Slab	=	3.000 m	For Outer Girder
Effective Width of Slab	=	2.50 m	For Inner Girder
Thickness of Slab	=	0.22 m	
Extra average slab thickness for camber	=	0.00 m	
Weight of green concrete	=	25 kN/m^3	

UDL due to deck slab weight	=	16.500 kN/m	For Outer Girder
on entire length of girder	=	13.750 kN/m	For Inner Girder
Supp. Reaction , R	=	205.838 kN	For Outer Girder
	=	171.531 kN	For Inner Girder

weight of deck slab has been Increase by 5 %

Supp. Reaction , R	=	216.129 kN	For Outer Girder
	=	180.108 kN	For Inner Girder

3.0 Weight of end cross beam

Depth of cross beam	=	1.57 m	
Thickness of cross beam	=	0.4 m	
Support Reaction , R	=	**47.100 kN**	on outer bearings
	=	**39.250 kN**	on Inner bearings

4.0 Weight due to wearing coat

Wearing coat width	=	2.500 m	For Outer Girder
Wearing coat width	=	2.500 m	For Inner Girder
Weight of wearing coat including future c	=	2.2 kN/m^2	
UDL due to Wearing coat	=	5.500 kN/m	For Outer Girder
on entire length of girder	=	5.500 kN/m	For Inner Girder
Supp. Reaction , R	=	**68.613 kN**	For Outer Girder
	=	**68.613 kN**	For Inner Girder

ANNEXURE-II (LOAD CALCULATION-CARRIAGEWAY LIVE LOAD)

Maximum Live Load Reaction Case

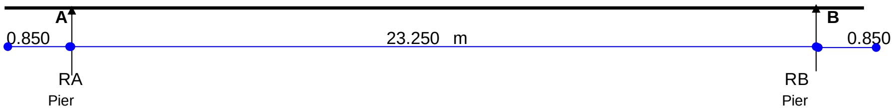
Nos. of Lane for design purpose = 3 LANE

Due to Class A 1-Lane , 2-Lanes & 3-Lanes

Considering **114.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	**=**	**23.25 m**
Projection beyond cL of bearing at Abut. end	=	0.850 m
Projection beyond cL of bearing at far end	=	0.850 m
Total length including Overhangs	=	24.95 m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support A in metres	Total Moment of all Loads @ Support A in kN-m	Reaction at Support A in kN	Reaction at Support B in kN
Ist Train	Total Load	554.0kN				
27.000		**0.000**	-0.850	-22.950		
27.000	1.100	1.100	0.250	6.750	**357.630**	**196.370**
114.000	3.200	4.300	3.450	393.300		
114.000	1.200	5.500	4.650	530.100		
68.000	4.300	9.800	8.950	608.600		
68.000	3.000	12.800	11.950	812.600		
68.000	3.000	15.800	14.950	1016.600		
68.000	3.000	18.800	17.950	1220.600		

Reactions (without Impact) for 1 Lane

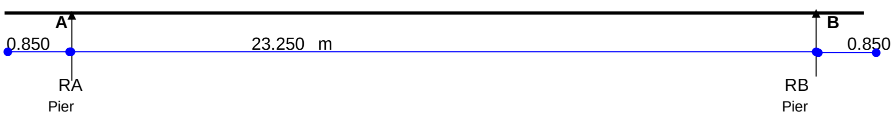
Description		At Supp-A RA	At Supp-B RB
Reaction	in kN	357.630	196.370

Due to Class 70R Wheeled

Considering **170.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	**=**	**23.25 m**
Projection beyond cL of bearing at Abut. end	=	0.850 m
Projection beyond cL of bearing at far end	=	0.850 m
Total length including Overhangs	=	24.95 m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support A in metres	Total Moment of all Loads @ Support A in kN-m	Reaction at Support A in kN	Reaction at Support B in kN
Ist Train	Total Load	1000.0kN				
170.000		**0.000**	-0.850	-144.500		
170.000	1.370	1.370	0.520	88.400	**816.181**	**183.819**
170.000	3.050	4.420	3.570	606.900		
170.000	1.370	5.790	4.940	839.800		
120.000	2.130	7.920	7.070	848.400		
120.000	1.520	9.440	8.590	1030.800		
80.000	3.960	13.400	12.550	1004.000		

Reactions (without Impact) for 70R Wheeled

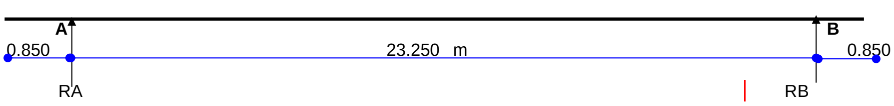
Description		At Supp-A RA	At Supp-B RB
Reaction	in kN	816.181	183.819

Due to Class A 1-Lane (along with Class 70R)

Considering **68.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	**=**	**23.25 m**
Projection beyond cL of bearing at Abut. end	=	0.850 m
Projection beyond cL of bearing at far end	=	0.850 m
Total length including Overhangs	=	24.95 m



Axle Load in kN	Spacing between two successive axles	Distance of the axles from Extreme Left Node	Distance of the axles from the Support A	Total Moment of all Loads @ Support A	Reaction at Support A	Reaction at Support B

DESIGN OF PIER P1 AND ITS FOUNDATION FOR MAJOR BRIDGE (LHS) AT CH-31+158

This Document Contains Design Calculations of Pier with Open Foundation

1. SALIENT FEATURES OF THE BRIDGE

Skew angle : 0 degree 0 Radian

SPAN DETAILS		Left span Right	Left span Skew	Right span Right	Right span Skew	Unit
C/C Expansion joint	=	25.000	25.000	25.000	25.00	m
C/C Expansion joint to C.L. brg	=	0.875	0.875	0.875	0.88	m
Expansion gap	=	50	50	50	50	mm
C/C bearing	=	23.250	23.250	23.250	23.250	m

SUPERSTRUCTURE DETAILS

		Left Span		Right Span	
Overall deck width of bridge	=	10.00	m	10.00	m
Carriage way width	=	9.00	m	9.00	m
Crash barrier width	=	0.45	m	0.45	m
Height of crash barrier	=	1.00	m	1.00	m
C.g of Crash barrier from bottom	=	0.40	m	0.40	m
Cross-slope	=	7.00	%	7.00	%
Wearing coat thickness	=	65	mm	65	mm
Nos. of Bearing	=	4		4	
Spacing of Bearing	=	2.50	m	2.50	m
Depth of Girder	=	1.220	m	1.220	m
Depth of slab	=	0.25	m	0.25	m
Depth of superstructure	=	1.470	m	1.470	m
Bearing + Pedestal height	=	0.30	m	0.30	m
Width of main girder at top	=	0.40	m	0.40	m
Width of cross girder	=	0.40	m	0.40	m
Nos. of cross-girders	=	2		2	
FRL to Soffit	=	1.62	m	1.62	m
Type of Bearing				OR SPHERICAL BR	

LEVEL DETAILS

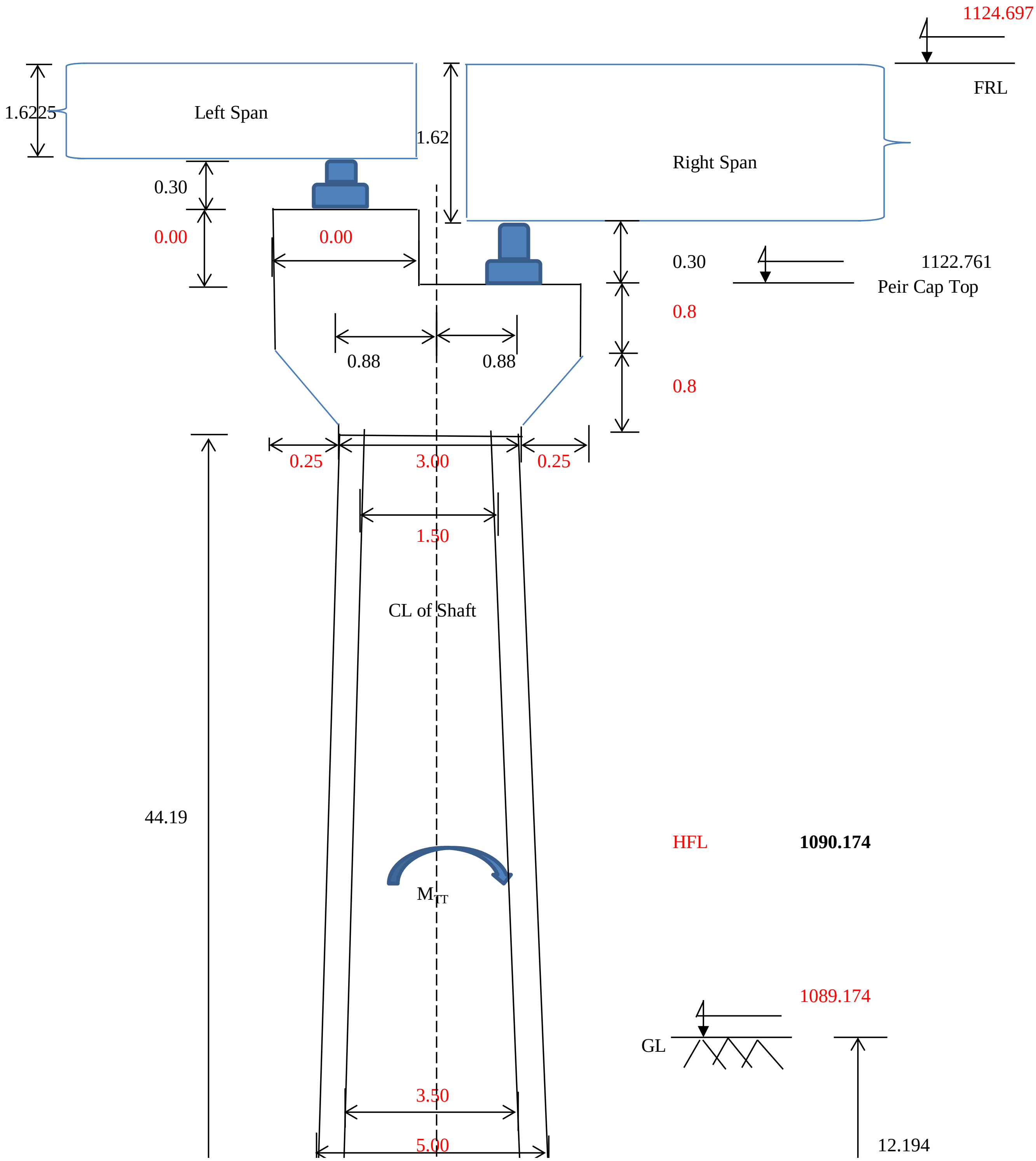
Formation level	=	1124.697	m
Pier cap top level	=	1122.761	m
HFL	=	1090.174	m
Ground level	=	1089.174	m
MSL (Normal)/Rock Level	=	1089.174	m
MSL (Seismic)/Rock Level	=	1089.174	m
Pier shaft bottom/Footing top level	=	1076.966	m
Founding level	=	1073.980	m

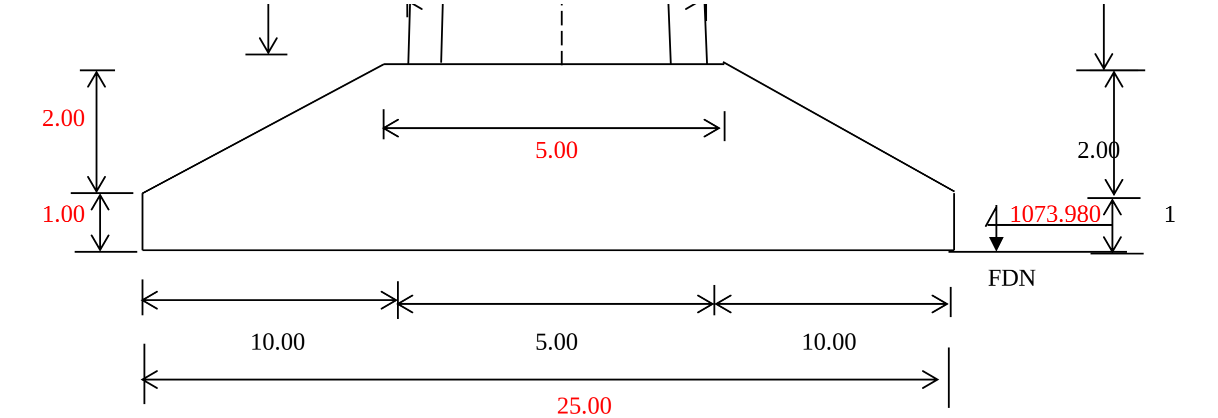
DIMENSION DETAILS

Pier cap:		Right		Skew	
Width of pier cap at top	=	3.50	m	3.50	m
Width of pier cap at bottom	=	3.50	m	3.50	m
Length of pier cap at top	=	9.20	m	9.20	m
Length of pier cap at bottom	=	3.00	m	3.00	m
Thickness of uniform portion	=	0.80	m	0.80	m
Thickness of tapered portion	=	0.80	m	0.80	m
Pier shaft:					
Width of pier at top	=	3.00	m	3.00	m
Width of pier at bottom	=	5.00	m	5.00	m
Length of pier (rectangle portion)	=	0.00	m	0.00	m
Length of pier(end circular portion Top)	=	1.50	m	1.50	m
Length of pier (end circular portion Bottom)	=	2.50	m	2.50	m

Total length of pier shaft at top	=	3.00 m	3.00 m
Total length of pier shaft at bottom	=	5.00 m	5.00 m
Footing:			
Width of footing at top	=	5.00 m	5.00 m
Width of footing at bottom	=	25.00 m	25.00 m
Length of footing	=	10.00 m	10.00 m
Thickness at tip	=	1.00 m	1.00 m
Maximum thickness	=	3.00 m	3.00 m

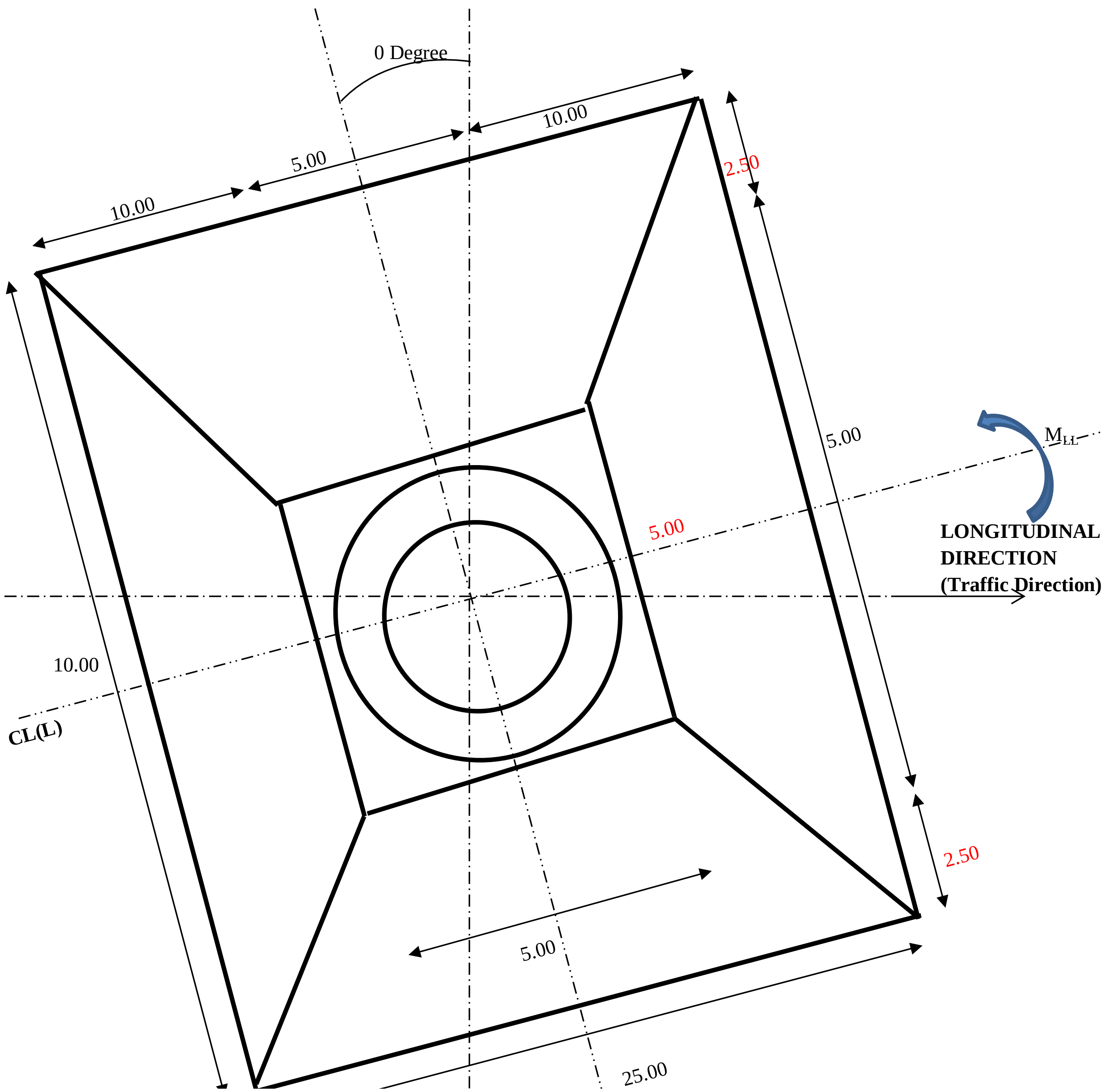
DIAGRAMS:

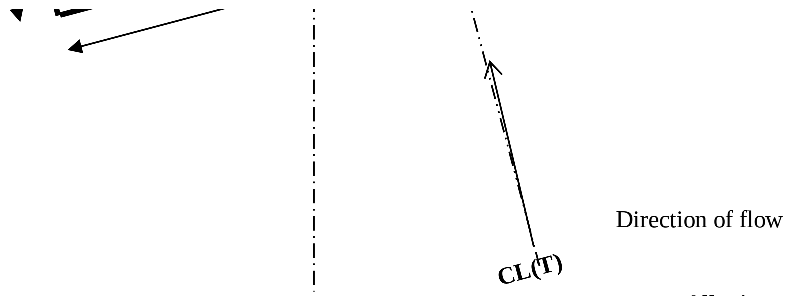




1. ELEVATION CL(L)

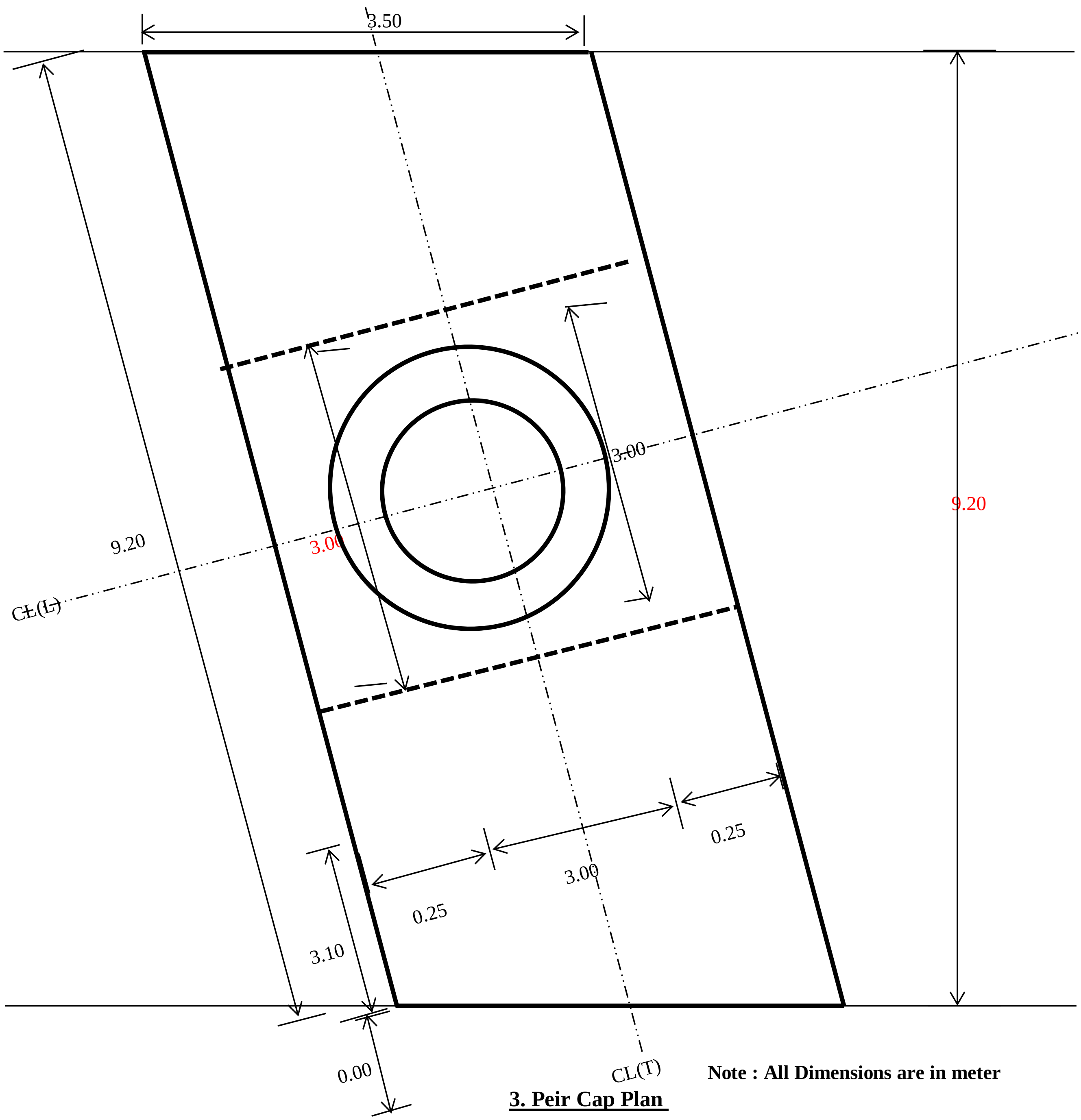
Note : All Dimensions are in meter





Note : All Dimensions are in meter

2. PLAN SHOWING FOOTING & PIER SHAFT



Note : All Dimensions are in meter

3. Peir Cap Plan

2. MATERIALS DETAILS

CONCRETE:

Grade of concrete	fck	=	M 35		
Mean value of concrete compressive strength, fcm		=	M 45	(28 days strength from table 6.5 of IRC:112)	
Design concrete compressive strength, fcd		=	0.447	x fck	(Basic and Seismic combination)
		=	15.633	Mpa	
Secant modulus of elasticity , Ecm		=	32000	Mpa	(from table 6.5 of IRC:112)
Mean axial tensile strength fctm		=	2.8	Mpa	(from table 6.5 of IRC:112)
Density of concrete		=	2.5	t/m^3	

SOIL :

Density dry	=	2	t/m^3	
Density Saturated	=	2.3	t/m^3	
Soil density (submerged)	=	2	t/m^3	
Angle of Internal friction φ	=	35		
Cohesion c	=	0		
Gross bearing capacity	=	40.00	t/m^2	(Normal case)
	=	50.00	t/m^2	(Seismic case)

CREEP COEFFICIENT:

(Table 6.5 of IRC:112)

Pier shaft cross-sectional area	Ac	=	44.635	m^2	
Perimeter in contact with atmosphere , u		=	25.708	m	
Notional size , ho = 2Ac/u		=	3472	mm	
Age of concrete at the time of loading to		=	90	days	
	t_a	=	25550	days	
	f(α 90)	=	1.2	(Table 6.9 IRC 112)	
Hence creep co-efficient for pier shaft		=	1.32	(increased by 10%)	
Creep co-efficient for foundation		=	1.0	(as ho = α for foundation)	
Hence modulus of elasticity for long term loading, Ecm'		=	13793	Mpa	Ecm ' = Ecm / (1 + f)

REINFORCING STEEL:

Grade of reinforcement	fy	=	Fe 500	Mpa
Modulus of elasticity	Es	=	200000	Mpa

3. PERMISSIBLE STRESSES

MAXIMUM PERMISSIBLE STRESS IN CONCRETE:

Rare combination	=	0.48	x fck
	=	16.8	Mpa
Quasi permanent combination	=	0.36	x fck
	=	12.6	Mpa

MAXIMUM PERMISSIBLE STRESS IN STEEL:

Rare Combination		=	300	Mpa
Permissible crack width	$W_{k,max}$	=	0.3	mm

4. SEISMIC PARAMETERS

Seismic zone		=	V
Type of soil		=	Type2(Medium)
Zone factor	Z	=	0.36
Importance factor	I	=	1.20
Response Reduction Factor(Long)	R	=	3
Response Reduction Factor(Trans)	R	=	3

5. ENVIRONMENTAL PARAMETERS

Relative humadity	=	80%
Condition of exposure	=	Moderate

6.OTHER PARAMETERS

Mean velocity of water current flow		=	4.00	m/s
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

7.LOADS FROM SUPERSTRUCTURES

Angle of Skew = **0** ° = **0.000 Radian**

No. of Bearing = 4.00

		Right		Skew	
c/c of bearing in Transverse Direction	=	2.500	m	2.500	m
c/c bearing on Longitudinal Direction	=	1.750	m	1.750	m

Impact Factor for Design of Pier Cap = 1.15

Left Span

	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
	1085.68	200.00								
Total Load	1285.68		274.45	0.000	0.00	0.00	0.00	0.00	0.00	0.00
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	1.210	1.000	1.000	0.300	0.300

p

Right Span

	Dead Load+SIDL(KN)		Surfacing(KN)	FLL(KN)	Live Load (70R + Class A) max	Live Load (70R + Class A) min	Live Load(3L Class A) max	Live Load(3L Class A) min	Live Load(SV Load) max	Live Load(SV Load) min
	DL	SIDL								
	1085.68	200.00								
Total Load	1285.68		274.45	0.00	1056.43	342.17	0.00	0.00	1592.52	1467.48
Resultant Transverse Ecc.	0.000		0.000	0.000	0.950	0.950	1.000	1.000	0.300	0.300

8. VOLUME OF SUBSTRUCTURE

PIER CAP

Uniform portion

No.		L(m)	B(m)	H(m)	V(m^3)	e_{LL}(m)	e_{TT}(m)	e_{VS}(m)	e_{VF}(m)
1	1	9.200	0.000	0.000	0.000	1.750	0.000	45.7945	48.79
2	1	9.200	3.500	0.800	25.760	0.000	0.000	45.3945	48.39
Tapered portion									
2a	Rectangle	3.000	3.500	0.800	8.400	0.000	0.000	44.594	47.594
	Triangle	3.100	3.500	0.800	8.680	0.000	0.000	44.728	47.728
			Total	**Inc. 10%**	**47.124**	**0.000**	**0.000**	**41.002**	**43.730**

PIER SHAFT

Above HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m^3)	e_{LL}(m)	e_{TT}(m)	e_{VS}(m)	e_{VF}(m)
1	1	4.000	2.500	31.000	237.390	0.000	0.000	28.694	31.694
2	0	4.000	0.701	31.000	0.000	-1.734	0.000	23.527	26.527
3	0	4.000	0.701	31.000	0.000	1.734	0.000	23.527	26.527
Cylinder/Conical Frustum portion									
4	0.000	1.951	1.5	31.000	0.000	0.000	0.000	28.694	31.694
			Total		**237.390**	**0.000**	**0.000**	**28.694**	**31.694**

Below HFL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m^3)	e_{LL}(m)	e_{TT}(m)	e_{VS}(m)	e_{VF}(m)
1	1	4.000	2.500	13.194	101.035	0.000	0.000	6.597	9.597
2	0	4.000	0.351	13.194	0.000	-1.930	0.000	6.211	9.211
3	0	4.000	0.351	13.194	0.000	1.930	0.000	6.211	9.211
Cylinder/Conical Frustum portion									
4	0.000	2.500	1.951	13.194	0.000	0.000	0.000	6.597	9.597
			Total		**101.035**	**0.000**	**0.000**	**6.597**	**9.597**

Above LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m^3)	e_{LL}(m)	e_{TT}(m)	e_{VS}(m)	e_{VF}(m)
1	1	4.000	2.500	32.000	245.048	0.000	0.000	28.194	31.194
2	0.0	4.000	0.000	32.000	0.000	-1.250	0.000	22.861	25.861
3	0.0	4.000	0.000	32.000	0.000	1.250	0.000	22.861	25.861
Cylinder/Conical Frustum portion									
4	0.000	1.250	1.250	32.000	0.000	0.000	0.000	29.337	32.337
			Total		**245.048**	**0.000**	**0.000**	**28.194**	**31.194**

Below LBL

Rectangular/Triangular Portion

No.		L/R1(m)	B/R2(m)	H(m)	V(m^3)	e_{LL}(m)	e_{TT}(m)	e_{VS}(m)	e_{VF}(m)
1	1	4.000	2.500	12.194	93.377	0.000	0.000	6.097	9.097
2	0	4.000	0.000	12.194	0.000	-1.583	0.000	4.065	7.065

3	0	4.000	0.000	12.194	0.000	1.583	0.000	4.065	7.065

Cylinder/Conical Frustum portion

4	0.000	2.5	1.250	12.194	0.000	0.000	0.000	4.931	7.931
Total					**93.377**	**0.000**	**0.000**	**6.097**	**9.097**

FOOTING

No.		L	B	H	V(m^3)	e_{LL}(m)	e_{TT}(m)	e_{VS}(m)	e_{VF}(m)
1	1	10.000	5.000	3.00	150.000	0.000	0.000	-1.500	1.500
2	1	10.000	10	2.000	200.000	-6.667	0.000	-1.917	1.083
3	1	10.000	10.000	2.000	200.000	6.667	0.000	-1.917	1.083
Total					**550**	**0.000**	**0.000**	**-1.803**	**1.197**

EARTH ABOVE FOOTING

No.		L	B	H	V(m^3)	e_{LL}(m)	e_{TT}(m)	e_{VS}(m)	e_{VF}(m)
1	1	10.000	25.000	15.194	3798.500	0.000	0.000	4.597	7.597
2	-1	Shaft Below LBL			-93.377	0.000	0.000	6.097	9.097
3	-1	Footing			-550.000	0.000	0.000	-1.803	1.197
Total					**3155.123**	**0.000**	**0.000**	**5.668**	8.668

9. CALCULATION OF SEISMIC FORCE

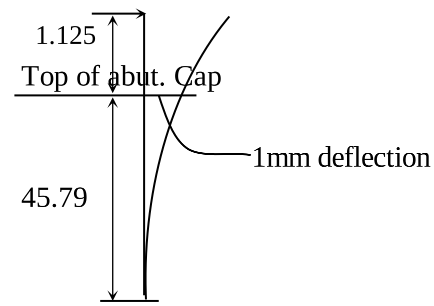
Time Period (T = $2\sqrt{\dfrac{D}{1000\ F}}$

D = Approximate DL of super-structure & LL in Tonne (DL+20% LL)
= 3120.26 KN + 211.29 KN
= 3332 KN

F =

Horizontal force in KN required to be applied at center of mass of super-structure for 1 mm deflection at the top of pier / abutment for the earthquake in the transverse direction;and the force to be applied at the top of the bearings for the earthquake in the longitudinal direction.

F = $\dfrac{6\ E\ I}{x^2 * (3L-x)}$ for 1 mm deflection at x



E = 32000 N/mm^2
Column Cross-Section
D1 = 4.00 m (Average Outer Dia)
D2 = 2.50 m (Average Inner Dia)
I_{TT} = 7.99E+12 mm^4 1E+13
I_{LL} = 7.99E+12 mm^4

Force required in Long. Dir.F_L = 8 KN
Force required in Trans. Dir. F_T = 8 KN

Time Period -Longitudinal Seismic Case = 1.292 seconds
Time Period -Transverse Seismic Case = 1.316 seconds

Sa/g -Longitudinal Seismic Case = 1.053
Sa/g -Transverse Seismic Case = 1.034

Seismic Zone		=	**V**	
Zone Factor	Z	=	0.36	
Importance Factor	I	=	1.20	
Response reduction Factor	R	=	3.00	Longitudinal
	R	=	3.00	Transverse
Avg response acceleration	S_a/g	=	1.053	Longitudinal
Avg response acceleration	S_a/g	=	1.034	Transverse

Elastic Seismic Coefficient	=	Z/2 x (Sa/g) x (I/R)	
In longitudinal direction	=	0.227	/R
In Transverse direction	=	0.223	/R

			Substructure	Foundation
Enhancement factor				1.35
Design Seismic coefficient	Long. Ah		**0.076**	**0.102**
	Trans. At		**0.074**	**0.100**
	Vert. Av		**0.051**	**0.068**

CALCULATION OF SEISMIC FORCES

SEISMIC COMPONENT OF SUPER-STRUCTURE DL, SIDL, WC & FPLL :

Loads & Their Lever arm

Description	LEFT			RIGHT		
	W	eVS	eVF	W	eVS	eVF
	Tonnes	(m)	(m)		(m)	(m)
Total Super-Structure DL	217.14	47.18	50.18	217.14	47.18	50.18
Total Super-Structure SIDL	40.00	48.12	51.12	40.00	48.12	51.12
Total Super-Structure WC	54.89	47.75	50.75	54.89	47.75	50.75
Total Super-Structure FPLL	0.00	47.75	50.75	0.00	47.75	50.75
Total	312.03	47.40	50.40	312.03	41.23	43.84
* Bearing level		46.09	49.09		46.09	49.09

SEISMIC COMPONENT OF SUB-STRUCTURE :

Description	W	eVS	eVF
	Tonnes	(m)	(m)
Total weight of shaft and pier cap	963.87	24.41	27.37
Total weight of foundation	1375.00	-1.80	1.20

SEISMIC COMPONENT OF LIVE LOAD(70R+Class A) :

Description	W	W	**eVS**	**eVF**
	Tonnes	Tonnes	(m)	(m)
	70R + Class A	70R + Class A		
Maximum Live Load	105.64	0.00	48.92	51.917
Minimum Live Load	34.22	0.00	48.92	51.917

Summary of Seismic force at shaft and foundation

Super structure

Dead load - Super structure about shaft	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		23.65		1090.076	
Seismic Transverse direction			23.22		1029.16

Seismic Vertical Direction	15.77				

Dead load - Super structure about foundation	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		31.93		1567.38	
Seismic Transverse direction			31.353		1477.40
Seismic Vertical Direction	21.28				

Dead load Left span Dislodged- about foundation	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		15.96		783.690	
Seismic Transverse direction			15.68		687.34
Seismic Vertical Direction	10.64				

Sub structure

Dead load - Sub structure about Shaft	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		73.05		1783.07	
Seismic Transverse direction			71.74		1751.09
Seismic Vertical Direction	48.70				

Dead load - Sub structure about foundation	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction		98.6213		2699.72	
Seismic Transverse direction			96.85		2651.30
Seismic Vertical Direction	65.75				

Live Load - Max

70R + Class A

Live load - Max about shaft	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.57		76.93
Seismic Vertical Direction	1.07				

Live load - Max about foundation	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.12		110.22
Seismic Vertical Direction	1.44				

70R

Live load - Max about shaft	V	H L	H T	M TT	M LL
	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			1.57		76.93
Seismic Vertical Direction	1.07				

Live load - Max	V	H L	H T	M TT	M LL

about foundation	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			2.12		110.22
Seismic Vertical Direction	1.44				

Live Load - Min

70R + Class A

Live load - Min	V	H L	H T	M TT	M LL
about shaft	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.51		24.92
Seismic Vertical Direction	0.35				

Live load - Min	V	H L	H T	M TT	M LL
about foundation	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.69		35.70
Seismic Vertical Direction	0.47				

70R

Live load - Min	V	H L	H T	M TT	M LL
about shaft	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.51		24.92
Seismic Vertical Direction	0.35				

Live load - Min	V	H L	H T	M TT	M LL
about foundation	Tonnes	Tonnes	Tonnes	Tonne meter	Tonne meter
Seismic longitudinal direction	Not to be considered - IRC:6 219.5.2				
Seismic Transverse direction			0.69		35.70
Seismic Vertical Direction	0.47				

10. HORIZONTAL FORCES

Consider Left span free and Right Span fix on pier

BOTH SPAN POSITION CONDITION(70R + Class A)

1. Normal Max Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

		Class 70R on First two Lane				Class A on third Lane		
Beaking Force	=	0.2	x	100	+	0.05	x	54
	+	0.1	x	0	+	0.05	x	0
Fh	=	22.7 Ton						

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	34.22)
	=	9.51	Ton					

Max of **(Fh/2 + μ (Rg + Rq)** **and** **Fh - μ (Rg + Rq)** **)**

	=	20.86	Ton
Fhr	=	20.86	Ton

Horizontal force	=	Fhr	-	Fhl
	=	20.86	-	7.80
	=	13.06 Ton		

2. Normal Min Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

		Class 70R on First two Lane				Class A on third Lane		
Beaking Force	=	0.2	x	100	+	0.05	x	54
Fh	=	22.7 Ton						

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	105.64)
	=	13.08	Ton					

Max of **(Fh/2 + μ (Rg + Rq)** **and** **Fh - μ (Rg + Rq)** **)**

	=	24.43	Ton
Fhr	=	24.43	Ton

Horizontal force	=	Fhr	-	Fhl
	=	24.43	-	7.80
	=	16.63 Ton		

3. Seismic Max Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

		Class 70R on First two Lane				Class A on third Lane		
Beaking Force	=	0.2	x	20	+	0.05	x	10.8

Fh = 4.54 Ton

Seismic Horizontal force(Shaft)	=	11.824	Ton
Seismic Horizontal force(foundation)	=	15.963	Ton
Total Horizontal force for Shaft(Fh)	=	16.364	Ton
Total Horizontal force for foundation(Fh)	=	20.503	Ton

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	6.84)
	=	8.14282	Ton					

Max of (Fh/2 + μ (Rg + Rq) and Fh - μ (Rg + Rq))

Fhr for shaft	=	18.60	Ton
Fhr for foundation	=	20.66	Ton

Horizontal force for shaft	=	Fhr	-	Fhl
	=	18.60	-	7.80
	=	10.79 Ton		
Horizontal force for foundation	=	Fhr	-	Fhl
	=	20.66	-	7.80
	=	12.86 Ton		

4. Seismic Min Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

		Class 70R on First two Lane				Class A on third Lane		
Beaking Force	=	0.2	x	20	+	0.05	x	10.8

Fh = 4.54 Ton

Seismic Horizontal force(Shaft)	=	11.824	Ton	(Including safty factor 1.5)
Seismic Horizontal force(foundation)	=	15.963	Ton	(Including safty factor 1.5 and 35

Total Horizontal force for Shaft(Fh)	=	16.364	Ton		% inc.)		
Total Horizontal force for foundation(Fh)	=	20.503	Ton				

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	21.13)
	=	8.85708	Ton					

Max of (Fh/2 + μ (Rg + Rq) and Fh - μ (Rg + Rq))

Fhr for shaft	=	19.31	Ton
Fhr for foundation	=	21.38	Ton

Horizontal force for shaft	=	Fhr	-	Fhl
	=	19.31	-	7.80
	=	11.51 Ton		
Horizontal force for foundation	=	Fhr	-	Fhl
	=	21.38	-	7.80
	=	13.58 Ton		

BOTH SPAN POSITION CONDITION(70R)

5. Normal Max Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

		Class 70R on First two Lane				Class A on third Lane		
Beaking Force	=	0.2	x	100	+	0.05	x	0.00)

Fh = 20 Ton

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	34.22)
	=	9.51	Ton					

Max of (Fh/2 + μ (Rg + Rq) and Fh - μ (Rg + Rq))

	=	19.51	Ton
Fhr	=	19.51	Ton

Horizontal force	=	Fhr	-	Fhl
	=	19.51	-	7.80
	=	11.71 Ton		

6. Normal Min Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					

Fhl = 7.80 Ton

Right Span

		Class 70R on First two Lane				Class A on third Lane	
Beaking Force	=	0.2	x	100	+	0.05	x	0

Fh = 20 Ton

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	105.64)
		=	13.08	Ton				

Max of (**Fh/2 + μ (Rg + Rq)** **and** **Fh - μ (Rg + Rq)**)

= 23.08 Ton

Fhr = 23.08 Ton

Horizontal force = Fhr - Fhl

= 23.08 - 7.80

= 15.28 Ton

7. Seismic Max Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
		=	7.80	Ton				

Fhl = 7.80 Ton

Right Span

		Class 70R on First two Lane				Class A on third Lane		
Beaking Force	=	0.2	x	20	+	0.05	x	0

Fh = 4 Ton

Seismic Horizontal force(Shaft)	=	11.824	Ton
Seismic Horizontal force(foundation)	=	15.963	Ton
Total Horizontal force for Shaft(Fh)	=	15.824	Ton
Total Horizontal force for foundation(Fh)	=	19.963	Ton

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	6.84)
		=	8.14282	Ton				

Max of (**Fh/2 + μ (Rg + Rq)** **and** **Fh - μ (Rg + Rq)**)

Fhr for shaft = 18.06 Ton

Fhr for foundation = 20.12 Ton

Horizontal force for shaft = Fhr - Fhl

= 18.06 - 7.80

= 10.25 Ton

Horizontal force for foundation = Fhr - Fhl

= 20.12 - 7.80

= 12.32 Ton

8. Seismic Min Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

		Class 70R on First two Lane				Class A on third Lane		
Beaking Force	=	0.2	x	20	+	0.05	x	0

Fh = 4 Ton

Seismic Horizontal force(Shaft)	=	11.824	Ton	(Including safty factor 1.5)
Seismic Horizontal force(foundation)	=	15.963	Ton	(Including safty factor 1.5 and 35 % inc.)
Total Horizontal force for Shaft(Fh)	=	15.824	Ton	
Total Horizontal force for foundation(Fh)	=	19.963	Ton	

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	21.13)
	=	8.85708	Ton					

Max of (Fh/2 + μ (Rg + Rq) and Fh - μ (Rg + Rq))

Fhr for shaft	=	18.77	Ton
Fhr for foundation	=	20.84	Ton

Horizontal force for shaft	=	Fhr	-	Fhl
	=	18.77	-	7.80
	=	10.97 Ton		
Horizontal force for foundation	=	Fhr	-	Fhl
	=	20.84	-	7.80
	=	13.04 Ton		

BOTH SPAN POSITION CONDITION(Special Vehicle)

9. Normal Max Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	146.75)
	=	15.14	Ton					
Fhr	=	15.14	Ton					

Horizontal force	=	Fhr	-	Fhl
	=	15.14	-	7.80
	=	7.34 Ton		

10. Normal Min Reaction on Fix End

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	159.25)
	=	15.76	Ton					
Fhr	=	15.76	Ton					

Horizontal force	=	Fhr	-	Fhl
	=	15.76	-	7.80
	=	7.96	Ton	

BOTH SPAN POSITION CONDITION(NO LIVE LOAD)

11. Normal No Reaction

Left Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhl	=	7.80	Ton					

Right Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80	Ton					
Fhr	=	7.80	Ton					

Horizontal force	=	Fhr	-	Fhl
	=	7.80	-	7.80
	=	0.00	Ton	

ONE SPAN DISLOGED CONDITION

12. Normal Span Dislodge Condition

Consider left Span dislodge

Left Span

Fhl = 0 Ton

Right Span

				Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x (	108.568	+	47.45	+	0.00)
	=	7.80065	Ton					
Fhr	=	7.80065	Ton					

Horizontal force	=	Fhr	-	Fhl
	=	7.80065	-	0.000
	=	7.80065 Ton		

13. Seismic Span Dislodge Condition

Consider left Span dislodge

Left Span

Fhl = 0 Ton

Right Span

		Class 70R on First two Lane				Class A on third Lane		
Beaking Force	=	0.2	x	0	+	0.05	x	0

Fh = 0 Ton

Seismic Horizontal force(Shaft)	=	11.824	Ton	(Including safty factor 1.5)
Seismic Horizontal force(foundation)	=	15.963	Ton	(Including safty factor 1.5 and 35 % inc.)
Total Horizontal force for Shaft(Fh)	=	11.824	Ton	
Total Horizontal force for foundation(Fh)	=	15.963	Ton	

					Total DL		Total SIDL load		CWLL
μ (Rg + Rq)	=	0.05	x	(	108.568	+	47.45	+	0.00)
		=	7.80065	Ton					

Max of (Fh/2 + μ (Rg + Rq) and Fh - μ (Rg + Rq))

Fhr for shaft	=	13.71	Ton	
Fhr for foundation	=	15.78	Ton	

Horizontal force for shaft	=	Fhr	-	Fhl
	=	13.71	-	0.00
	=	13.71 Ton		
Horizontal force for foundation	=	Fhr	-	Fhl
	=	15.78	-	0.00
	=	15.78 Ton		

Summary of forces

Cases		Horizontal force(Ton)	
		Shaft	Foundation
BOTH SPAN POSITION CONDITION(70R + Class A)			
	1. Normal Max Reaction on Fix End	13.06	13.06
	2. Normal Min Reaction on Fix End	16.63	16.63
	3. Seismic Max Reaction on Fix End	10.79	12.86
	4. Seismic Min Reaction on Fix End	11.51	13.58
BOTH SPAN POSITION CONDITION(70R)			
	5. Normal Max Reaction on Fix End	11.71	11.71
	6. Normal Min Reaction on Fix End	15.28	15.28
	7. Seismic Max Reaction on Fix End	10.25	12.32
	8. Seismic Min Reaction on Fix End	10.97	13.04
BOTH SPAN POSITION CONDITION(Special Vehicle)			
	9. Normal Max Reaction on Fix End	7.34	7.34
	10. Normal Min Reaction on Fix End	7.96	7.96
BOTH SPAN POSITION CONDITION(NO LIVE LOAD)			
	11. Normal No Reaction	0.00	0.00
ONE SPAN DISLOGED CONDITION			
	12. Normal Span Dislodge Condition	7.80	7.80
	13. Seismic Span Dislodge Condition	13.71	15.78

11.A CALCULATION OF CENTRIFUGAL FORCE

As per clause 212 of IRC:6-2014

$$c = \frac{WV^2}{127R}$$

70R + Class A

Maxium Reaction				
Live Load	W	=	105.64	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

C = 0.00 t

C (t)	e_{VS}(m)	e_{VF}(m)
0.00	48.92	51.92

Minimum Reaction				
Live Load	W	=	0.00	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

C = 0.00 t

C (t)	e_{VS}(m)	e_{VF}(m)
0	48.92	51.92

70R

Maxium Reaction				
Live Load	W	=	105.64	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

C = 0 KN

C (t)	e_{VS}(m)	e_{VF}(m)
0	48.92	51.92

Minimum Reaction				
Live Load	W	=	34.22	t
Design Speed	V	=	40	Kmph
Radius of Curvature	R	=	0	m

C = 0 KN

C (t)	e_{VS}(m)	e_{VF}(m)
0	48.92	51.92

Special Vehicle

Maxium Reaction				
Live Load	W	=	159.25	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	0	m

C = 0 KN

C (t)	e_{VS}(m)	e_{VF}(m)
0	48.92	51.92

Minimum Reaction				
Live Load	W	=	146.75	t
Design Speed	V	=	5	Kmph
Radius of Curvature	R	=	0	m

C = 0 KN

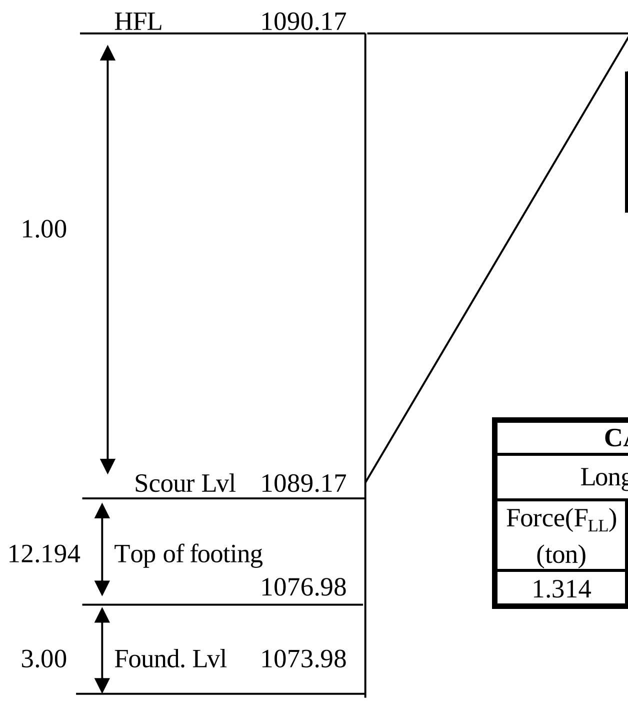
C (t)	e_{VS}(m)	e_{VF}(m)
0	48.92	51.92

12. WATER CURRENT FORCES

NORMAL CASE

Water current forces

HFL		=	1090.174	m
MSL (NORMAL)		=	1089.174	m
Water current pressure	P	=	52 KV^2	Kg/m^2
For piers with square ends	K	=	1.5	
For piers with semicircular ends	K	=	0.66	
Mean velocity of water current	V_{mean}	=	4.00	m/s
Max. velocity of water current	V	=	$\sqrt{2}$ x 4.00	
		=	5.66	m/s
Angle of variation		=	20	degree
Water current pressure at HFL (Trans direction)		=	0.97	t/m^2 52 K $(vcosq)^2$
Water current pressure at HFL (Long direction)		=	0.29	t/m^2 53 K $(vsinq)^2$

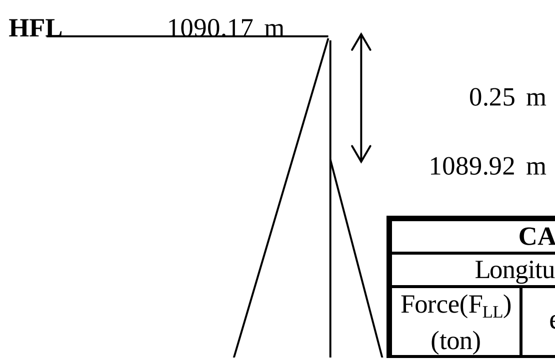


Size of structure			
Pier shaft		Footing	
Length	Width	Length	Width
9.00	4.00	10.00	25.00

CALCULATION OF WATER CURRENT FORCES					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	e_{VS}(m)	e_{VF}(m)	Force(F_{TT}) (ton)	e_{VS}(m)	e_{VF}(m)
1.314	12.861	15.861	1.940	12.861	15.861

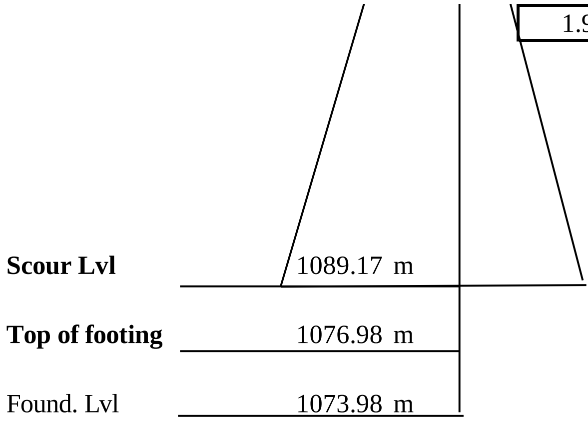
Pressure diagram (Normal case)

Static Force



CALCULATION OF HYDROSTATIC FORCES					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	e_{VS}(m)	e_{VF}(m)	Force(F_{TT}) (ton)	e_{VS}(m)	e_{VF}(m)

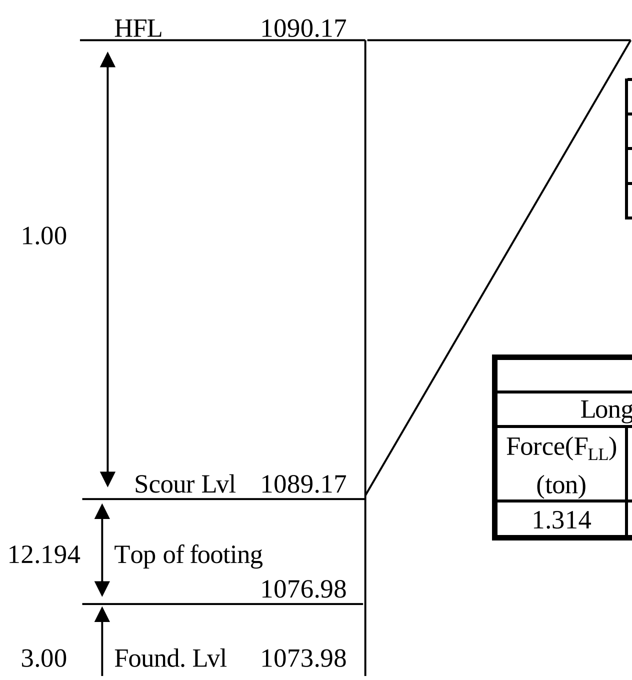
1.97	12.63	15.63	0.88	12.63	15.63



Governing					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	e_{VS}(m)	e_{VF}(m)	Force(F_{TT}) (ton)	e_{VS}(m)	e_{VF}(m)
1.969	12.634	15.634	1.940	12.861	15.861

SEISMIC CASE

HFL			=	1090.174 m	
MSL (SEISMIC)			=	1089.17 m	
Water current pressure		P	=	52 KV^2 Kg/m^2	
For piers with square ends		K	=	1.5	
For piers with semicircular ends		K	=	0.66	
Mean velocity of water current		V_{mean}	=	4.00 m/s	
Max. velocity of water current		V	=	$\sqrt{2}$ x 4.00	
			=	5.66 m/s	
Angle of variation			=	20 degree	
Water current pressure at HFL	(Trans direction)		=	0.97 t/m^2	52 K $(vcosq)^2$
Water current pressure at HFL	(Long direction)		=	0.29 t/m^2	53 K $(vsinq)^2$

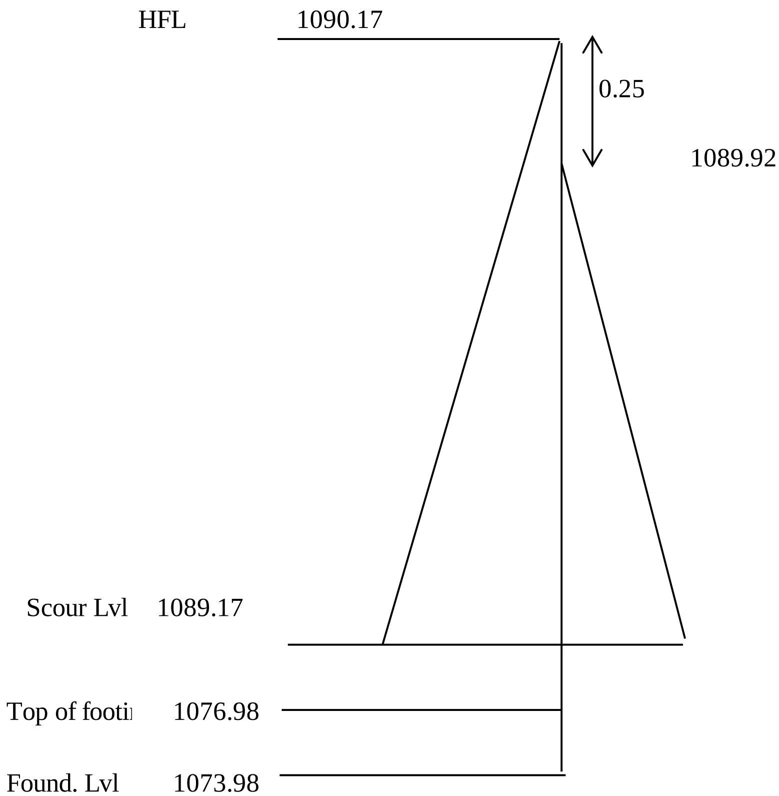


Size of structure			
Pier shaft		Footing	
Length	Width	Length	Width
9.00	4.00	10.00	25.00

CALCULATION OF WATER CURRENT					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	e_{VS}(m)	e_{VF}(m)	Force(F_{TT}) (ton)	e_{VS}(m)	e_{VF}(m)
1.314	12.861	15.861	1.940	12.861	15.861

Pressure diagram (seismic case)

Static Force



CALCULATION OF HYDROSTATIC FORCES					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	e_{VS}(m)	e_{VF}(m)	Force(F_{TT}) (ton)	e_{VS}(m)	e_{VF}(m)
1.97	12.63	15.63	0.88	12.63	15.63

Governing					
Longitudinal direction			Transverse direction		
Force(F_{LL}) (ton)	e_{VS}(m)	e_{VF}(m)	Force(F_{TT}) (ton)	e_{VS}(m)	e_{VF}(m)
1.969	12.634	15.634	1.940	12.861	15.861

13. LOAD COMBINATION DEFINATION

PIER SHAFT DESIGN

ULS

LC -1 ULS NORMAL LWL MAX REACTION
LC -2 ULS NORMAL LWL SPAN DISLOGED

LC - 5 ULS MAX REACTION 1X + 0.3Y + 0.3Z
LC - 6 ULS MAX REACTION 0.3X +1Y + 0.3Z

LC - 9 ULS NORMAL SV MAX REACTION

SLS

LC -1 RARE NORMAL MAX REACTION
LC -2 RARE NORMAL SPAN DISLOGED

LC -5 QP NORMAL

LC -7 QP NORMAL SPAN DISLOGED

LC -9 RARE NORMAL SV MAX REACTION

Footing design

LC - 1 ULS NORMAL MAX REACTION(70R +Class A)
LC - 2 ULS NORMAL SPAN DISLOGED

LC - 5 ULS NORMAL MAX REACTION(70R)

LC - 7 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)
LC - 8 ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z
LC - 9 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)
LC - 10 ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z

LC - 15 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)
LC - 16 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)

LC - 19 ULS NORMAL LWL SV MAX REACTION

BASE PRESSRE

LC - 1 NORMAL MAX REACTION(70R+Class A)
LC - 2 NORMAL SPAN DISLOGED

LC - 5 0
LC - 6 SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z
LC - 7 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R + class A)
LC - 8 SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z

LC - 13 SEISMIC NORMAL MAX REACTION(70R)

LC - 15 SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)
LC - 16 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)

LC - 13 NORMAL LWL SV MAX REACTION

14.A DESIGN FORCES FOR PIER SHAFT(ULS CASES)

LC -1 ULS NORMAL LWL MAX REACTION

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.497	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	1.5	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.497	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	1.5	
9	LL (70R)			105.643		0.875	0.950		92.438	100.361	1.5	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			48.917	0.0	0.000	1.5	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F_{LL})				13.061			46.094	602.033		1.5	
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
1902.88	**1027.84**	**135.49**

LC -2 ULS NORMAL LWL SPAN DISLOGED

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	1.5	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.497	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			48.917	0.000	0.000	1.5	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1.35	
17	Horizontal Force(F_{LL})				7.801			46.094	359.567		1.5	
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
1522.82	**733.25**	**0.00**

LC - 5 ULS MAX REACTION 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.88	0.000		-112.497	0.000	1.35	

2	Surfacing			27.445		-0.88	0.000		-24.014	0.000	1.75	1
3	FLL			0.000		-0.88	0.000		0.000	0.000	0.2	1
4	LL (70R)			0.000		-0.88	0.950		0.000	0.000	0.2	1
5	LL (Class-A)			0.000		-0.88	1.000		0.000	0.000	0.2	1
	Right Span											1
6	DL (superstructure)			128.568		0.88	0.000		112.497	0.000	1.35	1
7	Surfacing			27.445		0.88	0.000		24.014	0.000	1.75	1
8	FLL			0.000		0.88	0.000		0.000	0.000	0.2	1
9	LL (70R)			105.643		0.88	0.950		92.438	100.4	0.2	1
10	LL (Class-A)			0.000		0.88	1.000		0.000	0.0	0.2	1
												1
11	Centifugal force				0.000			48.917	0.0	0.0	0.2	1
12	Pier cap	47.12	2.50	117.81		0.00	0.000		0.000	0.000	1.35	1
13	Pier (above LBL)	245.05	2.50	612.62		0.00	0.000		0.000	0.000	1.35	1
14	Pier (below LBL)	93.38	2.50	233.44		0.00	0.000		0.000	0.000	1.35	1
17	Horizontal Force(F_{LL})				10.794			46.094	497.560		1.000	1
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1.000	1
18	**Seismic**											1
	Super structure											1
	Longitudinal				23.649				1090.08		1.5	1
	Transverse				23.225					1029.1626	0.45	1
	Vertical			15.766							0.45	1
	Sub structure											1
	Longitudinal				73.053				1783.07		1.5	1
	Transverse				71.743					1751.09	0.45	1
	Vertical			48.702							0.45	1
a)	**Max Live Load**											1
	Longitudinal										1.5	1
	Transverse				1.573					76.928633	0.45	1
	Vertical			1.068							0.45	1

SUMMARY OF FACTORED FORCES		
V(ton)	**MTT (tm)**	**MLL(tm)**
1795.039	**4825.77**	**1305.80**

LC - 6 ULS MAX REACTION 0.3X +1Y + 0.3Z

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.88	0.00		-112.50	0.00	1.35	1
2	Surfacing			27.445		-0.88	0.00		-24.01	0.00	1.75	1
3	FLL			0.000		-0.88	0.00		0.00	0.00	0.2	1
4	LL (70R)			0.000		-0.88	0.95		0.00	0.00	0.2	1
5	LL (Class-A)			0.000		-0.88	1.00		0.00	0.00	0.2	1
	Right Span											1
6	DL (superstructure)			128.568		0.88	0.00		112.50	0.00	1.35	1
7	Surfacing			27.445		0.88	0.00		24.01	0.00	1.75	1
8	FLL			0.000		0.88	0.00		0.00	0.00	0.2	1
9	LL (70R)			105.643		0.88	0.95		92.44	100.36	0.2	1
10	LL (Class-A)			0.000		0.88	1.00		0.00	0.00	0.2	1
												1
11	Centifugal force				0.000			48.917	0.0	0.000	0.2	1
12	Pier cap	47.124	2.500	117.810		0.000	0.000		0.000	0.000	1.35	1
13	Pier (above LBL)	245.048	2.500	612.620		0.000	0.000		0.000	0.000	1.35	1
14	Pier (below LBL)	93.377	2.500	233.443		0.000	0.000		0.000	0.000	1.35	1
17	Horizontal Force(F_{LL})				10.794			46.094	497.560		1.000	1
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1.000	1
18	**Seismic**											1
	Super structure											1
	Longitudinal				23.649				1090.08		0.45	1
	Transverse				23.225					1029.163	1.5	1
	Vertical			15.766							0.45	1
	Sub structure											1
	Longitudinal				73.053				1783.07		0.45	1
	Transverse				71.743					1751.090	1.5	1
	Vertical			48.702							0.45	1
a)	**Max Live Load**											1
	Longitudinal										0.45	1
	Transverse				1.573					76.929	1.5	1

	Vertical			1.068							0.45	1

SUMMARY OF FACTORED FORCES		
V(ton)	**MTT (tm)**	**MLL(tm)**
1795.039	**1808.96**	**4305.84**

LC - 9 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.497	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.875	0.300		0.000	0.000	1	1
	Right Span											
5	DL (superstructure)			128.568		0.875	0.000		112.497	0.000	1.35	
6	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
7	FLL			0.000		0.875	0.000		0.000	0.000	1.5	
8	LL			159.252		0.875	0.300		139.346	47.776	1	1
9	Centifugal force				0.000			48.917	0.000		1	
10	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1.35	
15	Horizontal Force(F_{LL})				7.337			46.094	338.214		1.5	
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1.5	

SUMMARY OF FACTORED FORCES

V(ton)	**M_{TT} (tm)**	**M_{LL}(tm)**
1903.67	**646.67**	**47.78**

14.B DESIGN FORCES FOR PIER SHAFT(SLS CASES)

LC -1 RARE NORMAL MAX REACTION

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.497	0.000	1	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.2	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	1	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.497	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.2	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			105.643		0.875	0.950		92.438	100.361	1	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	1	0.9
11	Centifugal force				0.000			48.917	0.000	0.000	1	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F_{LL})				0.000			12.634	0.000		1	
	Water Current Force(F_{TT})				0.000			12.861		0.000	1	
17	Horizontal Force(F_{LL})				13.061			46.094	602.033		1	
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
1392.52	**685.23**	**90.32**

LC-2 RARE NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	1	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.497	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.2	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	1	0.9
11	Centifugal force(F_{LL})				0.000			48.917	0.000	0.000	1	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F_{LL})				0.000			12.634	0.000		1	
	Water Current Force(F_{TT})				0.000			12.861		0.000	1	
17	Horizontal Force(F_{LL})				7.801			46.094	359.567		1	
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
1125.38	**500.88**	**0.00**

LC -5 QP NORMAL

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.497	0.000	1	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.2	
3	FLL			0.000		-0.875	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.497	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.2	
8	FLL			0.000		0.875	0.000		0.000	0.000	0	
9	LL (70R)			105.643		0.875	0.950		92.438	100.361	0	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			48.917	0.000	0.000	1	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F_{LL})				0.000			12.634	0.000		0	
	Water Current Force(F_{TT})				0.000			12.861		0.000	0	
17	Horizontal Force(F_{LL})				0.000			46.094	0.000		0	
	Horizontal Force(F_{TT})				0.000			46.094		0.000	0	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
1286.88	**0.00**	**0.00**

LC -7 QP NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1.2	
3	FLL			0.000		-0.875	0.000		0.000	0.000	0	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.497	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.2	
8	FLL			0.000		0.875	0.000		0.000	0.000	0	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	0	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			48.917	0.000	0.000	1	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0	
16	Water Current Force(F_{LL})				0.000			12.634	0.000		0	
	Water Current Force(F_{TT})				0.000			12.861		0.000	0	
17	Horizontal Force(F_{LL})				7.801			46.094	359.567		1	
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
1125.38	**500.88**	**0.00**

LC -9 RARE NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.497	0.000	1	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.2	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL			0.000		-0.875	0.300		0.000	0.000	1	1
	Right Span											
5	DL (superstructure)			128.568		0.875	0.000		112.497	0.000	1	
6	Surfacing			27.445		0.875	0.000		24.014	0.000	1.2	
7	FLL			0.000		0.875	0.000		0.000	0.000	1	
8	LL			159.252		0.875	0.300		139.346	47.776	1	1
9	Centifugal force				0.000			48.917	0.000		1	
10	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F_{LL})				0.000			12.634	0.000		1	
	Water Current Force(F_{TT})				0.000			12.861		0.000	1	
15	Horizontal Force(F_{LL})				7.337			46.094	338.214		1	
	Horizontal Force(F_{TT})				0.000			46.094		0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
1446.13	**477.56**	**47.78**

15. DESIGN FORCES FOR FOUNDATION

LC -1 ULS NORMAL MAX REACTION(70R +Class A)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors (Design)	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	1.5	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	1.5	
9	LL (70R)			105.643		0.875	0.950		92.4376	100.361	1.5	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			51.917	0.0	0.000	1.5	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				13.061			49.094	641.22		1.5	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1.5	
18	Footing	550.00	2.5	1375.000		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	3155.12	2	6310.246		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
12262.12	**1086.61**	**135.49**

LC -2 ULS NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors (Design)	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	1.5	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	1.5	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	1.5	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	1.5	0.9
11	Centifugal force				0.000			51.917	0.000	0.000	1.5	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				7.801			49.094	382.969		1.5	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1.5	
18	Footing	550.00	2.5	1375.000		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	3155.12	2	6310.246		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
11897.91	**768.35**	**0.00**

LC -5 ULS NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors (Design)	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1.5	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1.5	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	1.5	
9	LL (70R)			105.643		0.875	0.950		92.4376	100.361	1.5	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			51.917	0.0	0.000	1.5	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				11.711			49.094	574.94		1.5	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1.5	
18	Footing	550.00	2.5	1375.000		0.000	0.000		0.000	0.000	1.35	
19	Earth Over Footing	3155.12	2	6310.246		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
3743.288	**987.20**	**135.49**

LC - 7 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0.2	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	0.2	
9	LL (70R)			105.643		0.875	0.950		92.438	100.361	0.2	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0.2	
11	Centifugal force				0.000			51.917	0.0	0.000	0.2	
12	Pier cap	47.124	2.500	117.810		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	245.048	2.500	612.620		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	93.377	2.500	233.443		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				12.864			49.094	631.53		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.00	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1.35	

20	**Seismic**											
	Super structure											
	Longitudinal				31.926				1567.4		1.5	
	Transverse				31.353					1477.4	0.45	
	Vertical			21.284							0.45	
	Sub structure											
	Longitudinal				98.621				2699.7		1.5	
	Transverse				96.853					2651.3008	0.45	
	Vertical			65.75							0.45	
a)	**Max Live Load**											
	Longitudinal										1.5	
	Transverse				2.123					110.22283	0.45	
	Vertical			1.441							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	**MTT (tm)**	**MLL(tm)**
12180.506	**7050.67**	**1932.41**

LC - 8 ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	
11	Centifugal force				0.000			51.917	0.00	0.000	0.2	
12	Pier cap	47.12	2.50	117.81		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	245.05	2.50	612.62		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	93.38	2.50	233.44		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.00		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				15.782			49.094	774.81		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1.35	
20	**Seismic**											
	Super structure											
	Longitudinal				15.963				783.69		1.5	
	Transverse				15.677					687.33636	0.45	
	Vertical			10.642							0.45	
	Sub structure											
	Longitudinal				98.621				2699.7		1.5	
	Transverse				96.853					2651.3008	0.45	
	Vertical			65.748							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	**MTT (tm)**	**MLL(tm)**
11932.281	**6041.95**	**1502.39**

LC - 9 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	

3	FLL			0.000		-0.875	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0.2	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	0.2	
9	LL (70R)			105.643		0.875	0.950		92.4376	100.361	0.2	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0.2	
11	Centifugal force				0.000			51.917	0.0	0.000	0.2	
12	Pier cap	47.12	2.50	117.81		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	245.05	2.50	612.62		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	93.38	2.50	233.44		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.00		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				12.864			49.094	631.53		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1.35	
20	**Seismic**											
	Super structure											
	Longitudinal				31.926				1567.4		0.45	
	Transverse				31.353					1477.400	1.5	
	Vertical			21.284							0.45	
	Sub structure											
	Longitudinal				98.621				2699.7		0.45	
	Transverse				96.853					2651.301	1.5	
	Vertical			65.748							0.45	
a)	**Max Live Load**											
	Longitudinal										0.45	
	Transverse				2.123					110.223	1.5	
	Vertical			1.441							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	**MTT (tm)**	**MLL(tm)**
12180.506	**2570.22**	**6432.01**

LC - 10 ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1.35	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	0.2	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	
11	Centifugal force				0.000			51.917	0.00	0.000	0.2	
12	Pier cap	47.12	2.50	117.81		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	245.05	2.50	612.62		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	93.38	2.50	233.44		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.00		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				15.782			49.094	774.81		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1.35	
20	**Seismic**											
	Super structure											

	Longitudinal				15.963				783.69		0.45	
	Transverse				15.677					687.33636	1.5	
	Vertical			10.642							0.45	
	Sub structure											
	Longitudinal				98.621				2699.7		0.45	
	Transverse				96.853					2651.3008	1.5	
	Vertical			65.748							0.45	

SUMMARY OF FACTORED FORCES		
V(ton)	**MTT (tm)**	**MLL(tm)**
11932.281	**2384.37**	**5007.96**

LC -15 ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	0.2	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	0.2	
9	LL (70R)			105.643		0.875	0.950		92.438	100.361	0.2	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	
11	Centifugal force				0.000			51.917	0.0	0.000	0.2	
12	Pier cap	47.124	2.500	117.810		0.000	0.000		0.000	0.000	1.35	
13	Pier (above LBL)	245.048	2.500	612.620		0.000	0.000		0.000	0.000	1.35	
14	Pier (below LBL)	93.377	2.500	233.443		0.000	0.000		0.000	0.000	1.35	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				12.324			49.094	605.02		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.00	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1.35	
20	**Seismic**											
	Super structure											
	Longitudinal				31.926				1567.4		1.5	
	Transverse				31.353					1477.4	0.45	
	Vertical			21.284							0.45	
	Sub structure											
	Longitudinal				98.621				2699.7		1.5	
	Transverse				96.853					2651.3008	0.45	
	Vertical			65.75							0.45	
a)	**Max Live Load**											
	Longitudinal										1.5	
	Transverse				2.123					110.22	0.45	
	Vertical			1.441							0.45	
b)	**Min Live Load**											
	Longitudinal										1.5	1
	Transverse				0.688					35.700373	0.45	0.3
	Vertical			0.467							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	**MTT (tm)**	**MLL(tm)**
12180.506	**7024.16**	**1932.41**

LC -16 ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VS}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	0.2	

4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
8	FLL			0.000		0.875	0.000		0.000	0.000	0.2	
9	LL (70R)			105.643		0.875	0.950		92.4376	100.361	0.2	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	
11	Centifugal force				0.000			51.917	0.0	0.000	0.2	
12	Pier cap	47.12	2.50	117.81		0.00	0.00		0.00	0.00	1.35	
13	Pier (above LBL)	245.05	2.50	612.62		0.00	0.00		0.00	0.00	1.35	
14	Pier (below LBL)	93.38	2.50	233.44		0.00	0.00		0.00	0.00	1.35	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	0.15	
16	Water Current Force(F_{LL})				0.000			15.634	0.00		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				12.324			49.094	605.02		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1.35	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1.35	
20	**Seismic**											
	Super structure											
	Longitudinal				31.926				1567.4		0.45	
	Transverse				31.353					1477.400	1.5	
	Vertical			21.284							0.45	
	Sub structure											
	Longitudinal				98.621				2699.7		0.45	
	Transverse				96.853					2651.301	1.5	
	Vertical			65.748							0.45	
a)	**Max Live Load**											
	Longitudinal										0.45	
	Transverse				2.123					110.223	1.5	
	Vertical			1.441							0.45	
b)	**Min Live Load**											
	Longitudinal										0.45	0.3
	Transverse				0.688					35.700373	1.5	1
	Vertical			0.467							0.45	0.3

SUMMARY OF FACTORED FORCES

V(ton)	MTT (tm)	MLL(tm)
12180.506	**2543.70**	**6432.01**

LC - 19 ULS NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors (Design)	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1.35	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1.75	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1.5	
4	LL			0.000		-0.875	0.300		0.000	0.000	1	1
	Right Span											
5	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1.35	
6	Surfacing			27.445		0.875	0.000		24.014	0.000	1.75	
7	FLL			0.000		0.875	0.000		0.000	0.000	1.5	
8	LL			159.252		0.875	0.300		139.346	47.776	1	1
9	Centifugal force				0.000			51.917	0.0	0.000	1	
10	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1.35	
11	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1.35	
12	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1.35	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	0.15	
14	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
15	Horizontal Force(F_{LL})				7.337			49.094	360.23		1.5	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1.5	
16	Footing	550.00	2.5	1375.000		0.000	0.000		0.000	0.000	1.35	
17	Earth Over Footing	3155.12	2	6310.246		0.00	0		0.000	0.000	1.35	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
12278.75	**679.68**	**47.78**

16. DESIGN FORCES FOR BASE PRESSURE

LC -1 NORMAL MAX REACTION(70R+Class A)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	**Load factors**	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	1	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			105.643		0.875	0.950		92.4376	100.361	1	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	1	0.9
11	Centifugal force				0.000			51.917	0.0	0.000	1	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				13.061			49.094	641.22		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.5	1375.000		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	3155.12	2	6310.246		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
9056.22	**724.41**	**90.32**

LC -2 NORMAL SPAN DISLOGED

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	Load factors	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	1	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	1	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	1	0.9
11	Centifugal force				0.000			51.917	0.000	0.000	1	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				7.801			49.094	382.969		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.5	1375.000		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	3155.12	2	6310.246		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)		
8805.13	**519.48**	**0.00**	519.480	0.000

LC - 6 SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	0	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	
11	Centifugal force				0.000			51.917	0.00	0.000	0	
12	Pier cap	47.12	2.50	117.81		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	245.05	2.50	612.62		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	93.38	2.50	233.44		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F_{LL})				0.000			15.634	0.00		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				15.782			49.094	774.81		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1	
20	**Seismic**											
	Super structure											
	Longitudinal				15.963				783.69		1	
	Transverse				11.612					509.13805	0.3	
	Vertical			7.883							0.3	
	Sub structure											
	Longitudinal				98.621				2699.7		1	
	Transverse				96.853					2651.30	0.3	
	Vertical			65.748							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	**M_{TT} (tm)**	**M_{LL}(tm)**
8827.221	**4282.24**	**948.13**

LC - 8 SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	**0**	0
	Left Span											
1	DL (superstructure)			0.000		-0.875	0.000		0.000	0.000	1	
2	Surfacing			0.000		-0.875	0.000		0.000	0.000	1	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0.2	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			0.000		0.875	0.950		0.000	0.000	0.2	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0.2	
11	Centifugal force				0.000			51.917	0.00	0.000	0.2	
12	Pier cap	47.12	2.50	117.81		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	245.05	2.50	612.62		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	93.38	2.50	233.44		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F_{LL})				0.000			15.634	0.00		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				15.782			49.094	774.81		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1	

20	**Seismic**											
	Super structure											
	Longitudinal				0.000				0.00		0.3	
	Transverse				11.612					509.13805	1	
	Vertical			7.883							0.3	
	Sub structure											
	Longitudinal				98.621				2699.7		0.3	
	Transverse				96.853					2651.3008	1	
	Vertical			65.748							0.3	

SUMMARY OF FACTORED FORCES		
V(ton)	**M_{TT} (tm)**	**M_{LL}(tm)**
8827.221	**1608.74**	**3160.44**

LC -13 SEISMIC NORMAL MAX REACTION(70R)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	**Load factors**	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	1	0.9
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	0.9
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			105.643		0.875	0.950		92.4376	100.361	1	0.9
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	0.9
11	Centifugal force				0.000			51.917	0.0	0.000	1	
12	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				11.711			49.094	574.94		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.5	1375.000		0.000	0.000		0.000	0.000	1	
19	Earth Over Footing	3155.12	2	6310.246		0.00	0		0.000	0.000	1	

SUMMARY OF FACTORED FORCES

V(ton)	**M_{TT} (tm)**	**M_{LL}(tm)**
9056.22	**658.13**	**90.32**

LC - 15 SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			105.643		0.875	0.950		92.438	100.361	0.2	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	
11	Centifugal force				0.000			51.917	0.0	0.000	0.2	
12	Pier cap	47.124	2.500	117.810		0.000	0.000		0.000	0.000	1	
13	Pier (above LBL)	245.048	2.500	612.620		0.000	0.000		0.000	0.000	1	
14	Pier (below LBL)	93.377	2.500	233.443		0.000	0.000		0.000	0.000	1	
15	Buoyancy	0.000	1.000	0.000		0.000	0.000		0.000	0.000	1	
16	Water Current Force(F_{LL})				0.000			15.634	0.000		1	

	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				12.324			49.094	605.02		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.00	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1	
20	**Seismic**											
	Super structure											
	Longitudinal				31.926				1567.4		1	
	Transverse				31.353					1477.4	0.3	
	Vertical			21.284							0.3	
	Sub structure											
	Longitudinal				98.621				2699.7		1	
	Transverse				96.853					2651.30	0.3	
	Vertical			65.75							0.3	
a)	**Max Live Load**											
	Longitudinal										1	
	Transverse				2.123					110.22	0.3	
	Vertical			1.441							0.3	
b)	**Min Live Load**											
	Longitudinal										1.5	1
	Transverse				0.688					35.700373	0.45	0.3
	Vertical			0.467							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	**M_{TT} (tm)**	**M_{LL}(tm)**
9008.878	**4890.61**	**1296.57**

LC - 16 SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	0	0
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL (70R)			0.000		-0.875	0.950		0.000	0.000	0.2	
5	LL (Class-A)			0.000		-0.875	1.000		0.000	0.000	0	
	Right Span											
6	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1	
7	Surfacing			27.445		0.875	0.000		24.014	0.000	1	
8	FLL			0.000		0.875	0.000		0.000	0.000	1	
9	LL (70R)			105.643		0.875	0.950		92.4376	100.361	0.2	
10	LL (Class-A)			0.000		0.875	1.000		0.000	0.000	0	
11	Centifugal force				0.000			51.917	0.0	0.000	0.2	
12	Pier cap	47.12	2.50	117.81		0.00	0.00		0.00	0.00	1	
13	Pier (above LBL)	245.05	2.50	612.62		0.00	0.00		0.00	0.00	1	
14	Pier (below LBL)	93.38	2.50	233.44		0.00	0.00		0.00	0.00	1	
15	Buoyancy	0.00	1.00	0.00		0.00	0.00		0.00	0.00	1	
16	Water Current Force(F_{LL})				0.000			15.634	0.00		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
17	Horizontal Force(F_{LL})				12.324			49.094	605.02		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
18	Footing	550.00	2.50	1375.00		0.00	0.00		0.00	0.00	1	
19	Earth Over Footing	3155.12	2.00	6310.25		0.00	0.00		0.00	0.00	1	
20	**Seismic**											
	Super structure											
	Longitudinal				31.926				1567.4		0.3	
	Transverse				31.353					1477.4	1	
	Vertical			21.284							0.3	
	Sub structure											
	Longitudinal				98.621				2699.7		0.3	
	Transverse				96.853					2651.30	1	
	Vertical			65.748							0.3	
a)	**Max Live Load**											
	Longitudinal										0.3	
	Transverse				2.123					110.22	1	
	Vertical			1.441							0.3	
b)	**Min Live Load**											
	Longitudinal										0.45	0.3
	Transverse				0.688					35.7	1.5	1

	Vertical			0.467							0.45	0.3

SUMMARY OF FACTORED FORCES		
V(ton)	**M_{TT} (tm)**	**M_{LL}(tm)**
9008.878	**1903.64**	**4312.55**

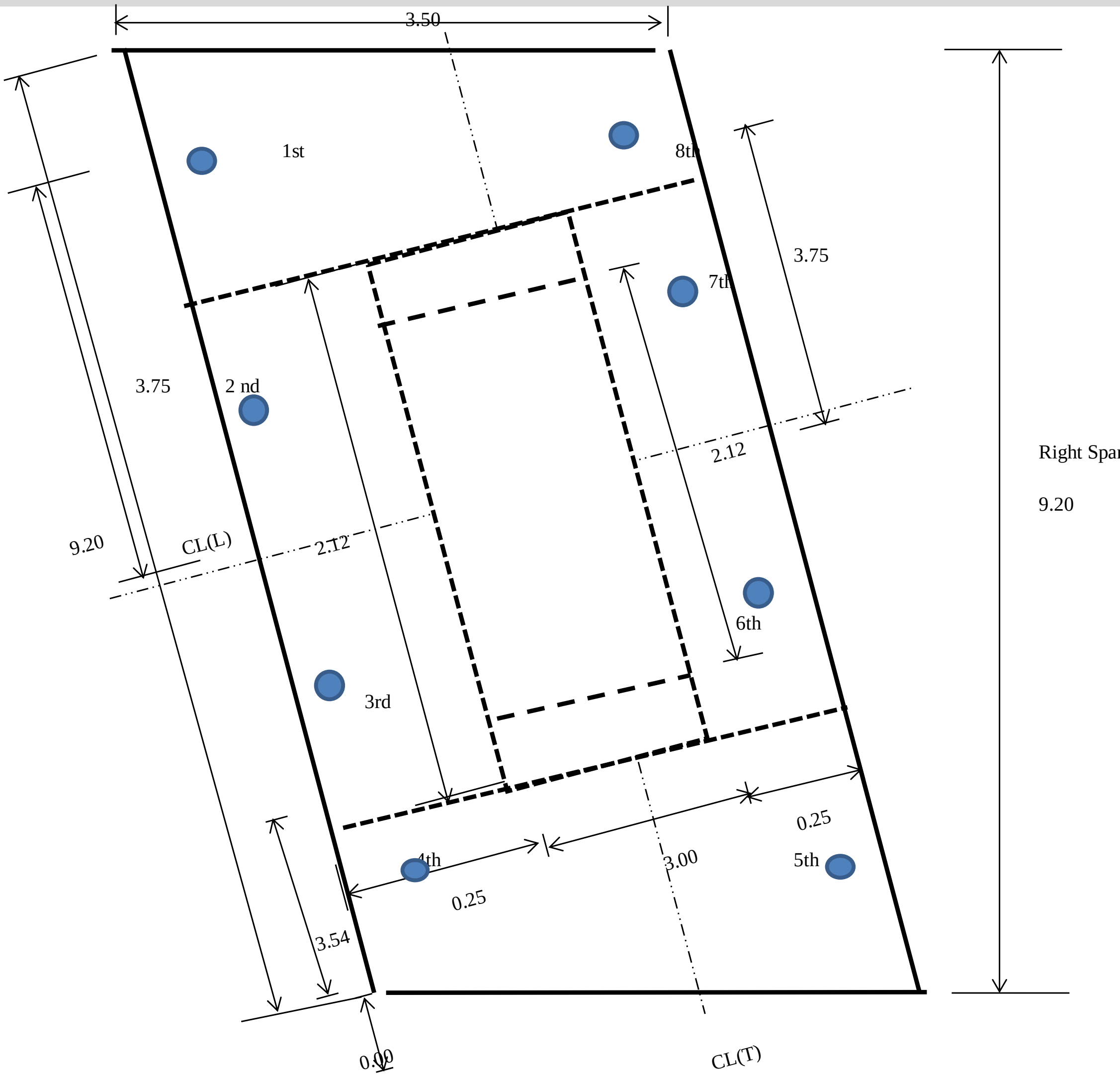
LC - 18 NORMAL SV MAX REACTION

Sr. No.	Description	Volume (m^3)	Unit weight (t/m^3)	Vertical Load (V in ton)	Horizontal Load(ton)	e_L(m)	e_T(m)	e_{VF}(m)	M_{TT} (tm)	M_{LL}(tm)	**Load factors**	Lane Reduction Factor
	Left Span											
1	DL (superstructure)			128.568		-0.875	0.000		-112.50	0.000	1	
2	Surfacing			27.445		-0.875	0.000		-24.014	0.000	1	
3	FLL			0.000		-0.875	0.000		0.000	0.000	1	
4	LL			0.000		-0.875	0.300		0.000	0.000	1	1
	Right Span											
5	DL (superstructure)			128.568		0.875	0.000		112.50	0.000	1	
6	Surfacing			27.445		0.875	0.000		24.014	0.000	1	
7	FLL			0.000		0.875	0.000		0.000	0.000	1	
8	LL			159.252		0.875	0.300		139.346	47.776	1	1
9	Centifugal force				0.000			51.917	0.0	0.000	1	
10	Pier cap	47.124	2.5	117.810		0.000	0.000		0.000	0.000	1	
11	Pier (above LBL)	245.048	2.5	612.620		0.000	0.000		0.000	0.000	1	
12	Pier (below LBL)	93.377	2.5	233.443		0.000	0.000		0.000	0.000	1	
13	Buoyancy	0.000	1	0.000		0.000	0.000		0.000	0.000	1	
14	Water Current Force(F_{LL})				0.000			15.634	0.000		1	
	Water Current Force(F_{TT})				0.000			15.861		0.000	1	
15	Horizontal Force(F_{LL})				7.337			49.094	360.23		1	
	Horizontal Force(F_{TT})				0.000			49.094		0.000	1	
16	Footing	550.00	2.5	1375.000		0.000	0.000		0.000	0.000	1	
17	Earth Over Footing	3155.12	2	6310.246		0.00	0		0.000	0.000	1	

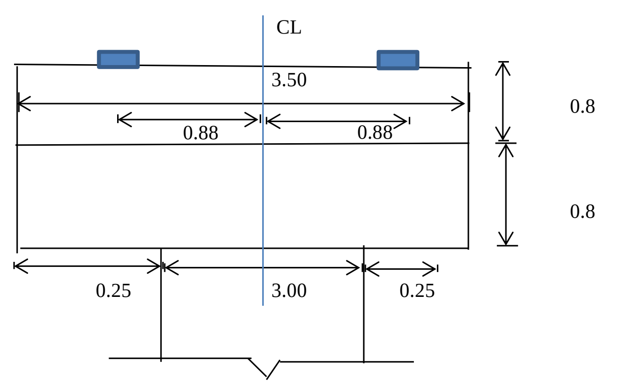
SUMMARY OF FACTORED FORCES

V(ton)	M_{TT} (tm)	M_{LL}(tm)
9120.40	**499.57**	**47.78**

17. DESIGN OF PIER CAP IN TRANSVERSE DIRECTION



Peir Cap Plan



Peir Cap Section(CL(L)).

Lever arm for 1st bearing	a1	=	2.689	m	2nd brg.=	0.189 m
Lever arm for 8th bearing	a8	=	2.689	m	7th brg =	0.189 m
width of wquivalentsquare		=	2.121	m		
Overall depth	h	=	1.6	m		
Clear cover to main reinforcement	c	=	50	mm		
Dia of main reinforcement	f	=	32	mm		
Dia of transverse reinforcement	f	=	12	mm		

Effective depth		d	=	1.490 m		
(Considering two layer reinforcement)						
Depth at effective depth		D	=	1.263 m		
Effective depth at effective depth		d'	=	0.8 m		
Hence ,	1st bearing	a1/d	=	1.80 m	>1.0	Design as cantilever
	8th bearing	a8/d	=	1.80 m	>1.0	Design as cantilever

1. CALCULATION OF FORCES

1.1 . SELF WEIGHT OF PIER CAP

Density of concrete = 25 KN/m^3

Description	**Unit**	**At face of Pier Shaft**	**At deff.**		
Volumn of straight portion(Top)	m3	9.910	5.738		
Weight of straight portion	KN	247.754	143.4538		
Lever arm	m	1.770	1.025		
Torsional eccentricity	m	0	0		
Volumn of straight portion(Bottom)	m3	1.230	0		
Weight of straight portion		30.754	0		
Lever arm		0.220	0		
Torsional eccentricity		0	0		
Volumn of tapered portion	m^2	4.955	4.530		
Weight of tapered portion	KN	123.877	113.2580		
Lever arm	m	1.180	0.6831		
Torsional eccentricity	m	0	0		
Total Weight	KN	402.384	256.712		
Lever arm	m	1.47	0.87		
Shear force at the section	KN	402.384	256.712		
BM at the section	KN-m	591.35	224.36		
Torsional moment at the section	KN-m	0	0		

1.2. LOAD FROM SUPERSTRUCTURE

Left Span Dominating

Description	Left Span(Brg 2)			Right Span(Brg 7)		
	V(KN)	Eccentricity for moment	Eccentricity for Torsion	V(KN)	Eccentricity for moment	Eccentricity for Torsion
DL	321.42	0.189	0.875	321.42	0.189	-0.875
Surfacing	68.61	0.189	0.875	68.61	0.189	-0.875
FPLL	0.00	0.189	0.875	0.00	0.189	-0.875
Class A	0.00	0.189	0.875	0.00	0.189	-0.875
70R	0.00	0.189	0.875	0.00	0.189	-0.875

Description	Shear at face of support	Shear at deff	oment at fa	Torsion
DL	642.84	642.840	121.715	0.000
Surfacing	137.23	137.225	25.982	0.000
FPLL	0.00	0.0002	0.00	0.000
Class A	0.00	0	0.00	0
70R	0.00	0	0.00	0

DESIGN MOMENT AND SHEAR

Description	Left Span(Brg 1)			Right Span(Brg 8)		
	V(KN)	Eccentricity for moment	Eccentricity for Torsion	V(KN)	Eccentricity for moment	Eccentricity for Torsion

DL including Crashbarrier	321.42	2.689	0.875	321.42	2.689	-0.875
Surfacing	68.61	2.689	0.875	68.61	2.689	-0.875
FPLL	0.00	2.689	0.875	0.00	2.689	-0.875
3L Class A	0.00	2.689	0.875	0.00	2.689	-0.875
70R	0.00	2.689	0.875	422.57	2.689	-0.875

Design Forces Normal Case

Description	Shear at face of support	Shear at deff	Moment at face	Torsion
Due to Cap Self weight	402.384	256.712	591.35	0
DL including Crashbarrier	1285.68	1285.68	1850.53	0.00
Surfacing	274.45	274.45	395.03	0.00
FPLL	0.00	0.00	0.00	0.00
3L Class A Including Impact	0.00	0.00	0.00	0.00
70R Including Impact	487.58	562.60	1311.28	426.64

Design Seismic forces

Av = 0.05052726

Description	Shear at face of support	Shear at deff	Moment at face	Torsion
Due to Cap Self weight	20	12.97	30	0.00
DL including Crashbarrier	65	64.96	94	0.00
Surfacing	14	13.87	20	0.00
FPLL	0	0.00	0	0.00
Class A(20% LL) Excluding Impact	0	0.00	0	0.00
70R Excluding Impact(20 % LL)	4	4.93	11	3.74

Load Combination 1 : Normal

Description	Factor for Strength(Basic)	Factored Shear at deff kN	Factored moment at face kNm	Factored Torsion(KNm)
Due to Cap Self weight	1.35	346.56	798.32	**0**
DL(Super Structure+Crashbarrier)	1.35	1735.67	2498.22	0
Surfacing	1.75	480.29	691.30	0
FPLL	1.5	0.00	0.00	0
Class A	1.5	0.00	0.00	0
70R	1.5	843.89	1966.91	640
Total		3406	5955	640

Load Combination 2 : Seismic

Description	Factor for Strength(Seismic)	Factored Shear at deff kN	Factored moment at face kNm	Factored Torsion(KNm)
Due to Cap Self weight	1.35	347	798	0
DL(Super Structure+Crashbarrier)	1.35	1736	2498	0
Surfacing	1.75	480	691	0
FPLL	0.2	0	0	0
Class A	0.2	0	0	0
70R	0.2	113	262	85
Seismic Load				
Due to Cap Self weight	1.5	19	45	0
DL(Super Structure+Crashbarrier)	1.5	97	140	0
Surfacing	1.5	21	30	0
FPLL	1.5	0	0	0
Class A	1.5	0	0	0
70R	1.5	7	17	6
Total		**2820**	**4482**	**91**

Design Forces		
Factored Shear at deff kN	Factored moment at face KNm	Factored Torsion(KNm)
3406	5955	640

DESIGN AS CANTILEVER

2.1 Design for flexture

Mu	=	5955	KNm
b	=	3500	mm
Fck	=	35	N/mm2
Fcd	=	15.63	N/mm2
Fyk	=	500	N/mm2
Fyd	=	435	N/mm2
Es	=	200000	N/mm2
xu,lim/d	=	0.617	
$R_{lim} = M_{u,Lim}/bd^2$		5.803	

Effective depth required	=	0.541	m
R = Mu/bd^2	=	0.766	
Ast required	=	9434	mm2
Minimum Ast required	=	7515	mm2
Governing Ast in Flexure	=	9434	mm2
Ast from torsion	=	5341	mm2
Total Ast required	=	14775	mm2

Provided	32	dia at	20	Nos	16085 mm2	>	14775 mm2	OK
	0	dia at	20	Nos				
	0	dia at	20	Nos				

2.2 Design for Shear

Design Shear	=	3406411	N
Shear due to torsion	=	191080	N
Total Shear	=	3597490	N

Design shear resistance of the member with shear reinforcement is given by:

Asw	=	905	mm2
fywd	=	435	Mpa
v1	=	0.53	
z	=	720.00	mm
acw	=	1	

q = 21.80 ^{o} Tan(q) = 0.4000
Cot(q) = 2.5002

Provided outer	12	dia	4	legged	at spacing	150	mm	905 mm2
Inner	12	dia	4	legged	at spacing	150	mm	

$V_{RD,S}$	=	4720921 N				
$V_{RD,Max}$	=	7230260.492 N				
V_{RD}	=	Min(4720921,7230260)	4720921 N	>	3597490 N	Ok

Minimum Shear Reinforcement

$$r_{,min} = \frac{0.072\sqrt{fck}}{fyk}$$

= 0.001

As per clause 10.3.3.5 of IRC:112-2011 minimum shear reinforcement required

Asw,min = $r_{,min}$ x s x bw

Asw,min = 447.256 mm^2 < 904.78 mm^2 Ok

Maximum Spacing	=0.75*d'	=	600 mm	>	150 mm	Ok

2.3 Design for Torsion

Torsional Inertia of section

b = 3.5 m

h = 1.6 m

$$I_{tor} = \frac{3.b^3.d^3}{10*(b^2+d^2)} \quad 3.557380149 \; m^4$$

Ultimate Torsion Moment , Ted	kNm	**640**
Total Area of section , A	m2	5.6
Total Perimeter of section , u	m	10.2
Effective cover	mm	110
tef,i = max(A / u, 2*eff. Cover)	m	0.55
Area of section , Ak	m2	1.21
Perimeter of section , uk	m	5.81
Shear stress due to pure Torsion, tt,i = TEd/ (2 .Ak. tef,i)	N/mm2	0.48
Shear force due to torsion =VEd,i = tt,i . tef . Zi	kN	191.08
Mean compr. stress at c.g. sec. scp = NEd / Ac ≤ 0.2 fcd	N/mm2	0
Coefficient acw=1+scp /fcd		1
strength reduction factor for section cracked in shear = n = 0.6 [1 - fck/310]		0.532
cot θ		2.50
θ smallest angle before concrete crushing starts hence	deg	21.8
Maximum Torsional Moment TRd,max = 2. n . acw. fcd .Ak. tef. sinq . cosq	kNm	3798.45
Torsional Long. Reinf. Asl = TEd . cot q*s /(2 . Ak. fyd)	mm2	5341.33
Total torsional moment, TRd,max	kNm	3798.45
Total shear force due to torsion, Vedi	kN	191.08
Design shear force, Vu	kN	3406
Total shear Force , VEd=Vu	kN	3597.49
Maximum shear capacity VRd,max	kN	7230
TEd/TRd,max + VEd/ VRd,max ≤ 1.0		0.64
		ok

$$\tau_{t,i} = \frac{T_{Ed}}{2A_k \cdot t_{ef,i}} \qquad \text{Eq. 10.46}$$

$$T_{Rd.max} = 2\nu\alpha_{cw} f_{cd} A_k t_{ef,i} \sin\theta\cos\theta \qquad \text{Eq. 10.48}$$

$$\frac{\sum A_{sl} f_{yd}}{u_k} = \frac{T_{Ed}}{2A_k}\cot\theta \qquad \text{Eq. 10.49}$$

$$V_{Rd.max} = \alpha_{cw} b_w z \ \nu_1 \frac{f_{cd}}{(\cot\theta + \tan\theta)} \qquad \text{Eq. 10.8}$$

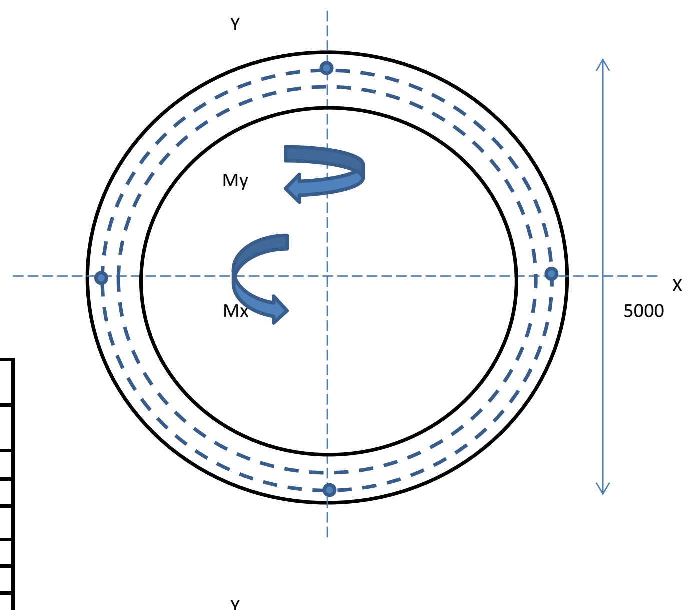
18. DESIGN OF PIER SHAFT

Grade of Concrete : 35 MPa
Grade of Steel : 500 MPa
ym : 1.5 (1.5 for Basic & Seismic combination, 1.2 for accidental combination)
ys : 1.15 (1.15 for basic and Seismic combination and 1.0 for accidental combination)
Es : 200000 MPa
Clear Cover for outer surface : 50 mm
Clear cover for Inner surface : 50 mm
fyd : 434.8 MPa
fcd : 15.63 MPa
fcm : 45 MPa
fctm : 2.77 MPa
Ecm : 32000 MPa
ec2 : 0.002
ecu2 : 0.0035
n : 2

As	:	49087.3	mm2
p	:	0.490	%
p/fck	:	0.014	
d'/D	:	0.01	

Outer Diameter : 5000 mm Inner Diameter : 3500 mm
Thickness : 750 mm Inner Radius : 1750 mm
Outer Radius : 2500 mm
Dia of Bar in First layer : 25 mm Area of bar 491 mm2
Dia of Bar in Second layer 25 mm Area of bar 490.8734375 mm2
Spacing b/w Layer :
Effective Cover for outer layer : 62.5 mm
Effective Cover for Inner layer : 62.5 mm
C/C distance between layer : 625 mm
Radius of outer layer : 2437.5 mm
Radius of Inner layer : 1812.5 mm
Number of Bar in outer layer : 50
Number of bar in inner layer : 50
Spacing in outer Side : 306 mm
Spacing in inner Side : 228 mm

number of division of circular section(outer) : 100
number of division of circular section(inner) : 100



X

ULS CASE

Load Combination	P	M_{LL}	M_{TT}	M_R
	KN	KNm	KNm	KNm
LC1	19028.84	1354.87	10278.41	16614.64
LC2	15228.24	0.00	7332.47	11470.52
LC5	17950.39	13058.04	48257.65	56317.2
LC6	17950.39	43058.44	18089.63	53028.1
LC9	19036.72	477.76	6466.66	12694.2

Final Moments with Slenderness effect

Load Combination	P	M_{LL}	M_{TT}	M_R
	KN	KNm	KNm	KNm
LC1	19028.84	31368.77	40292.31	51063.39
LC2	15228.24	24593.90	31956.25	40324.46

LC5	17950.39	40304.01	75576.58	85651.8
LC6	17950.39	70202.86	45773.33	83807.2

SLS CASE

Final Moments with Slenderness effect

Load Combination	P	M_{LL}	M_{TT}	M_R
	KN	KNm	KNm	KNm
LC1	13925.20	903.25	6852.27	6911.55
LC2	11253.75	0.00	5008.81	5008.81
LC3	14461.29	477.76	4775.59	4799.43

SLS CHECK OF PIER SHAFT USING OYASIS

Section : Elastic Properties

1 : Hollow Circular

Effective properties of the section, ignoring reinforcement.

Geometric Centroid	y	0.0mm
	z	0.0mm
Area		3.927E+6mm2
Second Moments of Area	Iyy	3.191E+12mm4
	Izz	3.191E+12mm4
	Iyz	0.0mm4
Principal Second Moments of Area	Iuu	3.191E+12mm4
	Izz	3.191E+12mm4
	Angle	0.0°
Shear Area Factor	ky	0.5000
	kz	0.5000
Torsion Constant		6.381E+12mm4
Section Modulus	Zy	2.127E+9mm3
	Zz	2.127E+9mm3
Plastic Modulus	Zpy	3.167E+9mm3
	Zpz	3.167E+9mm3
Radius of Gyration	Ry	901.4mm
	Rz	901.4mm

Properties of gross section, including reinforcement.

Geometric Centroid	y	-4.893E-6mm
	z	3.953E-6mm
EA		127.2E+6kN
EI	EIyy	103.7E+6kNm2
	EIzz	103.7E+6kNm2
	EIyz	-0.3650kNm2
Principal EI	EIuu	103.7E+6kNm2
	EIzz	103.7E+6kNm2
	Angle	-45.00°

Maximum compressive force	Nu	88530.kN
Strain at Nmax		0.003500
Moment at ref. pt. for Nmax	Myy	0.2169kNm
	Mzz	0.1156kNm

Note: Nmax is the maximum compressive force which can be carried by the section.
This is calculated by applying a constant strain across the entire section, using ultimate material properties.

Material : Concrete

1 : M35

Name		M35 (Modified)
Cube Strength	fck	35.00N/mm2
Tensile Strength	fcr	4.141N/mm2
Weight		Normal Weight
Density	r	2.400t/m3
Elastic Modulus	E	29580.N/mm2
Poisson's Ratio	n	0.2000
Coeff. Thermal Expansion	a	10.00E-6/°C
Partial Safety Factor	gm	1.500
Maximum Strain		0.003500
ULS Compression Curve		Parabola rectangle
ULS Tension Curve		No-tension
SLS Compression Curve		Linear
SLS Tension Curve		BS8110 Part 2
Design strength factor	a	0.6700
Aggregate Size		0.0mm

Material : Rebar

0.38889

Type		Steel rebar
Strength	fy	500.0N/mm2

Elastic Modulus E 200000.N/mm2
Hardening Modulus Eh 0.0N/mm2
Density r 7.850t/m3
Poisson's Ratio n 0.3000
Coeff. Thermal Expansion a 12.00E-6/°C
Ductility Normal
Partial Safety Factor gm 1.150
gme 1.000
Maximum Strain eu 0.004174
Maximum Strain eud 0.004174
Stress/Strain Curve Elastic-plastic

Loading

Applied loads

Load Case	N	Myy	Mzz	Note
	[kN]	[kNm]	[kNm]	
1	17220.	11900.	10810.	
2	7625.	4600.	10700.	
3	14720.	15920.	31580.	
4	14720.	34360.	14370.	
5	12420.	1821.	1042.	
6	5622.	0.0	4240.	
7	12220.	577.9	456.4	

Section 1 Details

1.65% reinforcement in section 1 (Hollow Circular). Check this against code requirements.

SLS Loads Analysis Summary

Case	Secant EI	Neutral Axis Angle	Neutral Axis Depth	k at M0
	[kNm²]	[°]	[mm]	[/m]
1	103.7E+6	-29.78	6328.	91.75E-12
2	103.7E+6	-90.00	2582.	92.50E-12
3	103.7E+6	-38.30	15030.	113.7E-12

Moment summary for SLS loads

Effective centroid is reported relative to the reference point.
Cracking moment is for short term loading

Case Eff. Centroid N M Mu M/Mu Mcr Note

y z
[mm] [mm] [kN] [kNm] [kNm] [kNm]
Maxima
1 18.71E-6 16.70E-6 12420. 2098. 38850. 0.05400 10200.
2 18.71E-6 16.70E-6 5622. 4240. 33570. 0.1263 6594.
1 18.71E-6 16.70E-6 12420. 2098. 38850. 0.05400 10200.
Minima
2 18.71E-6 16.70E-6 5622. 4240. 33570. 0.1263 6594.
3 18.71E-6 16.70E-6 12220. 736.3 38710. 0.01902 10080.
2 18.71E-6 16.70E-6 5622. 4240. 33570. 0.1263 6594.

Section Material Stresses/Strains at SLS Loads

Case Point Coordinates Notes
y z Strain Stress
[mm] [mm] [-] [N/mm²]
Maxima
1 6 750.7 1300. 128.0E-6 3.788
1 6 750.7 1300. 128.0E-6 3.788
Minima
2 46 -1501. 17.90E-6 -17.21E-6 -0.5091
2 46 -1501. 17.90E-6 -17.21E-6 -0.5091

Reinforcement Stresses/Strains at SLS Loads

Case Bar Coordinates Notes
y z Strain Stress
[mm] [mm] [-] [N/mm²]
Maxima
1 5 690.8 1257. 126.7E-6 25.34 500
1 5 690.8 1257. 126.7E-6 25.34 500
Minima
2 39 -1431. 90.04 -14.34E-6 -2.868 500
2 38 -1431. -90.04 -14.34E-6 -2.868 500

Crack Widths at SLS Loads

Crack widths calculated at 20mm intervals
Note: Cover to controlling bar measured to different side from crack location
Case 2
Crack Numbers
1 to 2 21 to 22 30 to 33 44 to 47 55 to 56 75 to 76 84 to 87 98 to 101 109 to 110 129 to 130

Case Face Point Coordinates Strain Control Bar acr Cover h x Crack
Width
y z cmin From
[mm] [mm] [mm] [mm] [mm] [mm] [mm]
Maxima
2 45 66 -1501. 17.90E-6 -17.21E-6 38 98.17 49.39 Face 45 3003. 2582. 0.004115

Confinement Reinforcement of Pier Shaft:

Width of shaft	Outer Dia	=	5000 mm	Average
Length of shaft	Inner dai	=	3500 mm	Average

.

Clear cover to earth face	=	50 mm
Clear cover to other face	=	50 mm
Confined area of concrete	=	9778207 mm^2

N_{ED}	=	1903 Tonne
Ac	=	10013827 mm^2
fck	=	35 Mpa
fcd	=	15.63 Mpa
fyd	=	435 Mpa

Normalized axial force

η_k = Max N_{ED}/Ac fck

η_k = 0.054 < 0.064
< 0.30

As	Long Bar		490.9	mm^2	
S As			981.7	mm^2	
St			150.0	mm	
At			92	mm^2	
Hence Provide	16 mm	Link Bar to each Long bar	@	150 mm	C/C
Provided reinforcedment			201.1	mm^2	

Extent of confinement = Depth of section within the plane of bending
= 5.00 m

Required volumentic ratio of transverse reinforcement

$\omega_{w,req}$ = 0.37 Ac/ Acc η_k +0.13 fyd/fcd (ρ_L-0.01)

Ac = Area of gross concrete section
= 10.0 m^2

Acc = Confined core concrete area of the section within the outside dia of loop.
= 9.78 m^2

ρ_L = Reinforcement ratio of the longitudinal reinforcement
= As/Acc

Area of steel provided As = 982 mm^2

ρ_L	=	0.00010 mm^2
$\omega_{w,req}$	=	0.02880

Minimum Confining Reinforcement

$\omega_{w,d}$	=	Max($\omega_{w,req}$, 0.18)
	=	0.1800

Volumentic ratio of transverse reinforcement

ρ_w	=	ω_{wd}fcd/fyd
	=	0.00647

Volumentic ratio of transverse reinforcement

ρ_w	=	Asw / b S_L
Area of the spiral or hoop bar		
AsW	=	ρ_w *b * S_L
b	=	Dimension of the core perpendicular to the direction of confinment.
	=	4200 mm
S_L	=	Spacing of hoops or ties in longitudinal direction (in vertical direction)
	<=	1/5 * smalllest dimension of confined core
	=	0.2 x 4200 = 840 mm
	=	840 mm
Asw	=	4077 mm2

Provide	32	dia	3	Leg @	150	mm c/c
	32	dia	3	Leg @	150	mm c/c

Area of reinforcement provided at one section = 4825 mm^2 OK

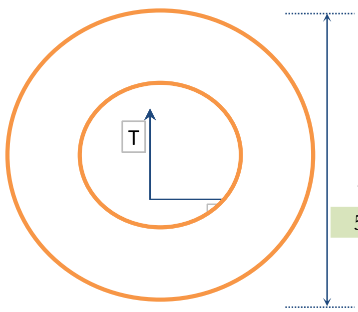
Transverse distance b/w hoops legs or suplementry cross ties :

S_T = Min { 1/3 * smalllest dimension of confined core; 200 mm }

= Min { 0.33 x 4200 = 1400 mm; 200 mm }

= 200 mm

CHECK FOR PIER SHAFT SECOND ORDER FORCES: *(IRC 112 / clause 11.2.1)*



T = 5000

L= 5000

Ac	=	1.00E+07	mm^2
As	=	49087	mm^2
fcd	=	15.6	Mpa
fyd	=	435	Mpa

Outer Diameter of Pier shaft =
Inner Diameter of Pier shaft
Gross Area of c/s A_g =
Moment if inertia, Ig =

Slenderness criteria

Moment of Inertia about TT axis	I_{TT}	=	2.33E+13	mm^4
Moment of Inertia about LL axis	I_{LL}	=	2.33E+13	mm^4
Radius of gyration along LL axis	i_L	=	$\sqrt{I_{TT}/A}$	
		=	1526	mm
Radius of gyration along TT axis	i_T	=	$\sqrt{I_{LL}/A}$	
		=	1526	mm

Clear Height of compression member	lo	=	45.79	m
Effective length of column along L-L	l_{eL}	=	2.3	*lo
		=	105.33	m
Selenderness ratio along L-L axis	λ_L	=	l_{eL}/ i_L	
		=	69.03	
Effective Length of column along TT -axis	l_{eT}	=	2.3	*lo
		=	105.33	m
Selenderness ratio along TT axis	λ_T	=	l_{eT}/ i_T	
		=	69.03	

Finding Limiting Value of Slenderness Ratio.

λ_{lim} = $20\ A\ B\ C/ \sqrt{n}$

$\phi(\infty,t_o)$ = 1.32 *Creep for abutment shaft*

Mo_{Eqp}/Mo_{Ed} = Ratio of BM in Quasi Permanent LC of SLS to BM in Design LC of ULS

ϕ_{ef} = $\phi(\infty,t_o) * Mo_{Eqp}/Mo_{Ed}$

A = $1/ (1+0.2\ \phi_{ef})$

ω = As fyd / (Ac fcd)
= 0.136

B = $\sqrt{(1 + 2\omega)}$
= 1.128

r_m = Mo1 /Mo2 (Ratio of First order moments at two ends of members
= 1

C = $1.7 - r_m$
= 0.7

n = N_{ED} / (Ac fcd)
= N_{ED} / 15654.949 */ (N_{ED} in Tonne)

SUMMERY OF FORCES AT BOTTOM OF SHAFT:		
S.N.	ULS FORCES	SLS (QP LC)

CHECK FOR SECOND ORDER EFFECT (along LL Axis)					
$Mo_{...}$					*Second Order Effect*

	N_{ED}	M_{ELL}	M_{ETT}	M_{ELL}	M_{ETT}
	Tonne	Tm	Tm	Tm	Tm
LC1	1903	135	1028	90	685
LC2	1523	0	733	0	501
LC5	1795	1306	4826	0	0
LC6	1795	4306	1809	0	0

Mo_{Eqp} /Mo_{Ed}	ϕ_{ef}	A	n	λ_{lim}	(λ <λlim) : Ignore (λ >λlim) : Consider
0.67	0.88	0.85	0.12	38.52	Consider Second order Effec
0.00	0.00	1.00	0.10	50.64	Consider Second order Effec
0.00	0.00	1.00	0.11	46.64	Consider Second order Effec
0.00	0.00	1.00	0.11	46.64	Consider Second order Effec

Load Case	*CHECK FOR SECOND ORDER EFFECT (along TT Axis)*					
	Mo_{Eqp} /Mo_{Ed}	ϕ_{ef}	A	n	λ_{lim}	*Second Order Effect* (λ <λlim) : Ignore (λ >λlim) : Consider
LC1	0.67	0.88	0.85	0.12	38.52	Consider Second order Effect
LC2	0.68	0.90	0.85	0.10	42.90	Consider Second order Effect
LC5	0.00	0.00	1.00	0.11	46.64	Consider Second order Effect
LC6	0.00	0.00	1.00	0.11	46.64	Consider Second order Effect

Second Order Moment (M2)

fcd	1.56E+01	N/mm2	Ac	1.00E+07		As	4.91E+04	mm2	fyd	434.78	Es	200000.00	N/mm2
fck	35.00		h	5000.00	mm	dia of main ba	25.00	mm	εyd	0.00217	c	10.00	
Leff long.	105327	mm	Leff trans	105327.35	mm	effective cove	74.50		is - radius of gyration of reinf		2425.50		

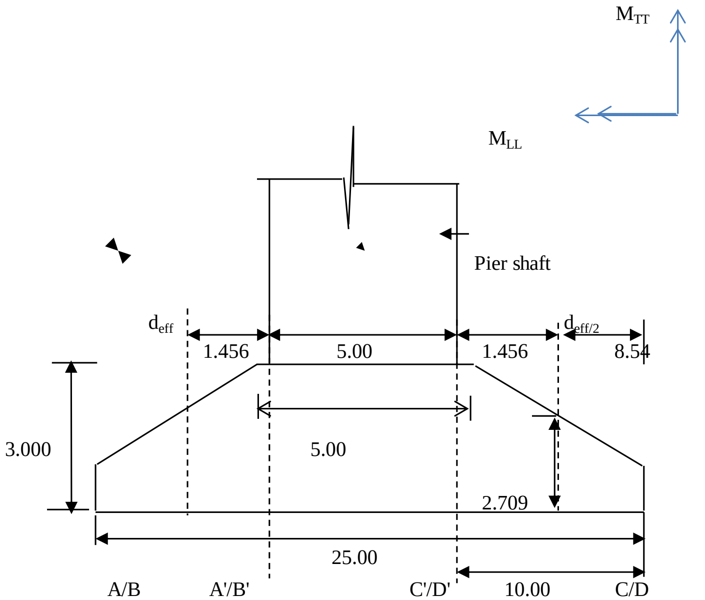
LOAD CASES	N_{Ed}	Kr = (nu - n)/(nu-nbal)			Kr	$K_ø = 1 + βø_{ef} ≥ 1$						Kø		$ε_{yd}/(0.45 d)$	1/ro	1/r = Kr Kø 1/ro	Deflection (e_2) = (1/r)* (l_{exx}^2/c)	M2 = N_{Ed} x e_2
		n= N_{Ed}/ (Ac fcd)	nu = 1+ (As fyd/Ac fcd)	nbal		øef = ø (inf, to) * MoEqp/MoEd				β = 0.35 + fck/200-λ/150				d = h/2 + is				
						ø (inf, to)	$M_{oEqp,long}$	$M_{oEd,Long.}$	øef	λ = Lx/B	β						mm	kNm
Normal Dry Case (Max)	19028.84	0.12	1.14	0.40	1.38	1.20	903.25	1354.87	0.80	69.03	0.06	1.05	>1 ok	4925.50	9.81E-07	1.42E-06	1577.28	30013.90
Normal Dry Case (Min)	15228.24	0.10	1.14	0.40	1.41	1.20	903.25	1354.87	0.80	69.03	0.06	1.05	>1 ok	4925.50	9.81E-07	1.46E-06	1615.02	24593.90
Longitudinal Seismic Case (Max)	17950.39	0.11	1.14	0.40	1.39	1.20	903.25	13058.04	0.08	69.03	0.06	1.01	>1 ok	4925.50	9.81E-07	1.37E-06	1517.85	27245.98
Longitudinal Seismic Case (Min)	17950.39	0.11	1.14	0.40	1.39	1.20	903.25	43058.44	0.03	69.03	0.06	1.00	>1 ok	4925.50	9.81E-07	1.36E-06	1512.19	27144.41

Second Order Moment (M2) ALONG Transverse Axis

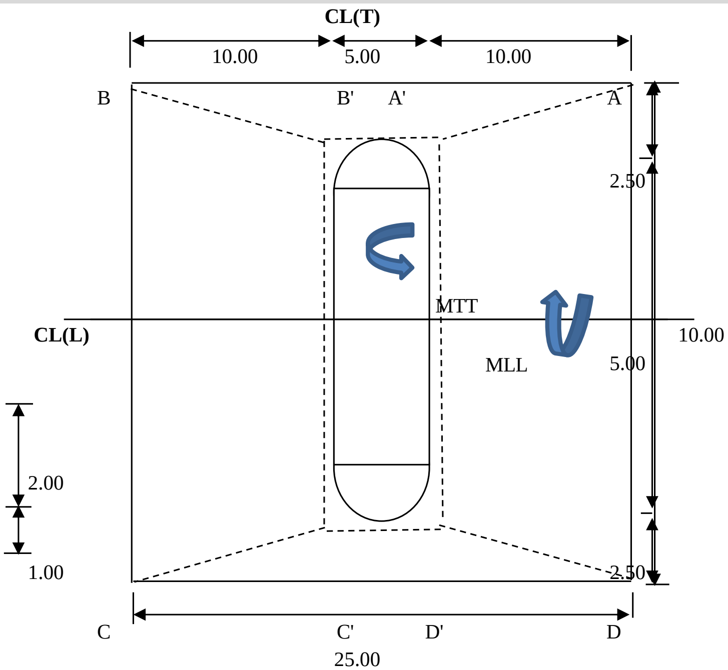
LOAD CASES	N_{Ed}	Kr = (nu - n)/(nu-nbal)			Kr	$K_ø = 1 + βø_{ef} ≥ 1$						Kø		$ε_{yd}/(0.45 d)$	1/ro	1/r = Kr Kø 1/ro	Deflection (e_2) = (1/r)* (l_{eyy}^2/c)	M2 = N_{Ed} x e_2
		n= N_{Ed}/ (Ac fcd)	nu = 1+ (As fyd/Ac fcd)	nbal		øef = ø (inf, to) * MoEqp/MoEd				β = 0.35 + fck/200-λ/150				d = h/2 + is = B/2+dia/4				
						ø (inf, to)	$M_{oEqp,trans}$	$M_{oEd,trans}$	øef	λ = Ly/B	β						mm	kNm
Normal Dry Case (Max)	19028.84	0.12	1.14	0.40	1.38	1.20	6852.27	10278.41	0.80	69.03	0.06	1.05	>1 ok	4925.50	9.81E-07	1.42E-06	1577.28	30013.90
Normal Dry Case (Min)	15228.24	0.10	1.14	0.40	1.41	1.20	5008.81	7332.47	0.82	69.03	0.06	1.05	>1 ok	4925.50	9.81E-07	1.46E-06	1616.98	24623.78
Longitudinal Seismic Case (Max)	17950.39	0.11	1.14	0.40	1.39	1.20	5008.81	48257.65	0.12	69.03	0.06	1.01	>1 ok	4925.50	9.81E-07	1.37E-06	1521.91	27318.93

Longitudinal Seismic Case (Min)	17950.39	0.11	1.14	0.40	1.39	1.20	**5008.81**	**18089.63**	0.33	69.03	0.06	**1.02**	>1 ok	4925.50	9.81E-07	1.39E-06	1542.23	**27683.70**

19A. DESIGN OF FOOTING LONGITUDINAL DIRECTION



CROSS SECTION CL(L) 1.091176471



PLAN SHOWING FOOTING

PROPERTIES OF BASE

Area = 25.00 10.00 = 250.00 m^2

I_{LL} = $\frac{25.00 \quad 10.00}{12}$ + 250.00 X 0.00^2 = 2083.33 m^4

I_{TT} = $\frac{10.00 \quad 25.00}{12}$ + 250.00 X 0.00^2 = 13020.83 m^4

COORDINATES OF BASE CORNERS

Edges	L(m)	T(m)
A	12.50	5.00
A'	2.50	5.00
B	-12.50	5.00
B'	-2.50	5.00
C	-12.50	-5.00
C'	-2.50	-5.00
D	12.50	-5.00
D'	2.5	-5.00

Base pressure = $P/A + M_{LL} * T/I_{LL} + M_{TT} * L/I_{TT}$

DESIGN FORCES

Lc. No.	Descriptions	V(Tonne)	M_{TT} (Tm)	M_{LL}(Tm)	MR
	ULS				
Normal					
LC - 1	ULS NORMAL MAX REACTION(70R +Class A)	12262.12	1086.61	135.49	**1095.03**
LC - 2	ULS NORMAL SPAN DISLOGED	11897.91	768.35	0.00	**768.35**

LC - 3	0	0.00	0.00	0.00	**0**
LC - 4	0	0.00	0.00	0.00	**0**
LC - 5	ULS NORMAL MAX REACTION(70R)	3743.29	987.20	135.49	**996.452**
LC - 6	0	0.00	0.00	0.00	**0**
SEISMIC					**0**
LC - 7	ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)	12180.51	7050.67	1932.41	**7310.69**
LC - 8	ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z	11932.28	6041.95	1502.39	**6225.94**
LC - 9	ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)	12180.51	2570.22	6432.01	**6926.52**
LC - 10	ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z	11932.28	2384.37	5007.96	**5546.61**
LC - 11	0	0.00	0.00	0.00	**0**
LC - 12	0	0.00	0.00	0.00	**0**
LC - 13	0	0.00	0.00	0.00	**0**
LC - 14	0	0.00	0.00	0.00	**0**
LC - 15	ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)	12180.51	7024.16	1932.41	**7285.12**
LC - 16	ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)	12180.51	2543.70	6432.01	**6916.73**
LC - 17	0	0.00	0.00	0.00	**0**
LC - 18	0	0.00	0.00	0.00	**0**
					0
LC - 19	ULS NORMAL SV MAX REACTION	0.00	0.00	0.00	**0**
LC - 20	0	0.00	0.00	0.00	**0**

Lc. No	**Descriptions**	**Gross Base pressures at critical points (Tm^2)**							
		A	**A'**	**B'**	**B**	**D**	**D'**	**C'**	**C**
	ULS								
LC - 1	ULS NORMAL MAX REACTION(70R +Class A)	50.42	49.58	49.17	48.33	49.77	48.93	48.51	47.68
LC - 2	ULS NORMAL SPAN DISLOGED	48.33	47.74	47.44	46.85	48.33	47.74	47.44	46.85
LC - 5	ULS NORMAL MAX REACTION(70R)	16.25	15.49	15.11	14.35	15.60	14.84	14.46	13.70
LC - 7	ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)	60.13	54.71	52.01	46.59	50.85	45.44	42.73	37.32
LC - 8	ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z	57.14	52.49	50.17	45.53	49.92	45.28	42.96	38.32
LC - 9	ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)	66.63	64.65	63.67	61.69	35.75	33.78	32.79	30.82
LC - 10	ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z	62.04	60.21	59.29	57.46	38.00	36.17	35.25	33.42
LC - 15	ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)	60.10	54.71	52.01	46.62	50.83	45.43	42.74	37.34
LC - 16	ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)	66.60	64.65	63.67	61.72	35.73	33.77	32.80	30.84
LC - 19	ULS NORMAL SV MAX REACTION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LONGITUDINAL DIRECTION

Downward pressure due to overburden (T/m^2)

LWL Case	Location			Load factor ULS		**HFL Case**	Location			Load factor ULS	
	A'/D'	A/D					A'/D'	A/D			
Due to Earth filling	24.39	28.388		1.35		Due to Earth filling	24.39	28.388		1.35	
Footing	7.5	2.5		1.35		Footing	7.5	2.5		1.35	
Total ULS	**43.05**	**41.6988**				**Total ULS**	**43.0488**	**41.70**			

Calculation of forces for Design of Bottom Reinforcement in Longitudinal Direction											
Lc. No	**Net Base pressures at critical points**							**Design Forces**			
	A'	**D'**	**A**	**D**	**Avg along A'D'**	**Avg Along AD**	$\mathbf{d_{eff/2}}$	$\mathbf{BM_{face}}$	$\mathbf{SF_{face}}$	$\mathbf{BM_{deff}}$	**Sfdeff/2**
ULS											
LC - 1	6.53	5.88	8.72	8.07	6.21	8.39	6.53	383.23	73.01	283.61	63.73
LC - 2	4.69	4.69	6.63	6.63	4.69	6.63	4.97	299.19	56.60	221.83	49.57
LC - 5	-27.56	14.84	-25.45	-26.10	-6.36	-12.73	-7.29	-530.24	-95.44	-398.33	-85.50
LC - 7	11.66	2.39	18.43	9.15	7.03	13.79	8.01	576.84	104.09	433.06	93.14
LC - 8	9.45	2.23	15.44	8.22	5.84	11.83	6.71	491.69	88.35	369.53	79.21
LC - 9	21.60	-9.27	24.93	-5.95	10.80	12.46	11.04	595.49	116.33	437.62	100.42
LC - 10	17.16	-6.88	20.34	-3.70	8.58	10.17	8.81	481.95	93.74	354.62	81.08
LC - 15	11.66	2.38	18.40	9.13	7.02	13.77	8.00	575.91	103.94	432.34	93.00
LC - 16	21.60	-9.28	24.90	-5.97	10.80	12.45	11.04	595.02	116.25	437.27	100.35
LC - 19	-43.05	-43.05	-41.70	-41.70	-21.52	-20.85	-21.43	-1053.72	-211.87	-767.97	-180.60

SUMMARY OF DESIGN FORCES

		Face of support	At effective depth/2
Normal case			
Max design Bending moment	=	383 Tm/m	284 Tm/m
Max design Shear force	=	73 T/m	64 T/m
Seismic case			
Max design Bending moment	=	595 Tm/m	438 Tm/m
Max design Shear force	=	116 T/m	100 T/m

DESIGN OF REINFORCEMENT IN LONGITUDINAL DIRECTION (Traffic direction)

Design Bending moment	M_{ED}	=	5954.9 Tm
Total depth of section at face of support	D	=	3.000 m
Total depth of section at half of effective depth	d	=	2.709 m
Effective Width,	"beff"	=	10.000 m
Clear cover		=	75 mm
Diameter of reinforcement provided		=	25 mm
Effective depth of section at face of support	D'	=	2.913 m

Effective depth of section at D'/2 from face of support	d'	=	2.621 m
Grade of concrete	fck	=	35 Mpa
Grade of steel	fyk	=	500 Mpa

MAIN STEEL :

Ast = 5367 mm^2/m

Hence depth of Neutral axis X_u = $\frac{0.87 fyk Ast}{0.362 f_{ck}\, b}$

= 184 mm

Limiting depth of Neutral axis $\frac{X_{umax}}{D'}$ = $\frac{0.0035}{0.0035+0.87fyk/Es}$

= 0.617

X_{umax} = 1796 mm > 184 mm **Underreinforced**

Area of steel Calculated = $M_{ED}/(0.87f_y(d-0.416x_u))$ = 4827 mm^2 /m

f_{ctm} = 2.77 Mpa

Ast Minimum = Max of = 4197 mm^2 /m

Ast Required = Max(4827,4197) = **4827 mm^2 /m**

Provide 25 mm @ 150 c/c

\+ 20 mm @ 150 c/c ALTERNATE

= **5367** mm^2/m > **4827** mm^2/m **OK**

DISTRIBUTION STEEL :

Minimum Steel Required = 20% of main steel = 1206.813 mm^2 /m As per clause 16.6.1 of IRC:112-2011

Provide 25 mm @ 150 c/c

= **3272** mm^2/m > **1207** mm^2/m **OK**

<u>As per cl. 10.3.2 of IRC:112-2011 shear resistance of section i.e. Shear capacity</u>

Design Shear force	=	100.42 Tonne/m
Design Bending Moment	=	437.62 Tm/m
Tan(Beta)	=	0.20
Vnet	=	67.03 T/m

<u>Max Shear Capacity of section</u>

ν = 0.6 * (1- fck /310) */ fck in Mpa

= 0.5322581

fcd = 0.447 *fck

= 15.63 Mpa

$V_{RDC,\,max}$ = 0.5 bw d ν fcd

= 1091 Tonne > 100.42 Tonne OK

V_{Rdc} = Max of $0.12\, K\, (80\, r1xfck)^{0.33} + 0.150 \times s_{cp}$ $b_w \times d$

and $(u_{min} + 0.15\ s_{cp})\ b_w \times d$

Here

K = Min. of $1 + 200/d$ Where d is depth in mm

and 2.0

r1 = Min. of $\frac{Asl}{b_w \times d}$ r1 = Reinforcement ratio for longitudinal reinforcement.

and 0.02

s_{cp} = (Mpa) Min. of N_{ed}/Ac

and $0.20\ f_{cd}$

s_{cp} = Compressive stress in the concrete from axial load or prestressing.

N_{ed} = design value of applied axial force.

Ac= cross-sectional area of concrete

$u_{min} = 0.031\ K^{3/2}\ fck^{1/2}$

<u>In the above case</u>

K =	1.3
r1 =	0.0020
s_{cp} =	0
u_{min} =	0.2644

V_{Rdc} =	Max of	714298	N	or	71.43	T/m
	and	693097	N	or	69.31	T/m

Hence V_{Rdc} = **71.43** T/m Shear reinf required

< **100.42** T/m

<u>SHEAR RESISTANCE WITH VERTICAL SHEAR REINFORCEMENT</u>

As per clause 10.2.3 of IRC:112-2011 design shear force V_{NS} shall be taken at the face of support for checking crushing of concrete.

$$V_{NS} = V_{ED} - V_{pd} - V_{ccd} - V_{td}$$

Where
V_{ED} = Design shear force from sectional analysis.
V_{pd} = Shear force due to prestressing tendons.
V_{ccd} = Design value of max shear component of the force in the compression area in the case of inclined compression chord.
V_{td} = Design value of shear component of the force in the tensile reinforcement in the case of inclined tensile chord.

As per clause 10.3.3.2 of IRC:112-2011 the shear resistance V_{Rd} is

V_{Rd} = Min of V_{Rds} = $\frac{A_{sw} \times z \times f_{ywd} \times \cot(q)}{s}$

and $V_{Rd.max}$ = $a_{cw} \times bw \times z \times v1 \times \frac{fcd}{\cot(q) + \tan(q)}$

Here A_{SW} = Cross-sectional area of the shear reinforcement.
s = Spacing of the stirrups
f_{ywd} = Design yield strength of the shear reinforcement = 0.8 f_{yk}
v1 = Strength reduction factor for concrete cracked in shear 0.6 x (1-fck/310)
= 0.6 for fck<= 80 Mpa
= 0.9- fck/250 > 0.5 for fck> 80Mpa

z = lever arm can be taken as 0.9d for RC section and to be calculated for PSC section.

a_{cw} = coefficient taking account of the state of the stress in the compression chord.
= 1 where s_{cp} = 0.0 (Mean compressive stress in the concrete.)
fcd = Design value of concrete compressive strength. g_m = 1.5
= a_{cc} xf_{ck} /g_m a_{cc} = 0.67
= 15.63333 Mpa

<u>In the above case:</u>

f_{ywd} = 435 Mpa
v1 = 0.532258
z = 2359.125 mm
a_{cw} = 1
q = 21.8 ^{0} Tan(q) = 0.40
cot (q) = 2.50

Providing shear reinforcement
10 4 L @ s= 200 c/c = 314.16 mm^2

VRd.s = 4028227.5 N or 403 T/m
$V_{Rd.max}$ = 6768685.8 N or 677 T/m

VRd. = Min(403,677) 403 T/m > 67.03 T/m Ok

Minimum Shear Reinforcement

$r_{,min}$ = $\frac{0.072 \ fck}{fyk}$
= 0.001

As per clause 10.3.3.5 of IRC:112-2011 minimum shear reinforcement required

Asw,min = $r_{,min}$ x s x bw

Asw,min = 170.383 mm^2 < 314.16 mm^2 Ok

Maximum Spacing	=0.75*d'	=	1966 mm	>	200 mm	Ok

PUNCHING SHEAR CHECK AT COLUMN FACE

Axial Force at the base of column	=	19036.717	kN
Pedestal dimension	=	5000.000	mm
Foundation depth at face of pier	=	3000.000	mm
deff	=	2912.500	mm
a, dist. From periphery of the column to contro	=	0.000	mm
Uo at column face	=	15707.963	mm
Area under perimeter	=	19.635	m2
Weight of footing under consider perimeter	=	1472.622	kN
Upward force due to base pressure	=	9566.799	kN
Net Shear Force	=	**9469.918**	kN
grade of concrete	=	35	Mpa
β	=	2.115	
Eccentricity	=	2958.347	mm
$V_{ED,red} = \beta\ V_{ED,red} / uo\ d$	=	**0.438**	Mpa
Concrete Shear capacity $V_{Rd} = [\ 0.12K(80\rho_l.f_{ck})^{1/3}]2$	=	**4.160**	Mpa
Checks	=	**OK**	

Axial Force at the base of column	=	19036.717	kN
Column dia	=	5000.000	mm
Foundation depth at face of pier	=	3000.000	mm
deff	=	2912.500	mm
a, dist. From periphery of the column to contro	=	1000.000	mm
Uo at column face	=	21991.149	mm
Area under perimeter	=	38.485	m2
Weight of footing under consider perimeter	=	2886.338	kN
Depth of Soil under consider perimeter	=	15.194	m
Weight of soil under cons. Perimeter	=	**8808.335**	kN
Total downward force	=	**11694.673**	kN
Upward force due to base pressure	=	18750.927	kN

Axial Load	=	19036.72	KN
Moment	=	56317.21	KNM
Stress	=	487.23	KN/m2

Depth at fa	=	3000.000
depth at de	=	2400
depth at 2 deff		1800

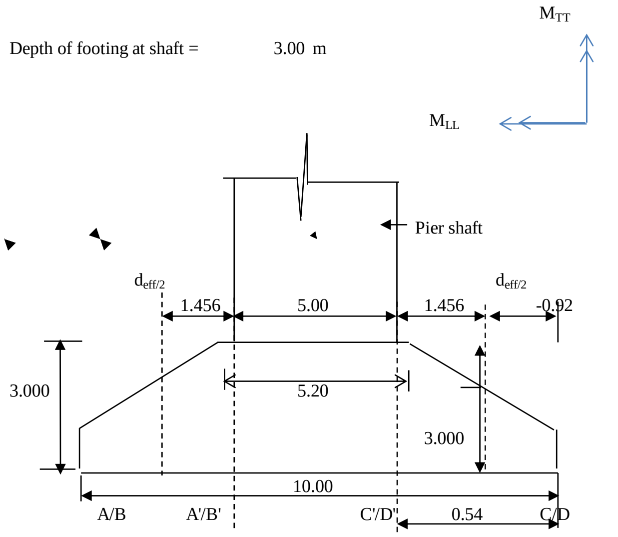
Net Shear Force	=	**11980.464**	kN
grade of concrete	=	35	Mpa
β	=	1.797	
Eccentricity	=	2958.347	mm
$v_{ED,red} = \beta V_{ED,red} / uo\ d$	=	**0.336**	Mpa
Concrete Shear capacity $V_{Rd} = [0.12K(80\rho_l.f_{ck})^{1/3}]2$	=	**1.579**	Mpa
K = 1+sqrt(200/d) <=2	=	1.262	
$v_{min} = 0.031K \wedge 1.5\ f_{ck}^{0.5}$	=	0.260	Mpa
Area of steel A1=sqrt(Ax x Ay)	=	4588.590	
A1/b/d	=	0.002	
$\rho_l = A_t / bd <= 0.02$	=	0.002	
Checks	=	**OK**	
Shear Resistance (At control perimeter d)			
Control perimeter distance , a	=	2500.000	mm
Axial Force at the base of column	=	19036.717	kN
Pier Diameter	=	5000.000	mm
Foundation depth at deff	=	1750.000	mm
deff at control perimeter	=	1662.500	mm
Uo at deff from column face	=	31415.927	mm
Area under perimeter	=	78.540	m2
Weight of footing under consider perimeter	=	**5890.486**	kN
Depth of Soil under consider perimeter	=	15.194	m
Weight of soil under cons. Perimeter	=	**17976.193**	kN
Total downward force	=	**23866.679**	kN
Upward force due to base pressure	=	38267.197	kN
Net Shear Force	=	**4636.200**	kN
grade of concrete	=	35	Mpa

Location of control perimeter	distance from face of pier	depth of footing along Long	depth of footing along Trans	depth at control perimeter , d = (dx + dy)/2
face of pedestal	1000	3000	3000	3000
deff or extreme edge	2500	2500	1000	1750
2 deff or extreme edge	2500	2500	1000	1750

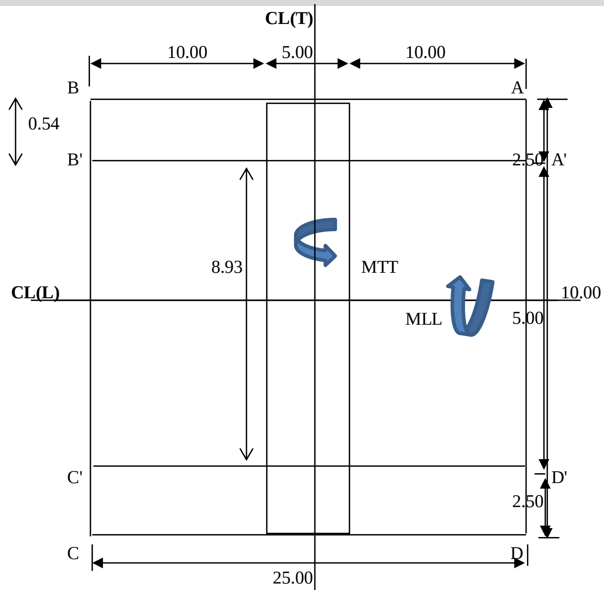
β = 1 + 0.6 pi (e + (D+4d))	=	1.558	
Eccentricity	=	2958.347	mm
$v_{ED,red} = \beta\ V_{ED,red} / uo\ d$	=	0.138	Mpa
Concrete Shear capacity $V_{Rd} = [\ 0.12K(80\rho_l.f_{ck})^{1/3}]2$	=	0.385	Mpa
K = 1+sqrt(200/d) <=2	=	1.347	
$v_{min} = 0.031K \wedge 1.5\ f_{ck}^{0.5}$	=	0.287	Mpa
$\rho_l = A_t / bd <= 0.02$	=	0.002	
Checks	=	**OK**	
Shear Resistance (At d to 2d)			
Control perimeter distance , a	=	2500.000	mm
Axial Force at the base of column	=	**19036.717**	kN
Moment at the base of column	=	**56317.214**	KNM
Pier Diameter	=	5000.000	mm
Foundation depth at face of pier	=	3000.000	mm
Eff depth at face of pier	=	2912.500	
Foundation depth at control perimeter	=	1750.000	mm
deff	=	1662.500	mm
$u_i = \pi(2a+\text{Dia of column})$ (critical)	=	31415.927	mm
Area under perimeter	=	78.540	m2
Weight of footing under consider perimeter	=	**5890.486**	kN
Depth of Soil under consider perimeter	=	15.194	m
Weight of soil under cons. Perimeter	=	**17976.193**	kN
Total downward force	=	23866.679	kN
Upward force due to base pressure	=	38267.197	kN
Net Shear Force	=	**4636.200**	kN
Eccentricity	=	2958.347	mm
β = 1 + 0.6 pi (e + (D+4d))	=	1.558	mm
Punching shear sress, $v_{Ed} = \beta V_{Ed} / u_i d$	=	0.159	Mpa
Concrete Shear capacity $V_{Rd} = [\ 0.12K(80\rho_l.f_{ck})^{1/3}]2$	=	0.385	Mpa
K = 1+sqrt(200/d) <=2	=	1.347	
$v_{min} = 0.031K \wedge 1.5\ f_{ck}^{0.5}$	=	0.287	Mpa
$\rho_l = A_t / bd <= 0.02$	=	0.002	
Checks	=	**OK**	

19B. DESIGN OF FOOTING TRANSVERSE DIRECTION

Depth of footing at shaft = 3.00 m



CROSS SECTION CL(TT) 1.091176471



PLAN SHOWING FOOTING

PROPERTIES OF BASE

Area = 25.00 x 10.00 = 250.00 m^2

I_{LL} = $\dfrac{25.00 \times 10.00^3}{12}$ + 250.00 X 0.00^2 = 2083.33 m^4

I_{TT} = $\dfrac{10.00 \times 25.00^3}{12}$ + 250.00 X 0.00^2 = 13020.83 m^4

COORDINATES OF BASE CORNERS

Edges	L(m)	T(m)
A	12.50	5.00
A'	12.50	4.46
B	-12.50	5.00
B'	-12.50	4.46
C	-12.50	-5.00
C'	-12.50	-4.46
D	12.50	-5.00
D'	12.5	-4.46

Base pressure = P/A ± M_{LL}* T/I_{LL} ± M_{TT}* L/ I_{TT}

DESIGN FORCES

Lc. No.	Descriptions	V(Tonne)	M_{TT} (Tm)	M_{LL}(Tm)
	ULS			
Normal				
LC - 1	ULS NORMAL MAX REACTION(70R +Class A)	12262.12	1086.61	135.49
LC - 2	ULS NORMAL SPAN DISLOGED	11897.91	768.35	0.00
LC - 5	ULS NORMAL MAX REACTION(70R)	3743.29	987.20	135.49
SEISMIC				
LC - 7	ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)	12180.51	7050.67	1932.41
LC - 8	ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z	11932.28	6041.95	1502.39
LC - 9	ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)	12180.51	2570.22	6432.01
LC - 10	ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z	11932.28	2384.37	5007.96
LC - 15	ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)	12180.51	7024.16	1932.41
LC - 16	ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)	12180.51	2543.70	6432.01
LC - 19	ULS NORMAL SV MAX REACTION	12278.75	679.68	47.78

Lc. No	Descriptions	Gross Base pressures at critical points (Tm^2)							
		A	A'	B'	B	D	D'	C'	C
	ULS								
LC - 1	ULS NORMAL MAX REACTION(70R +Class A)	50.42	50.38	48.30	48.33	49.77	49.80	47.72	47.68
LC - 2	ULS NORMAL SPAN DISLOGED	48.33	48.33	46.85	46.85	48.33	48.33	46.85	46.85

LC - 5	ULS NORMAL MAX REACTION(70R)	16.25	16.21	14.32	14.35	15.60	15.63	13.74	13.70
LC - 7	ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R + Class A)	60.13	59.63	46.09	46.59	50.85	51.35	37.81	37.32
LC - 8	ULS SPAN DISLODGED 1X + 0.3Y + 0.3Z	57.14	56.75	45.15	45.53	49.92	50.31	38.71	38.32
LC - 9	ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R +Class A)	66.63	64.97	60.04	61.69	35.75	37.41	32.47	30.82
LC - 10	ULS SPAN DISLODGED 0.3X + 1Y + 0.3Z	62.04	60.75	56.17	57.46	38.00	39.29	34.71	33.42
LC - 15	ULS MAX REACTION 1X + 0.3Y + 0.3Z(70R)	60.10	59.61	46.12	46.62	50.83	51.33	37.84	37.34
LC - 16	ULS MAX REACTION 0.3X + 1Y + 0.3Z(70R)	66.60	64.94	60.06	61.72	35.73	37.38	32.50	30.84
LC - 19	ULS NORMAL SV MAX REACTION	49.88	49.87	48.56	48.58	49.65	49.67	48.36	48.35

TRANSVERSE DIRECTION

Downward pressure due to overburden (T/m^2)

LWL Case	Location			Load factor ULS		HFL Case	Location			Load factor ULS	
	A'/B'	A/B					A'/B'	A/B			
Due to Earth filling	24.39	24.39		1.35		Due to Earth filling	24.39	24.39		1.35	
Footing	7.50	7.50		1.35		Footing	7.50	7.50		1.35	
Total ULS	**43.05**	**43.0488**				**Total ULS**	**43.0488**	**43.05**			

Calculation of forces for Design of Bottom Reinforcement in Longitudinal Direction											
Lc. No	**Net Base pressures at critical points**							**Design Forces**			
	A'	**B'**	**A**	**B**	**Avg along A'B'**	**Avg Along AD**	**$d_{eff/2}$**	**BM_{face}**	**SF_{face}**	**Bmdeff/2**	**Sfdeff/2**
ULS											
LC - 1	7.33	5.25	7.37	5.28	6.29	6.32	6.38	0.91	3.38	2.68	-5.84
LC - 2	5.28	3.81	5.28	3.81	4.54	4.54	4.54	0.65	2.44	1.92	-4.18
LC - 5	-26.84	-28.73	-26.80	-28.70	-13.42	-13.40	-13.37	-1.93	-7.19	-5.66	12.31
LC - 7	16.58	3.04	17.08	3.54	9.81	10.31	11.16	1.46	5.40	4.48	-9.88
LC - 8	13.70	2.10	14.09	2.49	7.90	8.29	8.95	1.17	4.34	3.60	-7.93
LC - 9	21.92	16.99	23.58	18.64	19.45	21.11	23.95	2.96	10.88	9.33	-20.72
LC - 10	17.70	13.12	18.99	14.41	15.41	16.70	18.91	2.34	8.61	7.37	-16.38
LC - 15	16.56	3.07	17.05	3.57	9.81	10.31	11.16	1.46	5.40	4.48	-9.88
LC - 16	21.90	17.01	23.55	18.67	19.45	21.11	23.95	2.96	10.88	9.33	-20.72
LC - 19	6.82	5.52	6.83	5.53	6.17	6.18	6.20	0.89	3.31	2.62	-5.69

SUMMARY OF DESIGN FORCES

		Face of support	At half of effective depth
Normal case			
Max design Bending moment	=	1 Tm/m	3 Tm/m
Max design Shear force	=	3 T/m	12 T/m
Seismic case			
Max design Bending moment	=	3 Tm/m	9 Tm/m
Max design Shear force	=	11 T/m	-8 T/m

DESIGN OF REINFORCEMENT IN TRANSVERSE DIRECTION (Perpendicular to Traffic direction)

Design Bending moment	M_{ED}	=	74.0 Tm
Total depth of section at face of support	D	=	3.000 m
Total depth of section at half of effective depth	d	=	3.000 m
Effective Width,	"beff"	=	7.500 m
Clear cover		=	75 mm
Diameter of reinforcement provided		=	25 mm
Effective depth of section at face of support	D'	=	2.913 m
Effective depth of section at D'/2 from face of support	d'	=	2.913 m
Grade of concrete	fck	=	35 Mpa
Grade of steel	fyk	=	500 Mpa

MAIN STEEL :

Ast = 5367 mm^2/m

Hence depth of Neutral axis X_u = $\frac{0.87 fykAst}{0.362 f_{ck}\, b}$

= 184 mm

Limiting depth of Neutral axis $\frac{X_{umax}}{D'}$ = $\frac{0.0035}{0.0035+0.87fyk/Es}$

= 0.617

X_{umax} = 1796 mm > 184 mm **Underreinforced**

Area of steel Calculated = $M_{ED}/(0.87 f_y (d-0.416 x_u))$ = 80 mm^2/m

f_{ctm} = 2.77 Mpa

deff = 2913 mm

Ast Minimum = Max of $0.26 . \frac{f_{ctm}}{f_{yk}} .b_t .d_{eff}$ $0.0013 .b_t .d_{eff}$ = 4197 mm^2/m

Ast Required = Max(80,4197) = **4197** mm^2/m

Provide 25 mm @ 150 c/c

\+ 20 mm @ 150 c/c ALTERNATE

= **5367** mm^2/m > **4197** mm^2/m **OK**

As per cl. 10.3.2 of IRC:112-2011 shear resistance of section i.e. Shear capacity

Design Shear force = 12.31 T/m

Vnet = 12.31 T/m

Max Shear Capacity of section

ν = 0.6 * (1- fck /310) */ fck in Mpa

= 0.532258

fcd = 0.447 *fck

= 15.63 Mpa

$V_{RDC, max}$ = 0.5 bw d ν fcd

= 1212 Tonne > 12.31 Tonne OK

V_{Rdc} = Max of $\left[0.12 K (80\, r1xfck)^{0.33} + 0.150 \times s_{cp}\right]$ $b_w \times d$

and $(u_{min} + 0.15\, s_{cp})\, b_w \times d$

Here

K = Min. of $1+\sqrt{200/d}$ Where d is depth in mm

and 2.0

r1 = Min. of $\frac{Asl}{b_w \times d}$ r1 = Reinforcement ratio for longitudinal reinforcement.

and 0.02

s_{cp} = (Mpa) Min. of N_{ed}/Ac s_{cp} = Compressive stress in the concrete from axial load or prestressing.

N_{ed} = design value of applied axial force.

and $0.20\, f_{cd}$ Ac= cross-sectional area of concrete

u_{min} = $0.031\, K^{3/2}\, fck^{1/2}$

In the above case

K = 1.3

r1 = 0.0018

s_{cp} = 0

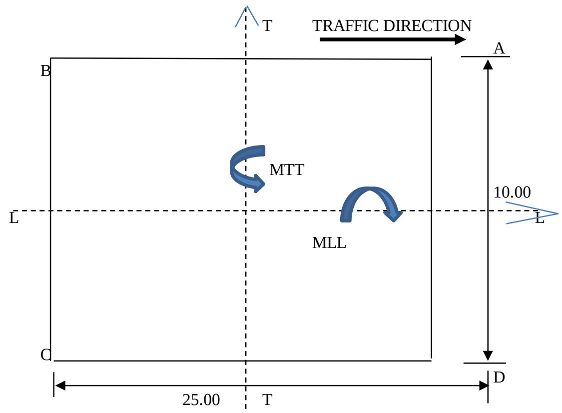
u_{min} = 0.2600

V_{Rdc} = Max of 758030 N or 75.80 t

and 757314 N or 75.73 t

Hence V_{Rdc}	=	**75.80 t**	Shear reinf not required
	>	**12.31 t**	

20. CHECK FOR BASE PRESSURE



Plan (showing footing dimensions)

PROPERTIES OF BASE

Area = 25.00 x 10.00 = 250.00 m^2

I_{LL} = $\frac{25.00 \times 10.00^3}{12}$ = 2083.33 m^4

I_{TT} = $\frac{10.00 \times 25.00^3}{12}$ = 13020.83 m^4

COORDINATES OF BASE CORNERS

Edges	L(m)	T(m)
A	12.50	5.00
B	-12.50	5.00
C	-12.50	-5.00
D	12.50	-5.00

SUMMARY OF FORCES

Base pressure = $P/A \pm M_{LL} * x/I_{LL} \pm M_{TT} * z / I_{TT}$

Sr. No.	Descriprion	Forces at founding levels			Base pressure at footing corners in T/m^2			
		V(Tonne)	M_{TT}(Tm)	M_{LL}(Tm)	A	B	C	D
LC -1	NORMAL MAX REACTION(70R+Class A)	9056.22	724.41	90.32	37.14	35.75	35.31	36.70
LC -2	NORMAL SPAN DISLOGED	8805.13	519.48	0.00	35.72	34.72	34.72	35.72
LC -6	SEISMIC SPAN DISLODGED 1X + 0.3Y + 0.3Z	8827.22	4282.24	948.13	41.70	33.47	28.92	37.14
LC -7	SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R + class A)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LC -8	SEISMIC LWL SPAN DISLODGED 0.3X + 1Y + 0.3Z	8827.22	1608.74	3160.44	44.44	41.35	26.18	29.27
LC -13	SEISMIC NORMAL MAX REACTION(70R)	9056.22	658.13	90.32	37.07	35.81	35.38	36.64
LC - 15	SEISMIC MAX REACTION 1X + 0.3Y + 0.3Z(70R)	9008.88	4890.61	1296.57	43.84	34.45	28.23	37.62
LC - 16	SEISMIC MAX REACTION 0.3X + 1Y + 0.3Z(70R)	9008.88	1903.64	4312.55	48.21	44.56	23.86	27.51
LC - 18	NORMAL SV MAX REACTION	9120.40	499.57	47.78	37.08	36.12	35.89	36.85

Sr. No.	Average pressure along BC	Average pressure along AD	Average pressure along AB	Average pressure along CD	Effective Length along TT	Effective Width along LL	Effective Area	I_{LL}	I_{TT}
	T/m2	T/m2	T/m2	T/m2	m	m	m^2	m^4	m^4
LC -1	35.53	36.92	36.44	36.01	10.00	25.00	250.00	2083.33	13020.83
LC -2	34.72	35.72	35.22	35.22	10.00	25.00	250.00	2083.33	13020.83
LC -6	31.20	39.42	37.58	33.03	10.00	25.00	250.00	2083.33	13020.83
LC -8	33.76	36.85	42.89	27.72	10.00	25.00	250.00	2083.33	13020.83
LC -13	35.59	36.86	36.44	36.01	10.00	25.00	250.00	2083.33	13020.83
LC -15	31.34	40.73	39.15	32.92	10.00	25.00	250.00	2083.33	13020.83
LC -16	34.21	37.86	46.39	25.69	10.00	25.00	250.00	2083.33	13020.83
LC -18	36.00	36.96	36.60	36.37	10.00	25.00	250.00	2083.33	13020.83

Sr. No.	M_{TT}	M_{LL}	A'	B'	C'	D'	Base Pressure(T/m^2)			
							A'	B'	C'	D'

DESIGN OF COUNTER FORT TYPE ABUTMENT (A2) WITH OPEN FOUNDATION

FOR ROTARY (LHS) AT CH:- 29+458

INDEX

Details of Superstructure:

Skew Angle of Bridge	=	0	Degree	=	0.000 Radians	COS θ =	1.000
						SIN θ =	0.000

Radius of Curvature of Superstructure	=	0	m	
Design speed of vehicle	=	100	kmph	
		Right Dimensions	**Skew Dimensions**	
Span -c/c of Brg.	=	11.500m	11.500m	
Thickness of Expansion Joint	=	0.020m	0.020m	
Slab projection Beyond C/L of Bearing (Back Side)	=	0.480m	0.480m	
Slab projection Beyond C/L of Bearing (Span Side)	=	0.000m	0.000m	
Span -c/c of E.J.	=	12.000m	12.00m	
Type of Superstructure	=	RCC SOLID SLAB		
Width of Crash barrier (Both Side)	=	0.500m		
Width of Carriageway	=	11.000m		
Projection beyond crash barrier	=	0.000m		
Thickness of Wearing coat	=	0.065m		
Length of Approach Slab (Right)	=	3.500m	3.500m	
Width of Footpath on both side	=	1.500m		
Railing/kerb on footpath edge	=	0.000m		
Total Width of Superstructure	=	13.500m		
Median Width minus 20mm gap	=	0.000m		

Bearings

Type of Bearing	=	Tar Paper Bearing		
Coeff. Of Friction for POT-PTFE Bearing	=	0.5		
Type of Soil	=	2	Medium Soil Strata	
NBC of soil -Normal Case	=	350	kN/m^2	(as per geotechnical report with ground improvement)
SBC of soil-Normal Case	=	399	kN/m^2	
SBC of soil-Seismic Case	=	499	kN/m^2	
Coeff. of friction between concrete and soil	=	0.7	for weathered rock	
Permissible FOS against Sliding	=	1.5	Normal Case	
	=	1.25	Seismic Case	
Permissible FOS against Overturning	=	2	Normal Case	
	=	1.5	Seismic Case	

Dirt Wall		**Right Dimensions**	**Skew Dimensions**
Width of Dirt wall at Top	=	0.300m	0.300m
Width of Dirt wall at Bottom	=	0.300m	0.300m
Height of Uniform portion	=	1.265m	
Height of Tapering portion	=	-0.155m	
Length of Dirt Wall at top (Uniform portion)	=	13.500m	13.500m
Length of Dirt Wall at bottom (Tapering Portion)	=	13.500m	13.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	1.600m	1.600m
Width of Abutmentcap at bottom of Tapering Portion	=	1.000m	1.000m

Projection of Abutment Cap (Span Side)	=	0.300m	0.300m
Projection of Abutment Cap Back Side	=	0.300m	0.300m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	13.500m	13.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	13.500m	13.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	13.500m	13.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.066m	1.066m
Thickness of Abutment shaft at Bottom	=	1.200m	1.200m

Solid Return Wall

Length of Return wall	=	4.500m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	0.500m

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m
Height of wall at abutment	=	0.000m
Length of Return wall	=	0.000m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	0.500m

Foundation

Along Traffic Direction:

Total Width of Footing	=	9.000m
abutment pedestal width	=	1.200m
abutment pedestal Height	=	1.500m
Width of Toe Slab	=	3.300m
Width of Heel Slab	=	4.500m
Thickness of Toe slab at tip	=	0.600m
Thickness of Toe slab near shaft	=	0.900m
Thickness of heel slab at tip	=	0.600m
Thickness of heel slab near shaft	=	0.900m
Width of backfill on heel slab	=	4.500m
Thickness of heel slab at back fill edge	=	0.900m
Height of back fill at bottom edge of heel slab	=	9.464m
Height of back fill at back fill edge of heel slab	=	9.164m

Across Traffic Direction:

Width of foundation -Uniform portion	=	13.500m (skew dimension)
Width of foundation -Tapering portion	=	13.500m (skew dimension)

Levels

Deck Level at Median Edge=	**1178.400m**	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	**1178.088m**	Height of Superstructure	=	0.900m
Deck level at center line =	1178.400m	Min. Height of Footpath Side Pedestal (1)	=	0.300m
Soffit Level at center of bridge =	1177.435m	Height of Pedestal (2)	=	0.300m
Abutment cap top level =	1177.134m	Height of Pedestal (3)	=	0.300m
Abutment cap bottom lvl (uniform portion ends	1176.834m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lvl (corbel portion ends)	1176.534m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1176.534m	Height (Avg.) of Dirt Wall	=	1.110m
Ground level/LBL =	1173.090m	Abutment shaft Above G.L	=	3.444m

Abutment shaft bottom level =	1169.080m	Abutment Shaft below G.L	=	4.010m
Foundation level =	1168.180m	Height of abutment shaft	=	7.454m
HFL	1174.090m	MSL	=	1173.090m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M	35	
Characteristic compressive strength of concrete,fck	=	35.00	Mpa at 28 days	
Design Compressive strength of Concrete, fcd	=	15.63	Mpa at 28 (	(0.67/1.5 * fck)
Tensile strength of concrete , fctm	=	2.77	MPa	
Strain at reaching Characteistic Strength, εc2	=	0.02		
Ultimate Strain, εcu2	=	0.035		
Ecm	=	32308.250	N/mm^2	
Steel Grade	=	Fe	500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500	Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78	Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00	Mpa	
Dry weight of Concrete	=	25	kN/m^3	
Dry unit weight of soil	=	20	kN/m^3	
Permissible Crack Width	=	0.3	mm - For Moderrate/ severe Exposure Condition	
Maximum compressive stress in concrete under rare combination	=	0.48 fck		
	=	16.8	N/mm^2	
Maximum tensile stress in steel under rare combination	=	300	N/mm^2	

Creep Coefficient

For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data: NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone		=	4	
Z	=Zone factor	=	0.24	
I	=Importance factor	=	1.2	
R	=Response Reduction factor	=	3	in Longitudinal direction
		=	1	In Transverse direction

Properties of backfill material :

c	=	0
φ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

Self weight of Slab	=	0.90	x	12.00	x	13.50	x	25.00
	=	3645.00	KN					
Reaction at one end	=	1822.50	KN					
Transverse Eccentricity	=	0.000	m					

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier	=	2	x	8.00	x	12.00
	=	192.00	KN			
Reaction at one end	=	96.00	KN			
Transverse Eccentricity	=	0.00	m			

Reaction Due to Wearing Course only

Weight due to Wearing Coat	=	2.2	x	12	x	13.5
	=	356.4	KN			
Reaction at one end	=	178.2	KN			
Transverse Eccentricity	=	0.00	m			

Carriageway Live Load Reactions

Reduction Factor = **0.9** (for 3 Lane)

Congestion factor = **1** (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:

1- 70RW + 2-CLASS A

Max CWLL

Vertical	Transverse ecc
957.51	1.95

Min CWLL

Vertical	Transverse ecc
441.09	2.63

SV Loading

Max CWLL

Vertical	Transverse ecc
782.61	0.30

Min CWLL

Vertical	Transverse ecc
657.39	0.30

MAXIMUM TRASVERSE MOMENT CASE:

1- 70RW + 2-CLASS A

Max CWLL

Vertical	Transverse ecc
536.57	3.66

Min CWLL

Vertical	Transverse ecc
441.09	2.63

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.129
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for Cl A Wheeled loading

Impact Factor upto abut. cap	=	1.129
Impact Factor for Abut. Shaft Base	=	1.000

VOLUME CALCULATION

C.G. Of Footing = 4.500 m
C.G. Of shaft from toe tip = 3.900 m
Distance between c.g. of shaft and footing = 0.600 m

Description		No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
			m	m	m	m^3	m	m	m	
Dirt Wal -Uniform portion		1	13.50	0.300	1.265	5.123	-0.650	-0.050	-4.550	0.000
-Trapering portion		1	13.50	0.300	-0.155	-0.629	-0.650	-0.050	-4.550	0.000
Bracket (Rectangle)		1	13.50	0.300	0.300	1.215	-0.950	-0.350	-4.850	0.000
(Corbel)	0.5	1	13.50	0.300	0.300	0.608	-0.900	-0.300	-4.800	0.000
Cap (uniform portion)		1	13.50	1.600	0.300	6.480	0.000	0.600	-3.900	0.000
Cap (Corbel Portion)		1	13.50	1.600	0.300	5.218	0.000	0.600	-3.900	0.000
			13.50	1.000						
Shaft above HFL		1	13.50	1.033	2.444	34.076	0.083	0.683	-3.817	0.000
Shaft below HFL		1	13.50	1.133	4.410	67.441	0.033	0.633	-3.867	0.000
Solid Return Wall		2	4.50	0.500	9.470	42.615	-2.850	-2.250	-6.750	0.000
Cantilever Return wall(Rectangular portion)		2	0.00	0.500	0.000	0.000	-0.600	0.000	-4.500	0.000
Cantilever Return wall(Traingular portion)		2	0.00	0.500	0.000	0.000	-0.600	0.000	-4.500	0.000
Footing										
Heel Slab		1	13.50	4.500	0.750	45.563		-2.100	-6.600	0.000
Toe Slab		1	13.50	3.300	0.750	33.413		2.740	-1.760	0.000
Portion between Heel and Toe		1	13.50	1.200	0.900	14.580		0.600	-3.900	0.000
Back filling above HFL over Heel Slab		1	13.50	4.500	4.310	261.833		-2.250	-6.750	0.000
Back filling below HFL over Heel Slab		1	13.50	4.500	5.160	313.470		-2.272	-6.772	0.000
Backfill above Heel slab		1	13.50	4.500	9.314	565.810		-2.262	-6.762	0.000
Front Filling over Toe Slab		1	13.50	3.300	4.160	185.328		2.830	-1.670	0.000
Side filling between heel and toe		1	0.00	1.200	4.160	0.000		0.000	0.000	0.000
Aproach Slab		1	13.500	1.750	0.300	7.088	-0.950	-0.350	-4.850	0.000
Back fill above HFL on flared portion of stem		1	13.50	0.066	4.310	3.816		0.085	-4.415	0.000
Back fill below HFL on flared portion of stem		1	13.50	0.134	5.160	9.364		0.045	-4.455	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Bai	2	8 kN/m	1.750	28.00kN		-0.650	-0.050	-4.550

SECTIONAL PROPERTIES

Width of Footing (B) = 9 m
Length of Footing (L) = 13.500 m

A = 9.000 x 13.500 = 121.500 m^2
ZL = 13.500 x 13.500 = 182.250 m^3
ZT = $\frac{IT1 + IT2}{\text{distance of extreme point from centre}}$

IT1 = 9.000 x 205.031 = 1845.28 m^4
IT2 (moment of inertia of triangle) = 9.000 x 0.000 + 0.500 x 9.000 x 0.000 x 45.563
from centre of footing = 0.000 m^4

Moment of inertia of two triangle = 0.000 m^4

Total moment of inertia = 1845.28 m^4

Distance of extreme point from centre of footing = 6.750 + 0.000 = 6.750 m

Total Section modulus (ZT) = 273.375 m^3

Load Factors (As per IRC:6-2014)

Table 3.1 Partial Safety Factor For Verification of Equilibrium

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Laod,SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Servicibilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone 4.0

Feq	=	Seismic forces to be resisted
Feq	=	Ah x (Dead load + Appropriate Live load)
Ah	=	horizontal seismic coefficient

$$= \frac{\frac{Z}{2}\;\frac{Sa}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.24	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \left(\frac{D}{1000F}\right)^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 9.254 m

C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 10.098 m

Abutment Cap Top Level - Foundation Level
= 8.954 m

Dimensions of Abutment Shaft

Length	=	13.50	m
Width	=	1.10	m
Moment of Inertia , $I_{longitudinal}$	=	1.497	m^4
Moment of Inertia , $I_{transverse}$	=	225.534	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction				**Transverse Direction**			
Force	=	96.247	KN	Force	=	12776.704	KN
D	=	2096.70	KN	D	=	2376.420	KN
T	=	0.2952	sec	T	=	0.0273	sec

Medium Soil Strata

Sa/g	=	2.5	Sa/g	=	2.5

Seismic Coeff. In Longitudinal Direction = 0.12

Seismic Coeff. In Transverse Direction = 0.36

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.120	In Longitudinal direction
Ah	=	0.360	In Transverse direction
Av	=	0.240	In Vertical direction

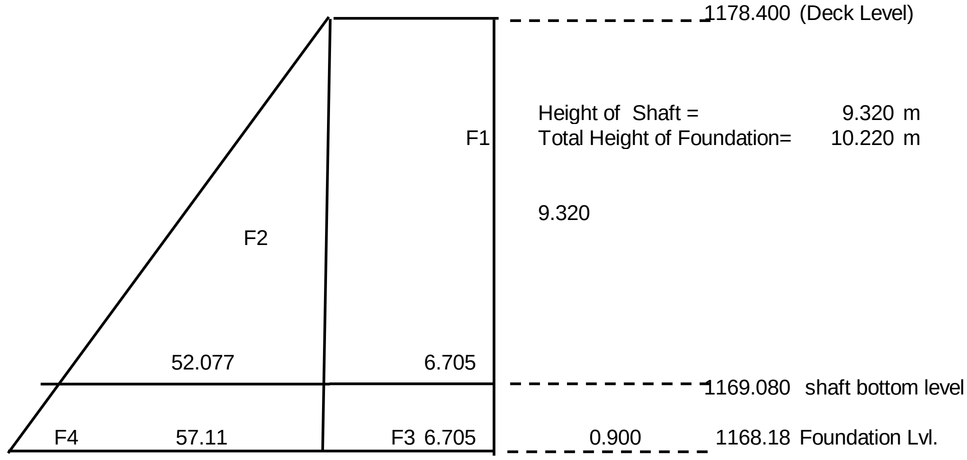
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2014,Clause No. 219.8)

Ah	=	0.162	In Longitudinal direction
Ah	=	0.360	In Transverse direction
Av	=	0.240	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :	c	=	0		
	ϕ	=	30 degree	0.524	radians
	θ	=	90.00 degree	1.571	radians
	$\theta 1$	=	90.00 degree	1.571	radians
	β	=	0	0	radians
	δ	=	20.0 degree	0.349	radians
	Kah	=	0.279 active component		
	Kph	=	3.766 Passive component		
	γ	=	20 kN/m^3		

Equivalent Live Load Surcharge height = 1.2 m
Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL 1169.080 m (at Shaft Base)
@ RL 1168.180 m (at Foundation Level)

Due to Live Load Surcharge

Intensity for rectangular portion	=	0.279	x	20	x	1.2	=	6.705 kN/m^2		
F1	=	6.705	x	9.320	x	13.500	=	**843.649 kN**		
M1	=	843.65	x	4.66	=	**3931.405**	**kN.m**	**at Shaft Bottom**		
F3	=	6.705	x	10.220	x	13.500	=	**925.117 kN**		
M3	=	925.117	x	5.110	=	**4727.350**	**kN.m**	**at Foundation**		

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

	=	0.279	x	20	x	9.320	=	52.077 kN/m^2
F2	=	0.5	x	52.08	x	9.320	x	13.50
	=	**3276.171 kN**						

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)

M2	=	3276.17	x	3.91	=	**12824.244**	**kN.m**	**at Shaft Bottom**

Intensity for triangular portion (At Foundation level)

	=	0.279	x	20	x	10.220	=	57.106 kN/m^2
F4	=	0.5	x	57.11	x	10.220	x	13.50
	=	**3939.458 kN**						
M4	=	3939.46	x	4.29	=	**16909.732**	**kN.m**	**at Foundation**

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m^3

Intensity for triangular portion (At Shaft bottom level)
= 4.800 x 9.320 = 44.736 kN/m^2

F = 0.5 x 44.736 x 9.320 x 13.500
= **2814.342 kN**

M = 2814.34 x 3.107 = **8743.222 kN.m** **at Shaft Bottom**

Intensity for triangular portion (At Foundation level)
= 4.800 x 10.220 = 49.06 kN/m^2

F = 0.5 x 49.056 x 10.22 x 13.500
= **3384.128 kN**

M = 3384.13 x 3.407 = **11528.597 kN.m** **at Foundation**

Intensity of Passive pressure
= 3.766 x 20 x 0.000 = 0.000 kN/m^2
Force due to passive @ Foundation, F
= 0.5 x 0.000 x 0.000 x 13.50
= **0.000 kN**

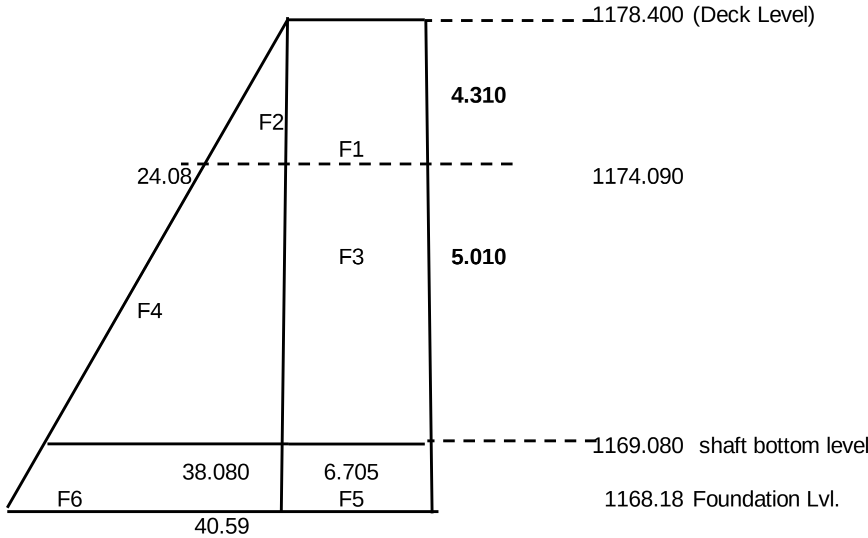
Moment due to passive @ Foundation, M
= 0.000 x 0.000 = **0.000 kN.m** **at Foundation**

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl kN	At Foundation Lvl kN
Due to active Earth Pressure	12824.244	16909.732	3276.171	3939.458
Due to Minimum Fluid Pressure	8743.222	11528.597	2814.342	3384.128
Governing of Two	**12824.244**	**16909.732**	**3276.171**	**3939.458**
Due to Live Load Surcharge	**3931.405**	**4727.350**	**843.649**	**925.117**
Due to Passive pressure		**0.000**		**0.000**

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0		
	ϕ	=	30 degree	0.524	radians
	θ	=	90.00 degree	1.571	radians
	β	=	0	0	radians
	δ	=	20.0 degree	0.349	radians
	Kah	=	0.279 active component		
	Kph	=	3.766 passive component		
	γd	=	20 kN/m^3		
	γwater	=	10 kN/m^3		
Equivalent Live Load Surcharge height Assuming		=	1.2 m		



Earth Pressure Diagram

Horizontal Forces and Moments @ RL 1169.1 m (at Shaft Base)

Due to Live Load Surcharge

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m^2	
F1	=	6.705	x	9.320	x	13.500	=	**843.649 kN**	
M1	=	843.65	x	4.66	=	**3931.405 kN.m**		**at Shaft Bottom**	
F3	=	6.705	x	10.220	x	13.500	=	**925.117 kN**	
M3	=	925.12	x	5.11	=	**4727.350 kN.m**		**at Foundation Level**	

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	4.310	=	24.083 kN/m^2
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	5.010	=	13.997 kN/m^2
F2	=	0.5	x	24.08	x	4.310	x	13.50
	=	**700.631 kN**						
F4	=	(24.08 +		38.08)	x	5.01	x	13.50

2

= **2102.192 kN**

Total Force = 2802.823 kN

M2 = 700.63 x 6.82 = **4778.443 kN.m**

M4 = 2102.19 x 2.32 = **4870.747 kN.m**

Total Mome = 9649.19 kN.m at Shaft Bottom

Intensity for triangular portion

Upto HFL = 0.279 x 20 x 4.310 = 24.083 kN/m^2

at Foundation = 0.279 x 10 x 5.910 = 16.512 kN/m^2

F2 = 0.5 x 24.08 x 4.310 x 13.50
= **700.631 kN**

F6 = $\frac{(24.08 + 40.59) \ \text{x}}{2}$ 5.91 x 13.50

= **2580.140 kN**

Total Force = 3280.771 kN

M2 = 700.63 x 7.72 = **5409.011 kN.m**

M6 = 2580.14 x 2.70 = **6975.505 kN.m**

Total Mome = 12384.52 kN.m Foundation Lvl.

Intensity of Passive pressure:
= 3.766 x 10 x 0.00 = 0.000 kN/m^2
Force due to passive @ Foundation, F
= 0.5 x 0.000 x 0.00 x 13.50
= **0.000 kN**

Moment due to passive @ Foundation, M
= 0.000 x 0.000 = **0.000 kN.m** **Foundation Lvl.**

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	9649.190	12384.516	2802.823	3280.771
Due to Minimum Fluid Pressure	8743.222	11528.597	2814.342	3384.128
Governing of Two	**9649.190**	**12384.516**	**2814.342**	**3384.128**
Due to Live Load Surcharge	**3931.405**	**4727.350**	**843.649**	**925.117**
Due to Passive pressure		**0.000**		**0.000**

Earth Pressure : Seismic Dry Case

As per Clause 219.5.4 , IRC:6-2014

Seismic Zone =	4.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha)\cos\delta \qquad (1 \pm \alpha v)}{\cos^2\alpha\cos(\alpha+\delta+\lambda)\cos\lambda\,[1+\mathrm{sqrt}(\sin(\phi+\delta)\sin(\phi-\beta-\lambda)/(\cos(\alpha+\delta+\lambda)\cos(\alpha-\beta)))]^2}$$

α h	=	0.120	
α v	=	0.240	
ϕ	=	30.00	0.524
δ	=	20.00	0.349
α	=	0.00	0.000
β	=	0.00	0.000

α h	=	HORIZONTAL SEISMIC COEFFICIENT
α v	=	VERTICAL SEISMIC COEFFICIENT
ϕ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

$$\lambda = \tan^{-1}\frac{\alpha\ h}{(1 \pm \alpha\ v)} = \begin{matrix}0.096\\0.157\end{matrix}$$

		1	2
C_a	=	0.423	0.296

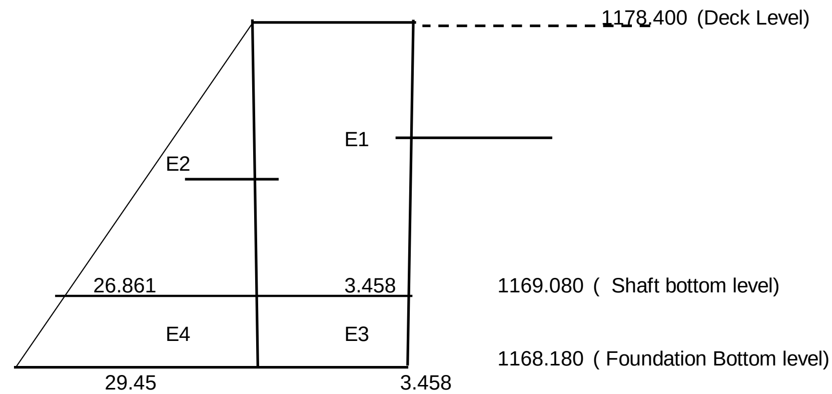
Ca	=	0.423		
Ka	=	**0.279**		
Dynamic Increment	=	0.423	-0.279	**0.144**

3 Earth Pressure : **DRY CASE (Seismic case)**

Equivalent Live Load Surcharge height = 1.2 m

Assuming γdry = 20 kN/m^3

γwater = 10.00 kN/m^3



Earth Pressure Diagram for Dynamic Increment

Horizontal Forces and Moments @ RL **1169.1 m (at Shaft Base)**
1168.2 m (at Foundation Bottom Level)

Due to Dynamic Live Load Surcharge

	=	0.144	x	20	x	1.2	=	3.458	kN/m^2
at Shaft Bottom Level									
E1	=	3.458	x	9.320	x	13.500	=	**435.141**	kN
M1	=	435.141	x	6.244			=	**2717.194**	kN.m
at Foundation Bottom Level									
E3	=	3.458	x	10.220	x	13.500	=	**477.161**	kN

M3	=	477.161	x	6.847				=	**3267.312**	kN.m

<u>Due to Dynamic Active Earth Pressure</u>

(At Shaft bottom level)

= 0.144 x 20 x 9.320 = 26.861 kN/m^2

(at Foundation Bottom Level)

= 0.144 x 20 x 10.220 = 29.454 kN/m^2

E2 = 0.50 x 26.86 x 9.32 x 13.500

= **1689.797** kN

E4 = 0.50 x 29.45 x 10.22 x 13.500

= **2031.910** kN

M2 = 1689.80 x 4.66 = **7874.454** kN.m **(Shaft bottom level)**

M4 = 2031.91 x 5.11 = **10383.061** kN.m **(Foundation Bottom level)**

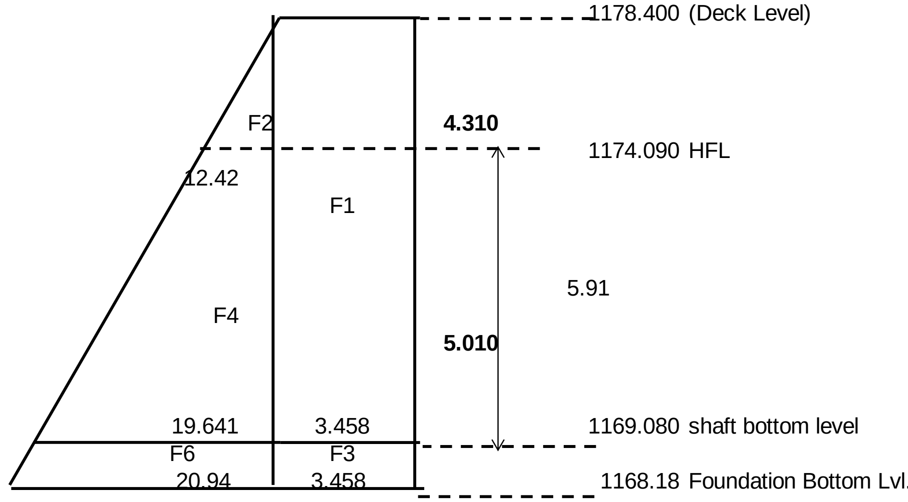
Summary of Moment and Horizontal Force **Dry Seismic Case**

	MOMENTS		**HORIZONTAL FORCE**	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	12824.244	16909.732	3276.171	3939.458
Due to active Earth Pressure (dynamic Increment)	7874.454	10383.061	1689.797	2031.910
Total Earth Pressure	20698.698	27292.792	4965.968	5971.369
Due to Minimum Fluid Pressure	8743.222	11528.597	2814.342	3384.128
Governing of Two	**12824.244**	**27292.792**	**4965.968**	**5971.369**
Due to Live Load Surcharge (Static)	**3931.405**	**4727.350**	**843.649**	**925.117**
Due to Live Load Surcharge(Dynamic)	**2717.194**	**3267.312**	**435.141**	**477.161**
Due to Passive pressure		**0.000**		**0.000**

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.144
γd	=	20 kN/m³
γwater	=	10 kN/m³
Equivalent Live Load Surcharge height	=	1.2 m

Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL **1169.080 m (at Shaft Base)**
1168.180 m (at Foundation Bottom Level)

Due to Live Load Surcharge

Intensity for rectangular portion	=	0.144	x	20	x	1.200	=	3.458 kN/m²
at Shaft Bottom Level								
F1	=	3.458	x	9.320	x	13.500	=	**435.141 kN**
M1	=	435.14	x	6.15	=	**2676.638 kN.m**		
at Foundation Bottom Level								
F3	=	3.458	x	10.220	x	13.500	=	**477.161 kN**
M3	=	477.16	x	6.75	=	**3218.546 kN.m**		

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.144	x	20	x	4.310	=	12.422 kN/m²
(At Shaft bottom level) Below HFL	=	0.144	x	10	x	5.010	=	7.219 kN/m²
(At Foundatic bottom level) Below HFL	=	0.144	x	10	x	5.910	=	8.516 kN/m²
F2	=	0.5	x	12.42	x	4.31	x	13.50
	=	**361.374 kN**						

$$F4 = \frac{(12.42 + 19.64)}{2} \times 5.01 \times 13.50$$

= **1084.278 kN**

$$F6 = \frac{(12.42 + 20.94)}{} \times 5.91 \times 13.50$$

2

= **1330.795 kN**

Total Force (F2 + F4)	**=**	**1445.652**	**kN**	**at Shaft Bottom Level**
Total Force (F2 + F6)	**=**	**1692.169**	**kN**	**at Foundation Bottom Level**

M2	=	361.37	x	7.16	=	**2589.247 kN.m**
M4	=	1084.28	x	2.32	=	**2512.254 kN.m**
Total Mome =		**5101.501 kN.m**		**at Shaft Bottom**		
M2	=	361.37	x	8.06	=	**2914.484 kN.m**
M6	=	1330.80	x	2.70	=	**3597.855 kN.m**
Total Mome =		**6512.338 kN.m**		**at Foundation Bottom Level**		

Summary of Moment and Horizontal Force

	MOMENTS		**HORIZONTAL FORCE**	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundation Bottom Lvl kN
Due to active Earth Pressure(Static)	9649.190	12384.516	2802.823	3280.771
Due to active Earth Pressure (Dynamic Increment)	5101.501	6512.338	1445.652	1692.169
Total Earth Pressure	14750.690	18896.854	4248.475	4972.940
Due to Minimum Fluid Pressure	8743.222	11528.597	2814.342	3384.128
Governing of Two	**14750.690**	**18896.854**	**4248.475**	**4972.940**
Due to Live Load Surcharge(Static	**3931.405**	**4727.350**	**843.649**	**925.117**
Due to Live Load Surcharge (Dynamic Increment)	**2676.638**	**3218.546**	**435.141**	**477.161**
Due to passive pressure		**0.000**		**0.000**

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1822.50	1.35	1.35	2460.38	2460.38	
SIDL except wc	=	96.00	1.35	1.35	129.60	129.60	
WC	=	178.20	1.75	1.75	311.85	311.85	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax-Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

Braking Force = 0.2 x 1000 + 0.05 x 554

= 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	µ R	Max (Fh/2 or µR)		
DL+SIDL	2901.83	0	1450.913	1450.913		
DL+SIDL+LL-Max Reaction case	2901.83	341.55	1450.913	1450.913	1- 70RW + 2-CLASS A	Dry Case
	2901.83	0	1450.913	1450.913	SV Loading	
DL+SIDL+LL-Min Reaction case	2901.83	341.55	1450.913	1450.913	1- 70RW + 2-CLASS A	HFL Case
	2901.83	0	1450.913	1450.913	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2901.83	341.55	1450.913	1450.913		

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	µ R	Max (Fh/2 or µR)	
DL+SIDL	2096.70	2901.83	754.81	1450.913	1450.913	
DL+SIDL+LL-Max Reaction case		2901.83	800.35	1450.913	1450.913	Dry Case
DL+SIDL+LL-Min Reaction case		2901.83	800.35	1450.913	1450.913	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2901.83	800.35	1450.913	1450.913	

Transverse Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	µ R	Max (Fh/2 or µR)	
DL+SIDL	2096.70	2901.83	226.444	1450.913	1450.913	
DL+SIDL+LL-Max Reaction case		2901.83	271.984	1450.913	1450.913	Dry Case

DL+SIDL+LL-Min Reaction case		2901.83	271.984	1450.913	1450.913	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2901.83	271.984	1450.913	1450.913	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1822.50	1.35	1.35	2460.38	2460.38
SIDL except wc	=	96.00	1.35	1.35	129.60	129.60
WC	=	178.20	1.75	1.75	311.85	311.85
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)		
DL+SIDL	2901.83	0.000	1450.913	1450.913		
DL+SIDL+LL-Max Reaction case	2901.83	341.550	1450.913	1450.913	1- 70RW + 2-CLASS A	Dry Case
	2901.83	0.000	1450.913	1450.913	SV Loading	
DL+SIDL+LL-Min Reaction case	2901.83	341.550	1450.913	1450.913	1- 70RW + 2-CLASS A	HFL Case
	2901.83	0.000	1450.913	1450.913	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2901.83	341.550	1450.913	1450.913		

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	2901.83	1019.00	1450.913	1450.913	
DL+SIDL+LL-Max Reaction case		2901.83	1064.54	1450.913	1450.913	Dry Case
DL+SIDL+LL-Min Reaction case		2901.83	1064.54	1450.913	1450.913	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2901.83	1064.54	1450.913	1450.913	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	2901.83	305.699	1450.913	1450.913	
DL+SIDL+LL-Max Reaction case		2901.83	351.239	1450.913	1450.913	Dry Case

DL+SIDL+LL-Min Reaction case		2901.83	351.239	1450.913	1450.913	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2901.83	351.239	1450.913	1450.913	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1822.50	1	1.00	1822.50	1822.50
SIDL except wc	=	96.00	1	1.00	96.00	96.00
WC	=	178.20	1	1.00	178.20	178.20
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)		
DL+SIDL	2096.70	0.000	1048.350	1048.350		
DL+SIDL+LL-Max Reaction case	2096.70	227.700	1048.350	1048.350	1- 70RW + 2-CLASS A	Dry Case
	2096.70	0.000	1048.350	1048.350	SV Loading	
DL+SIDL+LL-Min Reaction case	2096.70	227.700	1048.350	1048.350	1- 70RW + 2-CLASS A	HFL Case
	2096.70	0.000	1048.350	1048.350	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2096.70	227.700	1048.350	1048.350		

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	679.331	1048.350	1048.350	
DL+SIDL+LL-Max Reaction case	2096.70	724.871	1048.350	1048.350	Dry Case
DL+SIDL+LL-Min Reaction case	2096.70	724.871	1048.350	1048.350	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2096.70	724.871	1048.350	1048.350	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	203.799	1048.350	1048.350	
DL+SIDL+LL-Max Reaction case	2096.70	249.339	1048.350	1048.350	Dry Case

DL+SIDL+LL-Min Reaction case	2096.70	249.339	1048.350	1048.350	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2096.70	249.339	1048.350	1048.350	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1822.50	1.05	1.05	1913.63	1913.63
SIDL except wc	=	96.00	1.05	1.05	100.80	100.80
WC	=	178.20	1.35	1.35	240.57	240.57
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)		
DL+SIDL	2255.00	0.000	1127.498	1127.498		
DL+SIDL+LL-Max Reaction case	2255.00	341.550	1127.498	1127.498	1- 70RW + 2-CLASS A	Dry Case
	2255.00	0.000	1127.498	1127.498	SV Loading	
DL+SIDL+LL-Min Reaction case	2255.00	341.550	1127.498	1127.498	1- 70RW + 2-CLASS A	HFL Case
	2255.00	0.000	1127.498	1127.498	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2255.00	341.550	1127.498	1127.498		

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	2255.00	1019.00	1127.498	1127.498	
DL+SIDL+LL-Max Reaction case		2255.00	1019.00	1127.498	1127.498	Dry Case
DL+SIDL+LL-Min Reaction case		2255.00	1019.00	1127.498	1127.498	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2255.00	1019.00	1127.498	1127.498	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	2255.00	305.699	1127.498	1127.498	
DL+SIDL+LL-Max Reaction case		2255.00	305.699	1127.498	1127.498	Dry Case
DL+SIDL+LL-Min Reaction case		2255.00	305.699	1127.498	1127.498	HFL Case

DL+SIDL+LL-Max Transv. Moment case		2255.00	305.699	1127.498	1127.498

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1822.50	1	1	1	1822.50	1822.50	1822.50
SIDL except wc	=	96.00	1	1	1	96.00	96.00	96.00
WC	=	178.20	1.20	1.20	1.20	213.84	213.84	213.84
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)		
DL+SIDL	2132.34	0.000	1066.170	1066.170		
DL+SIDL+LL-Max Reaction case	2132.34	227.700	1066.170	1066.170	1- 70RW + 2-CLASS A	Dry Case
	2132.34	0.000	1066.170	1066.170	SV Loading	
DL+SIDL+LL-Min Reaction case	2132.34	227.700	1066.170	1066.170	1- 70RW + 2-CLASS A	HFL Case
	2132.34	0.000	1066.170	1066.170	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2132.34	227.700	1066.170	1066.170		

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2132.34	0.000	1066.170	1066.170	
DL+SIDL+LL-Max Reaction case	2132.34	170.775	1066.170	1066.170	Dry Case
DL+SIDL+LL-Min Reaction case	2132.34	170.775	1066.170	1066.170	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2132.34	170.775	1066.170	1066.170	

Normal Case: Quasi Permenant Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2132.34	0.000	1066.170	1066.170	
DL+SIDL+LL-Max Reaction case	2132.34	0.000	1066.170	1066.170	Dry Case
DL+SIDL+LL-Min Reaction case	2132.34	0.000	1066.170	1066.170	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2132.34	0.000	1066.170	1066.170	

Centrifugal Force Calculation

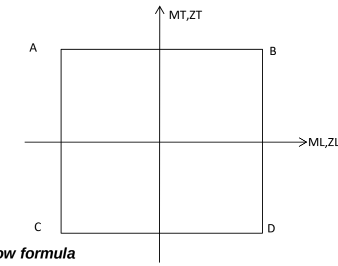
As per clause 212 of IRC:6-2014

CENTRIFUGAL FORCE C = $\frac{W V^2}{127 R}$

			Normal Case		Seismic Case	
Design Speed	V	=	100.00	kmph	100.00	kmph
Live Load	W	=	957.51	kN	957.51	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION

Foundation Lvl = 1168.180 m



Properties of Footing Base:

A	=	121.500	m^2
ZL	=	182.250	m^3
ZT	=	273.375	m^3

For Skew bridges, Resolve the moment due to braking force,Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	**ML = ML Cos θ + MT Sin θ**
Moment along transverse axis	**MT = MT Cos θ - ML Sin θ**

Case 1 : DL+SIDL-Normal Dry Case

Vertical Forces For SBC Calculation / **Vertical Forces For Restoring or Resisting Effect**

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
Superstructure												
Dead Load	1			1822.500	0.600	1093.500	0.000	0.000	0.950	1731.375	-3.900	-6752.363
SIDL except Wearing Course	1			96.000	0.600	57.600	0.000	0.000	0.950	91.200	-3.900	-355.680
Wearing Course	1			178.200	0.600	106.920	0.000	0.000	1.000	178.200	-3.900	-694.980
				2096.700		**1258.020**		**0.000**		**2000.775**		**-7803.023**
Substructure & Foundation -Portion 1												
Dirt Wall-Uniform portion	1	25	5.123	128.081	-0.050	-6.404	0.000	0.000	0.950	121.677	-4.550	-553.631
Dirt Wall-Tapered portion	1	25	-0.629	-15.719	-0.050	0.786	0.000	0.000	0.950	-14.933	-4.550	67.946
Bracket - Uniform portion	1	25	1.215	30.375	-0.350	-10.631	0.000	0.000	0.950	28.856	-4.850	-139.953
Bracket - Tapered portion	1	25	0.608	15.188	-0.300	-4.556	0.000	0.000	0.950	14.428	-4.800	-69.255
Cap - (uniform portion)	1	25	6.480	162.000	0.600	97.200	0.000	0.000	0.950	153.900	-3.900	-600.210
Cap - (corbel portion)	1	25	5.218	130.441	0.600	78.264	0.000	0.000	0.950	123.919	-3.900	-483.283
Cantilever Return Wall-Rectangle p	1	25	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.000	-4.500	0.000
Cantilever Return Wall-Traingle port	1	25	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.000	-4.500	0.000
RCC Railing or Crash Barrier	1			28.000	-0.050	-1.400	0.000	0.000	0.950	26.600	-4.550	-121.030
Aproach Slab	1	25	7.088	177.188	-0.350	-62.016	0.000	0.000	0.950	168.328	-4.850	-816.391
				655.553		**91.243**		**0.000**		**622.775**		**-2715.808**
Substructure & Foundation -Portion 2												
Solid Return wall	1	25	42.615	1065.375	-2.250	-2397.094	0.000	0.000	0.950	1012.106	-6.750	-6831.717
Abutment Shaft	1	25	101.516	2537.908	0.633	1606.347	0.000	0.000	0.950	2411.013	-3.867	-9323.527
Back filling over heel slab	1	20	565.810	11316.206	-2.262	-25598.152	0.000	0.000	0.950	10750.396	-6.762	-72695.026
Front Filling over toe slab	1	20	185.328	3706.560	2.830	10490.188	0.000	0.000	0.950	3521.232	-1.670	-5879.865
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.000	0.000	0.000
Heel slab	1	25	45.563	1139.063	-2.100	-2392.031	0.000	0.000	0.950	1082.109	-6.600	-7141.922
Toe slab	1	25	33.413	835.313	2.740	2288.756	0.000	0.000	0.950	793.547	-1.760	-1396.643
portion between heel & toe	1	25	14.580	364.500	0.600	218.700	0.000	0.000	0.950	346.275	-3.900	-1350.473
Vertical Components of active earth pressure	1			1433.846	-4.500	-6452.305	0.000	0.000	0.950	1362.153	-9.000	-12259.380
				22662.360		**-22218.524**		**0.000**		**21529.242**		**-117984.196**
Total				**25414.613**		**-20869.261**		**0.000**		**24152.793**		**-128503.027**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.435	9702.479
due to Earth pressure	1	3939.458		16909.732

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	9702.48	0.00	0.00
3939.46	16909.73	0.00	0.00
4987.808	26612.211	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Earth pressure	1.5	5909.188		25364.597
		7036.685		35799.587

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
5909.19	25364.60	0.00	0.00
7036.685	35799.587	0.000	0.000

Summary of Forces For SBC		
P	25414.613	KN
ML	5742.950	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		25414.613		-20869.261		0.000
CWLL-Max. Reaction case	1	957.514	0.600	574.508	1.955	1871.716
Vertical Components of LL Surcharge	1	336.715	-4.500	-1515.218	0.000	0.000
Total		**26708.842**		**-21809.971**		**1871.716**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	24152.793		-128503.03
0.000		-3.900	0.00
0.950		-9.000	-2878.92
	24152.793		**-131381.94**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.435	9702.479
due to Earth pressure	1	3939.458		16909.732
due to Live load surcharge	1	925.117		4727.350

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	9702.48	0.00	0.00
3939.46	16909.73	0.00	0.00
925.117	4727.350	0.000	0.000
5912.93	**31339.56**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Earth pressure	1.5	5909.188		25364.597
due to Live load surcharge	1.2	1110.141		5672.820
		8146.826		**41472.407**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
5909.19	25364.60	0.00	0.00
1110.14	5672.82	0.00	0.00
8146.826	**41472.407**	**0.000**	**0.000**

Summary of Forces For SBC		
P	26708.842	KN
ML	9529.590	kNm
MT	1871.716	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		25414.613		-20869.261		0.000
CWLL-Max. Reaction case	1	782.609	0.600	469.565	0.300	234.783
Vertical Components of LL Surcharge	1	336.715	-4.500	-1515.218	0.000	0.000
Total		**26533.937**		**-21914.914**		**234.783**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	24152.79255		-128503.027
0.000		-3.900	0.00
0.950		-9.000	-2878.92
	24152.793		**-131381.94**

Horizontal Forces For SBC Calculation

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.435	9702.479
due to Earth pressure	1	3939.458		16909.732
due to Live load surcharge	1	925.117		4727.350

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	9702.48	0.00	0.00
3939.46	16909.73	0.00	0.00
925.117	4727.350	0.000	0.000
5912.93	**31339.56**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Earth pressure	1.5	5909.188		25364.597
due to Live load surcharge	1.2	1110.141		5672.820
		8146.826		**41472.407**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
5909.19	25364.60	0.00	0.00
1110.14	5672.82	0.00	0.00
8146.826	**41472.407**	**0.000**	**0.000**

Summary of Forces For SBC		
P	26533.937	KN
ML	9424.647	kNm
MT	234.783	kNm

Case 3 : DL+SIDL-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				**2096.700**		**1258.020**		**0.000**
Substructure & Foundation -Portion 1				**655.553**		**91.243**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	42.615	1065.375	-2.250	-2397.094	0.000	0.000
Shaft above HFL	1	25	34.076	851.895	0.683	582.213	0.000	0.000
Shaft below HFL	1	15	67.441	1011.608	0.633	640.289	0.000	0.000
Back filling above HFL over heel sla	1	20	261.833	5236.650	-2.250	-11782.463	0.000	0.000
Back filling below HFL over heel sla	1	10	313.470	3134.700	-2.272	-7121.419	0.000	0.000
Front Filling over toe slab	1	10	185.328	1853.280	2.830	5245.094	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	45.563	683.438	-2.100	-1435.219	0.000	0.000
Toe slab	1	15	33.413	501.188	2.740	1373.254	0.000	0.000
Portion between Heel & Toe	1	15	14.580	218.700	0.600	131.220	0.000	0.000
Vertical Components of active earth pressure	1			1231.722	-4.500	-5542.749	0.000	0.000
				15958.505		**-20296.215**		**0.000**
Total				**18710.758**		**-18946.952**		**0.000**

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
Superstructure		**2000.775**		**-7803.023**
Substructure & Foundation -Portion 1		**622.775**		**-2715.808**
Substructure & Foundation -Portion 2				
Solid Return wall	0.950	1012.106	-6.750	-6831.717
Shaft above HFL	0.950	809.300	-3.817	-3088.749
Shaft below HFL	0.950	961.027	-3.867	-3716.349
Back filling above HFL over heel sla	0.950	4974.818	-6.750	-33580.018
Back filling below HFL over heel sla	0.950	2977.965	-6.772	-20166.190
Front Filling over toe slab	0.950	1760.616	-1.670	-2939.932
Side filling between heel and toe	0.950	0.000	0.000	0.000
Heel slab	0.950	649.266	-6.600	-4285.153
Toe slab	0.950	476.128	-1.760	-837.986
Portion between Heel & Toe	0.950	207.765	-3.900	-810.284
Vertical Components of active earth pressure	0.950	1170.136	-9.000	-10531.222
		15160.580		**-87504.014**
Total		**17784.130**		**-98022.844**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.435	9702.479
due to Earth pressure	1	3384.128		12384.516

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	9702.48	0.00	0.00
3384.13	12384.52	0.00	0.00
4432.48	**22086.99**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Earth pressure	1.5	5076.192		18576.774
		6203.690		**29011.763**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
5076.19	18576.77	0.00	0.00
6203.69	**29011.76**	**0.00**	**0.00**

Summary of Forces For SBC		
P	18710.758	KN
ML	3140.043	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		18710.758		-18946.952		0.000
CWLL-Min. Reaction case	1	441.086	0.600	264.652	2.633	1161.363
Vertical Components of LL Surcharge	1	336.715	-4.500	-1515.218	0.000	0.000
Total		**19488.559**		**-20197.519**		**1161.363**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	17784.130		-98022.844
0.000	0.000	-3.900	0
0.950	319.879	-9.000	-2878.915
	18104.010		**-100901.759**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.435	9702.479
due to Earth pressure	1	3384.128		12384.516
due to Live load surcharge	1	925.117		4727.350

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	9702.48	0.00	0.00
3384.13	12384.52	0.00	0.00
925.117	4727.350	0.000	0.000
5357.60	**26814.35**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Earth pressure	1.5	5076.192		18576.774
due to live load surcharge	1.2	1110.141		5672.820
		7313.831		**34684.583**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
5076.19	18576.77	0.00	0.00
1110.141	5672.820	0.000	0.000
7313.83	**34684.58**	**0.00**	**0.00**

Summary of Forces For SBC		
P	19488.559	KN
ML	6616.826	kNm
MT	1161.363	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		18710.758		-18946.952		0.000
CWLL-Min. Reaction case	1	657.391	0.600	394.435	0.300	197.217
Vertical Components of LL Surcharge	1	336.715	-4.500	-1515.218	0.000	0.000
Total		**19704.864**		**-20067.736**		**197.217**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	17784.130		-98022.844
0.000	0.000	-3.900	0.00
0.950	319.879	-9.000	-2878.915
	18104.010		**-100901.759**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.435	9702.479
due to Earth pressure	1	3384.128		12384.516
due to Live load surcharge	1	925.117		4727.350

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	9702.48	0.00	0.00
3384.13	12384.52	0.00	0.00
925.117	4727.350	0.000	0.000
5357.60	**26814.35**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Earth pressure	1.5	5076.192		18576.774

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
5076.19	18576.77	0.00	0.00

due to live load surcharge	1.2	1110.141		5672.820
		7313.831		**34684.583**

1110.141	5672.820	0.000	0.000
7313.83	**34684.58**	**0.00**	**0.00**

Summary of Forces For SBC		
P	19704.864	KN
ML	6746.609	kNm
MT	197.217	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1

αh= 0.162 In Longitudinal direction

αh= 0.360 In Transverse direction

αv= 0.240 In Vertical direction

Weight of shaft below Ground level = 1484.828 KN

Weight of back fill below Ground level = 4872.150 KN

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1822.500		196.830	131.220	0.600	1093.500	78.732	1178.035		0.000	0.000	1939.760
SIDL except Wearing Course	1			96.000		10.368	6.912	0.600	57.600	4.147	1178.849		0.000	0.000	110.615
Wearing Course	1			178.200		19.246	12.830	0.600	106.920	7.698	1178.400		0.000	0.000	196.690
				2096.700		**226.444**	**150.962**		**1258.020**	**90.577**				**0.000**	**2247.065**
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	5.123	128.081	20.749	13.833	9.222	-0.050	-6.404	-0.461	1177.768	198.933	0.000	0.000	132.622
Dirt Wall-Tapered portion	1	25	-0.629	-15.719	-2.546	-1.698	-1.132	-0.050	0.786	0.057	1177.213	-23.001	0.000	0.000	-15.334
Bracket - Uniform portion	1	25	1.215	30.375				-0.350	-10.631						
Bracket - Tapered portion	1	25	0.608	15.188				-0.300	-4.556						
Cap - (uniform portion)	1	25	6.480	162.000	26.244	17.496	11.664	0.600	97.200	6.998	1176.984	231.052	0.000	0.000	154.035
Cap - (corbel portion)	1	25	5.218	130.441	21.131	14.088	9.392	0.600	78.264	5.635	1176.684	179.701	0.000	0.000	119.801
Cantilever Return Wall-Rectangle p	1	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1178.400	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle port	1	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1178.400	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				-0.050	-1.400				0.000	0.000	
Aproach Slab	1	25	7.088	177.188				-0.350	-62.016				0.000	0.000	
				655.553	**65.578**	**43.719**	**29.146**		**91.243**	**12.229**		**586.685**		**0.000**	**391.123**
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	42.615	1065.375	172.591	115.061	76.707	-2.250	-2397.094	-172.591	1173.743	960.144	0.000	0.000	640.096
Abutment Shaft	1	25	101.516	2537.908	170.599	113.733	75.822	0.633	1606.347	47.991	1174.812	1131.412	0.000	0.000	754.275
Back filling over heel slab	1	20	565.810	11316.206	0.000	0.000	0.000	-2.262	-25598.152	0.000	1173.743	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	185.328	3706.560				2.830	10490.188				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	45.563	1139.063				-2.100	-2392.031				0.000	0.000	
Toe slab	1	25	33.413	835.313				2.740	2288.756				0.000	0.000	
portion between heel & toe	1	25	14.580	364.500				0.600	218.700				0.000	0.000	
Vertical component of active earth pressure	1			1433.846				-4.500	-6452.305				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			739.555				-4.500	-3327.997				0.000	0.000	
				23401.915	**343.190**	**228.793**	**152.529**		**-25546.521**	**-124.600**		**2091.556**		**0.000**	**1394.371**
Total =				**26154.168**	**408.768**	**498.955**	**332.637**		**-24197.258**	**-21.794**		**2678.241**		**0.000**	**4032.559**
							-332.637			21.794					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1731.375	124.659	-3.900	-6752.363	-486.170
SIDL except Wearing Course	0.95			91.200	6.566	-3.900	-355.680	-25.609
Wearing Course	1.00			178.200	12.830	-3.900	-694.980	-50.039
				2000.775	**144.056**		**-7803.023**	**-561.818**

For Overturning or Sliding Effect

Load Factor	FL = αh x P (kN)	C.g. of Force (m)	MLs due to FL

Substructure & Foundation -Portion 1													
Dirt Wall-Uniform portion	0.95	25	5.123	121.677	8.761	-4.550	-553.631	-39.861		1.0	20.749	1177.768	198.933
Dirt Wall-Tapered portion	0.95	25	-0.629	-14.933	-1.075	-4.550	67.946	4.892		1.0	-2.546	1177.213	-23.001
Bracket - Uniform portion	0.95	25	1.215	28.856									
Bracket - Tapered portion	0.95	25	0.608	14.428									
Cap - (uniform portion)	0.95	25	6.480	153.900	11.081	-3.900	-600.210	-43.215		1.0	26.244	1176.984	231.052
Cap - (corbel portion)	0.95	25	5.218	123.919	8.922	-3.900	-483.283	-34.796		1.0	21.131	1176.684	179.701
Cantilever Return Wall-Rectangle p	0.95	25	0.000	0.000	0.000	-4.500	0.000	0.000		1.0	0.000	1178.400	0.000
Cantilever Return Wall-Traingle port	0.95	25	0.000	0.000	0.000	-4.500	0.000	0.000		1.0	0.000	1178.400	0.000
RCC Railing or Crash Barrier	0.95			26.600		-4.550	-121.030						
Aproach Slab	0.95	25	7.088	168.328		-4.850	-816.391						
				622.775	**27.689**		**-2506.600**	**-112.981**			**65.578**		**586.685**
Substructure & Foundation -Portion 2													
Abutment Shaft	0.95	25	101.516	2411.013	66.685	-3.867	-9323.527	-257.876		1.0	157.939	1174.812	1047.450
Solid Return wall	0.95	25	42.615	1012.106	72.872	-6.750	-6831.717	-491.884		1.0	172.591	1173.743	960.144
Back filling over heel slab	0.95	20	565.810	10750.396	0.000	-6.762	-72695.026	0.000		1.0	0.000	1173.743	0.000
Front Filling over Pile Cap	0.95	20	185.328	3521.232		-1.670	-5879.865						
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000						
Heel slab	0.95	25	45.563	1082.109		-6.600	-7141.922						
Toe slab	0.95	25	33.413	793.547		-1.760	-1396.643						
portion between heel & toe	0.95	25	14.580	346.275		-3.900	-1350.473						
Vertical component of active earth pressure	0.95			1362.153		-9.000	-12259.380						
Vertical component of dynamic increment of earth pressure	0.95			702.577		-9.000	-6323.194						
				22231.819	**139.557**		**-124307.39**	**-749.760**			**330.530**		**2007.594**
Total =				**24855.370**	**311.301**		**-134617.01**	**-1424.558**			**396.108**		**2594.279**
					-311.301			1424.558					

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	226.444	1177.435	9702.479	2247.065
due to Substructure	1	408.768	272.512		2678.241	1785.494
due to Earth pressure	1	5971.369			27292.792	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	9702.48	0.00	0.00	0.00	0.00	226.44	2247.07
408.77	2678.24	0.00	0.00	0.00	0.00	272.51	1785.49
5971.37	27292.79						
7428.49	**39673.51**	**0.00**	**0.00**	**0.00**	**0.00**	**498.96**	**4032.56**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.99
due to Substructure	1.5	594.162		3891.42
due to Active Earth pressure	1.5	5909.188		25364.60
due to dynamic Earth pressure	1.5	3047.865		15574.59
		10678.712		**55265.597**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
594.16	3891.42	0.00	0.00
5909.188	25364.597	0.000	0.000
3047.865	15574.591	0.000	0.000
10678.71	**55265.60**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	26486.805	25821.531	KN
ML	15454.461	15498.049	kNm
MT	4032.559	4032.559	kNm

Summary of Restoring Forces

Vertical Load	24544.068	kN
Moment	-136041.571	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				2096.700		226.444	150.962		1258.020	90.577				0.000	2247.065

Forces from Substructure				24057.468	408.768	272.512	181.675		-25455.278	-112.371		2678.241		0.000	1785.494
CWLL-Max. Reaction case	0.20			191.50		20.682	13.788	0.600	114.902	8.273	1179.600		1.955	374.343	236.192
Vertical component of LL Surcharge	0.20			67.34				-4.500	-303.044				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			34.73				-4.500	-156.305				0.000	0.000	
Total =				**26447.748**	**408.768**	**519.638**	**346.425**		**-24541.705**	**-13.521**		**2678.241**		**374.343**	**4268.751**
							-346.425			13.521					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstucture				2000.775	144.056	0.000	-7803.02	-561.818
Forces from Substructure				22854.595	167.245	0.000	-126813.99	-862.740
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.900	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-9.000	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.000	0.00	
Total =				**24855.370**	**311.301**		**-134617.01**	**-1424.558**
					-311.301			**1424.558**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	247.126	1177.435	9702.479	2483.257
due to Substructure	1	408.768	272.512		2678.241	1785.494
due to Earth pressure	1	5971.369			27292.792	
due to Live load surcharge	0.20	280.456			1598.932	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	9702.48	0.00	0.00	0.00	0.00	247.13	2483.26
408.77	2678.24	0.00	0.00	0.00	0.00	272.51	1785.49
5971.37	27292.79						
280.46	1598.93						
7708.94	**41272.45**	**0.00**	**0.00**	**0.00**	**0.00**	**519.64**	**4268.75**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Substructure	1.5	594.162		3891.419
due to Active Earth pressure	1.5	5909.188		25364.597
due to dynamic Earth pressure	1.5	3047.865		15574.5913
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		10678.712		**55265.597**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
594.16	3891.42	0.00	0.00
5909.188	25364.597		
3047.865	15574.591		
0.000	0.000		
0.000	0.000		
10678.71	**55265.60**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	26794.173	26101.323	KN
ML	16717.219	16744.261	kNm
MT	4643.094	4643.094	kNm

Summary of Restoring Forces

Vertical Load	24544.068	kN
Moment	-136041.571	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2096.700**		**226.444**	**150.962**		**1258.020**	**90.577**				**0.000**	**2247.065**

Substructure & Foundation -Portion 1				**655.553**	**65.578**	**43.719**	**29.146**		**91.243**	**12.229**		**586.685**		**0.000**	**391.123**
Substructure & Foundation -Portion 2															
Solid Return wall	1		42.62	1065.38	172.591	115.061	76.707	-2.25	-2397.094	-172.591	1173.74	960.144	0.00	0.000	640.096
Shaft above HFL	1	25	34.076	851.895	138.007	92.005	61.336	0.683	582.213	41.919	1175.312	984.266	0.000	0.000	656.177
Shaft below HFL	1	15	67.441	1011.608	-76.662	-51.108	-34.072	0.633	640.289	-21.565	1173.590	-414.740	0.000	0.000	-276.493
Back filling above HFL over heel sla	1	20	261.833	5236.650	848.337	565.558	377.039	-2.250	-11782.463	-848.337	1176.245	6841.84	0.000	0.000	4561.23
Back filling below HFL over heel sla	1	10	313.470	3134.700	-281.467	-187.645	-125.096	-2.272	-7121.419	284.194	1171.360	-895.06	0.000	0.000	-596.71
Front Filling over Pile Cap	1	10	185.328	1853.280				2.830	5245.094				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	45.563	683.438				-2.100	-1435.219				0.000	0.000	
Toe slab	1	15	33.413	501.188				2.740	1373.254				0.000	0.000	
portion between heel & toe	1	15	14.580	218.700				0.600	131.220				0.000	0.000	
Vertical component of active earth pressure	1			1194.103				-4.500	-5373.463				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			615.899				-4.500	-2771.547				0.000	0.000	
				16536.785	**828.338**	**552.226**	**368.150**		**-22909.134**	**-716.380**		**7612.853**		**0.000**	**5075.235**
Total =				**19289.038**	**893.916**	**822.388**	**548.259**		**-21559.871**	**-613.574**		**8199.538**		**0.000**	**7713.423**
							-548.259			613.574					

Vertical Forces For Restoring or Resisting Effect

For Overturning or Sliding Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv	Load Factor	FL = αh x P (kN)	C.g. of Force (m)	MLs due to FL
Superstructure				**2000.775**	**144.056**		**-7803.023**	**-561.818**				
Substructure & Foundation -Portion 1				**622.775**	**27.689**		**-2506.600**	**-112.981**		**65.578**		**586.685**
Substructure & Foundation -Portion 2												
Solid Return wall	0.95	25	42.615	1012.106	72.872	-6.75	-6831.717	-491.884	1.0	172.591	1173.743	960.144
Shaft above HFL	0.95	25	34.076	809.300	58.270	-3.817	-3088.749	-222.390	1.0	138.007	1175.312	984.266
Shaft below HFL	0.95	15	67.441	961.027	-37.714	-3.867	-3716.349	145.841	1.0	-89.322	1173.590	-483.231
Back filling above HFL over heel sla	0.95	20	261.833	4974.818	0.000	-6.750	-33580.018	0.000	1.0	0.000	1176.245	0.000
Back filling below HFL over heel sla	0.95	10	313.470	2977.965	0.000	-6.772	-20166.190	0.000	1.0	0.000	1171.360	0.000
Front Filling over Pile Cap	0.95	10	185.328	1760.616		-1.670	-2939.932					
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000					
Heel slab	0.95	15	45.563	649.266		-6.600	-4285.153					
Toe slab	0.95	15	33.413	476.128		-1.760	-837.986					
portion between heel & toe	0.95	15	14.580	207.765		-3.900	-810.284					
Vertical component of active earth pressure	0.95			1134.398		-9.000	-10209.579					
Vertical component of dynamic increment of earth pressure	0.95			585.104		-9.000	-5265.939					
				15709.946	**105.052**		**-92448.309**	**-620.014**		**221.276**		**1461.179**
Total =				**18333.496**	**276.797**		**-102757.93**	**-1294.813**		**286.854**		**2047.864**
					-276.797			1294.813				

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	226.444	1177.435	9702.479	2247.065
due to Substructure	1	893.916	595.944		8199.538	5466.358
due to Earth pressure	1	4972.940			18896.854	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	9702.48	0.00	0.00	0.00	0.00	226.44	2247.07
893.92	8199.54	0.00	0.00	0.00	0.00	595.94	5466.36
4972.94	18896.85						
6915.21	**36798.87**	**0.00**	**0.00**	**0.00**	**0.00**	**822.39**	**7713.42**

Horizontal Forces For Overturning or Sliding Effect

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Substructure	1.5	430.281		3071.795
due to Active Earth pressure	1.5	4921.156		18576.774
due to dynamic Earth pressure	1.5	2538.254		9768.508
		9017.188		**41852.066**

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
430.28	3071.80	0.00	0.00
4921.156	18576.774		
2538.254	9768.508		
9017.19	**41852.07**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	19837.297	18740.780	KN
ML	14625.427	15852.574	kNm
MT	7713.423	7713.423	kNm

Summary of Restoring Forces

Vertical Load	18056.700	kN
Moment	-104052.745	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2096.700		226.444	150.962		1258.020	90.577				0.000	2247.065
Forces from Substructure				17192.338	893.916	595.944	397.296		-22817.891	-704.151		8199.538		0.000	5466.358
CWLL-Max. Reaction case	0.20			88.22		9.527	6.352	0.600	52.930	3.811	1179.600		2.633	232.273	108.804
Vertical component of LL Surcharge	0.20			67.34				-4.500	-303.044				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			34.73				-4.500	-156.305				0.000	0.000	
Total =				**19479.333**	**893.916**	**831.915**	**554.610**		**-21966.289**	**-609.763**		**8199.538**		**232.273**	**7822.227**
							-554.610			609.763					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2000.775	144.056		-7803.023	-561.818
Forces from Substructure				16332.721	132.741		-94954.909	-732.995
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.90	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.900	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-9.000	0.000	0.000
Total =				**18333.496**	**276.797**		**-102761.83**	**-1294.813**
					-276.797			**1294.813**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	235.971	1177.435	9702.479	2355.869
due to Substructure	1	893.916	595.944		8199.538	5466.358
due to Earth pressure	1	4972.940			18896.854	
due to Live load surcharge	0.20	280.456			1589.179	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	9702.48	0.00	0.00	0.00	0.00	235.97	2355.87
893.92	8199.54	0.00	0.00	0.00	0.00	595.94	5466.36
4972.94	18896.85						
280.46	1589.18						
7195.66	**38388.05**	**0.00**	**0.00**	**0.00**	**0.00**	**831.92**	**7822.23**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00

due to Substructure	1.5	430.281		3071.79547	430.28	3071.80	0.00	0.00
due to Active Earth pressure	1.5	4921.156		18576.774	4921.156	18576.774		
due to dynamic Earth pressure	1.5	2538.254064		9768.50768	2538.254	9768.508		
due to Live load surcharge	0	0		0	0.000	0.000		
due to dynamic increment of live load surcharge	0	0		0	0.000	0.000		
		9017.188		**41852.066**	**9017.19**	**41852.07**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	20033.943	18924.723	KN
ML	15811.999	17031.524	kNm
MT	8054.500	8054.500	kNm

Summary of Restoring Forces

Vertical Load	18056.700	kN
Moment	-104056.645	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2096.700**		**754.812**	**150.962**		**1258.020**	**90.577**				**0.000**	**7490.217**
Substructure & Foundation -Portion 1				**655.553**	**19.673**	**145.729**	**29.146**		**91.243**	**12.229**		**176.005**		**0.000**	**1303.744**
Substructure & Foundation -Portion 2				**23401.915**	**102.957**	**762.644**	**152.529**		**-25546.521**	**-124.600**		**627.467**		**0.000**	**4647.903**
Total =				**26154.168**	**122.630**	**1663.185**	**332.637**		**-24197.258**	**-21.794**		**803.472**		**0.000**	**13441.863**
							-332.637			21.794					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				**2000.775**	**144.056**		**-7803.02**	**-561.818**
Substructure & Foundation -Portion 1				**622.775**	**27.689**		**-2506.60**	**-112.981**
Substructure & Foundation -Portion 2				**22231.819**	**139.557**		**-124307.39**	**-749.760**
Total =				**24855.370**	**311.301**		**-134617.01**	**-1424.558**
					-311.301			1424.558

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x αh x P (kN)	C.g. of Force (m)	MLs due to FL
	65.578		**586.685**
	330.530		**2007.594**
	396.108		**2594.279**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	754.812	1177.435	9702.479	7490.217
due to Substructure	1	122.630	908.373		803.472	5951.647
due to Earth pressure	1	5971.369			27292.792	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	9702.48	0.00	0.00	0.00	0.00	754.81	7490.22
122.63	803.47	0.00	0.00	0.00	0.00	908.37	5951.65
5971.37	27292.79						
7142.35	**37798.74**	**0.00**	**0.00**	**0.00**	**0.00**	**1663.18**	**13441.86**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.989
due to Substructure	1.5	594.162		3891.41863
due to Active Earth pressure	1.5	5909.188		25364.5974
due to dynamic Earth pressure	1.5	914.360		4672.3774
		8545.206		**44363.383**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
594.16	3891.42	0.00	0.00
5909.188	25364.597		
914.360	4672.377		
8545.21	**44363.38**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward

Summary of Restoring Forces

Vertical Load	24544.068	kN

P	26486.805	25821.531	KN
ML	13579.693	13623.280	kNm
MT	13441.863	13441.863	kNm

Moment	-136041.571	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	**26447.748**	**346.425**	**-24541.70**	**-13.521**	**374.343**
		-346.425		13.521	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL2	MLs due to Fv
Total =	**24855.370**	**311.301**	**-134617.01**	**-1424.558**
		-311.301		**1424.558**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	823.753	1177.435	9702.479	8277.523
due to Substructure	1	122.630	908.373		803.472	5951.647
due to Earth pressure	1	5971.369			27292.792	
due to Live load surcharge	0.2	280.456			1598.932	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	9702.48	0.00	0.00	0.00	0.00	823.75	8277.52
122.63	803.47	0.00	0.00	0.00	0.00	908.37	5951.65
5971.37	27292.79						
280.46	1598.93						
7422.80	**39397.68**	**0.00**	**0.00**	**0.00**	**0.00**	**1732.13**	**14229.17**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.50	1177.435	10434.989
due to Substructure	1.5	178.25		1167.426
due to Active Earth pressure	1.5	5909.19		25364.597
due to dynamic Earth pressure	1.5	914.36		4672.377
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		8129.29		**41639.390**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
178.25	1167.43	0.00	0.00
5909.188	25364.597		
914.360	4672.377		
0.000	0.000		
0.000	0.000		
8129.29	**41639.39**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	26794.173	26101.323	KN
ML	14842.451	14869.492	kNm
MT	14603.513	14603.513	kNm

Summary of Restoring Forces

Vertical Load	24544.068	kN
Moment	-136041.571	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads		Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure		**2096.700**	**150.962**	**1258.020**	**90.577**	**0.000**
Substructure & Foundation -Portion 1		**655.553**	**29.146**	**91.243**	**12.229**	**0.000**
Substructure & Foundation -Portion 2		**16536.785**	**368.150**	**-22909.134**	**-716.380**	**0.000**
Total =		**19289.038**	**548.259**	**-21559.871**	**-613.574**	**0.000**
			-548.259		613.574	

Vertical Forces For Restoring or Resisting Effect

Loads		Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure		**2000.775**	**144.056**		**-7803.023**	**-561.818**
Substructure & Foundatio		**622.775**	**27.689**		**-2506.600**	**-112.981**
Substructure & Foundatio		**15709.946**	**105.052**		**-92448.309**	**-620.014**
Total =		**18333.496**	**276.797**		**-102757.932**	**-1294.813**
			-276.797			1294.813

Horizontal Forces For SBC Calculation

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.35	754.81	1177.44	9702.48	7490.22
due to Substructure	1	268.17	1986.48		2459.86	18221.19
due to Earth pressure	1	4972.94			18896.85	

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	9702.48	0.00	0.00	0.00	0.00	754.81	7490.22
268.17	2459.86	0.00	0.00	0.00	0.00	1986.48	18221.19
4972.94	18896.85						
6289.46	**31059.19**	**0.00**	**0.00**	**0.00**	**0.00**	**2741.29**	**25711.41**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.435	10434.99
due to Substructure	1.5	129.084		921.54
due to Active Earth pressure	1.5	4921.156		18576.77
due to dynamic Earth pressure	1.5	761.476		2930.55
		6939.214		**32863.85**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
129.08	921.54	0.00	0.00
4921.156	18576.774		
761.476	2930.552		
6939.21	**32863.85**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	19837.297	18740.780	KN
ML	8885.750	10112.898	kNm
MT	25711.412	25711.412	kNm

Summary of Restoring Forces

Vertical Load	18056.700	kN
Moment	-104052.745	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	**19479.333**	**554.610**	**-21966.29**	**-609.763**	**232.273**
		-554.610		609.763	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	**18333.496**	**276.797**		**-102761.83**	**-1294.813**
		-276.797			**1294.813**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	786.5701983	1177.435	9702.479	7852.89532
due to Substructure	1	268.175	1986.481104		2459.861	18221.1949
due to Earth pressure	1	4972.940			18896.854	
due to Live load surcharge	0.2	280.456			1589.179	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	9702.48	0.00	0.00	0.00	0.00	786.57	7852.90
268.17	2459.86	0.00	0.00	0.00	0.00	1986.48	18221.19
4972.94	18896.85						
280.46	1589.18						
6569.92	**32648.37**	**0.00**	**0.00**	**0.00**	**0.00**	**2773.05**	**26074.09**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.50	1177.435	10434.99
due to Substructure	1.5	129.08		921.54
due to Active Earth pressure	1.5	4921.16		18576.77
due to dynamic Earth pressure	1.5	761.48		2930.55
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		6939.21		**32863.85**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	10434.99	0.00	0.00
129.08	921.54	0.00	0.00
4921.156	18576.774		
761.476	2930.552		
0.000	0.000		
0.000	0.000		
6939.21	**32863.85**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	20033.943	18924.723	KN
ML	10072.322	11291.847	kNm
MT	26306.363	26306.363	kNm

Summary of Restoring Forces

Vertical Load	18056.700	kN
Moment	-104056.645	kNm

	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.600 - 1168.180) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.600 - 1168.180) = 0.000 kNm

Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT

Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= μP + c.A + Fp	FOS	Overturning moment	Restoring Moment = ΣP.eToe+Mp	FOS
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	25414.613	5742.950	0.000	177.662	240.685	177.662	240.685	240.685	177.662	7036.685	16906.955	2.40	35799.587	128503.03	3.59
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	26708.842	9529.590	1871.716	174.384	278.961	160.691	265.268	278.961	160.691	8146.826	16906.955	2.08	41472.407	131381.94	3.17
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	26533.937	9424.647	234.783	167.532	270.958	165.815	269.240	270.958	165.815	8146.826	16906.955	2.08	41472.407	131381.94	3.17
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	18710.758	3140.043	0.000	136.769	171.227	136.769	171.227	171.227	136.769	6203.690	12448.891	2.01	29011.763	98022.84	3.38
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	19488.559	6616.826	1161.363	128.342	200.954	119.845	192.458	200.954	119.845	7313.831	12672.807	1.73	34684.583	100901.76	2.91
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	19704.864	6746.609	197.217	125.883	199.920	124.440	198.477	199.920	124.440	7313.831	12672.807	1.73	34684.583	100901.76	2.91
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	26486.805	15498.049	4032.559	147.712	317.787	118.210	288.285	317.787	118.210	10678.712	17180.848	1.61	55265.597	136041.57	2.46
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	26794.173	16744.261	4643.094	145.637	329.388	111.669	295.419	329.388	111.669	10678.712	17180.848	1.61	55265.597	136041.57	2.46
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															

Case 7 : DL+SIDL-Long. Seismic HFL Case	19837.297	15852.574	7713.423	104.503	278.468	48.072	222.037	278.468	48.072	9017.188	12639.690	1.40	41852.066	104052.74	2.49
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	20033.943	17031.524	8054.500	100.900	287.803	41.974	228.877	287.803	41.974	9017.188	12639.690	1.40	41852.066	104056.64	2.49
								SAFE	**SAFE**			**SAFE**			**SAFE**
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	26486.805	13623.280	13441.863	192.418	341.919	94.078	243.579	341.919	94.078	8545.206	17180.848	2.01	44363.383	136041.57	3.07
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	26794.173	14869.492	14603.513	192.359	355.536	85.520	248.697	355.536	85.520	8129.293	17180.848	2.11	41639.390	136041.57	3.27
								SAFE	**SAFE**			**SAFE**			**SAFE**
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	19837.297	10112.898	25711.412	201.833	312.811	13.729	124.707	312.811	13.729	6939.214	12639.690	1.82	32863.854	104052.74	3.17
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	20033.943	11291.847	26306.363	199.159	323.075	6.702	130.618	323.075	6.702	6939.214	12639.690	1.82	32863.854	104056.64	3.17
								SAFE	**SAFE**			**SAFE**			**SAFE**

DESIGN OF FOUNDATION

Foundation Lvl = 1168.180 m

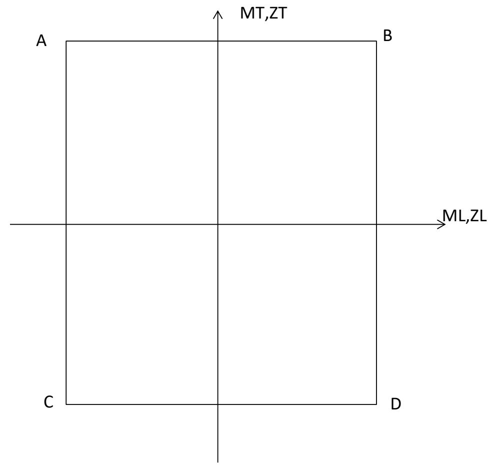
Properties of Footing Base:

A	=	121.500	m^2
ZL	=	182.250	m^3
ZT	=	273.375	m^3

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.35			2460.375	0.600	1476.225	0.000	0.000
SIDL except Wearing Course	1.35			129.600	0.600	77.760	0.000	0.000
Wearing Course	1.75			311.850	0.600	187.110	0.000	0.000
				2901.825		**1741.095**		**0.000**
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1.35	25	5.123	172.910	-0.050	-8.645	0.000	0.000
Dirt Wall-Tapered portion	1.35	25	-0.629	-21.221	-0.050	1.061	0.000	0.000
Bracket - Uniform portion	1.35	25	1.215	41.006	-0.350	-14.352	0.000	0.000
Bracket - Tapered portion	1.35	25	0.608	20.503	-0.300	-6.151	0.000	0.000
Cap - (uniform portion)	1.35	25	6.480	218.700	0.600	131.220	0.000	0.000
Cap - (corbel portion)	1.35	25	5.218	176.095	0.600	105.657	0.000	0.000
Cantilever Return Wall-Rectangle p	1.35	25	0.000	0.000	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle por	1.35	25	0.000	0.000	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier or Crash Barrier	1.35			37.800	-0.050	-1.890	0.000	0.000
Aproach Slab	1.35	25	7.088	239.203	-0.350	-83.721	0.000	0.000
				884.996		**123.178**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.35	25	42.615	1438.256	-2.250	-3236.077	0.000	0.000
Abutment Shaft	1.35	25	101.516	3426.176	0.633	2168.569	0.000	0.000
Back filling over heel slab	1.35	20	565.810	15276.878	-2.262	-34557.505	0.000	0.000
Front Filling over toe slab	1.35	20	185.328	5003.856	2.830	14161.754	0.000	0.000
Side filling between heel and toe	1.35	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.35	25	45.563	1537.734	-2.100	-3229.242	0.000	0.000
Toe slab	1.35	25	33.413	1127.672	2.740	3089.821	0.000	0.000
portion between heel & toe	1.35	25	14.580	492.075	0.600	295.245	0.000	0.000
Vertical Components of active earth pressure	1.5			2150.768	-4.500	-9678.458	0.000	0.000
				30809.263		**-30962.854**		**0.000**
Total				**34596.085**		**-29098.580**		**0.000**



Summary of Forces About C.G. OF Footing

P	34596.085	KN
ML	9694.212	kNm
MT	0.000	kNm

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.435	13428.195
due to Earth pressure	1.5	5909.188		25364.597

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	13428.20	0.00	0.00
5909.19	25364.60	0.00	0.00
7360.100	**38792.793**	**0.000**	**0.000**

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		34596.085		-29098.580		0.000
CWLL-Max. Reaction case	1.5	1436.271	0.600	861.763	1.955	2807.573
Vertical Components of LL Surcharge	1.2	404.058	-4.500	-1818.262	0.000	0.000
Total		**36436.414**		**-30055.080**		**2807.573**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.435	13428.195
due to Earth pressure	1.5	5909.188		25364.597
due to Live load surcharge	1.2	1110.141		5672.820
		8470.241		**44465.613**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	13428.20	0.00	0.00
5909.19	25364.60		
1110.14	5672.82		
8470.241	**44465.613**	**0.000**	**0.000**

Summary of Forces About C.G. OF Footing

P	36436.414	KN
ML	14410.533	kNm
MT	2807.573	kNm

Case 3 : DL+SIDL-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				**2901.825**		**1741.095**		**0.000**
Substructure & Foundation -Portion 1				**884.996**		**123.178**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.35	25	42.615	1438.256	-2.250	-3236.077	0.000	0.000
Shaft above HFL	1.35	25	34.076	1150.058	0.683	785.987	0.000	0.000
Shaft below HFL	1.35	15	67.441	1365.671	0.633	864.389	0.000	0.000
Back filling above HFL over heel slab	1.35	20	261.833	7069.478	-2.250	-15906.324	0.000	0.000
Back filling below HFL over heel slab	1.35	10	313.470	4231.845	-2.272	-9613.915	0.000	0.000
Front Filling over toe slab	1.35	10	185.328	2501.928	2.830	7080.877	0.000	0.000
Side filling between heel and toe	1.35	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.35	15	45.563	922.641	-2.100	-1937.545	0.000	0.000
Toe slab	1.35	15	33.413	676.603	2.740	1853.893	0.000	0.000
Portion between Heel & Toe	1.35	15	14.580	295.245	0.600	177.147	0.000	0.000
Vertical Components of active earth pressure	1.5			1847.583	-4.500	-8314.123	0.000	0.000
				21728.740		**-28231.303**		**0.000**
Total				**25515.562**		**-26367.030**		**0.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.435	13428.195
due to Earth pressure	1.5	5076.192		18576.774

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	13428.20	0.00	0.00
5076.19	18576.77		
6527.105	**32004.969**	**0.000**	**0.000**

Summary of Forces About C.G. OF Footing

P	25515.562	KN
ML	5637.939	kNm

MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		25515.562		-26367.030		0.000
CWLL-Min. Reaction case	1.5	661.629	0.600	396.977	2.633	1742.045
Vertical Components of LL Surcharge	1.2	404.058	-4.500	-1818.262	0.000	0.000
Total		**26581.249**		**-27788.314**		**1742.045**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.435	13428.195
due to Earth pressure	1.5	5076.192		18576.774
due to Live load surcharge	1.2	1110.141		5672.820

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	13428.20	0.00	0.00
5076.19	18576.77		
1110.14	5672.82		
7637.246	**37677.789**	**0.000**	**0.000**

Summary of Forces About C.G. OF Footing

P	26581.249	KN
ML	9889.474	kNm
MT	1742.045	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1.50 αh= 0.162 In Longitudinal direction Weight of shaft below Ground level = 1484.83 KN

αh= 0.360 In Transverse direction Weight of back fill below Ground level = 4872.15 KN

αv= 0.240 In Vertical direction

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1.35			2460.375		295.245	196.830	0.600	1476.225	118.098	1178.035		0.000	0.000	2909.639
SIDL except Wearing Course	1.35			129.600		15.552	10.368	0.600	77.760	6.221	1178.849		0.000	0.000	165.923
Wearing Course	1.75			311.850		28.868	19.246	0.600	187.110	11.547	1178.400		0.000	0.000	295.035
				2901.825		**339.665**	**226.444**		**1741.095**	**135.866**				**0.000**	**3370.598**
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1.35	25	5.123	172.910	31.124	20.749	13.833	-0.050	-8.645	-0.692	1177.768	298.399	0.000	0.000	198.933
Dirt Wall-Tapered portion	1.35	25	-0.629	-21.221	-3.820	-2.546	-1.698	-0.050	1.061	0.085	1177.213	-34.502	0.000	0.000	-23.001
Bracket - Uniform portion	1.35	25	1.215	41.006				-0.350	-14.352						
Bracket - Tapered portion	1.35	25	0.608	20.503				-0.300	-6.151						
Cap - (uniform portion)	1.35	25	6.480	218.700	39.366	26.244	17.496	0.600	131.220	10.498	1176.984	346.578	0.000	0.000	231.052
Cap - (corbel portion)	1.35	25	5.218	176.095	31.697	21.131	14.088	0.600	105.657	8.453	1176.684	269.552	0.000	0.000	179.701
Cantilever Return Wall-Rectangle p	1.35	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1178.400	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle por	1.35	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1178.400	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1.35			37.800				-0.050	-1.890				0.000	0.000	
Aproach Slab	1.35	25	7.088	239.203				-0.350	-83.721				0.000	0.000	
				884.996	**98.367**	**65.578**	**43.719**		**123.178**	**18.343**		**880.027**		**0.000**	**586.685**
Substructure & Foundation -Portion 2															
Solid Return wall	1.35	25	42.615	1438.256	258.886	172.591	115.061	-2.250	-3236.077	-258.886	1173.743	1440.216	0.000	0.000	960.144
Abutment Shaft	1.35	25	101.516	3426.176	349.443	232.962	155.308	0.633	2168.569	98.301	1174.812	2317.503	0.000	0.000	1545.002
Back filling over heel slab	1.35	20	565.810	15276.878	0.000	0.000	0.000	-2.262	-34557.505	0.000	1173.743	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1.35	20	185.328	5003.856				2.830	14161.754				0.000	0.000	
Side filling between heel and toe	1.35	20	0.000	0.000				0.000	0.000				0.000	0.000	

Heel slab	1.35	25	45.563	1537.734				-2.100	-3229.242				0.000	0.000	
Toe slab	1.35	25	33.413	1127.672				2.740	3089.821				0.000	0.000	
portion between heel & toe	1.35	25	14.580	492.075				0.600	295.245				0.000	0.000	
Vertical component of active earth pressure	1.00			1433.846				-4.500	-6452.305						
Vertical component of dynamic increment of earth pressure	1.50			1109.332				-4.500	-4991.995						
				31201.673	**608.329**	**405.552**	**270.368**		**-32728.696**	**-160.585**		**3757.719**		**0.000**	**2505.146**
Total =				**34988.494**	**706.696**	**810.796**	**540.531**		**-30864.423**	**-6.376**		**4637.746**		**0.000**	**6462.428**
							-540.531			6.376					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	339.665	1177.435	13428.195	3370.598
due to Substructure		706.696	471.131		4637.746	3091.831
due to Active Earth pressure	1.00	3939.458			16909.732	
due to dynamic increment of EP	1.50	3047.865			15574.591	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	13428.20	0.00	0.00	0.00	0.00	339.67	3370.60
706.70	4637.75	0.00	0.00	0.00	0.00	471.13	3091.83
3939.46	16909.73						
3047.87	15574.59						
9144.93	**50550.26**	**0.00**	**0.00**	**0.00**	**0.00**	**810.80**	**6462.43**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	35529.025	34447.963	KN
ML	19679.466	19692.218	kNm
MT	6462.428	6462.428	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				2901.825		339.665	226.444		1741.095	135.866				0.000	3370.598
Forces from Substructure				32086.669	706.696	471.131	314.087		-32605.518	-142.242		4637.746		0.000	3091.831
CWLL-Max. Reaction case	0.75			718.14		116.338	77.559	0.600	430.881	46.535	1179.600		1.955	1403.787	1328.579
Vertical component of LL Surcharge	0.20			67.343				-4.500	-303.044						
Vertical component of dynamic increment LL Surcharge	1.50			260.509				-4.500	-1172.288						
Total =				**36034.481**	**706.696**	**927.134**	**618.089**		**-31908.874**	**40.159**		**4637.746**		**1403.787**	**7791.008**
							-618.089			-40.159					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	456.003	1177.435	13428.195	4699.177
due to Substructure		706.696	471.131		4637.746	3091.831
due to Active Earth pressure	1	3939.458			16909.732	
due to dynamic increment of EP	1.50	3047.865			15574.591	
due to Live load surcharge	0.20	185.023			945.470	
due to dynamic increment of Surcharge	1.50	715.741			4900.967	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	13428.20	0.00	0.00	0.00	0.00	456.00	4699.18
706.70	4637.75	0.00	0.00	0.00	0.00	471.13	3091.83
3939.46	16909.73						
3047.87	15574.59						
185.02	945.47						
715.74	4900.97						
10045.70	**56396.70**	**0.00**	**0.00**	**0.00**	**0.00**	**927.13**	**7791.01**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	36652.570	35416.392	KN
ML	24527.988	24447.669	kNm
MT	9194.794	9194.794	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2901.825**		**339.665**	**226.444**		**1741.095**	**135.866**				**0.000**	**3370.598**
Substructure & Foundation -Portion 1				**884.996**	**98.367**	**65.578**	**43.719**		**123.178**	**18.343**		**880.027**		**0.000**	**586.685**
Substructure & Foundation -Portion 2															
Solid Return wall	1.35	25	42.615	1438.256	258.886	172.591	115.061	-2.250	-3236.077	-258.886	1173.743	1440.216	0.000	0.000	960.144
Shaft above HFL	1.35	25	34.076	1150.058	207.010	138.007	92.005	0.683	785.987	62.879	1175.312	1476.399	0.000	0.000	984.266
Shaft below HFL	1.35	15	67.4405196	1365.671	-21.448	-14.299	-9.533	0.633	864.389	-6.034	1173.590	-116.036	0.000	0.000	-77.357
Back filling above HFL over heel slab	1.35	20	261.8325	7069.478	0.000	0.000	0.000	-2.250	-15906.324	0.000	1176.245	0.000	0.000	0.000	0.000
Back filling below HFL over heel slab	1.35	10	313.47	4231.845	0.000	0.000	0.000	-2.272	-9613.915	0.000	1171.360	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1.35	10	185.328	2501.928				2.830	7080.877				0.000	0.000	
Side filling between heel and toe	1.35	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1.35	15	45.563	922.641				-2.100	-1937.545				0.000	0.000	
Toe slab	1.35	15	33.413	676.603				2.740	1853.893				0.000	0.000	
portion between heel & toe	1.35	15	14.580	295.245				0.600	177.147				0.000	0.000	
Vertical component of active earth pressure	1.00			1194.103				-4.500	-5373.463						
Vertical component of dynamic increment of earth pressure	1.50			923.849				-4.500	-4157.320						
				21999.109	**444.448**	**296.299**	**197.533**		**-29447.963**	**-202.041**		**2800.579**		**0.000**	**1867.053**
Total =				**25785.930**	**542.815**	**701.542**	**467.695**		**-27583.690**	**-47.831**		**3680.606**		**0.000**	**5824.335**
							-467.695			47.831					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	339.665	1177.435	13428.195	3370.598
due to Substructure		542.815	361.877		3680.606	2453.737
due to Active Earth pressure	1.00	3280.771			12384.516	
due to dynamic increment of EP	1.50	2538.254			9768.508	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	13428.20	0.00	0.00	0.00	0.00	339.67	3370.60
542.82	3680.61	0.00	0.00	0.00	0.00	361.88	2453.74
3280.77	12384.52						
2538.25	9768.51						
7812.75	**39261.82**	**0.00**	**0.00**	**0.00**	**0.00**	**701.54**	**5824.33**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	26253.625	25318.236	KN
ML	11630.304	11725.966	kNm
MT	5824.335	5824.335	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT

Forces from Superstructure				2901.825		339.665	226.444		1741.095	135.866				0.000	3370.598
Forces from Substructure				22884.105	542.815	361.877	241.251		-29324.785	-183.697		3680.606		0.000	2453.737
CWLL-Min. Reaction case	0.75			330.81		53.592	35.728	0.600	198.489	21.437	1179.600		2.633	871.023	612.020
Vertical component of LL Surcharge	0.20			67.343				-4.500	-303.044						
Vertical component of dynamic increment LL Surcharge	1.50			260.509				-4.500	-1172.288						
Total =				**26444.597**	**542.815**	**755.134**	**503.423**		**-28860.533**	**-26.394**		**3680.606**		**871.023**	**6436.355**
							-503.423			26.394					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	393.257	1177.435	13428.195	3982.618
due to Substructure		542.815	361.877		3680.606	2453.737
due to Active Earth pressure	1	3280.771			12384.516	
due to dynamic increment of EP	1.50	2538.254			9768.508	
due to Live load surcharge	0.20	185.023			945.470	
due to dynamic increment of Surcharge	1.50	715.741			4827.819	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	13428.20	0.00	0.00	0.00	0.00	393.26	3982.62
542.82	3680.61	0.00	0.00	0.00	0.00	361.88	2453.74
3280.77	12384.52						
2538.25	9768.51						
185.02	945.47						
715.74	4827.82						
8713.52	**45035.11**	**0.00**	**0.00**	**0.00**	**0.00**	**755.13**	**6436.36**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	26948.019	25941.174	KN
ML	16148.186	16200.975	kNm
MT	7307.378	7307.378	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m³)	Volume (m³)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2901.825**		**1132.218**	**226.444**		**1741.095**	**135.866**				**0.000**	**11235.325**
Substructure & Foundation -Portion 1				**884.996**	**29.510**	**218.594**	**43.719**		**123.178**	**18.343**		**264.008**		**0.000**	**1955.616**
Substructure & Foundation -Portion 2				**31201.673**	**182.499**	**1351.842**	**270.368**		**-32728.696**	**-160.585**		**1127.316**		**0.000**	**8350.487**
Total =				**34988.494**	**212.009**	**2702.653**	**540.531**		**-30864.423**	**-6.376**		**1391.324**		**0.000**	**21541.428**
							-540.531			6.376					

Forces due to Horizontal Load

		FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1132.218	1177.435	13428.195	11235.325
due to Substructure		212.009	1570.435		1391.324	10306.103
due to Active Earth pressure		3939.458			16909.732	
due to dynamic increment of EP		914.360			4672.377	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	13428.20	0.00	0.00	0.00	0.00	1132.22	11235.33
212.01	1391.32	0.00	0.00	0.00	0.00	1570.44	10306.10
3939.46	16909.73						
914.36	4672.38						
6516.74	**36401.63**	**0.00**	**0.00**	**0.00**	**0.00**	**2702.65**	**21541.43**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	35529.025	34447.963	KN
ML	5530.830	5543.581	kNm

MT	21541.428	21541.428	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**36034.481**	**618.089**	**-31908.874**	**40.159**	**1403.787**
					-618.089		-40.159	

Forces due to Horizontal Load

		FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1520.011	1177.435	13428.195	15663.9226
due to Substructure		212.009	1570.435		1391.324	10306.1029
due to Earth pressure		3939.458			16909.732	
due to dynamic increment of EP		914.360			4672.377	
due to Live load surcharge		185.023			945.470	
due to dynamic increment of Surcharge		214.722			1470.290	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	13428.20	0.00	0.00	0.00	0.00	1520.01	15663.92
212.01	1391.32	0.00	0.00	0.00	0.00	1570.44	10306.10
3939.46	16909.73						
914.36	4672.38						
185.02	945.47						
214.72	1470.29						
6916.49	**38817.39**	**0.00**	**0.00**	**0.00**	**0.00**	**3090.45**	**25970.03**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	36652.570	35416.392	KN
ML	6948.674	6868.355	kNm
MT	27373.812	27373.812	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure				**2901.825**	**226.444**	**1741.095**	**135.866**	**0.000**
Substructure & Foundation -Portion 1				**884.996**	**43.719**	**123.178**	**18.343**	**0.000**
Substructure & Foundation -Portion 2				**21999.109**	**197.533**	**-29447.963**	**-202.041**	**0.000**
Total =				**25785.930**	**467.695**	**-27583.690**	**-47.831**	**0.000**
					-467.695		47.831	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1132.218	1177.435	13428.195	11235.325
due to Substructure		162.845	1206.256		1104.182	8179.125
due to Active Earth pressure	1.00	3280.771			12384.516	
due to dynamic increment of EP	1.50	761.476			2930.552	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	13428.20	0.00	0.00	0.00	0.00	1132.22	11235.33
162.84	1104.18	0.00	0.00	0.00	0.00	1206.26	8179.12
3280.77	12384.52						
761.48	2930.55						
5656.00	**29847.45**	**0.00**	**0.00**	**0.00**	**0.00**	**2338.47**	**19414.45**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	26253.625	25318.236	KN
ML	2215.924	2311.586	kNm
MT	19414.450	19414.450	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Forces due to Vertical Load

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	**26444.597**	**503.423**	**-28860.533**	**-26.394**	**871.023**
		-503.423		26.394	

Forces due to Horizontal Load

		FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1310.858	1177.435	13428.195	13275.3923
due to Substructure		162.845	1206.256		1104.182	8179.12489
due to Earth pressure		3280.771			12384.516	
due to dynamic increment of EP		761.476			2930.552	
due to Live load surcharge		185.023			945.470	
due to dynamic increment of Surcharge		214.722			1448.346	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	13428.20	0.00	0.00	0.00	0.00	1310.86	13275.39
162.84	1104.18	0.00	0.00	0.00	0.00	1206.26	8179.12
3280.77	12384.52						
761.48	2930.55						
185.02	945.47						
214.72	1448.35						
6055.75	**32241.26**	**0.00**	**0.00**	**0.00**	**0.00**	**2517.11**	**21454.52**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	26948.019	25941.174	KN
ML	3354.333	3407.122	kNm
MT	22325.540	22325.540	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.50 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.600 - 1168.180) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.75 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.600 - 1168.180) = 0.000 kNm

	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

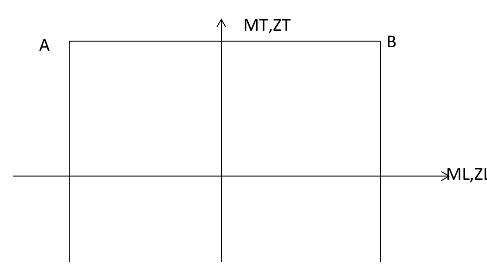
Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT

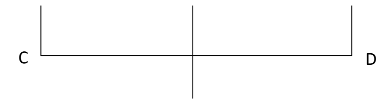
Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

Summary of Design Base Pressure

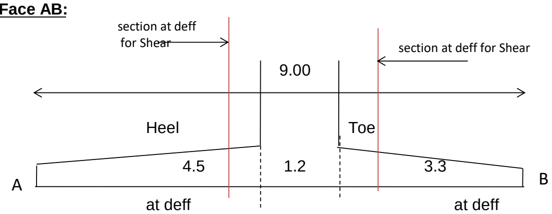
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2
Case 1 : DL+SIDL-Normal Dry Case	34596.085	9694.212	0.000	231.550	337.933	231.550	337.933
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	36436.414	14410.533	2807.573	231.088	389.228	210.548	368.688
Normal HFLCase							
Case 3 : DL+SIDL-Normal HFL Case	25515.562	5637.939	0.000	179.069	240.940	179.069	240.940
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	26581.249	9889.474	1742.045	170.885	279.411	158.140	266.667
Longitudinal Seismic Dry Case							



Case 5 : DL+SIDL-Long. Seismic Dry Case	35529.025	19692.218	6462.428	208.009	424.110	160.730	376.831
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	36652.570	24527.988	9194.794	200.717	469.886	133.449	402.617
Longitudinal Seismic HFL Case							
Case 7 : DL+SIDL-Long. Seismic HFL Case	26253.625	11725.966	5824.335	173.045	301.725	130.434	259.114
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	26948.019	16200.975	7307.378	159.630	337.419	106.170	283.958
Transverse Seismic Dry Case							
Case 9 : DL+SIDL-Trans. Seismic Dry Case	35529.025	5543.581	21541.428	340.801	401.636	183.204	244.039
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	36652.570	6948.674	27373.812	363.673	439.927	163.407	239.662
Transverse Seismic HFL Case							
Case 11 : DL+SIDL-Trans. Seismic HFL Case	26253.625	2311.586	19414.450	274.413	299.780	132.378	157.745
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	26948.019	3407.122	22325.540	284.766	322.156	121.433	158.823



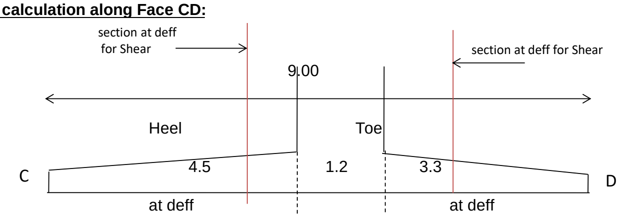
Pressure calculation along Face AB:



Case : 1	231.550	275.137	284.74	298.926	308.530	337.933
Case : 2	231.088	295.882	310.16	331.244	345.520	389.228
Case : 3	179.069	204.419	210.00	218.254	223.840	240.940
Case : 4	170.885	215.351	225.15	239.618	249.416	279.411
Case : 5	208.009	296.550	316.06	344.873	364.382	424.110
Case : 6	200.717	311.002	335.30	371.191	395.491	469.886
Case : 7	173.045	225.768	237.38	254.542	266.159	301.725
Case : 8	159.630	232.474	248.52	272.230	288.280	337.419
Case : 9	340.801	365.726	371.22	379.329	384.821	401.636
Case : 10	363.673	394.916	401.80	411.967	418.851	439.927
Case : 11	274.413	284.807	287.10	290.479	292.769	299.780
Case : 12	284.766	300.085	303.46	308.446	311.821	322.156

Average MAX Base Pressure for Design of Heel Slab-along Face AB = 382.736 kN/m^2
Average MIN Base Pressure for Design of Heel Slab-along Face AB = 194.537 kN/m^2
Average MAX Base Pressure for Design of Toe Slab-along Face AB = 425.947 kN/m^2
Max. Base Pressure at deff for Design of Toe Slab-along Face AB = 418.851 kN/m^2
Max. Base Pressure at deff for Design of Heel Slab-along Face AB = 394.916 kN/m^2

Pressure calculation along Face CD:



Case : 1	231.550	275.137	284.74	298.926	308.530	337.933
Case : 2	210.548	275.342	289.62	310.704	324.980	368.688
Case : 3	179.069	204.419	210.00	218.254	223.840	240.940
Case : 4	158.140	202.606	212.40	226.874	236.671	266.667
Case : 5	160.730	249.271	268.78	297.594	317.103	376.831
Case : 6	133.449	243.733	268.03	303.922	328.222	402.617
Case : 7	130.434	183.157	194.77	211.931	223.548	259.114
Case : 8	106.170	179.014	195.06	218.769	234.820	283.958
Case : 9	183.204	208.130	213.62	221.733	227.225	244.039
Case : 10	163.407	194.650	201.53	211.702	218.586	239.662
Case : 11	132.378	142.771	145.06	148.444	150.734	157.745
Case : 12	121.433	136.753	140.13	145.113	148.489	158.823

Average MAX Base Pressure for Design of Heel Slab-along Face CD = 258.146 kN/m^2
Average MIN Base Pressure for Design of Heel Slab-along Face CD = 130.781 kN/m^2
Average Base Pressure for Design of Toe Slab-along Face CD = 353.270 kN/m^2
Max. Base Pressure at deff for Design of Toe Slab-along Face CD = 328.222 kN/m^2
Max. Base Pressure at deff for Design of Heel Slab-along Face CD = 275.342 kN/m^2

Calculation of Moment and Shear Force Along Traffic Direction:

Case 1 : Maximum Base Pressure Case (Dry Case)
Heel Slab - Maximum Moment Calculation

Max Average Base Pressure for Design of Heel Slab = 382.736 kN/m^2

Upward moment due to Base pressure = 3875.207 kNm/m

factor

Downward moment due to backfill = 1.35 x 565.810 / 13.500 x 20 x 2.250

	=	2546.146	kNm/m								
Downward moment due to self weight of Heel slab	=	1.35	x	45.563	/	13.500	x	25	x	2.100	
	=	239.203	kNm/m								
Net Moment at face of shaft	=	3875.207	-2546.146	-239.203 =		1089.858	kNm/m	**Tension at Bottom of Heel Slab**			

Case 2 : Minimum Base Pressure Case (HFL Case)

Heel Slab - Maximum Moment Calculation

Min Average Base Pressure for Design of Heel Slab	=	130.781	kN/m^2							
Upward moment due to Base pressure	=	1324.154	kNm/m							
		factor								
Downward moment due to backfill	=	1.35	x	565.810	/	13.500	x	10	x	2.250
	=	1273.073	kNm/m							
Downward moment due to self weight of Heel slab	=	1.35	x	45.563	/	13.500	x	15	x	2.100
	=	143.522	kNm/m							
Net Moment at face of shaft	=	1324.154	-1273.073	-143.522 =		-92.441	kNm/m	**Tension at Top of Heel Slab**		

Heel Slab - Shear Calculation at deff from face of Wall

Depth of slab at critical section	=	0.846	m					
effective depth at critical section	=	0.758	m					
Base pressure at deff from face of wall	=	394.916	kN/m^2					
Shear Force due to upward pressure at deff from face of wall	=	379.294	x	3.688 x	13.500	=	18881.752	KN
		factor						
Downward Force due to backfill	=	1.35	x	565.810 x	20	=	15276.878	KN
Downward Force due to self weight of Heel slab	=	1.35	x	45.563 x	25	=	1537.734	KN
Net Shear Force	=	18881.752		-15276.878	-1537.734	=	2067.140	KN
Net Shear Force / unit meter	=	2067.140	/	13.500		=	153.121	KN/m

Toe Slab - Moment Calculation

Maximum Average Base Pressure for Design of Toe Slab	=	425.947	kN/m^2							
Upward moment due to Base pressure	=	2319.283	kNm/m							
Downward moment due to self weight of Toe slab	=	1.35	x	33.413	/	13.500	x	25	x	1.540
	=	128.6381	kNm/m							
Net Moment at face of shaft	=	2319.283		-128.638 =		2190.645	kNm/m	**Tension at Bottom of Toe Slab**		

Toe Slab - Shear Calculation at deff from Face of Wall

For shear, critical section is assumed to be located at a distance equal to effective depth from face of wall

Depth of slab at critical section	=	0.826	m							
effective depth at critical section	=	0.735	m							
Base pressure at deff from face of wall	=	418.851	kN/m^2							
upward shear force due to base pressure	=	429.389	x	2.488 x		13.500		=	14419.430	KN
C.g. Of base pressure	=	1.178	m							
moment due to upward pressure at critical section	=	16986.251	kNm							
$\tan\beta$	=	0.091								
reduction in shear force (V_{ccd})	=	$\frac{M \tan\beta}{d}$	=	1869.189	KN					
Downward force due to self weight of toe slab	=	1.35	x	0.713	x	2.4875	x	13.500	x 25	
	=	808.168	KN							
Net Shear Force at deff	=	14419.430	-	808.168	-	1869.189		=	11742.073	KN
Net Shear Force / unit meter	=	11742.073	/	13.500				=	869.783	KN/m

Design Input :

Design length	=	1000	mm
Clear Cover For Foundation	=	75	mm
Grade of Concrete for Footing	=	M	**35**

fck	=	35.00	N/mm^2	
fctm	=	2.77	N/mm^2	
Grade of Reinforcement Steel	=	Fe	500D	(HYSD Bars)
fy or fyk	=	500.00	N/mm^2	
fyd	=	434.78	N/mm^2	(fy/1.15)
Es	=	200000.00	N/mm^2	

Flexural Reinforcement Calculation:

		Along Traffic Direction	
		Heel Slab	Toe Slab
Ultimate bending moment,Mu (kNm/m)	**=**	**1089.86**	**2190.64**
Effective depth required (dreq) (mm)	=	431.81	612.20
Effective depth provided (dpro) (mm)	=	812.50	812.50
Check for provided depth	**=**	**SAFE**	**SAFE**
R = Mu/(b d2)	**=**	**1.65**	**3.32**
Total depth provided (mm)	=	900.00	900.00
Limiting depth of neutral axis (mm)	=	501.20	501.20
Actual depth of neutral axis (mm)	=	169.38	370.02
Check for Neutral axis depth	**=**	**OK**	**OK**
Lever arm (z) , mm	=	742.04	658.57
Moment of Resistance w.r.to steel	=	1583.68	3070.45
Check for Moment Capacity	**=**	**SAFE**	**SAFE**
Ast reqd (mm2 / m)	=	3624.41	7842.25
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S,min}$ = 0.26 f_{ctm} b_t d / f_{yk} >= 0.0013 b_t d	=	1170.86	1170.86
Governing Ast (mm2 / m)	=	3624.41	7842.25
Tension Reinforcement			
Dia (mm)	=	**25.00**	**32.00**
Spacing (mm)	=	**200.00**	**150.00**
+ Dia (mm)	=	**25.00**	**32.00**
Spacing (mm)	=	**200.00**	**150.00**
Ast provided (mm2 / m)	=	4908.74	10723.30
Check for Ast provided	**=**	**OK**	**OK**
As per Clause 16.6.1.1. of IRC:112-2011 , Secondary Reinforcement shall be at least			
Secondary Reinforcement (mm2/m)	=	981.75	2144.66
Dia (mm)	=	16.00	25.00
Spacing (mm)	=	200.00	150.00
Ast provided (mm2 /m)	=	1005.31	3272.49
Check for Ast provided	**=**	**OK**	**OK**

Shear Reinforcement Calculation:

		Along Traffic Direction		
		Heel Slab	Toe Slab	
Ultimate Shear Force (V_{Ed})	=	**153.121**	**869.783**	kN/m
Ast provided	=	4908.739	10723.30	mm2/m
Depth of slab at critical section	=	**845.833**	**826.136**	mm
Effective depth at critical section	=	758.333	735.136	mm
Percentage of steel provided ($\rho 1$)	=	0.0058	0.0130	
cl. 10.3.1 of IRC :112-2011				
$\rho 1 = A_{sl}/(b_w\ d) <= 0.02$	=	OK	OK	
Actual shear stress=v_{ED} = (V_{Ed}/b*0.9d)	**=**	**0.224**	**1.315**	N/mm^2
Max shear capacity, 0.135 fck(1-fck/310)	=	4.192	4.192	N/mm^2
Depth Check for Shear Resistance	**=**	**SAFE**	**SAFE**	
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010				
K = 1+Sqrt(200/d) <= 2.0	=	1.514	1.522	

cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010				
$\nu_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	=	0.342	0.344	N/mm^2
$0.12\ K\ (80\ \rho 1\ f_{ck})^{0.33}$	=	0.456	0.598	N/mm^2
$\sigma_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	=	0.000	0.000	N/mm^2
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2011				
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d$ subjected to minimum ($\nu_{min} + 0.15\ \sigma_{cp}$) b_w d	=	370.323	485.564	kN
Check for Shear Reinforcement		**OK, No shear reinf. Req.**	**Provide Shear Reinf.**	
Balance Shear Force= $V_{Rd,s} = V_{Ed} - V_{Rd,c}$	=	0.000	384.219	KN/m
b	=	13.500	13.500	m
Total Shear Force	=	0.000	5186.961	kN
θ = 0.5 x sin^-1 [vEd / (0.18 fck (1- fck/250))]		1.187	7.021	
cot θ = (< 1 cotθ <2.5)	=	2.500	2.500	
fywd = 0.8 x fy/1.15	=	347.826	347.826	N/mm^2
Provide Shear Reinforcement				
Legged	=	**0**	**20**	
Dia	=	**0**	**12**	mm
Area of Shear Reinf, Asw	=	0.000	2261.947	mm^2
z = 0.9 * d	=	682.500	661.623	mm
Spacing of shear Reinforcement required				
S = Asw*z* fywd* cotθ / V_{Rd}	=	0.000	250.889	mm
As per Clause 10.3.3.5 of IRC:112-2011				
Asw/ (b S) = $\rho_{w,min}$ = ($0.072\ f_{ck}^{0.5}$) / f_{yk}	=	0.001	0.001	
Spacing of shear Reinforcement required	=	0.000	196.676	mm
As per Clause 16.5.2 , eq. 16.6 of IRC:112-2011				
S_{max} = 0.75 d	=	568.750	551.352	mm
Governing Spacing of Shear Reinf.	=	**0.000**	**196.676**	mm
Provided Spacing of Shear Reinf.	=	**200**	**150**	mm

SLS CHECK OF FOUNDATION

Foundation Lvl = 1168.180 m

Properties of Footing Base:

A	=	121.500	m^2
ZL	=	182.250	m^3
ZT	=	273.375	m^3

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.00			1822.500	0.600	1093.500	0.000	0.000
SIDL except Wearing Course	1.00			96.000	0.600	57.600	0.000	0.000
Wearing Course	1.20			213.840	0.600	128.304	0.000	0.000
				2132.340		**1279.404**		**0.000**
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1.00	25	5.123	128.081	-0.050	-6.404	0.000	0.000
Dirt Wall-Tapered portion	1.00	25	-0.629	-15.719	-0.050	0.786	0.000	0.000
Bracket - Uniform portion	1.00	25	1.215	30.375	-0.350	-10.631	0.000	0.000
Bracket - Tapered portion	1.00	25	0.608	15.188	-0.300	-4.556	0.000	0.000
Cap - (uniform portion)	1.00	25	6.480	162.000	0.600	97.200	0.000	0.000
Cap - (corbel portion)	1.00	25	5.218	130.441	0.600	78.264	0.000	0.000
Cantilever Return Wall-Rectangle portion	1.00	25	0.000	0.000	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle portion	1.00	25	0.000	0.000	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier or Crash Barrier	1.00	25		28.000	-0.050	-1.400	0.000	0.000
Aproach Slab	1.00	25	7.088	177.188	-0.350	-62.016	0.000	0.000
				655.553		**91.243**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.00	25	42.615	1065.375	-2.250	-2397.094	0.000	0.000
Abutment Shaft	1.00	25	101.516	2537.908	0.633	1606.347	0.000	0.000
Back filling over heel slab	1.00	20	565.810	11316.206	-2.262	-25598.152	0.000	0.000
Front Filling over toe slab	1.00	20	185.328	3706.560	2.830	10490.188	0.000	0.000
Side filling between heel and toe	1.00	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.00	25	45.563	1139.063	-2.100	-2392.031	0.000	0.000
Toe slab	1.00	25	33.413	835.313	2.740	2288.756	0.000	0.000
portion between heel & toe	1.00	25	14.580	364.500	0.600	218.700	0.000	0.000
Vertical Components of active earth pressure	1.00			1433.846	-4.500	-6452.305	0.000	0.000
				22662.360		**-22218.524**		**0.000**
Total				**25450.253**		**-20847.877**		**0.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1066.170	1177.435	9867.403
due to Earth pressure	1.00	3939.458		16909.732

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1066.17	9867.40	0.00	0.00
3939.46	16909.73		
5005.628	**26777.135**	**0.000**	**0.000**

Summary of Forces

P	25450.253	KN
ML	5929.258	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		25450.253		-20847.877		0.000
CWLL-Max. Reaction case	1.00	957.514	0.600	574.508	1.955	1871.716
Vertical Components of LL Surcharge	0.80	269.372	-4.500	-1212.175	0.000	0.000
Total		**26677.139**		**-21485.544**		**1871.716**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1066.170	1177.435	9867.403
due to Earth pressure	1.00	3939.458		16909.732
due to Live load surcharge	0.80	740.094		3781.880

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1066.17	9867.40	0.00	0.00
3939.46	16909.73		
740.09	3781.88		

5745.722	30559.015	0.000	0.000

Summary of Forces

P	26677.139	KN
ML	9073.472	kNm
MT	1871.716	kNm

Case 3 : DL+SIDL-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				**2132.340**		**1279.404**		**0.000**
Substructure & Foundation -Portion 1				**655.553**		**91.243**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.00	25	42.615	1065.375	-2.250	-2397.094	0.000	0.000
Shaft above HFL	1.00	25	34.076	851.895	0.683	582.213	0.000	0.000
Shaft below HFL	1.00	15	67.441	1011.608	0.633	640.289	0.000	0.000
Back filling above HFL over heel slab	1.00	20	261.833	5236.650	-2.250	-11782.463	0.000	0.000
Back filling below HFL over heel slab	1.00	10	313.470	3134.700	-2.272	-7121.419	0.000	0.000
Front Filling over toe slab	1.00	10	185.328	1853.280	2.830	5245.094	0.000	0.000
Side filling between heel and toe	1.00	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.00	15	45.563	683.438	-2.100	-1435.219	0.000	0.000
Toe slab	1.00	15	33.413	501.188	2.740	1373.254	0.000	0.000
Portion between Heel & Toe	1.00	15	14.580	218.700	0.600	131.220	0.000	0.000
Vertical Components of active earth pressure	1.00			1231.722	-4.500	-5542.749	0.000	0.000
				15958.505		**-20296.215**		**0.000**
Total				**18746.398**		**-18925.568**		**0.000**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	Moment @ FND. (kNm)
due to Superstructure		1066.170	1177.435	9867.403
due to Earth pressure	1.00	3384.128		12384.516

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1066.17	9867.40	0.00	0.00
3384.13	12384.52		
4450.298	**22251.919**	**0.000**	**0.000**

Summary of Forces

P	18746.398	KN
ML	3326.351	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		18746.398		-18925.568		0.000
CWLL-Min. Reaction case	1.00	441.086	0.600	264.652	2.633	1161.363
Vertical Components of LL Surcharge	0.80	269.372	-4.500	-1212.175	0.000	0.000
Total		**19456.856**		**-19873.091**		**1161.363**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	Moment @ FND. (kNm)
due to Superstructure		1066.170	1177.435	9867.403
due to Earth pressure	1.00	3384.128		12384.516
due to Live load surcharge	0.80	740.094		3781.880

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1066.17	9867.40	0.00	0.00
3384.13	12384.52		
740.09	3781.88		
5190.392	**26033.799**	**0.000**	**0.000**

Summary of Forces

P	19456.856	KN
ML	6160.708	kNm
MT	1161.363	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.600 - 1168.180)

= 0.000 kNm

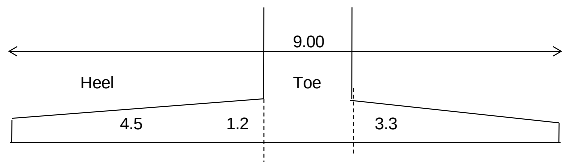
Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT
Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

LOAD CASES	Design Base Pressure						
	P	ML	MT	σ_A	σ_B	σ_C	σ_D
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2
Case 1 : DL+SIDL-Normal Dry Case	25450.253	5929.258	0.000	176.933	242.001	176.933	242.001
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	26677.139	9073.472	1871.716	176.626	276.197	162.932	262.504
Normal HFLCase							
Case 3 : DL+SIDL-Normal HFL Case	18746.398	3326.351	0.000	136.040	172.543	136.040	172.543
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	19456.856	6160.708	1161.363	130.583	198.191	122.087	189.694

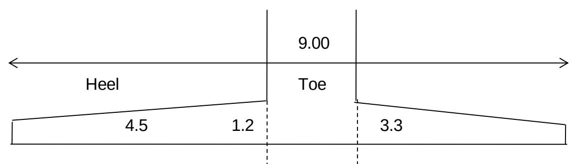
Pressure calculation along Face AB:



Case 1 :	176.933	209.47	218.143	242.001
Case 2:	176.626	226.41	239.688	276.197
Case 4:	136.040	154.29	159.158	172.543
Case 5:	130.583	164.39	173.401	198.191

For Rare Combination
Average Base Pressure for Design of Heel Slab-along Face AB = 201.519 kN/m^2
Average Base Pressure for Design of Toe Slab-along Face AB = 257.943 kN/m^2
For Quasi Permenant Combination
Average Base Pressure for Design of Heel Slab-along Face AB = 193.200 kN/m^2
Average Base Pressure for Design of Toe Slab-along Face AB = 230.072 kN/m^2

Pressure calculation along Face CD:



Case 1 :	176.933	209.47	218.143	242.001
Case 2:	162.932	212.72	225.994	262.504
Case 4:	136.040	154.29	159.158	172.543
Case 5:	122.087	155.89	164.905	189.694

For Rare Combination
Average Base Pressure for Design of Heel Slab-along Face CD = 193.200 kN/m^2
Average Base Pressure for Design of Toe Slab-along Face CD = 244.249 kN/m^2
For Quasi Permenant Combination
Average Base Pressure for Design of Heel Slab-along Face CD = 193.200 kN/m^2
Average Base Pressure for Design of Toe Slab-along Face CD = 230.072 kN/m^2

Moment Calculation

	Rare Combination		Quasi-Parmenant		
	Heel Slab	Toe Slab	Heel Slab	Toe Slab	
Max Average Base Pressure	201.52	257.94	193.20	230.07	kN/m^2
Upward moment due to Base pressure	2040.38	1404.50	1956.15	1252.74	kNm/m
Downward moment due to backfill	1886.03	0.00	1886.03	0.00	kNm/m
Downward moment due to self weight of slab	177.19	95.29	177.19	95.29	kNm/m
Net Moment	**-22.85**	**1309.21**	**-107.07**	**1157.45**	kNm/m
	Tension at Top of Heel Slab	**Tension at Bottom of Toe Slab**	**Tension at Top of Slab**	**Tension at Bottom of Toe Slab**	

Check For Stresses in Rare and Quasi-Permanent Load Combination

Creep Coeff	=	1.2		
Ecm	=	32308.25 N/mm^2		
Es	=	200000.00 N/mm^2		
Eceff	=	$\frac{Ecm}{(1+ø)}$	=	1.47E+04
Modular Ratio (m)	=	Es/ Eceff	=	13.62

		Rare Combination		Quasi Permanent Comb.		
		Heel Slab	Toe Slab	Heel Slab	Toe Slab	
Working bending moment, M	**=**	**22.85**	**1309.21**	**-107.07**	**1157.45**	kNm/m
Dx	**=**	**1.00**	**1.00**			m
Dy	**=**	**0.90**	**0.90**			m
Section Modulus (ZL) of uncracked sect	**=**	**0.14**	**0.14**			m^3
Bending Stress (M/ZL)	=	0.169	9.698			N/mm^2
Tensile stress of concrete , fctm	=	2.771	2.771			N/mm^2
Cracked or Uncracked Section	**=**	**Uncracked**	**Cracked**			
Section properties of Cracked section:						
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.						
Clear Cover, c	=	75.000	75.000			mm
Maximum dia used, ϕ	=	25.000	32.000			mm
Effective Depth deff (dy)	=	812.500	812.500			mm
Ast provided	=	4908.739	10723.303			mm^2/m
Percentage of steel , pt	=	0.0060	0.0132			
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.332	0.446			
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	269.456	362.528			mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	543.044	449.972			mm
Depth of neutral axis from c.g. Of tesnion steel (ys)	=	455.544	358.972			mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2				
Icr	=	2.624E+10	4.545E+10			mm^4
Maximum compressive stress in concrete	=	**0.235**	**10.443**	**-1.100**	**9.232**	**< 16.8, SAFE**
Maximum Tensile stress in steel	=	**5.402**	**140.820**	**-25.319**	**124.497**	**< 300, SAFE**

Check For Crack Width in Quasi-Permanent Load Combination

Crack width , Wk = Sr max (εsm - εcm)

Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+φ/2)

5*(c+φ/2)	=	437.500	455.000	mm
Provided Spacing	=	100.000	75.000	mm
Check for Applicability of Formula	=	OK	OK	
Maximum crack spacing , $S_{r\,max}$	=	3.4 c +	$\frac{0.425\ k1\ k2\ \varphi}{\rho_{\rho\ eff}}$	
K1	=	0.800	0.800	for deformed bars
K2	=	0.500	0.500	for bending
depth of neutral axis , yc	=	269.456	362.528	mm
$\rho_{\rho\ eff}$ = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.		
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	218.750	218.750	mm
Ac, eff = Dx * hc,eff	=	218750.000	218750.000	mm
$\rho_{\rho\ eff}$ = As/Ac eff	=	0.022	0.049	
Maximum crack spacing , $S_{r\,max}$	=	444.394	365.973	mm
$(\varepsilon_{sm} - \varepsilon_{cm})$	=	$\frac{\sigma_{sc} - k_t f_{ct\,eff} (1 + \alpha_e \rho_{\rho\,eff})}{\rho_{\rho\,eff}}$	/ Es	
tensile stress in steel, ,σsc	=	-25.319	124.497	N/mm^2
Kt	=	0.500	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.771	2.771	N/mm^2
αe = Es/Ecm	=	6.190	6.190	
(εsm - εcm)	=	-0.00008	0.0004	
Crack width , Wk=Sr max (εsm - εcm)	**=**	**0.000**	**0.160**	mm
Check	**=**	**SAFE**	**SAFE**	

CALCULATION OF ULS FORCES FOR DESIGN OF ABUTMENT SHAFT

Abutment shaft bottom M = 1169.080 m

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.35			2460.375	0.000	0.000	0.000	0.000
SIDL except Wearing Course	1.35			129.600	0.000	0.000	0.000	0.000
Wearing Course	1.75			311.850	0.000	0.000	0.000	0.000
				2901.825		**0.000**		**0.000**
Substructure-Portion 1								
Dirt Wall-Uniform portion	1.35	25	5.123	172.910	-0.650	-112.391	0.000	0.000
Dirt Wall-Tapered portion	1.35	25	-0.629	-21.221	-0.650	13.793	0.000	0.000
Bracket - Uniform portion	1.35	25	1.215	41.006	-0.950	-38.956	0.000	0.000
Bracket - Tapered portion	1.35	25	0.608	20.503	-0.900	-18.453	0.000	0.000
Cap - (uniform portion)	1.35	25	6.480	218.700	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1.35	25	5.218	176.095	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1.35	25		37.800	-0.650	-24.570	0.000	0.000
Aproach Slab	1.35	25	7.088	239.203	-0.950	-227.243	0.000	0.000
				884.996		**-407.820**		**0.000**
Substructure-Portion 2								
Abutment Shaft	1.35	25	101.516	3426.176	0.083	285.855	0.000	0.000
Total				**7212.997**		**-121.965**		**0.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.91	1177.435	12122.37
due to Earth pressure	1.5	4914.26		19236.37

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	12122.37	0.00	0.00
4914.26	19236.37	0.00	0.00
6365.17	**31358.74**	**0.000**	**0.000**

Summary of Forces

P	7213.00	KN
ML	31236.77	kNm
MT	0.00	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		7212.997		-121.965		0.000
CWLL-Max. Reaction case	1.5	1436.271	0.000	0.000	1.955	2807.573
Total		**8649.268**		**-121.965**		**2807.573**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.435	12122.374
due to Earth pressure	1.5	4914.256		19236.366
due to Live load surcharge	1.2	1012.379		4717.686

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	12122.37	0.00	0.00
4914.26	19236.37		
1012.38	4717.69		
7377.548	**36076.426**	**0.000**	**0.000**

Summary of Forces

P	8649.268	KN
ML	35954.461	kNm
MT	2807.573	kNm

Case 3 : DL+SIDL-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2901.825		0.000		0.000
Substructure-Portion 1				884.996		-407.820		0.000
Substructure-Portion 2								
Shaft above HFL	1.35	25.000	34.076	1150.058	0.083	129.536	0.000	0.000
Shaft below HFL	1.35	23.500	67.441	2139.550	0.033	95.148	0.000	0.000
Total				**7076.430**		**-183.136**		**0.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.435	12122.374
due to Earth pressure	1.5	4221.513		14473.785

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	12122.37	0.00	0.00
4221.51	14473.78	0.00	0.00
5672.425	**26596.158**	**0.000**	**0.000**

Summary of Forces

P	7076.430	KN
ML	26413.023	kNm

MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		7076.430		-183.136		0.000
CWLL-Max. Reaction case	1.5	661.629	0.000	0.000	2.633	1742.045
Total		**7738.059**		**-183.136**		**1742.045**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.435	12122.374
due to Earth pressure	1.5	4221.513		14473.785
due to Live load surcharge	1.2	1012.379		4717.686

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	12122.37	0.00	0.00
4221.51	14473.78		
1012.38	4717.69		
6684.804	**31313.845**	**0.000**	**0.000**

Summary of Forces

P	7738.059	KN
ML	31130.709	kNm
MT	1742.045	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1.50 αh= 0.120 In Longitudinal direction

αh= 0.360 In Transverse direction

αv= 0.240 In Vertical direction

Weight of shaft below Ground level = 1484.8 KN

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1.35			2460.375		295.245	196.830	0.000	0.000	0.000	1178.035		0.000	0.000	2643.919
SIDL except Wearing Course	1.35			129.600		15.552	10.368	0.000	0.000	0.000	1178.849		0.000	0.000	151.926
Wearing Course	1.75			311.850		28.868	19.246	0.000	0.000	0.000	1178.400		0.000	0.000	269.053
				2901.825		**339.665**	**226.444**		**0.000**	**0.000**				**0.000**	**3064.899**
Substructure-Portion 1															
Dirt Wall-Uniform portion	1.35	25	5.123	172.910	23.055	20.749	13.833	-0.650	-112.391	-8.991	1177.768	200.287	0.000	0.000	180.258
Dirt Wall-Tapered portion	1.35	25	-0.629	-21.221	-2.829	-2.546	-1.698	-0.650	13.793	1.103	1177.213	-23.011	0.000	0.000	-20.710
Bracket - Uniform portion	1.35	25	1.215	41.006				-0.950	-38.956						
Bracket - Tapered portion	1.35	25	0.608	20.503				-0.900	-18.453						
Cap - (uniform portion)	1.35	25	6.480	218.700	29.160	26.244	17.496	0.000	0.000	0.000	1176.984	230.481	0.000	0.000	207.433
Cap - (corbel portion)	1.35	25	5.218	176.095	23.479	21.131	14.088	0.000	0.000	0.000	1176.684	178.537	0.000	0.000	160.683
RCC Railing or Crash Barrier	1.35	25		37.800				-0.650	-24.570				0.000		
Aproach Slab	1.35	25	7.088	239.203				-0.950	-227.243				0.000		
				884.996	**72.865**	**65.578**	**43.719**		**-407.820**	**-7.888**		**586.294**		**0.000**	**527.664**
Substructure-Portion 2															
Abutment Shaft	1.35	25	101.516	**3426.176**	**258.846**	**232.962**	**155.308**	**0.083**	**285.855**	**12.958**	**1174.812**	**1483.707**	**0.000**	**0.000**	**1335.337**
Total =				**7212.997**	**331.711**	**638.205**	**425.470**		**-121.965**	**5.070**		**2070.001**		**0.000**	**4927.900**
							-425.470			-5.070					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	339.665	1177.435	12122.374	3064.899
due to Substructure		331.711	298.540		2070.001	1863.001
due to Active Earth pressure	1.00	3276.171			12824.244	
due to dynamic increment of EP	1.50	2534.695			11811.681	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	12122.37	0.00	0.00	0.00	0.00	339.67	3064.90
331.71	2070.00	0.00	0.00	0.00	0.00	298.54	1863.00
3276.17	12824.24						
2534.70	11811.68						
7593.49	**38828.30**	**0.00**	**0.00**	**0.00**	**0.00**	**638.21**	**4927.90**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	7638.467	6787.527	KN
ML	38711.405	38701.265	kNm
MT	4927.900	4927.900	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				2901.825		339.665	226.444		0.000	0.000				0.000	3064.899
Forces from Substructure				4311.172	331.711	298.540	199.027		-121.965	5.070		2070.001		0.000	1863.001
CWLL-Max. Reaction case	0.20			191.50		31.023	20.682	0.000	0.000	0.000	1179.600		1.955	374.343	326.367
Total =				**7404.500**	**331.711**	**669.229**	**446.152**		**-121.965**	**5.070**		**2070.001**		**374.343**	**5254.266**
							-446.152			-5.070					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	370.689	1177.435	12122.374	3391.265
due to Substructure		331.711	298.540		2070.001	1863.001

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	12122.37	0.00	0.00	0.00	0.00	370.69	3391.27
331.71	2070.00	0.00	0.00	0.00	0.00	298.54	1863.00

due to Active Earth pressure	1.00	3276.171			12824.244	
due to dynamic increment of EP	1.50	2534.695			11811.681	
due to Live load surcharge	0.20	168.730			786.281	
due to dynamic increment of Surcharge	1.50	652.711			4075.790	

3276.17	12824.24						
2534.70	11811.68						
168.73	786.28						
652.71	4075.79						
8414.93	**43690.37**	**0.00**	**0.00**	**0.00**	**0.00**	**669.23**	**5254.27**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	7850.652	6958.348	KN
ML	43573.477	43563.337	kNm
MT	5628.610	5628.610	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2901.825		339.665	226.444		0.000	0.000				0.000	3064.899
Substructure-Portion 1				884.996	72.865	65.578	43.719		-407.820	-7.888		586.294		0.000	527.664
Substructure-Portion 2															
Shaft above HFL	1.350	25.000	34.076	1150.058	153.341	138.007	92.005	0.083	95.952	7.676	1175.312	955.622	0.000	0.000	860.060
Shaft below HFL	1.350	23.500	67.441	2139.550	87.296	78.567	52.378	0.033	70.480	1.725	1173.590	393.706	0.000	0.000	354.336
				3289.609	**240.637**	**216.574**	**144.382**		**166.432**	**9.402**		**1349.328**		**0.000**	**1214.395**
Total =				**7076.430**			**414.545**		**-241.387**	**1.514**				**0.000**	
							-414.545			-1.514					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	339.665	1177.435	12122.374	3064.899
due to Substructure		313.502	282.152		1935.622	1742.060
due to Active Earth pressure	1.00	2802.823			9649.190	
due to dynamic increment of EP	1.50	2168.478			7652.251	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	12122.37	0.00	0.00	0.00	0.00	339.67	3064.90
313.50	1935.62	0.00	0.00	0.00	0.00	282.15	1742.06
2802.82	9649.19						
2168.48	7652.25						
6735.72	**31359.44**	**0.00**	**0.00**	**0.00**	**0.00**	**621.82**	**4806.96**

Summary of Forces

	Downward	Upward	
P	7490.975	6661.89	KN
ML	31119.563	31116.54	kNm
MT	4806.958	4806.96	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2901.825		339.665	226.444		0.000	0.000				0.000	3064.899
Forces from Substructure				4174.605	313.502	282.152	188.101		-241.387	1.514		1935.622		0.000	1742.060
CWLL-Min. Reaction case	0.20			88.22		14.291	9.527	0.000	0.000	0.000	1179.600		2.633	232.273	150.343
Total =				**7164.647**	**313.502**	**636.108**	**424.072**		**-241.387**	**1.514**		**1935.622**		**232.273**	**4957.302**
							-424.072			-1.514					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	353.957	1177.435	12122.37	3215.242
due to Substructure		313.502	282.152		1935.62	1742.060
due to Active Earth pressure	1.00	2802.823			9649.19	
due to dynamic increment of EP	1.50	2168.478			7652.25	
due to Live load surcharge	0.20	168.730			786.28	
due to dynamic increment of Surcharge	1.50	652.711			4014.96	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	12122.37	0.00	0.00	0.00	0.00	353.96	3215.24
313.50	1935.62	0.00	0.00	0.00	0.00	282.15	1742.06
2802.82	9649.19						
2168.48	7652.25						
168.73	786.28						
652.71	4014.96						
7557.16	**36160.68**	**0.00**	**0.00**	**0.00**	**0.00**	**636.11**	**4957.30**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	7588.720	6740.575	KN
ML	35920.802	35917.774	kNm
MT	5189.574	5189.574	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = Pxe L1	MLs due to Fv	MT = PxeT
Total =				**7212.997**	**425.470**	**-121.965**	**5.070**	**0.000**
					-425.470		-5.070	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1132.218	1177.435	12122.374	10216.3288
due to Substructure		99.513	995.1327		621.000	6210.00376
due to Active Earth pressure	1.00	3276.171			12824.244	
due to dynamic increment of EP	1.50	760.409			3543.504	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	12122.37	0.00	0.00	0.00	0.00	1132.22	10216.33
99.51	621.00	0.00	0.00	0.00	0.00	995.13	6210.00
3276.17	12824.24						
760.41	3543.50						
5587.01	**29111.12**	**0.00**	**0.00**	**0.00**	**0.00**	**2127.35**	**16426.33**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	7638.467	6787.527	KN
ML	28994.228	28984.088	kNm
MT	16426.333	16426.333	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = Pxe L1	MLs due to Fv	MT = PxeT
Total =				**7404.500**	**446.152**	**-121.965**	**5.070**	**374.343**
					-446.152		-5.070	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1235.6295	1177.435	12122.374	11304.2178
due to Substructure		99.513	995.1327		621.000	6210.004
due to Earth pressure	1.00	3276.171			12824.244	
due to dynamic increment of EP	1.50	760.409			3543.504	
due to Live load surcharge	0.20	168.730			786.281	
Surcharge	1.50	195.813			1222.737	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	12122.37	0.00	0.00	0.00	0.00	1235.63	11304.22
99.51	621.00	0.00	0.00	0.00	0.00	995.13	6210.00
3276.17	12824.24						
760.41	3543.50						
168.73	786.28						
195.81	1222.74						
5951.55	**31120.14**	**0.00**	**0.00**	**0.00**	**0.00**	**2230.76**	**17514.22**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	7850.652	6958.348	KN
ML	31003.246	30993.106	kNm
MT	17888.565	17888.565	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = Pxe L1	MLs due to Fv	MT = PxeT
Total =				**7076.430**	**414.545**	**-241.387**	**1.514**	**0.000**
					-414.545		-1.514	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1132.218	1177.435	12122.374	10216.329
due to Substructure		94.051	940.50588		580.687	5806.866
due to Active Earth pressure	1.00	2802.823			9649.190	
due to dynamic increment of EP	1.50	650.543			2295.675	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	12122.37	0.00	0.00	0.00	0.00	1132.22	10216.33
94.05	580.69	0.00	0.00	0.00	0.00	940.51	5806.87
2802.82	9649.19						
650.54	2295.68						
4998.33	**24647.93**	**0.00**	**0.00**	**0.00**	**0.00**	**2072.72**	**16023.19**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	7490.975	6661.885	KN
ML	24408.052	24405.025	kNm
MT	16023.195	16023.195	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = Pxe L1	MLs due to Fv	MT = PxeT
Total =				**7164.647**	**424.072**	**-241.387**	**1.514**	**232.273**
					-424.072		-1.514	

Forces due to Horizontal Load

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1179.8553	1177.435	12122.374	10717.4732
due to Substructure		94.051	940.50588		580.687	5806.866
due to Earth pressure	1.00	2802.823			9649.190	
due to dynamic increment of EP	1.50	650.543			2295.675	
due to Live load surcharge	0.20	168.730			786.281	
Surcharge	1.50	195.813			1204.487	

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	12122.37	0.00	0.00	0.00	0.00	1179.86	10717.47
94.05	580.69	0.00	0.00	0.00	0.00	940.51	5806.87
2802.82	9649.19						
650.54	2295.68						
168.73	786.28						
195.81	1204.49						
5362.87	**26638.69**	**0.00**	**0.00**	**0.00**	**0.00**	**2120.36**	**16524.34**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	7588.72	6740.58	KN
ML	26398.82	26395.79	kNm
MT	16756.61	16756.61	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.50 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.600 - 1169.080) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.600 - 1169.080) = 0.000 kNm

	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Summary of ULS Forces for Design of Abutment Shaft

LOAD CASES		Total forces at bottom of abutment shaft P	ML	MT
		kN	kNm	kNm
Normal Dry Case				
Case 1 : DL+SIDL-Normal Dry Case		7212.997	31236.775	0.000
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case		8649.268	35954.461	2807.573
Normal HFLCase				
Case 3 : DL+SIDL-Normal HFL Case		7076.430	26413.023	0.000
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case		7738.059	31130.709	1742.045
Longitudinal Seismic Dry Case				
Case 5 : DL+SIDL-Long. Seismic Dry Case	DN	7638.467	38711.405	4927.900
	UP	6787.527	38701.265	4927.900
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	DN	7850.652	43573.477	5628.610
	UP	6958.348	43563.337	5628.610
Longitudinal Seismic HFL Case				
Case 7 : DL+SIDL-Long. Seismic HFL Case	DN	7490.975	31119.563	4806.958
	UP	6661.885	31116.536	4806.958
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	DN	7588.720	35920.802	5189.574
	UP	6740.575	35917.774	5189.574
Transverse Seismic Dry Case				
Case 9 : DL+SIDL-Trans. Seismic Dry Case	DN	7638.467	28994.228	16426.333
	UP	6787.527	28984.088	16426.333
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	DN	7850.652	31003.246	17888.565
	UP	6958.348	30993.106	17888.565
Transverse Seismic HFL Case				
Case 11 : DL+SIDL-Trans. Seismic HFL Case	DN	7490.975	24408.052	16023.195
	UP	6661.885	24405.025	16023.195
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	DN	7588.720	26398.820	16756.612
	UP	6740.575	26395.793	16756.612
	MAX =	**8649.27**	**43573.48**	**17888.56**

Design of Wall:

Material Property:

Grade of Concrete	=	M 35
fck	=	35 N/mm^2
fcd	=	15.633 N/mm^2
Grade of steel	=	Fe 500
fy	=	500 N/mm^2
fyd	=	434.783 N/mm^2
Es	=	200000.00 N/mm^2

Cross section of Wall:

Thickness of Wall (B)	=	1.200 m
Depth of Wall (D)	=	13.500 m
Area of Concrete (Ac)	=	16.200 m^2
Clear Cover to earth faces	=	75 mm
Clear Cover to non earth faces	=	50 mm
Maximum Dia of Vertical Reinf.	=	32 mm
Dia of Horizontal Reinf.	=	20 mm
Effective cover	=	127 mm

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = **8649.27** kN

0.1 fcd Ac = 0.1 x 15.63 x 16200000
= 25326000 N
= **25326.00** kN

Since Axial Force is less than axial capacity of section , Section will design as bending element . Neglecting axial force

PART 1: LONGITUDINAL MOMENT : VERTICAL REINFORCEMENT ON EARTH FACE

Ultimate Design bending moment (ML)	=	43573.48 kNm	=	**3227.665 kNm/m**

Check For Depth of Wall :

Mult = 0.165 x fck x b x d^2
= 3227.66 kNm/m

b = 1000.00 mm

Effective Depth Required (dreq) = $SQRT\left(\frac{3227.66 \times 1000000}{0.165 \times 35.00 \times 1000}\right)$

(dreq) = 747.598 mm

Total Depth Required (Dreq)	=	858.60 mm	
Total Depth Provided (Dprov)	=	1200.00 mm	OK
Effective depth provided(deff)	=	1073.00 mm	

R= Mu/(b d^2) = **2.80**

Minimum Longitudinal Reinforcement in wall on each face

= 0.0012 x b x D

Ast min = **1440.00** mm^2/m

Area of Steel Required:

$\frac{pt}{} = \frac{Ast_{req}}{} = \frac{fck}{} \{ 1 - sqrt(1- 4.598 R/fck) \}$

100 b D 2 fy

= 0.0072

Ast_{req} = 8618.322 mm^2/m

Ast required = max(Astmin, Astreq) = **8618.32** mm^2/m

Total are of steel required in full length w = **116347.34** mm^2

Provide	32	mm dia	@	150.00	mm c/c	=	10723.30	mm^2/m	**OK**
Provide	32	mm dia	@	150.00	mm c/c	=			

Effective length of shaft = 13254 mm

Calculation of reinforcement in numbers

Provide	32	mm dia	-	88.00	nos	=	142351.85	mm^2	**OK**
Provide	32	mm dia	-	89.00	nos	=			

Percentage of steel = **0.879** %

Check for Moment of Resistance of Section due to Steel

Limiting Depth of Neutral Axis , Xm $= \frac{0.0035 \cdot d}{(0.0035 + fyd/Es)}$

$= \frac{0.0035 \times 1073.00}{0.0035 + 0.0022}$

= 661.89 mm

Depth of Neutral Axis , X $= \frac{fyd \cdot Ast}{0.36 \cdot fck \cdot b}$

$= \frac{434.78 \times 10723.30}{0.36 \times 35.00 \times 1000.00}$

= 370.02 mm **OK**

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X

= 1073.00 - 153.93

= 919.07 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 10723.30 x 919.07

= 4.28E+09 Nmm /m

= 4284.98 kNm/m > 3227.66 kNm/m

Moment of Resistance of Wall is More than Design Bending Moment , HENCE Wall IS SAFE IN BENDING

LONGITUDINAL REINFORCEMENT ON NON EARTH FACE

Minimum Longitudinal Reinforcement in wall on each face

= 0.0012 x b x D

Ast min = **1440.00** mm^2/m

= **19440.00** mm^2

Provide	20	mm dia	@	150.00	mm c/c	=	2094.40 mm^2/m	OK

Calculation of reinforcement in numbers

Provide	20	mm dia	@	88.00	nos	=	27646.02 mm^2	OK

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

maximum of following	=	0.2500	x	12817.70 =	3204.425	As per IRC: 112-2011 , Clause
	=	0.001	x	1.20E+06 =	1200.000	16.3.2
Maximum Horizontal Reinf.		**3204**	mm^2 per meter			
Min dia of bar	=	0.250	x	32 =	8 mm	
	or	8	mm			
Maximum Spacing between l	<=	300	mm c/c			

2 Legged	20 dia	@	150 c/c	=	4188.790 mm^2	OK

Confinement Reinforcement

As per Clause 17.2.1.3 (Note 2)of IRC:112-2011

Distance between links or ties (ST)	=	1/3	x	1035 =	345.000
	or	200.00 mm			
Governing Spacing	=	200.00 mm			

As per Clause 17.2.1.3 (Note 1)of IRC:112-2011

The Spacing of hoops and ties in the longitudinal direction (SL)

SL	=		5	x	32 =	160 mm
	or	1/5		x	1035 =	207 mm
Min	=		100 mm			

2 Legged	20 dia	@	100 c/c	=	6283.185 mm^2	OK
24 Legged	10 dia	@	100 c/c	=	18849.556 mm^2	
40 links	10 dia	@	100 c/c	=	31415.927 mm^2	
					56548.668 mm^2	

Minimum Confinement Reinforrcement:

$nk = \frac{NED}{Ak\ fck} = \frac{8649268.1}{567000000} = 0.0153$

AC	=	16.200 mm^2				
ACC	=	1.075	x	13.400	=	14.405 mm^2
ρL	=	0.00880 per meter				
ρL	=	0.11886				
fyd	=	434.783				
fcd	=	15.633				

$$\boxed{\omega_{wd.req} = 0.37\frac{A_C}{A_{CC}}\eta_k + 0.13\frac{f_{yd}}{f_{cd}}(\rho_L - 0.01)}$$

$\omega_{wd.req}$ = 0.3999

ω_{wd} = max ($\omega_{wd,req}$, 0.12) = 0.3999

As per Clause 17.2.1.1 (4) of IRC:112-2011

Confined Reinforcement = $\omega_{wd} = \rho_w f_{yd} / f_{cd}$ where , $\rho_w = \frac{A_{sw}}{S_L . b}$

Volumetric ratio,

Asw	=	56548.668	mm^2
SL	=	100.000	mm
b	=	1035.000	mm
ρw	=	0.546	
$\omega_{wd.c}$	=	15.195	
$\omega_{wd,c}$	$\geq$	ω_{wd}	as per equation 17.7 of IRC:112-2011

$\omega_{wd,c}$ = 15.20 OK

Length of Potential Plastic Hinges Refer clause 17.2.1.4 of IRC:112-2011

$$nk = \frac{NED}{Ak\ fck} = 0.0153 < 0.30$$

CALCULATION OF SLS FORCES FOR DESIGN ABUTMENT SHAFT

Abutment shaft bottom lvl = 1169.080 m

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1822.500	0.000	0.000	0.000	0.000
SIDL except Wearing Course	1			96.000	0.000	0.000	0.000	0.000
Wearing Course	1			178.200	0.000	0.000	0.000	0.000
				2096.700		**0.000**		**0.000**
Substructure-Portion 1								
Dirt Wall-Uniform portion	1	25	5.123	128.081	-0.650	-83.253	0.000	0.000
Dirt Wall-Tapered portion	1	25	-0.629	-15.719	-0.650	10.217	0.000	0.000
Bracket - Uniform portion	1	25	1.215	30.375	-0.950	-28.856	0.000	0.000
Bracket - Tapered portion	1	25	0.608	15.188	-0.900	-13.669	0.000	0.000
Cap - (uniform portion)	1	25	6.480	162.000	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	5.218	130.441	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier or Crash Barrier	1	25		28.000	-0.650	-18.200	0.000	0.000
Aproach Slab	1	25	7.088	177.188	-0.950	-168.328	0.000	0.000
				655.553		**-302.089**		**0.000**
Substructure-Portion 2								
Abutment Shaft	1	25	101.516	2537.908	0.083	211.744	0.000	0.000
Total				**5290.161**		**-90.344**		**0.000**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	Moment @ Shaft (kNm)
due to Superstructure		1066.170	1177.435	8907.850
due to Earth pressure	1	3276.171		12824.244
				21732.094

Summary of Forces at Bottom of abutment shaft

P	5290.161	KN
ML	21641.750	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		5290.161		-90.344		0.000
CWLL-Max. Reaction case	1	957.514	0.000	0.000	1.955	1871.716
Total		**6247.675**		**-90.344**		**1871.716**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	ML @ Shaft (kNm)
due to Superstructure		1066.170	1177.435	8907.850
due to Earth pressure	1	3276.171		12824.244
due to Live load surcharge	0.8	674.919		3145.124
				24877.218

Summary of Forces at Bottom of abutment shaft

P	6247.675	KN
ML	24786.874	kNm
MT	1871.716	kNm

Case 3 : DL+SIDL-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2096.700		0.000		0.000
Substructure-Portion 1				655.553		-302.089		0.000

Substructure-Portion 2								
Shaft above HFL	1.000	25.000	34.076	851.895	0.08	71.08	0.00	0.00
Shaft below HFL	1.000	23.500	67.441	1584.852	0.03	52.21	0.00	0.00
				5189.000		**-178.805**		**0.000**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	Moment @ Shaft (kNm)
due to Superstructure		1066.170	1177.435	8907.850
due to Earth pressure	1	2814.342		9649.190
				18557.040

Summary of Forces at Bottom of abutment shaft

P	5189.000	KN
ML	18378.235	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		5189.000		-178.805		0.000
CWLL-Max. Reaction case	1	441.086	0.000	0.000	2.633	1161.363
Total		**5630.086**		**-178.805**		**1161.363**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	ML @ Shaft (kNm)
due to Superstructure		1066.170	1177.435	8907.850
due to Earth pressure	1	2814.342		9649.190
due to Live load surcharge	0.8	674.919		3145.124
				21702.164

Summary of Forces at Bottom of abutment shaft

P	5630.086	KN
ML	21523.359	kNm
MT	1161.363	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.600 - 1169.080) = 0.000 kNm

Summary of SLS Forces for Design of Abutment Shaft

LOAD CASES	**Total forces at bottom of abutment shaft**		
Normal Dry Case	P	ML	MT
	kN	kNm	kNm
Case 1 : DL+SIDL-Normal Dry Case	5290.161	21641.750	0.000
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	6247.675	24786.874	1871.716
Normal HFLCase			
Case 3 : DL+SIDL-Normal HFL Case	5189.000	18378.235	0.000
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	5630.086	21523.359	1161.363

IN RARE COMBINATION

Max SLS Moment = 24786.874 kNm

Max Moment per meter = 1836.065 kNm/m

IN QUASI-PERMANENT

Max SLS Moment = 21641.750 kNm

Max Moment per meter = 1603.093 kNm/m

Check For Stresses in Rare and Quasi-Permanent Load Combination

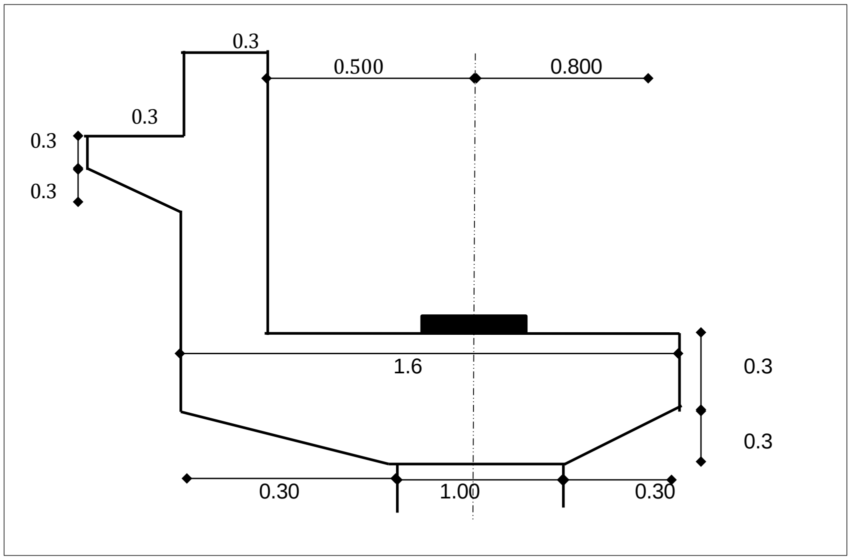
Creep Coeff = 1.2

		Rare Combination		Quasi permanent	
		Short term	Long Term		
Working bending moment, M	=	1836.06	1836.06	1603.09	kNm/m
Dx (unit width of shaft)	=	1.00	1.00	1.00	m
Dy (Thickness of shaft)	=	1.20	1.20	1.20	m
Section Modulus (ZL) of uncrack	=	0.24	0.24	0.24	m^3
Bending Stress (M/ZL)	=	7.650	7.650	6.680	N/mm^2
Tensile stress of concrete , fctm	=	2.771	2.771	2.771	N/mm^2
Cracked or Uncracked Section	=	**Cracked**	**Cracked**	**Cracked**	
Section properties of Cracked section:					
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.					
Es	=	200000.00	200000.00	200000.00	N/mm^2
Ecm	=	32308.25	32308.25	32308.25	N/mm^2
Eceff	=	32308.25	14685.57	14685.57	N/mm^2
Modular Ratio (m)	=	6.19	13.62	13.62	
Clear Cover, c	=	75.000	75.000	75.00	mm
Maximum dia used, ϕ	=	32.000	32.000	32.00	mm
Effective Depth deff (dy)	=	1073.000	1073.000	1073.00	mm
Ast provided	=	10723.303	10723.303	10723.30	mm^2/m
Percentage of steel , pt	=	0.0088	0.0088	0.0088	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m		0.280	0.384	0.384	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	300.327	412.009	412.009	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	772.673	660.991	660.991	mm
Depth of neutral axis from c.g. Of tension steel (ys)	=	681.673	569.991	569.991	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2			
Icr	=	4.866E+10	8.712E+10	8.712E+10	mm^4
Maximum compressive stress in concrete	=	**11.332**	**8.683**	**7.581**	**< 16.8, SAFE**
Maximum tensile stress in concrete	=	29.155	13.931	12.163	
Maximum Tensile stress in steel	=	**159.222**	**163.600**	**142.842**	**< 300, SAFE**

Check For Crack Width in Quasi-Permanent Case

Crack width , Wk	=	Sr max (εsm - εcm)	
Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+φ/2)			
5*(c+φ/2)	=	455.000	mm
Provided Spacing	=	150.000	mm
Check for Applicability of Formula	=	OK	
Maximum crack spacing , $S_{r\ max}$	=	3.4 c +	$\frac{0.425\ k1\ k2\ \varphi}{\rho_{\rho\ eff}}$
K1	=	0.800	for deformed bars
K2	=	0.500	for bending
depth of neutral axis , yc	=	412.009	mm
$\rho_{\rho\ eff}$ = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.	
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	317.500	mm
Ac, eff = Dx * hc,eff	=	317500.000	mm
$\rho_{\rho\ eff}$ = As/Ac eff	=	0.034	
Maximum crack spacing , $S_{r\ max}$	=	416.070	mm
$(\varepsilon_{sm} - \varepsilon_{cm})$	=	$\sigma_{sc} - \frac{k_t f_{ct\ eff} (1 + \alpha_e \rho_{\rho\ eff})}{\rho_{\rho\ eff}}$	/ Es
tensile stress in steel, ,σsc	=	142.842	N/mm^2
Kt	=	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.771	N/mm^2
αe = Es/Ecm	=	13.619	
(εsm - εcm)	=	0.00043	
Crack width , Wk=Sr max (εsm - ε	=	**0.178**	**mm**
Check	=	**< 0.3 ,SAFE**	

DESIGN OF ABUTMENT CAP



As the cap is fully supported on the abutment. Minimum thickness of the cap required as per cl. 710.8.7 of IRC : 78-2014 is 225 mm.

Assuming a cap thickness of	=	225 mm				
Volume of abutment cap	=	225	x	1600	x	13500
	=	4.86E+09 mm^3				
as per cl. 710.8.7 of IRC : 78- 2014						
Quantity of steel	=	1 % of volume				
	=	$\frac{1}{100}$	x	4.86E+09	=	4.86E+07 mm^3

(a) Longitudinal steel

Quantity of steel to be provided in longitudinal direction

	=	2.43E+07 mm^3			
Clear cover	=	50 mm			
Length of bar	=	13500 -100	=	13400 mm	
Area of steel required in longitudinal directi	=	$\frac{2.43E+07}{13400}$	=	1813.433 mm^2	(top +Bottom)

Provide	12	Nos. of	12	mm dia bar as longitudinal steel on top & Bottom face of abutment cap.

Provided steel = 1357 mm^2

(b) Transverse steel

Volume of steel to be provided in transverse direction			=	2.43E+07 mm^3
Volume of steel required per meter	=	$\frac{2.43E+07}{13.50}$	=	1.80E+06 mm^3/m

Provide	**2 L**	**12 mm dia bar @**	**150 mm c/c stirrups**

Length of each stirrups	=	1600	-100	-12	=	1488 mm
Volume of steel provided per meter	=	2.24E+06 mm^3/m	**OK**			

DESIGN OF DIRT WALL

Dirt wall will be designed as a vertical cantilever.

1.) NORMAL CASE

1a. Dead Load

Self Weight of Dirt Wall	=	4.494	m^3 x	25.00	=	112.362 kN
Self Weight of Dirt Wall/ m	=	112.362 /		13.50	=	8.323 kN

1b. Live Load

Assuming Class 70R Boggie load, One Axle is Directly over Dirt Wall

Vertical Load on Dirt Wall = 200 kN

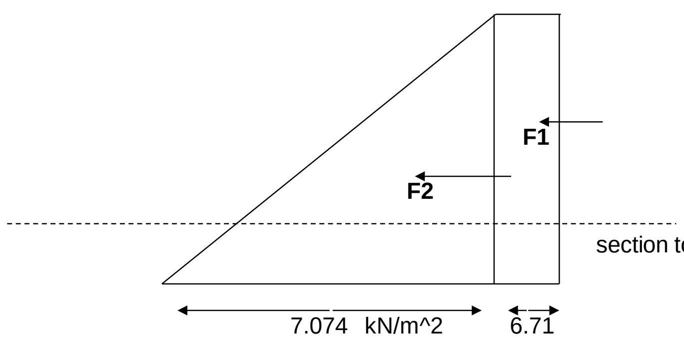
Braking Load

Assuming 20% braking Force i.e. 0.2 *200 = 40.000 kN acting at 1.2 m above deck

Effective Width = 2.79 m

Moment (due to Breaking) = $\frac{40.000 \times 2.466}{2.79}$ = 35.355 kNm/m

1c. EARTH PRESSURE



Height of dirt wall = 1.266 m

Normal Earth Pressure

Earth Pressure Diagram

Intensity for rectangular portion	=	0.279	x 20	x 1.2	=	6.705	kN/m^2	
F1	=	6.705	x 1.27	x 1.00	=	8.489	kN/m	
Intensity for triangular portion	=	0.2794	x 20	x 1.266	=	7.074	kN/m^2	
F2	=	0.50	x 7.07	x 1.266	x 1.00	=	4.478	kN/m

Moment @ RL **1177.13** m (at dirt wall base)

M1 = 8.489 x 0.633 = 5.373 kN.m/m

(Centre of pressure considered at an elevation of 0.42 x the height of the wall as per cl. 217.1 of IRC:6-2014)

M2 = 4.478 x 0.532 = 2.381 kN.m/m

Design Horizontal Forces (Normal Case):

Load Factor For Live Load Surcharge = 1.2
Ultimate Moment due to Live Load Surcharge = 6.448 kN.m/m

Load Factor For Earth Pressure	=	1.5	
Ultimate Moment due to Earth Pressure	=	3.571	kN.m/m
Load Factor For Braking Force	=	1.5	
Ultimate Moment due to Braking Force	=	53.032	kN.m/m
Total Ultimate Moment	**=**	**63.052**	**kN.m/m**

Material Property:

Grade of Concrete	=	M	35
Characteristic Strength of Concrete,fck	=	35.00	Mpa at 28 days
Grade of Reinforcement	=	Fe	500
Yield Strength of Reinforcement, fy or fyk	=	500	N/mm^2
Design Yield Strength of Reinforcement, fyd	=	434.783	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2

(a) Vertical steel on earth face As per Clause 16.3.1 of IRC:112-2011

Adorting clear cover on either face	=	50	mm
Minimum Dia of Reinforcement	=	12	mm
Maximum Spacing of Steel	=	150	mm
Thickness of dirtwall	=	0.300	m
Available effective depth	=	300 -50 -6 = 244	mm

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 63.05 kNm/m

Effective Depth of Cap Required (dreq) = $SQRT\left(\frac{63.05 \times 1000000}{0.165 \times 35.00 \times 1000}\right)$ = 104.490 mm

Total Depth Required (Dreq) = 160.49 mm

Total Depth Provided (Dprov) = 300.00 mm **OK**

R= Mu/(b d^2) = 1.059

Area of Steel Required:

$$\frac{pt}{100} = \frac{Ast_{req}}{b\ d} = \frac{fck\ \{ 1 - sqrt(1- 4.598\ R/fck) \}}{2\ fy} = 0.003$$

Ast_{req} = 616.322 mm^2/m

As per Clause 16.3.1 of IRC:112-2011

Minimum Reinforcement = 0.12/100 b x D = 360 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 616.322 mm^2/m

Provide 12 mm dia bar @ 150 mm c/c as vertical steel at earth face.

Provide Ast = 754 mm^2/m) OK

Percentage of Steel Provided = 0.309 %

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\frac{0.0035\ .\ d}{(0.0035 + fyd/ Es)}$ = $\frac{0.0035 \times 244}{0.0035 + 0.00217}$

= 150.5134 mm

Depth of Neutral Axis , = $\frac{fyd\ .\ Ast}{0.36\ .\ fck\ .\ b}$

= $\frac{435 \times 754}{0.36 \times 35.00 \times 1000}$ = 26.030 mm

OK

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X = 244 - 10.829
= 233.171 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z = 434.78 x 754 x 233.17

= 7.6E+07 Nmm = 76.438 kNm/m > 63.05 kNm/m
SAFE

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

(b) Horizontal steel Refer Clause 16.3.2 of IRC:112-2011

Adopting distribution steel bars Dia. = 10 mm
Minimum Area of Steel = 0.001x 0.5 x b x D OR 25% of Ast on Vertical Face
0.001x0.5xbxD = 150 mm^2/m OR 154.080 mm^2/m

Governing Ast = 154.080 mm^2/m

Maximum Spacing of Bars = 300 mm

Provide 10 mm dia bar @ 200 mm c/c horizontal steel at non earth face.

Provided Ast = **393 mm^2/m)** **OK**

(c) Vertical steel on other face
As per Clause 16.3.1 of IRC:112-2011
Minimum Reinforcement = 0.12/100 b x D = 360 mm^2/m

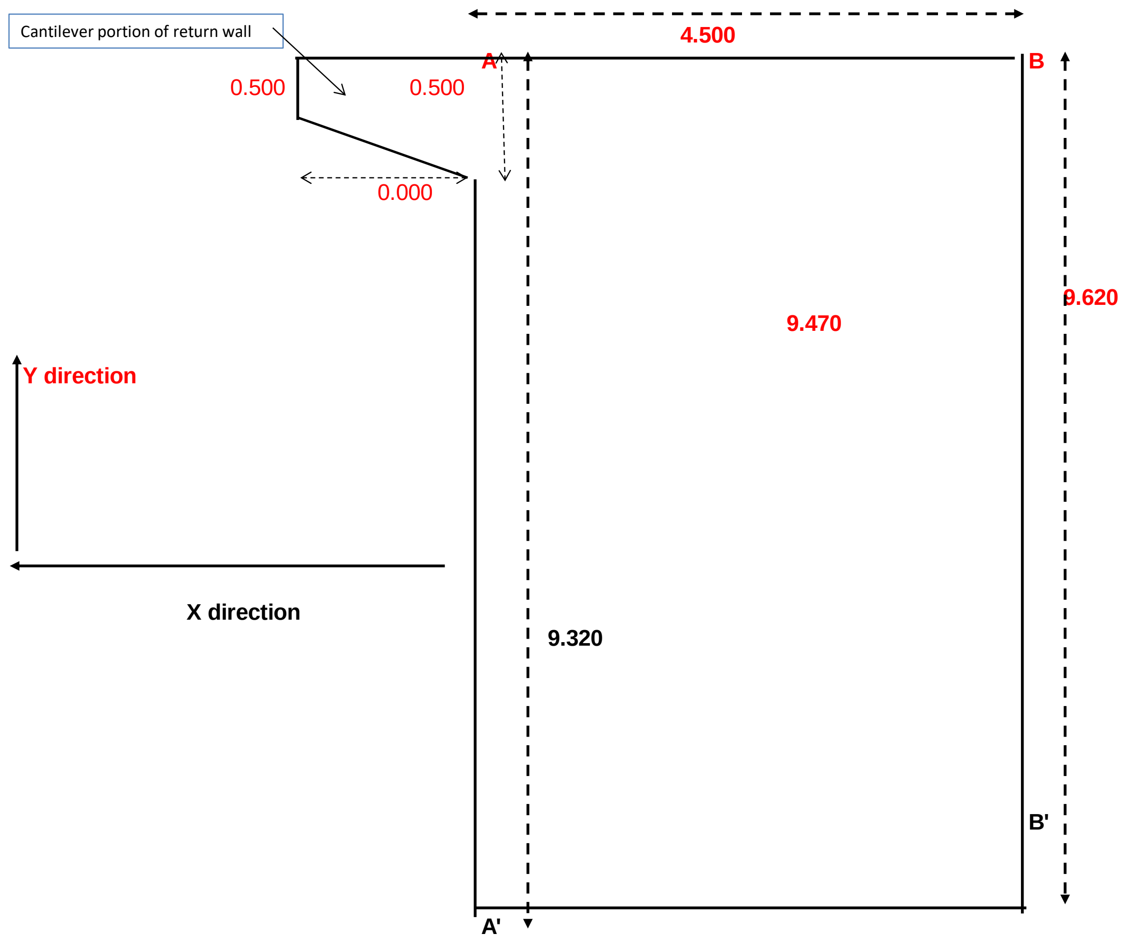
Provide 10 mm dia bar @ 150 mm c/c as vertical steel at earth face.

Provided Ast= 524 mm^2/m) OK

Design of Solid Return wall

THICKNESS OF SOLID RETURN WALL = 0.500 m

THICKNESS OF CANTILEVER RETURN WALL = 0.500 m



Width of Solid Return **a** = 4.50 m
Avg. Heigth of Solid Return **b** = 9.470 m

a) Design of Solid Return wall

For design of return wall Load case 11.a & 11.d and their formulae given by Roark have been used.

Here, a/b = 0.475

a/b =	0.375	$\beta1$ =	0.353	$\beta2$ =	0.398
a/b =	0.5	$\beta1$ =	0.631	$\beta2$ =	0.632

For uniformly distributed load over entire plate

For, a/b = 0.475 $\beta1$ = 0.576
$\beta2$ = 0.586

Live Load Surcharge Intensity:
q = 0.2794 x 20.00 x 1.200 = 6.705 kN/m^2

Max. .σ b = $\frac{\beta1 \;\text{x}\; q \;\text{x}\; b\text{^}2}{(t1)\text{^}2}$

.σ a = β2 x q ›b^2 / (t2)^2

.σ b = 0.576 x 6.705 x 89.681 / 0.250

At bottom edge = 1385.007 kN/m2 = **1.385 MPa**

For 1000 mm of width , Z = 1000 x 250000 / 6

= 4.17E+07 mm^3

Hence Moment /m width along Y direction -

My /m width = 1.385 x 4.167E+07

= 57708643 Nmm/m = **57.709 kN.m/m**

.σ a = 0.586 x 6.705 x 89.681 / 0.250

= 1408 = **1.4084 MPa**

For 1000 mm of height , Z = 1000 x 250000 / 6

= 4.167E+07 mm^3

Hence, Moment /m height along X direction -

Mx /m height = 1.4084 x 4.167E+07 = 5.868E+07 Nmm/m

= **58.684 kN.m/m**

For triangular loading due to Earth Pressure

Refer Load case No. 11 d

a/b	=	0.375	β1	=	0.212	β2	=	0.148
a/b	=	0.5	β1	=	0.328	β2	=	0.2

For, a/b = 0.475 β1 = **0.305**

β2 = **0.190**

q = 0.279 x 20.00 x 9.47

= 52.915 kN/m^2

Max. .σ b = β1 x q ›b^2 / (t1)^2

.σ a = β2 x q ›b^2 / (t2)^2

σ b = 0.305 x 52.915 x 89.681 / 0.25

= 5788.95 kN/m^2

= **5.789 MPa**

For 1000 mm of width , Z = 1000 x 250000 / 6

= 4.167E+07 mm^3

Hence Moment /m width along Y direction -

My /m width = 5.789 x 4.167E+07

= 241206435 Nmm/m = **241.206 kN.m/m**

$.\sigma$ a	=	0.190	x	52.915	x	89.681	
				0.25			
	=	3600.4	kN/m^2	=	3.600	MPa	

For 1000 mm of height , Z = (1000 x 250000) / 6

= 4.167E+07 mm^3

Hence Moment /m height along X direction -

Mx /m height = 3.600 x 4.167E+07 = 1.500E+08 Nmm/m

= **150.018 kN.m/m**

Total Moment in Solid Return Wall / m height = 208.703 kN.m/m

Total Moment in Solid Return Wall / m width = 298.915 kN.m/m

Final Design Moments:

Load Factor for Earth pressure	=	1.50	
Load Factor for live load surcharge	=	1.20	
Total Moment(Mx) in Solid Return Wall / m height	=	295	kN.m/m
Total Moment(My) in Solid Return Wall / m width	=	431	kN.m/m

Material Property:

- Refer Table No 6.5 of IRC : 112-2011

Grade of Concrete	=	M 35	
Characteristic Strength of Concrete,fck	=	35.00 Mpa at 28 days	
Grade of Reinforcement	=	Fe 500	
Yield Strength of Reinforcement, fy or fyk	=	500.00 Mpa	
Design Yield Strength of Reinforcement, fyd	=	434.78 Mpa	(1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00 Mpa	

1. Design of Face BB'

Moment in Solid Return /m height (including cantilever moment) =

= **295.448** **+** **0.00**

= **295.45 kN.m / m**

Adorting clear cover on either face	=	75 mm		
Minimum Dia of Reinforcement	=	20 mm		
Maximum Spacing of Steel	=	150 mm		
Thickness of wall	=	0.500 m		
Available effective depth	=	500	-75	-10
	=	415 mm		

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 295.45 kNm/m

Effective Depth of Cap Required (dreq) = SQRT((295.45 x 1000000) / (0.165 x 35.00 x 1000))

Effective Depth of Cap Required (dreq) = 226.186 mm

Total Depth Required (Dreq) = 311.19 mm

Total Depth Provided (Dprov) = 500.00 mm **OK**

R= Mu/(b d^2) = 1.72

Area of Steel Required:

$$\frac{pt}{100} = \frac{Ast_{req}}{b\ d} = \frac{fck \{ 1 - sqrt(1- 4.598\ R/fck) \}}{2\ fy}$$

= 0.004

Ast_{req} = 1741.061 mm^2/m

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011

= 600 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 1741.061 mm^2/m

Provide 20 mm dia bar @ 150 mm c/c as Horizontal steel at earth face.

Provide Ast= 2094 mm^2/m) OK

Percentage of Steel Provided = 0.505 %

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\dfrac{0.0035 \cdot d}{(0.0035 + fyd/Es)}$

= $\dfrac{0.0035 \times 415}{0.0035 + 0.00217}$

= 255.996 mm

Depth of Neutral Axis , X = $\dfrac{fyd \cdot Ast}{0.36 \cdot fck \cdot b}$

= $\dfrac{434.78 \times 2094}{0.36 \times 35.00 \times 1000}$

= 72.270 mm OK

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X

= 415 - 30.064

= 384.936 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 2094 x 384.936

= 3.51E+08 Nmm

= 350.525 kNm/m > 295.45 kNm/m

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

Provide 12 mm dia bar @ 150 mm c/c as Horizontal steel at non earth face.

Provided Ast = **754 mm^2/m)**

2. Design for Face A'B'

Moment in Solid Return /m width = 431.06 kN.m / m

Adorting clear cover on either face = 75 mm

Minimum Dia of Reinforcement = 25 mm

Maximum Spacing of Steel = 150 mm

Thickness of wall = 0.500 m

Available effective depth = 500 -75 -20 -12.5

= 392.5 mm

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 431.06 kNm/m

Effective Depth of Cap Required (dreq) = SQRT($\frac{431.06 \times 1000000}{0.165 \times 35.00 \times 1000}$)

Effective Depth of Cap Required (dreq) = 273.208 mm

Total Depth Required (Dreq) = 360.71 mm

Total Depth Provided (Dprov) = 500.00 mm **OK**

R= Mu/(b d^2) = 2.80

Area of Steel Required:

$\frac{pt}{100} = \frac{Ast_{req}}{b\ d} = \frac{fck \{ 1 - sqrt(1- 4.598\ R/fck) \}}{2\ fy}$

= 0.007

Ast_{req} = 2812.830 mm^2/m

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011

= 600 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 2812.830 mm^2/m

Provide 25 mm dia bar @ 150 mm c/c as vertical steel at earth face.

Provide Ast= 3272 mm^2/m) OK

Percentage of Steel Provided = 0.8338 %

Provide 12 mm dia bar @ 150 mm c/c as Vertical steel at non earth face.

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\frac{0.0035\ .\ d}{(0.0035 + fyd/ Es)}$

= $\frac{0.0035 \times 392.5}{0.0035 + 0.00217}$

= 242.12 mm

Depth of Neutral Axis , X = $\frac{fyd\ .\ Ast}{0.36\ .\ fck\ .\ b}$

= $\frac{434.78 \times 3272}{0.36 \times 35.00 \times 1000}$

= 112.922 mm OK

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X

= 392.5 - 46.976

= 345.52 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 3272 x 345.524

= 4.92E+08 Nmm

= 491.620 kNm/m > 431.06 kNm/m

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

b) Cantilever Portion of Return Wall

Self-weight of cantilever portion of return wall	=	6	kN/m
Crash Barrier weight	=	10.0	kN/m
Total Load	=	16	kN/m
Moment at Cantilever Face	=	0	kNm
Load Factor	=	1.35	
Design Moment	=	0	kNm
Effective Depth	=	442.000	mm

R= Mu/(b d^2) = 0.00

Area of Steel Required:

$$\frac{pt}{100} = \frac{Ast_{req}}{b\,d} = \frac{fck \{ 1 - sqrt(1- 4.598 R/fck) \}}{2\,fy}$$

= 0.000

Ast_{req} = 0.000 mm^2

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011

= 265.2 mm^2

Maximum (Ast_{req}, Ast_{min}) = 265.2000 mm^2

Provide	**16**	**2**	**=**	**402**	**mm^2**

ANNEXURE-I (LOAD CALCULATION-CARRIAGEWAY LIVE LOAD)

Nos. of Lane for design purpose = 3 LANE

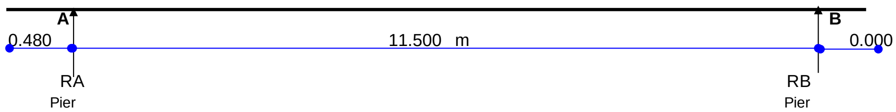
Maximum Live Load Reaction Case

Due to Class A 1-Lane , 2-Lanes, 3-Lanes & 4-Lanes

Considering **114.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	=	**11.50**	**m**
Projection beyond cL of bearing at Abut. end	=	0.480	m
Projection beyond cL of bearing at far end	=	0.000	m
Total length including Overhangs	=	11.98	m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support A in metres	Total Moment of all Loads @ Support A in kN-m	Reaction at Support A in kN	Reaction at Support B in kN
Ist Train	Total Load	500.0kN				
					251.583	**248.417**
114.000	3.200	**0.000**	0.000	0.000		
114.000	1.200	1.200	1.200	136.800		
68.000	4.300	5.500	5.500	374.000		
68.000	3.000	8.500	8.500	578.000		
68.000	3.000	11.500	11.500	782.000		
68.000	3.000	14.500	14.500	986.000		

Reactions (without Impact) for 1 Lane

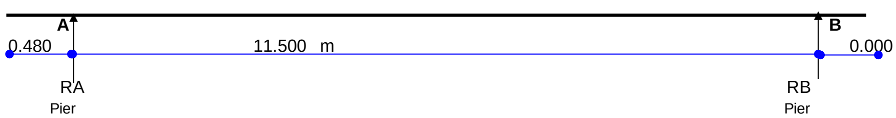
Description		At Supp-A RA	At Supp-B RB
Reaction	in kN	251.583	248.417

Due to Class 70R Wheeled

Considering **170.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	=	**11.50**	**m**
Projection beyond cL of bearing at Abut. end	=	0.480	m
Projection beyond cL of bearing at far end	=	0.000	m
Total length including Overhangs	=	11.98	m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support A in metres	Total Moment of all Loads @ Support A in kN-m	Reaction at Support A in kN	Reaction at Support B in kN
Ist Train	Total Load	1000.0kN				
170.000		**0.000**	-0.480	-81.600		
170.000	1.370	1.370	0.890	151.300	**596.191**	**403.809**
170.000	3.050	4.420	3.940	669.800		
170.000	1.370	5.790	5.310	902.700		
120.000	2.130	7.920	7.440	892.800		
120.000	1.520	9.440	8.960	1075.200		
80.000	3.960	13.400	12.920	1033.600		

Reactions (without Impact) for 70R Wheeled

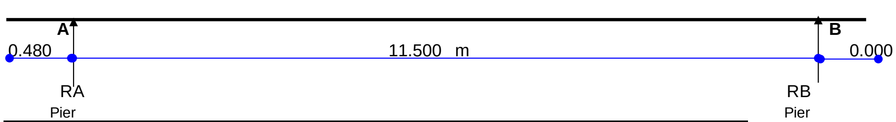
Description		At Supp-A RA	At Supp-B RB
Reaction	in kN	596.191	403.809

Due to Class A 1-Lane/2-Lane (along with Class 70R)

Considering **68.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	=	**11.50**	**m**
Projection beyond cL of bearing at Abut. end	=	0.480	m
Projection beyond cL of bearing at far end	=	0.000	m
Total length including Overhangs	=	11.98	m



Axle Load in kN	Spacing between two successive axles	Distance of the axles from Extreme Left Node	Distance of the axles from the Support A	Total Moment of all Loads @ Support A	Reaction at Support A	Reaction at Support B

	in metres	in metres	in metres	in kN-m	in kN	in kN
Ist Train	Total Load	554.0kN				
68.000		**0.000**	0.000	0.000		
68.000	3.000	3.000	3.000	204.000	**86.287**	**467.713**
68.000	3.000	6.000	6.000	408.000		
68.000	3.000	9.000	9.000	612.000		
114.000	4.300	13.300	13.300	1516.200		
114.000	1.200	14.500	14.500	1653.000		
27.000	3.200	17.700	17.700	477.900		
27.000	1.100	18.800	18.800	507.600		

Reactions (without Impact) for 1 Lane

Description		At Supp-**A** **RA**	At Supp-**B** **RB**
Reaction	in kN	467.713	86.287

Due to Class SV Loading

Considering **180.00** kN

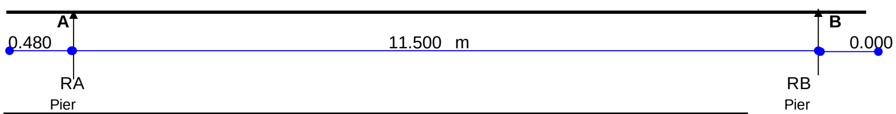
(I.e. **0.000m** from extreme Left End)

Length of the Span = **11.50 m**

Projection beyond cL of bearing at Abut. end = 0.480 m

Projection beyond cL of bearing at far end = 0.000 m

Total length including Overhangs = 11.98 m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support **A** in metres	Total Moment of all Loads @ Support **A** in kN-m	Reaction at Support **A** in kN	Reaction at Support **B** in kN
Ist Train	Total Load	1440.0kN				
180.000		**0.000**	0.000	0.000		
180.000	1.500	1.500	1.500	270.000	**782.609**	**657.391**
180.000	1.500	3.000	3.000	540.000		
180.000	1.500	4.500	4.500	810.000		
180.000	1.500	6.000	6.000	1080.000		
180.000	1.500	7.500	7.500	1350.000		
180.000	1.500	9.000	9.000	1620.000		
180.000	1.500	10.500	10.500	1890.000		
0.000	1.500	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		

Reactions for SV Loading

Description		At Supp-**A** **RA**	At Supp-**B** **RB**
Reaction	in kN	782.609	657.391

Deck Width = **13.500** m

SV LOAD

transverse ecc. = 0.300 m

Maximum Reaction (RA) = 782.609 KN Corr. MT = 234.783 kNm

Minimum Reaction (RB) = 657.391 KN Corr. MT = 197.217 kNm

1-CLASS A

transverse ecc. = 6.75 -0.5 -0.4 -0.9 0 0 = 4.95 m

Maximum Reaction (RA) = 251.583 KN Corr. MT = 1245.334 kNm

Minimum Reaction (RB) = 248.417 KN Corr. MT = 1229.666 kNm

2-CLASS A

transverse ecc. = 6.75 -0.5 -0.4 -1.8 -0.85 0 = 3.20 m

Maximum Reaction (RA) = 503.165 KN Corr. MT = 1610.129 kNm

Minimum Reaction (RB) = 496.835 KN Corr. MT = 1589.871 kNm

3-CLASS A

transverse ecc. = 6.75 -0.5 -0.4 -1.8 -1.7 -0.9 = 1.45 m

Maximum Reaction (RA) = 754.748 KN Corr. MT = 1094.384 kNm

Minimum Reaction (RB) = 745.252 KN Corr. MT = 1080.616 kNm

4-CLASS A

transverse ecc. = 6.75 -0.5 -0.4 -1.8 -1.7 -1.8 -0.85 = -0.3 m

Maximum Reaction (RA) = 1006.330 KN Corr. MT = -301.899 kNm

Minimum Reaction (RB) = 993.670 KN Corr. MT = -298.101 kNm

1- 70RW

Transverse Ecc. for 70RW = 6.75 -0.5 -1.2 -1.395 = 3.655 m

Maximum Reaction (RA) = 596.191 KN Corr. MT = 2179 kNm

Minimum Reaction (RB) = 403.809 KN Corr. MT = 1476 kNm

1-CLASS A + 1-70RW 3 LANE

Transverse Ecc. for Class A = 6.75 -0.5 -0.4 -0.9 = 4.95 m
for 70RW = 6.75 -0.5 -0.4 -1.8 -0.25 -2.8 -1.395 = -0.395

Maximum Reaction (RA) = 1063.904 KN Corr. MT = 467.71 x 4.95 + 596.19 x -0.395 = 2080
Minimum Reaction (RB) = 490.096 KN Corr. MT = 86.287 4.95 + 403.809 -0.395 = 268

2-CLASS A + 1-70RW 4 LANE

Transverse Ecc. for 1st Class A = 4.95 m
for 2nd Class A = 4.95 -0.90 -0.85 0 = 3.2 m
for 70RW = 3.2 -0.85 -1.8 -0.25 -1.2 -1.395 = -2.295

Maximum Reaction (RA) = 1531.617 KN Corr. MT = 467.71 x 4.95 + 467.71 x 3.200 = 2444
\+ 596.19 x -2.295

Minimum Reaction (RB) = 576.383 KN Corr. MT = 86.287 4.95 + 86.29 x 3.200 = -224
\+ 403.81 x -2.295

1- 70RW + 1-CLASS A - 3 LANE

Transverse Ecc. for 70RW = 6.75 -0.5 -1.2 -1.395 = 3.655 m
for Class A = 6.75 -0.5 -7.25 -0.25 -0.9 = -2.150 m

Maximum Reaction (RA) = 1063.904 KN Corr. MT = 596.19 x 3.655 + 467.71 x -2.150 = 1173
Minimum Reaction (RB) = 490.096 KN Corr. MT = 403.809 3.655 + 86.287 -2.150 = 1290

1- 70RW + 2-CLASS A - 4 LANE

Transverse Ecc. for 70RW = 3.655 m
for 1st Class = -2.150 m
for 2nd Clas = -2.150 -0.9 -0.85 = -3.900 m

Maximum Reaction (RA) = 1531.617 KN Corr. MT = 596.19 x 3.655 + 467.71 x -2.150 = -651
\+ 467.71 x -3.900

Minimum Reaction (RB) = 576.383 KN Corr. MT = 403.809 3.655 + 86.287 -2.150 = 954
\+ 86.29 x -3.900

2- 70RW - 4 LANE

Transverse Ecc. for 1-70RW = 3.655 m
for 2-70RW = 3.655 -1.395 -1.26 -1.40 = -0.395 m

Maximum Reaction (RA) = 1192.383 KN Corr. MT = 596.19 x 3.655 + 596.19 x -0.395 = 1944

Minimum Reaction (RB) = 807.617 KN Corr. MT = 403.809 3.655 + 403.809 -0.395 = 1316

Summary of Reaction and Corresponding moments

Max Reaction Cases	Reaction (RA) , (kN)	Corr. MT (kNm)	Reaction RB, , (kN)	Corr. MT (kNm)
1-CLASS A	251.583	1245.334	248.417	1229.666
2-CLASS A	503.165	1610.129	496.835	1589.871
3-CLASS A	754.748	1094.384	745.252	1080.616
4-CLASS A	0.000	0.000	0.000	0.000
1- 70RW	596.191	2179.079	403.809	1475.921
1-CLASS A + 1-70RW	1063.904	2079.684	490.096	267.616
1- 70RW + 1-CLASS A	1063.904	1173.496	490.096	1290.404
2-CLASS A + 1-70RW	0.000	0.000	0.000	0.000
1- 70RW + 2-CLASS A	0.000	0.000	0.000	0.000
2- 70RW	0.000	0.000	0.000	0.000

Maximum Reaction & Corresponding Transverse Moment

Reaction RA = 1063.904 KN & Corresponding momen = 2079.684 kNm
Reaction RB = 490.096 KN & Corresponding momen = 1290.404 kNm

Maximum Transverse Moment & Corresponding Reaction

Reaction RA = 596.191 KN & Max moment = 2179.079 kNm
Reaction RB = 490.096 KN & Max moment = 1290.404 kNm

DESIGN OF COUNTER FORT TYPE ABUTMENT (A2) WITH OPEN FOUNDATION

FOR ROTARY (RHS) AT CH:- 29+470

INDEX

Details of Superstructure:

Skew Angle of Bridge	=	0	Degree	=	0.000 Radians	COS θ =	1.000
						SIN θ =	0.000

Radius of Curvature of Superstructure	=	0	m
Design speed of vehicle	=	100	kmph

		Right Dimensions	Skew Dimensions
Span -c/c of Brg.	=	11.500m	11.500m
Thickness of Expansion Joint	=	0.020m	0.020m
Slab projection Beyond C/L of Bearing (Back Side)	=	0.480m	0.480m
Slab projection Beyond C/L of Bearing (Span Side)	=	0.000m	0.000m
Span -c/c of E.J.	=	12.000m	12.00m
Type of Superstructure	=	RCC SOLID SLAB	
Width of Crash barrier (Both Side)	=	0.450m	
Width of Carriageway	=	11.000m	
Projection beyond crash barrier	=	0.050m	
Thickness of Wearing coat	=	0.065m	
Length of Approach Slab (Right)	=	3.500m	3.500m
Width of Footpath on both side	=	1.500m	
Railing/kerb on footpath edge	=	0.000m	
Total Width of Superstructure	=	13.500m	
Median Width minus 20mm gap	=	0.000m	

Bearings

Type of Bearing	=	Tar Paper Bearing	
Coeff. Of Friction for POT-PTFE Bearing	=	0.5	
Type of Soil	=	2	Medium Soil Strata
NBC of soil -Normal Case	=	350	kN/m^2 (as per geotechnical report with ground improvement)
SBC of soil-Normal Case	=	380	kN/m^2
SBC of soil-Seismic Case	=	475	kN/m^2
Coeff. of friction between concrete and soil	=	0.7	for weathered rock
Permissible FOS against Sliding	=	1.5	Normal Case
	=	1.25	Seismic Case
Permissible FOS against Overturning	=	2	Normal Case
	=	1.5	Seismic Case

Dirt Wall		Right Dimensions	Skew Dimensions
Width of Dirt wall at Top	=	0.300m	0.300m
Width of Dirt wall at Bottom	=	0.300m	0.300m
Height of Uniform portion	=	1.265m	
Height of Tapering portion	=	-0.155m	
Length of Dirt Wall at top (Uniform portion)	=	13.500m	13.500m
Length of Dirt Wall at bottom (Tapering Portion)	=	13.500m	13.500m

Abutment Cap

Width of Abutment cap of Uniform portion	=	1.600m	1.600m
Width of Abutmentcap at bottom of Tapering Portion	=	1.000m	1.000m

Projection of Abutment Cap (Span Side)	=	0.300m	0.300m
Projection of Abutment Cap Back Side	=	0.300m	0.300m
Abutmentcap thickness (Uniform portion)	=	0.300m	
Abutmentcap thickness (Tapering Portion)	=	0.300m	
Length of Abutment Cap at top (Uniform portion)	=	13.500m	13.500m
Length of Abutment Cap at bottom (Tapering Portion)	=	13.500m	13.500m

Abutment- Wall Type

Thickness of Abutment	=	1.000m	
Width of abutment shaft	=	13.500m	13.500m
Thickness of Abutment shaft at Top	=	1.000m	1.000m
Thickness of Abutment shaft at HFL	=	1.000m	1.000m
Thickness of Abutment shaft at Bottom	=	1.000m	1.000m

Solid Return Wall

Length of Return wall	=	4.000m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	0.500m

Cantilever Return Wall

Height of Return Wall-Free edge	=	0.000m
Height of wall at abutment	=	0.000m
Length of Return wall	=	0.000m
Thickness of Return wall at Top	=	0.500m
Thickness of Return wall at Bottom	=	0.500m

Foundation

Along Traffic Direction:

Total Width of Footing	=	8.000m
abutment pedestal width	=	1.000m
abutment pedestal Height	=	1.000m
Width of Toe Slab	=	3.000m
Width of Heel Slab	=	4.000m
Thickness of Toe slab at tip	=	0.500m
Thickness of Toe slab near shaft	=	1.000m
Thickness of heel slab at tip	=	0.500m
Thickness of heel slab near shaft	=	1.000m
Width of backfill on heel slab	=	4.000m
Thickness of heel slab at back fill edge	=	1.000m
Height of back fill at bottom edge of heel slab	=	8.032m
Height of back fill at back fill edge of heel slab	=	7.532m

Across Traffic Direction:

Width of foundation -Uniform portion	=	13.500m (skew dimension)
Width of foundation -Tapering portion	=	13.500m (skew dimension)

Levels

Deck Level at Median Edge=	**1178.323m**	Cross Slope (Bi-directional)	=	2.500%
Deck level at Outer Edge =	**1178.011m**	Height of Superstructure	=	0.900m
Deck level at center line =	1178.323m	Min. Height of Footpath Side Pedestal (1)	=	0.300m
Soffit Level at center of bridge =	1177.358m	Height of Pedestal (2)	=	0.300m
Abutment cap top level =	1177.057m	Height of Pedestal (3)	=	0.300m
Abutment cap bottom lvl (uniform portion ends	1176.757m	Height of Pedestal (4)	=	0.000m
Abutment cap bottom lvl (corbel portion ends)	1176.457m	Distance of nearest girder to c.l. of deck	=	0.000m
Abutment shaft top level =	1176.457m	Height (Avg.) of Dirt Wall	=	1.110m
Ground level/LBL =	1172.636m	Abutment shaft Above G.L	=	3.821m

Abutment shaft bottom level =	1170.635m	Abutment Shaft below G.L	=	2.001m
Foundation level =	1169.635m	Height of abutment shaft	=	5.822m
HFL	1173.636m	MSL	=	1172.636m
		Wedge over girder flange	=	0.0020m

Material Specification

Concrete Grade	=	M 35	
Characteristic compressive strength of concrete,fck	=	35.00	Mpa at 28 days
Design Compressive strength of Concrete, fcd	=	15.63	Mpa at 28 ((0.67/1.5 * fck)
Tensile strength of concrete , fctm	=	2.77	MPa
Strain at reaching Characteistic Strength, $\varepsilon c2$	=	0.02	
Ultimate Strain, $\varepsilon cu2$	=	0.035	
Ecm	=	32308.250	N/mm^2
Steel Grade	=	Fe 500D	(HYSD Steel)
Yield Strength of Reinforcement, fy or fyk	=	500	Mpa
Design Yield Strength of Reinforcement, fyd	=	434.78	Mpa (1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00	Mpa
Dry weight of Concrete	=	25	kN/m^3
Dry unit weight of soil	=	20	kN/m^3
Permissible Crack Width	=	0.3	mm - For Moderrate/ severe Exposure Condition
Maximum compressive stress in concrete under rare combination	=	0.48 fck	
	=	16.8	N/mm^2
Maximum tensile stress in steel under rare combination	=	300	N/mm^2

Creep Coefficient

For Abutment Shaft	=	1.2	for 365 days
For Footing	=	1.2	for 365 days

Clear Cover to Reinforcement

Earth Face	=	75	mm
Non-Earth Face	=	50	mm

Seismic Data: NO NEED TO CHECK FOR SEISMIC EFFECT

Seismic Zone		=	4	
Z	=Zone factor	=	0.24	
I	=Importance factor	=	1.2	
R	=Response Reduction factor	=	3	in Longitudinal direction
		=	1	In Transverse direction

Properties of backfill material :

c	=	0
ϕ	=	30
θ	=	90
β	=	0
δ	=	20.0

REACTION FROM SUPERSTRUCTURE (in kN)

Dist between c.g of Bearing and c.g. of abutment shaft	=	0.000m	in longitudinal direction
Dist between c.g of superstructure and c.g. of abutment shaft	=	0.000m	in Transverse direction
C.G. of crash barrier above deck level	=	0.449m	

From Superstructure analysis

Dead Load

Self weight of Slab	=	0.90	x	12.00	x	13.50	x	25.00
	=	3645.00	KN					
Reaction at one end	=	1822.50	KN					
Transverse Eccentricity	=	0.000	m					

Super Imposed Dead Load Reactions (Excluding Wearing Course)

Weight of Crash barrier	=	2	x	8.00	x	12.00
	=	192.00	KN			
Reaction at one end	=	96.00	KN			
Transverse Eccentricity	=	0.00	m			

Reaction Due to Wearing Course only

Weight due to Wearing Coat	=	2.2	x	12	x	13.5
	=	356.4	KN			
Reaction at one end	=	178.2	KN			
Transverse Eccentricity	=	0.00	m			

Carriageway Live Load Reactions

Reduction Factor = **0.9** (for 3 Lane)

Congestion factor = **1** (As per Table 3 of IRC :112-2014)

MAXIMUM REACTION CASE:

1- 70RW + 2-CLASS A

Max CWLL

Vertical	Transverse ecc
957.51	1.95

Min CWLL

Vertical	Transverse ecc
441.09	2.63

SV Loading

Max CWLL

Vertical	Transverse ecc
782.61	0.30

Min CWLL

Vertical	Transverse ecc
657.39	0.30

MAXIMUM TRASVERSE MOMENT CASE:

1- 70RW + 2-CLASS A

Max CWLL

Vertical	Transverse ecc
536.57	3.66

Min CWLL

Vertical	Transverse ecc
441.09	2.63

Impact Factor for 70R Wheeled loading

Impact Factor upto abut. cap	=	1.129
Impact Factor for Abut. Shaft Base	=	1.000

Impact Factor for Cl A Wheeled loading

Impact Factor upto abut. cap	=	1.129
Impact Factor for Abut. Shaft Base	=	1.000

VOLUME CALCULATION

C.G. Of Footing = 4.000 m
C.G. Of shaft from toe tip = 3.500 m
Distance between c.g. of shaft and footing = 0.500 m

Description	No.	LENGTH	WIDTH	HEIGHT	VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe	Trans. Ecc (eT)
		m	m	m	m^3	m	m	m	
Dirt Wal -Uniform portion	1	13.50	0.300	1.265	5.123	-0.650	-0.150	-4.150	0.000
-Trapering portion	1	13.50	0.300	-0.155	-0.629	-0.650	-0.150	-4.150	0.000
Bracket (Rectangle)	1	13.50	0.300	0.300	1.215	-0.950	-0.450	-4.450	0.000
(Corbel) 0.5	1	13.50	0.300	0.300	0.608	-0.900	-0.400	-4.400	0.000
Cap (uniform portion)	1	13.50	1.600	0.300	6.480	0.000	0.500	-3.500	0.000
Cap (Corbel Portion)	1	13.50 13.50	1.600 1.000	0.300	5.218	0.000	0.500	-3.500	0.000
Shaft above HFL	1	13.50	1.000	2.821	38.084	0.000	0.500	-3.500	0.000
Shaft below HFL	1	13.50	1.000	2.501	33.763	0.000	0.500	-3.500	0.000
Solid Return Wall	2	4.00	0.500	7.938	31.752	-2.500	-2.000	-6.000	0.000
Cantilever Return wall(Rectangular portion)	2	0.00	0.500	0.000	0.000	-0.500	0.000	-4.000	0.000
Cantilever Return wall(Traingular portion)	2	0.00	0.500	0.000	0.000	-0.500	0.000	-4.000	0.000
Footing									
Heel Slab	1	13.50	4.000	0.750	40.500		-1.778	-5.778	0.000
Toe Slab	1	13.50	3.000	0.750	30.375		2.333	-1.667	0.000
Portion between Heel and Toe	1	13.50	1.000	1.000	13.500		0.500	-3.500	0.000
Back filling above HFL over Heel Slab	1	13.50	4.000	4.687	253.098		-2.000	-6.000	0.000
Back filling below HFL over Heel Slab	1	13.50	4.000	3.251	175.554		-2.051	-6.051	0.000
Backfill above Heel slab	1	13.50	4.000	7.782	420.215		-2.021	-6.021	0.000
Front Filling over Toe Slab	1	13.50	3.000	2.251	91.165		2.444	-1.556	0.000
Side filling between heel and toe	1	0.00	1.000	2.251	0.000		0.000	0.000	0.000
Aproach Slab	1	13.500	1.750	0.300	7.088	-0.950	-0.450	-4.450	0.000
Back fill above HFL on flared portion of stem	1	13.50	0.000	4.687	0.000		0.000	0.000	0.000
Back fill below HFL on flared portion of stem	1	13.50	0.000	3.251	0.000		0.000	0.000	0.000

			L			eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Bai	2	8 kN/m	1.750	28.00kN		-0.650	-0.150	-4.150

SECTIONAL PROPERTIES

Width of Footing (B) = 8 m
Length of Footing (L) = 13.500 m

A = 8.000 x 13.500 = 108.000 m^2
ZL = 13.500 x 10.667 = 144.000 m^3
ZT = $\frac{\text{IT1} + \text{IT2}}{\text{distance of extreme point from centre}}$

IT1 = 8.000 x 205.031 = 1640.25 m^4
IT2 (moment of inertia of triangle) = 8.000 x 0.000 + 0.500 x 8.000 x 0.000 x 45.563
from centre of footing = 0.000 m^4

Moment of inertia of two triangle = 0.000 m^4

Total moment of inertia = 1640.25 m^4

Distance of extreme point from centre of footing = 6.750 + 0.000 = 6.750 m

Total Section modulus (ZT) = 243.000 m^3

Load Factors (As per IRC:6-2014)

Table 3.1 Partial Safety Factor For Verification of Equilibrium

-Refer Table 3.1 of IRC:6-2014

Loads	Basic Combination		Seismic Combination	
	Overturning or Sliding	Restoring or Resisting	Overturning or Sliding	Restoring or Resisting
Dead Laod,SIDL & Backfill except wearing course	1.050	0.950	1.050	0.950
Wearing Course only	1.350	1.000	1.350	1.000
Earth Pressure due to back filling	1.500	-	1.500	-
Carriageway Live Load	1.500	0.000	0.000	0.000
Live Load Surcharge	1.200	0.000	0.000	0.000
Seismic Effect (During Service)			1.500	0.000
Seismic Effect (During Construction)			0.750	0.000

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.500	1.00
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL(Service)	1.500	0.20
CWLL and Associate load and FPLL(Construction)	1.350	1.00
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Table 3.3 Partial Safety Factor For Verification of Servicibilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
wearing course	1.200	1.20	1.20
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
CWLL and Associate load and FPLL	1.000	0.750	0.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination	Seismic Combination
Dead Laod+SIDL except wearing course	1.350	1.35
Wearing Course only	1.750	1.75
Back Filling Weight	1.350	1.35
Earth Pressure due to back filling	1.500	1.000
CWLL and Associate load and FPLL	1.500	0.75
Live Load Surcharge	1.200	0.20
Seismic Effect (During Service)		1.50
Seismic Effect (During Construction)		0.75

Possible Load Combination

Normal Dry Case	Case 1 : DL+SIDL-Normal Dry Case Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case
Normal HFLCase	Case 3 : DL+SIDL-Normal HFL Case Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case
Longitudinal Seismic Dry Case	Case 5 : DL+SIDL-Long. Seismic Dry Case Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case
Longitudinal Seismic HFL Case	Case 7 : DL+SIDL-Long. Seismic HFL Case Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case
Transverse Seismic Dry Case	Case 9 : DL+SIDL-Trans. Seismic Dry Case Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case
Transverse Seismic HFL Case	Case 11 : DL+SIDL-Trans. Seismic HFL Case Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Seismic Coefficient Calculation

(As Per IRC:6-2014 , Clause 219)

Horizontal Seismic Force For Zone 4.0

Feq = Seismic forces to be resisted
Feq = Ah x (Dead load + Appropriate Live load)
Ah = horizontal seismic coefficient

$$= \frac{\frac{Z}{2} \quad \frac{Sa}{g}}{\frac{R}{I}}$$

Z	=	Zone factor	=	0.24	
I	=	Importance factor	=	1.2	
R	=	Response Reduction factor	=	3.0	in Longitudinal direction
			=	1.0	In Transverse direction

T = Fundamental period of the bridge member (in sec.) or horizontal vibrations.

$$= 2.0 \left(\frac{D}{1000F}\right)^{1/2}$$

D = Appropriate dead load of the superstructure , and live load in KN

F = Horizontal force in KN required to be applied at the center of mass of the superstructure for one mm horizontal deflection at the top of the pier/abutment along the considered direction of horizontal force.

C.g. of Horizontal Force acting at a height from Foundation Level in Longitudinal direction
= 7.722 m
C.g. of Horizontal Force acting at a height from Foundation Level in Tranverse direction
= 8.566 m

Abutment Cap Top Level - Foundation Level
= 7.422 m

Dimensions of Abutment Shaft

Length	=	13.50	m
Width	=	1.00	m
Moment of Inertia , $I_{longitudinal}$	=	1.125	m^4
Moment of Inertia , $I_{transverse}$	=	205.031	m^4
Ecm	=	3.231E+07	kN/m^2

Longitudinal Direction				**Transverse Direction**			
Force	=	125.727	KN	Force	=	19739.298	KN
D	=	2096.70	KN	D	=	2376.420	KN
T	=	0.2583	sec	T	=	0.0219	sec

Medium Soil Strata

Sa/g	=	2.5	Sa/g	=	2.5

Seismic Coeff. In Longitudinal Direction = 0.12

Seismic Coeff. In Transverse Direction = 0.36

Summary of Horizontal and Vertical Seismic Coeff.

For Design of Substructure

Ah	=	0.120	In Longitudinal direction
Ah	=	0.360	In Transverse direction
Av	=	0.240	In Vertical direction

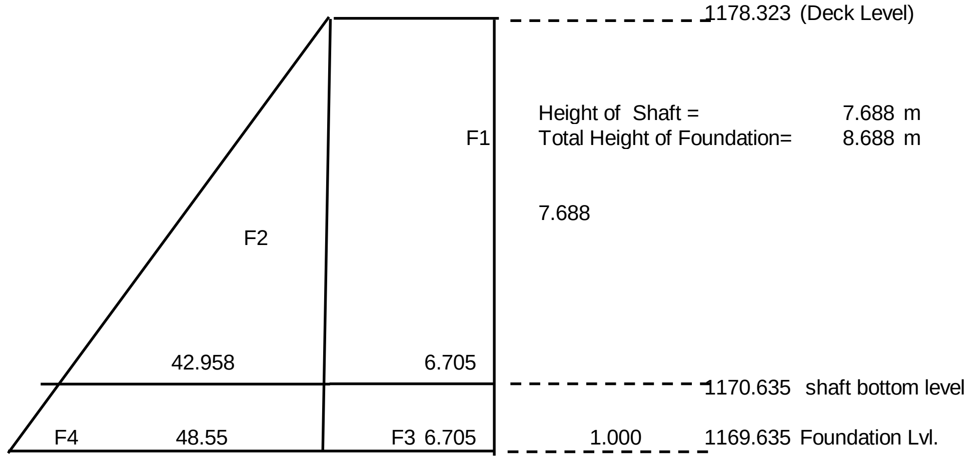
For Design of Foundation (35% increment in Seismic Coeff for Foundation as per IRC:6-2014,Clause No. 219.8)

Ah	=	0.162	In Longitudinal direction
Ah	=	0.360	In Transverse direction
Av	=	0.240	In Vertical direction

Earth Pressure : Normal Dry Case

Properties of backfill material :				
	c	=	0	
	ϕ	=	30 degree	0.524 radians
	θ	=	90.00 degree	1.571 radians
	$\theta 1$	=	90.00 degree	1.571 radians
	β	=	0	0 radians
	δ	=	20.0 degree	0.349 radians
	Kah	=	0.279 active component	
	Kph	=	3.766 Passive component	
	γ	=	20 kN/m^3	

Equivalent Live Load Surcharge height = 1.2 m
Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL 1170.635 m (at Shaft Base)
@ RL 1169.635 m (at Foundation Level)

Due to Live Load Surcharge

Intensity for rectangular portion	=	0.279	x	20	x	1.2	=	6.705 kN/m^2	
F1	=	6.705	x	7.688	x	13.500	=	**695.920 kN**	
M1	=	695.92	x	3.84	=	**2675.117 kN.m**		**at Shaft Bottom**	
F3	=	6.705	x	8.688	x	13.500	=	**786.440 kN**	
M3	=	786.440	x	4.344	=	**3416.297 kN.m**		**at Foundation**	

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

	=	0.279	x	20	x	7.688	=	42.958 kN/m^2
F2	=	0.5	x	42.96	x	7.688	x	13.50
	=	**2229.264 kN**						

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC:6-2014)

M2	=	2229.26	x	3.23	=	**7198.204 kN.m**		**at Shaft Bottom**

Intensity for triangular portion (At Foundation level)

	=	0.279	x	20	x	8.688	=	48.546 kN/m^2
F4	=	0.5	x	48.55	x	8.688	x	13.50
	=	**2846.914 kN**						
M4	=	2846.91	x	3.65	=	**10388.276 kN.m**		**at Foundation**

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 γ fluid = 4.8 kN/m³

Intensity for triangular portion (At Shaft bottom level)
= 4.800 x 7.688 = 36.902 kN/m^2

F = 0.5 x 36.902 x 7.688 x 13.500
= **1915.013 kN**

M = 1915.01 x 2.563 = **4907.540 kN.m** **at Shaft Bottom**

Intensity for triangular portion (At Foundation level)
= 4.800 x 8.688 = 41.70 kN/m^2

F = 0.5 x 41.702 x 8.69 x 13.500
= **2445.596 kN**

M = 2445.60 x 2.896 = **7082.445 kN.m** **at Foundation**

Intensity of Passive pressure
= 3.766 x 20 x 0.000 = 0.000 kN/m^2
Force due to passive @ Foundation, F
= 0.5 x 0.000 x 0.000 x 13.50
= **0.000 kN**

Moment due to passive @ Foundation, M
= 0.000 x 0.000 = **0.000 kN.m** **at Foundation**

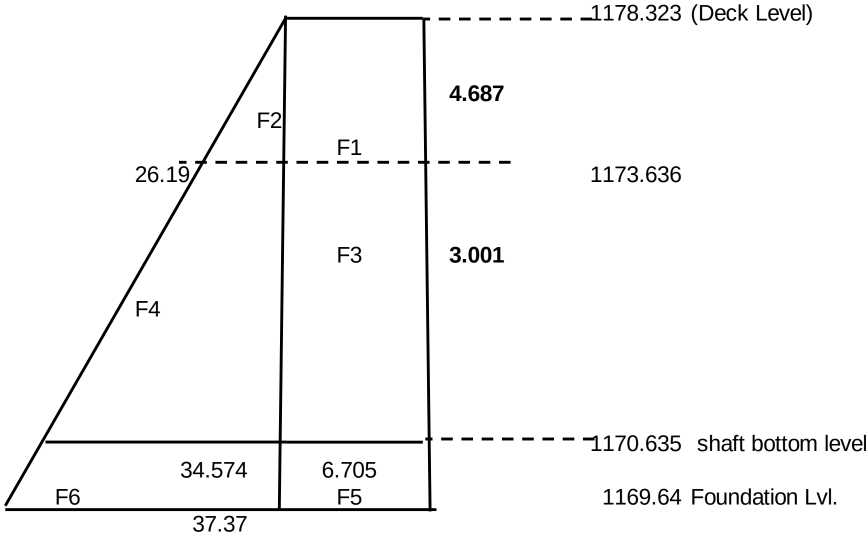
Summary of Moment and Horizontal Force

	MOMENTS		**HORIZONTAL FORCE**	
	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl kN	At Foundation Lvl kN
Due to active Earth Pressure	7198.204	10388.276	2229.264	2846.914
Due to Minimum Fluid Pressure	4907.540	7082.445	1915.013	2445.596
Governing of Two	**7198.204**	**10388.276**	**2229.264**	**2846.914**
Due to Live Load Surcharge	**2675.117**	**3416.297**	**695.920**	**786.440**
Due to Passive pressure		**0.000**		**0.000**

Earth Pressure : Normal HFL Case

Properties of backfill material :	c	=	0		
	ϕ	=	30 degree	0.524	radians
	θ	=	90.00 degree	1.571	radians
	β	=	0	0	radians
	δ	=	20.0 degree	0.349	radians
	Kah	=	0.279 active component		
	Kph	=	3.766 passive component		
	γd	=	20 kN/m^3		
	γwater	=	10 kN/m^3		
Equivalent Live Load Surcharge height		=	1.2 m		

Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL 1170.6 m (at Shaft Base)

Due to Live Load Surcharge

Intensity for rectangular portion	=	0.279	x	20	x	1.200	=	6.705 kN/m^2
F1	=	6.705	x	7.688	x	13.500	=	**695.920 kN**
M1	=	695.92	x	3.84	=	**2675.117 kN.m**		**at Shaft Bottom**
F3	=	6.705	x	8.688	x	13.500	=	**786.440 kN**
M3	=	786.44	x	4.34	=	**3416.297 kN.m**		**at Foundation Level**

Due to Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.279	x	20	x	4.687	=	26.189 kN/m^2
(At Shaft bottom level) Below HFL	=	0.279	x	10	x	3.001	=	8.384 kN/m^2
F2	=	0.5	x	26.19	x	4.687	x	13.50
	=	**828.561 kN**						
F4	=	(26.19 +		34.57)	x	3.00	x	13.50

2

= **1230.864 kN**

Total Force = 2059.425 kN

M2 = 828.56 x 4.97 = **4117.569 kN.m**

M4 = 1230.86 x 1.43 = **1761.964 kN.m**

Total Mome = 5879.53 kN.m at Shaft Bottom

Intensity for triangular portion

Upto HFL = 0.279 x 20 x 4.687 = 26.189 kN/m^2

at Foundation = 0.279 x 10 x 4.001 = 11.178 kN/m^2

F2 = 0.5 x 26.19 x 4.687 x 13.50
= **828.561 kN**

F6 = (26.19 + 37.37) / 2 x 4.00 x 13.50

= **1716.468 kN**

Total Force = 2545.029 kN

M2 = 828.56 x 5.97 = **4946.130 kN.m**

M6 = 1716.47 x 1.88 = **3232.486 kN.m**

Total Mome = 8178.62 kN.m Foundation Lvl.

Intensity of Passive pressure:
= 3.766 x 10 x 0.00 = 0.000 kN/m^2
Force due to passive @ Foundation, F
= 0.5 x 0.000 x 0.00 x 13.50
= **0.000 kN**

Moment due to passive @ Foundation, M
= 0.000 x 0.000 = **0.000 kN.m** **Foundation Lvl.**

Summary of Moment and Horizontal Force

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation kN-m	At Shaft Bottom Lvl kN	at Foundatio kN
Due to active Earth Pressure	5879.532	8178.616	2059.425	2545.029
Due to Minimum Fluid Pressure	4907.540	7082.445	1915.013	2445.596
Governing of Two	**5879.532**	**8178.616**	**2059.425**	**2545.029**
Due to Live Load Surcharge	**2675.117**	**3416.297**	**695.920**	**786.440**
Due to Passive pressure		**0.000**		**0.000**

Earth Pressure : Seismic Dry Case

As per Clause 219.5.4 , IRC:6-2014

Seismic Zone =	4.0

Dynamic increment due to seismic force

$$C_a = \frac{\cos^2(\phi - \lambda - \alpha)\cos\delta \qquad (1 \pm \alpha v)}{\cos^2\alpha \cos(\alpha + \delta + \lambda)\cos\lambda\,[1 + \mathrm{sqrt}(\sin(\phi + \delta)\sin(\phi - \beta - \lambda) / (\cos(\alpha + \delta + \lambda)\cos(\alpha - \beta)))]^2}$$

α h	=	0.120	
α v	=	0.240	
φ	=	30.00	0.524
δ	=	20.00	0.349
α	=	0.00	0.000
β	=	0.00	0.000

α h	=	HORIZONTAL SEISMIC COEFFICIENT
α v	=	VERTICAL SEISMIC COEFFICIENT
φ	=	ANGLE OF INTERNAL FRICTION OF SOIL
δ	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL
α	=	ANGLE OF FRICTION BETWEEN THE WALL AND EARTH FILL,
β	=	SLOPE OF EARTH FILL

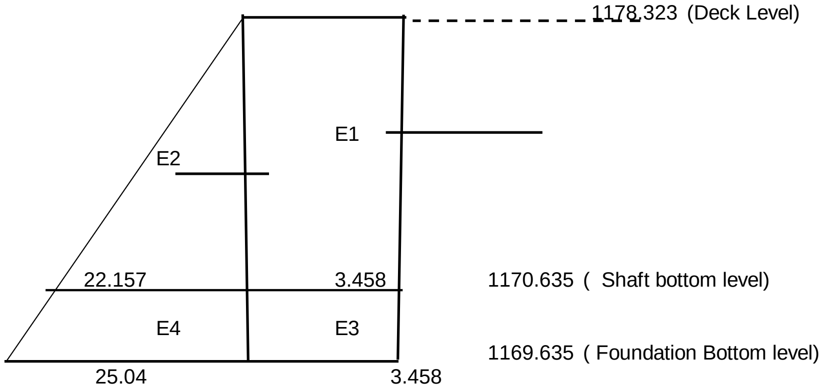
$$\lambda = \tan^{-1} \frac{\alpha\ h}{(1 \pm \alpha\ v)} = \begin{matrix} 0.096 \\ 0.157 \end{matrix}$$

		1	2
C_a	=	0.423	0.296

Ca	=	0.423		
Ka	=	**0.279**		
Dynamic Increment	=	0.423	-0.279	**0.144**

3 Earth Pressure : **DRY CASE (Seismic case)**

Equivalent Live Load Surcharge height		=	1.2	m
Assuming	γdry	=	20	kN/m^3
	γwater	=	10.00	kN/m^3



Earth Pressure Diagram for Dynamic Increment

Horizontal Forces and Moments @ RL **1170.6 m (at Shaft Base)**
1169.6 m (at Foundation Bottom Level)

Due to Dynamic Live Load Surcharge

	=	0.144	x	20	x	1.2	=	3.458	kN/m^2
at Shaft Bottom Level									
E1	=	3.458	x	7.688	x	13.500	=	**358.945**	kN
M1	=	358.945	x	5.151			=	**1848.909**	kN.m
at Foundation Bottom Level									
E3	=	3.458	x	8.688	x	13.500	=	**405.633**	kN

M3	=	405.633	x	5.821	=	**2361.176**	kN.m

Due to Dynamic Active Earth Pressure

(At Shaft bottom level)

=	0.144	x	20	x	7.688	=	22.157 kN/m^2

(at Foundation Bottom Level)

=	0.144	x	20	x	8.688	=	25.039 kN/m^2

E2	=	0.50	x	22.16	x	7.69	x	13.500
	=	**1149.819** kN						
E4	=	0.50	x	25.04	x	8.69	x	13.500
	=	**1468.393** kN						

M2	=	1149.82	x	3.84	=	**4419.904** kN.m	**(Shaft bottom level)**
M4	=	1468.39	x	4.34	=	**6378.700** kN.m	**(Foundation Bottom level)**

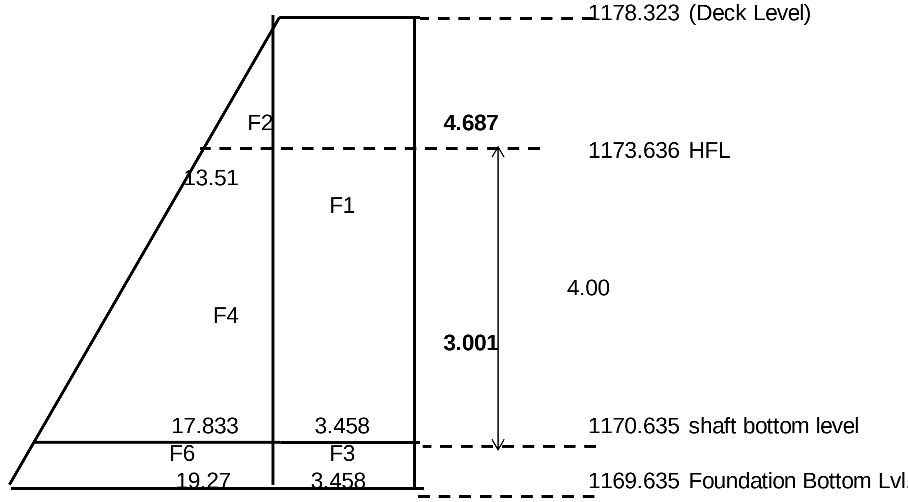
Summary of Moment and Horizontal Force **Dry Seismic Case**

	MOMENTS		HORIZONTAL FORCE	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom kN	At Foundation Bottom kN
Due to active Earth Pressure(Static)	7198.204	10388.276	2229.264	2846.914
Due to active Earth Pressure (dynamic Increment)	4419.904	6378.700	1149.819	1468.393
Total Earth Pressure	11618.108	16766.975	3379.083	4315.307
Due to Minimum Fluid Pressure	4907.540	7082.445	1915.013	2445.596
Governing of Two	**7198.204**	**16766.975**	**3379.083**	**4315.307**
Due to Live Load Surcharge (Static)	**2675.117**	**3416.297**	**695.920**	**786.440**
Due to Live Load Surcharge(Dynamic)	**1848.909**	**2361.176**	**358.945**	**405.633**
Due to Passive pressure		**0.000**		**0.000**

Earth Pressure : Normal HFL Case

Dynamic Increment	=	0.144
γd	=	20 kN/m^3
γwater	=	10 kN/m^3
Equivalent Live Load Surcharge height	=	1.2 m

Assuming



Earth Pressure Diagram

Horizontal Forces and Moments @ RL **1170.635 m (at Shaft Base)**
1169.635 m (at Foundation Bottom Level)

Due to Live Load Surcharge

Intensity for rectangular portion	=	0.144	x	20	x	1.200	=	3.458 kN/m^2
at Shaft Bottom Level								
F1	=	3.458	x	7.688	x	13.500	=	**358.945 kN**
M1	=	358.94	x	5.07	=	**1821.313 kN.m**		
at Foundation Bottom Level								
F3	=	3.458	x	8.688	x	13.500	=	**405.633 kN**
M3	=	405.63	x	5.73	=	**2325.935 kN.m**		

Due to Dynamic Active Earth Pressure

Intensity for triangular portion

Upto HFL	=	0.144	x	20	x	4.687	=	13.508 kN/m^2
(At Shaft bottom level) Below HFL	=	0.144	x	10	x	3.001	=	4.324 kN/m^2
(At Foundatio bottom level) Below HFL	=	0.144	x	10	x	4.001	=	5.766 kN/m^2
F2	=	0.5	x	13.51	x	4.69	x	13.50
	=	**427.359 kN**						

F4 = $\dfrac{(13.51 + 17.83)}{2}$ x 3.00 x 13.50

= **634.860 kN**

F6 = (13.51 + 19.27) x 4.00 x 13.50

2

= **885.327 kN**

Total Force (F2 + F4)	**=**	**1062.219 kN**	**at Shaft Bottom Level**
Total Force (F2 + F6)	**=**	**1312.685 kN**	**at Foundation Bottom Level**

M2	=	427.36	x	5.34	=	**2284.019 kN.m**
M4	=	634.86	x	1.43	=	**908.793 kN.m**
Total Mome =		**3192.812 kN.m**		**at Shaft Bottom**		
M2	=	427.36	x	6.34	=	**2711.378 kN.m**
M6	=	885.33	x	1.88	=	**1667.265 kN.m**
Total Mome =		**4378.643 kN.m**		**at Foundation Bottom Level**		

Summary of Moment and Horizontal Force

	MOMENTS		**HORIZONTAL FORCE**	
	At Shaft Bottom kN-m	At Foundation Bottom kN-m	At Shaft Bottom Lvl kN	At Foundation Bottom Lvl kN
Due to active Earth Pressure(Static)	5879.532	8178.616	2059.425	2545.029
Due to active Earth Pressure (Dynamic Increment)	3192.812	4378.643	1062.219	1312.685
Total Earth Pressure	9072.344	12557.259	3121.644	3857.714
Due to Minimum Fluid Pressure	4907.540	7082.445	1915.013	2445.596
Governing of Two	**9072.344**	**12557.259**	**3121.644**	**3857.714**
Due to Live Load Surcharge(Static	**2675.117**	**3416.297**	**695.920**	**786.440**
Due to Live Load Surcharge (Dynamic Increment)	**1821.313**	**2325.935**	**358.945**	**405.633**
Due to passive pressure		**0.000**		**0.000**

Horizontal Force AT Bearings (HL) IN ULTIMATE LIMIT STATE

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)	
DL	=	1822.50	1.35	1.35	2460.38	2460.38	
SIDL except wc	=	96.00	1.35	1.35	129.60	129.60	
WC	=	178.20	1.75	1.75	311.85	311.85	
FPLL	=	0.00	1.5	0.20	0.00	0.00	
CWLLmax-Reaction case	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmin	=	0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A
CWLLmin	=	0.00	1	0.20	0.00	0.00	SV Loading
CWLLmax-Transv. Moment Case		0.00	1.5	0.20	0.00	0.00	1- 70RW + 2-CLASS A

Braking Force = 0.2 x 1000 + 0.05 x 554

= 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	µ R	Max (Fh/2 or µR)		
DL+SIDL	2901.83	0	1450.913	1450.913		
DL+SIDL+LL-Max Reaction case	2901.83	341.55	1450.913	1450.913	1- 70RW + 2-CLASS A	Dry Case
	2901.83	0	1450.913	1450.913	SV Loading	
DL+SIDL+LL-Min Reaction case	2901.83	341.55	1450.913	1450.913	1- 70RW + 2-CLASS A	HFL Case
	2901.83	0	1450.913	1450.913	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2901.83	341.55	1450.913	1450.913		

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Factored Vertical Force (R)	Fh	µ R	Max (Fh/2 or µR)	
DL+SIDL	2096.70	2901.83	754.81	1450.913	1450.913	
DL+SIDL+LL-Max Reaction case		2901.83	800.35	1450.913	1450.913	Dry Case
DL+SIDL+LL-Min Reaction case		2901.83	800.35	1450.913	1450.913	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2901.83	800.35	1450.913	1450.913	

Transverse Seismic Case: Seismic effect = 1.50

Unfactored Vertical Force	Factored Vertical Force (R)	Fh	µ R	Max (Fh/2 or µR)

DL+SIDL	2096.70	2901.83	226.444	1450.913	1450.913	
DL+SIDL+LL-Max Reaction case		2901.83	271.984	1450.913	1450.913	Dry Case
DL+SIDL+LL-Min Reaction case		2901.83	271.984	1450.913	1450.913	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2901.83	271.984	1450.913	1450.913	

Horizontal Force AT Bearings (HL) For Foundation Design

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1822.50	1.35	1.35	2460.38	2460.38
SIDL except wc	=	96.00	1.35	1.35	129.60	129.60
WC	=	178.20	1.75	1.75	311.85	311.85
FPLL	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.75	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1.5	0.75	0.00	0.00
CWLLmin	=	0.00	1.5	0.75	0.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	µ R	Max (Fh/2 or µR)		
DL+SIDL	2901.83	0.000	1450.913	1450.913		
DL+SIDL+LL-Max Reaction case	2901.83	341.550	1450.913	1450.913	1- 70RW + 2-CLASS A	Dry Case
	2901.83	0.000	1450.913	1450.913	SV Loading	
DL+SIDL+LL-Min Reaction case	2901.83	341.550	1450.913	1450.913	1- 70RW + 2-CLASS A	HFL Case
	2901.83	0.000	1450.913	1450.913	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2901.83	341.550	1450.913	1450.913		

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force	Fh	µ R	Max (Fh/2 or µR)	
DL+SIDL	2096.70	2901.83	1019.00	1450.913	1450.913	
DL+SIDL+LL-Max Reaction case		2901.83	1064.54	1450.913	1450.913	Dry Case
DL+SIDL+LL-Min Reaction case		2901.83	1064.54	1450.913	1450.913	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2901.83	1064.54	1450.913	1450.913	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	2901.83	305.699	1450.913	1450.913	
DL+SIDL+LL-Max Reaction case		2901.83	351.239	1450.913	1450.913	Dry Case
DL+SIDL+LL-Min Reaction case		2901.83	351.239	1450.913	1450.913	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2901.83	351.239	1450.913	1450.913	

Horizontal Force AT Bearings (HL) For Base Pressure Calculation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1822.50	1	1.00	1822.50	1822.50
SIDL except wc	=	96.00	1	1.00	96.00	96.00
WC	=	178.20	1	1.00	178.20	178.20
FPLL	=	0.00	1	1.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.20	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1	0.20	0.00	0.00
CWLLmin	=	0.00	1	0.20	0.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)		
DL+SIDL	2096.70	0.000	1048.350	1048.350		
DL+SIDL+LL-Max Reaction case	2096.70	227.700	1048.350	1048.350	1- 70RW + 2-CLASS A	Dry Case
	2096.70	0.000	1048.350	1048.350	SV Loading	
DL+SIDL+LL-Min Reaction case	2096.70	227.700	1048.350	1048.350	1- 70RW + 2-CLASS A	HFL Case
	2096.70	0.000	1048.350	1048.350	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2096.70	227.700	1048.350	1048.350		

Longitudinal Seismic Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	679.331	1048.350	1048.350	
DL+SIDL+LL-Max Reaction case	2096.70	724.871	1048.350	1048.350	Dry Case
DL+SIDL+LL-Min Reaction case	2096.70	724.871	1048.350	1048.350	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2096.70	724.871	1048.350	1048.350	

Transverse Seismic Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	203.799	1048.350	1048.350	
DL+SIDL+LL-Max Reaction case	2096.70	249.339	1048.350	1048.350	Dry Case
DL+SIDL+LL-Min Reaction case	2096.70	249.339	1048.350	1048.350	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2096.70	249.339	1048.350	1048.350	

Horizontal Force AT Bearings (HL) For Stability of Foundation

(Refer Clause 211.5.1.1 of IRC:6-2014)

Type of bearing - Tar Paper Bearing

Loads		Unfactored Load	Basic Comb	Seismic Comb	Load (Basic Comb)	Load (Seismic Comb)
DL	=	1822.50	1.05	1.05	1913.63	1913.63
SIDL except wc	=	96.00	1.05	1.05	100.80	100.80
WC	=	178.20	1.35	1.35	240.57	240.57
FPLL	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1.5	0.00	0.00	0.00
CWLLmax-Transv. Moment Case		0.00	1.5	0.00	0.00	0.00
CWLLmin	=	0.00	1.5	0.00	0.00	0.00

Braking Force = 227.7 KN

Normal Case:

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)		
DL+SIDL	2255.00	0.000	1127.498	1127.498		
DL+SIDL+LL-Max Reaction case	2255.00	341.550	1127.498	1127.498	1- 70RW + 2-CLASS A	Dry Case
	2255.00	0.000	1127.498	1127.498	SV Loading	
DL+SIDL+LL-Min Reaction case	2255.00	341.550	1127.498	1127.498	1- 70RW + 2-CLASS A	HFL Case
	2255.00	0.000	1127.498	1127.498	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2255.00	341.550	1127.498	1127.498		

Longitudinal Seismic Case: Seismic effect = 1.50

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	2255.00	1019.00	1127.498	1127.498	
DL+SIDL+LL-Max Reaction case		2255.00	1019.00	1127.498	1127.498	Dry Case
DL+SIDL+LL-Min Reaction case		2255.00	1019.00	1127.498	1127.498	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2255.00	1019.00	1127.498	1127.498	

Transverse Seismic Case:

	Unfactored Vertical Force	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2096.70	2255.00	305.699	1127.498	1127.498	
DL+SIDL+LL-Max Reaction case		2255.00	305.699	1127.498	1127.498	Dry Case
DL+SIDL+LL-Min Reaction case		2255.00	305.699	1127.498	1127.498	HFL Case
DL+SIDL+LL-Max Transv. Moment case		2255.00	305.699	1127.498	1127.498	

Horizontal Force At Bearings (HL) IN SLS CASE

Loads		Unfactored Load	Rare Comb	Frequent Comb	Quasi-Permanent Comb	Load (Rare Comb)	Load (Frequent Comb)	Load (Quasi-Permanent Comb)
DL	=	1822.50	1	1	1	1822.50	1822.50	1822.50
SIDL except wc	=	96.00	1	1	1	96.00	96.00	96.00
WC	=	178.20	1.20	1.20	1.20	213.84	213.84	213.84
FPLL	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Reaction case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmax-Transv. Moment Case	=	0.00	1	0.75	0	0.00	0.00	0.00
CWLLmin	=	0.00	1	0.75	0	0.00	0.00	0.00

Braking Force = 227.7 KN

Normal Case: Rare Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)		
DL+SIDL	2132.34	0.000	1066.170	1066.170		
DL+SIDL+LL-Max Reaction case	2132.34	227.700	1066.170	1066.170	1- 70RW + 2-CLASS A	Dry Case
	2132.34	0.000	1066.170	1066.170	SV Loading	
DL+SIDL+LL-Min Reaction case	2132.34	227.700	1066.170	1066.170	1- 70RW + 2-CLASS A	HFL Case
	2132.34	0.000	1066.170	1066.170	SV Loading	
DL+SIDL+LL-Max Transv. Moment case	2132.34	227.700	1066.170	1066.170		

Normal Case: Frequent Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2132.34	0.000	1066.170	1066.170	
DL+SIDL+LL-Max Reaction case	2132.34	170.775	1066.170	1066.170	Dry Case
DL+SIDL+LL-Min Reaction case	2132.34	170.775	1066.170	1066.170	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2132.34	170.775	1066.170	1066.170	

Normal Case: Quasi Permenant Combination

	Vertical Force (R)	Fh	μ R	Max (Fh/2 or μR)	
DL+SIDL	2132.34	0.000	1066.170	1066.170	
DL+SIDL+LL-Max Reaction case	2132.34	0.000	1066.170	1066.170	Dry Case
DL+SIDL+LL-Min Reaction case	2132.34	0.000	1066.170	1066.170	HFL Case
DL+SIDL+LL-Max Transv. Moment case	2132.34	0.000	1066.170	1066.170	

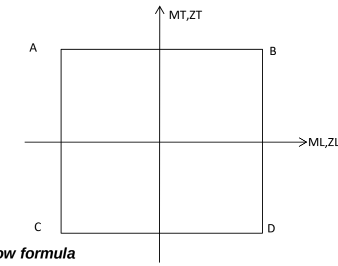
Centrifugal Force Calculation

As per clause 212 of IRC:6-2014

CENTRIFUGAL FORCE C = $\frac{W\,V^2}{127\,R}$

			Normal Case		Seismic Case	
Design Speed	V	=	100.00	kmph	100.00	kmph
Live Load	W	=	957.51	kN	957.51	kN
Radius of Curvature	R	=	0.00	m	0.00	m
CENTRIFUGAL FORCE	C	=	0.00	kN	0.00	kN

SBC AND STABILITY CHECK OF FOUNDATION



Foundation Lvl = 1169.635 m

Properties of Footing Base:

A	=	108.000	m^2
ZL	=	144.000	m^3
ZT	=	243.000	m^3

For Skew bridges, Resolve the moment due to braking force,Seismic force due to superstructure & substructure in both major and minor principal axis using below formula

Moment along longitudinal axis	**ML = ML Cos θ + MT Sin θ**
Moment along transverse axis	**MT = MT Cos θ - ML Sin θ**

Case 1 : DL+SIDL-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1822.500	0.500	911.250	0.000	0.000
SIDL except Wearing Course	1			96.000	0.500	48.000	0.000	0.000
Wearing Course	1			178.200	0.500	89.100	0.000	0.000
				2096.700		**1048.350**		**0.000**
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1	25	5.123	128.081	-0.150	-19.212	0.000	0.000
Dirt Wall-Tapered portion	1	25	-0.629	-15.719	-0.150	2.358	0.000	0.000
Bracket - Uniform portion	1	25	1.215	30.375	-0.450	-13.669	0.000	0.000
Bracket - Tapered portion	1	25	0.608	15.188	-0.400	-6.075	0.000	0.000
Cap - (uniform portion)	1	25	6.480	162.000	0.500	81.000	0.000	0.000
Cap - (corbel portion)	1	25	5.218	130.441	0.500	65.220	0.000	0.000
Cantilever Return Wall-Rectangle p	1	25	0.000	0.000	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle port	1	25	0.000	0.000	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000	-0.150	-4.200	0.000	0.000
Aproach Slab	1	25	7.088	177.188	-0.450	-79.734	0.000	0.000
				655.553		**25.688**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	31.752	793.800	-2.000	-1587.600	0.000	0.000
Abutment Shaft	1	25	71.847	1796.175	0.500	898.088	0.000	0.000
Back filling over heel slab	1	20	420.215	8404.290	-2.021	-16988.580	0.000	0.000
Front Filling over toe slab	1	20	91.165	1823.310	2.444	4457.025	0.000	0.000
Side filling between heel and toe	1	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	25	40.500	1012.500	-1.778	-1800.000	0.000	0.000
Toe slab	1	25	30.375	759.375	2.333	1771.875	0.000	0.000
portion between heel & toe	1	25	13.500	337.500	0.500	168.750	0.000	0.000
Vertical Components of active earth pressure	1			1036.192	-4.000	-4144.768	0.000	0.000
				15963.142		**-17225.210**		**0.000**
Total				**18715.395**		**-16151.173**		**0.000**

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
Superstructure				
Dead Load	0.950	1731.375	-3.500	-6059.813
SIDL except Wearing Course	0.950	91.200	-3.500	-319.200
Wearing Course	1.000	178.200	-3.500	-623.700
		2000.775		**-7002.713**
Substructure & Foundation -Portion 1				
Dirt Wall-Uniform portion	0.950	121.677	-4.150	-504.960
Dirt Wall-Tapered portion	0.950	-14.933	-4.150	61.972
Bracket - Uniform portion	0.950	28.856	-4.450	-128.410
Bracket - Tapered portion	0.950	14.428	-4.400	-63.484
Cap - (uniform portion)	0.950	153.900	-3.500	-538.650
Cap - (corbel portion)	0.950	123.919	-3.500	-433.715
Cantilever Return Wall-Rectangle p	0.950	0.000	-4.000	0.000
Cantilever Return Wall-Traingle port	0.950	0.000	-4.000	0.000
RCC Railing or Crash Barrier	0.950	26.600	-4.150	-110.390
Aproach Slab	0.950	168.328	-4.450	-749.060
		622.775		**-2466.698**
Substructure & Foundation -Portion 2				
Solid Return wall	0.950	754.110	-6.000	-4524.660
Abutment Shaft	0.950	1706.366	-3.500	-5972.282
Back filling over heel slab	0.950	7984.076	-6.021	-48075.453
Front Filling over toe slab	0.950	1732.144	-1.556	-2694.404
Side filling between heel and toe	0.950	0.000	0.000	0.000
Heel slab	0.950	961.875	-5.778	-5557.500
Toe slab	0.950	721.406	-1.667	-1202.344
portion between heel & toe	0.950	320.625	-3.500	-1122.188
Vertical Components of active earth pressure	0.950	984.382	-8.000	-7875.059
		15164.985		**-77023.889**
Total		**17788.535**		**-86493.300**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.358	8096.407
due to Earth pressure	1	2846.914		10388.276

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	8096.41	0.00	0.00
2846.91	10388.28	0.00	0.00
3895.264	18484.683	0.000	0.000

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Earth pressure	1.5	4270.371		15582.413
		5397.869		24290.077

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
4270.37	15582.41	0.00	0.00
5397.869	24290.077	0.000	0.000

Summary of Forces For SBC		
P	18715.395	KN
ML	2333.510	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		18715.395		-16151.173		0.000
CWLL-Max. Reaction case	1	957.514	0.500	478.757	1.955	1871.716
Vertical Components of LL Surcharge	1	286.241	-4.000	-1144.964	0.000	0.000
Total		**19959.150**		**-16817.379**		**1871.716**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	17788.535		-86493.30
0.000		-3.500	0.00
0.950		-8.000	-2175.43
	17788.535		**-88668.73**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.358	8096.407
due to Earth pressure	1	2846.914		10388.276
due to Live load surcharge	1	786.440		3416.297

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	8096.41	0.00	0.00
2846.91	10388.28	0.00	0.00
786.440	3416.297	0.000	0.000
4681.70	**21900.98**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Earth pressure	1.5	4270.371		15582.413
due to Live load surcharge	1.2	943.728		4099.556
		6341.597		**28389.633**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
4270.37	15582.41	0.00	0.00
943.73	4099.56	0.00	0.00
6341.597	**28389.633**	**0.000**	**0.000**

Summary of Forces For SBC		
P	19959.150	KN
ML	5083.600	kNm
MT	1871.716	kNm

Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		18715.395		-16151.173		0.000
CWLL-Max. Reaction case	1	782.609	0.500	391.304	0.300	234.783
Vertical Components of LL Surcharge	1	286.241	-4.000	-1144.964	0.000	0.000
Total		**19784.244**		**-16904.832**		**234.783**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	17788.53518		-86493.2996
0.000		-3.500	0.00
0.950		-8.000	-2175.43
	17788.535		**-88668.73**

Horizontal Forces For SBC Calculation

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.358	8096.407
due to Earth pressure	1	2846.914		10388.276
due to Live load surcharge	1	786.440		3416.297

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	8096.41	0.00	0.00
2846.91	10388.28	0.00	0.00
786.440	3416.297	0.000	0.000
4681.70	**21900.98**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Earth pressure	1.5	4270.371		15582.413
due to Live load surcharge	1.2	943.728		4099.556
		6341.597		**28389.633**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
4270.37	15582.41	0.00	0.00
943.73	4099.56	0.00	0.00
6341.597	**28389.633**	**0.000**	**0.000**

Summary of Forces For SBC		
P	19784.244	KN
ML	4996.148	kNm
MT	234.783	kNm

Case 3 : DL+SIDL-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				**2096.700**		**1048.350**		**0.000**
Substructure & Foundation -Portion 1				**655.553**		**25.688**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1	25	31.752	793.800	-2.000	-1587.600	0.000	0.000
Shaft above HFL	1	25	38.084	952.088	0.500	476.044	0.000	0.000
Shaft below HFL	1	15	33.763	506.452	0.500	253.226	0.000	0.000
Back filling above HFL over heel sla	1	20	253.098	5061.960	-2.000	-10123.920	0.000	0.000
Back filling below HFL over heel sla	1	10	175.554	1755.540	-2.051	-3601.080	0.000	0.000
Front Filling over toe slab	1	10	91.165	911.655	2.444	2228.512	0.000	0.000
Side filling between heel and toe	1	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1	15	40.500	607.500	-1.778	-1080.000	0.000	0.000
Toe slab	1	15	30.375	455.625	2.333	1063.125	0.000	0.000
Portion between Heel & Toe	1	15	13.500	202.500	0.500	101.250	0.000	0.000
Vertical Components of active earth pressure	1			926.315	-4.000	-3705.259	0.000	0.000
				12173.435		**-15975.702**		**0.000**
Total				**14925.688**		**-14901.664**		**0.000**

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
Superstructure		**2000.775**		**-7002.713**
Substructure & Foundation -Portion 1		**622.775**		**-2466.698**
Substructure & Foundation -Portion 2				
Solid Return wall	0.950	754.110	-6.000	-4524.660
Shaft above HFL	0.950	904.483	-3.500	-3165.691
Shaft below HFL	0.950	481.130	-3.500	-1683.955
Back filling above HFL over heel sla	0.950	4808.862	-6.000	-28853.172
Back filling below HFL over heel sla	0.950	1667.763	-6.051	-10092.078
Front Filling over toe slab	0.950	866.072	-1.556	-1347.202
Side filling between heel and toe	0.950	0.000	0.000	0.000
Heel slab	0.950	577.125	-5.778	-3334.500
Toe slab	0.950	432.844	-1.667	-721.406
Portion between Heel & Toe	0.950	192.375	-3.500	-673.313
Vertical Components of active earth pressure	0.950	879.999	-8.000	-7039.992
		11564.763		**-61435.968**
Total		**14188.313**		**-70905.379**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.358	8096.407
due to Earth pressure	1	2545.029		8178.616

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	8096.41	0.00	0.00
2545.03	8178.62	0.00	0.00
3593.38	**16275.02**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Earth pressure	1.5	3817.543		12267.924
		4945.041		**20975.587**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
3817.54	12267.92	0.00	0.00
4945.04	**20975.59**	**0.00**	**0.00**

Summary of Forces For SBC		
P	14925.688	KN
ML	1373.360	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		14925.688		-14901.664		0.000
CWLL-Min. Reaction case	1	441.086	0.500	220.543	2.633	1161.363
Vertical Components of LL Surcharge	1	286.241	-4.000	-1144.964	0.000	0.000
Total		**15653.015**		**-15826.084**		**1161.363**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	14188.313		-70905.379
0.000	0.000	-3.500	0
0.950	271.929	-8.000	-2175.431
	14460.242		**-73080.809**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.358	8096.407
due to Earth pressure	1	2545.029		8178.616
due to Live load surcharge	1	786.440		3416.297

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	8096.41	0.00	0.00
2545.03	8178.62	0.00	0.00
786.440	3416.297	0.000	0.000
4379.82	**19691.32**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Earth pressure	1.5	3817.543		12267.924
due to live load surcharge	1.2	943.728		4099.556
		5888.769		**25075.144**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
3817.54	12267.92	0.00	0.00
943.728	4099.556	0.000	0.000
5888.77	**25075.14**	**0.00**	**0.00**

Summary of Forces For SBC		
P	15653.015	KN
ML	3865.236	kNm
MT	1161.363	kNm

Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case : DL+SIDL		14925.688		-14901.664		0.000
CWLL-Min. Reaction case	1	657.391	0.500	328.696	0.300	197.217
Vertical Components of LL Surcharge	1	286.241	-4.000	-1144.964	0.000	0.000
Total		**15869.320**		**-15717.931**		**197.217**

Vertical Forces For Restoring or Resisting Effect

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
	14188.313		-70905.379
0.000	0.000	-3.500	0.00
0.950	271.929	-8.000	-2175.431
	14460.242		**-73080.809**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure	1	1048.350	1177.358	8096.407
due to Earth pressure	1	2545.029		8178.616
due to Live load surcharge	1	786.440		3416.297

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1048.35	8096.41	0.00	0.00
2545.03	8178.62	0.00	0.00
786.440	3416.297	0.000	0.000
4379.82	**19691.32**	**0.00**	**0.00**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Earth pressure	1.5	3817.543		12267.924

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
3817.54	12267.92	0.00	0.00

due to live load surcharge	1.2	943.728		4099.556		943.728	4099.556	0.000	0.000
		5888.769		**25075.144**		**5888.77**	**25075.14**	**0.00**	**0.00**

Summary of Forces For SBC		
P	15869.320	KN
ML	3973.389	kNm
MT	197.217	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor =	1	αh=	0.162	In Longitudinal direction	Weight of shaft below Ground level	=	675.337	KN
		αh=	0.360	In Transverse direction	Weight of back fill below Ground level	=	2161.080	KN
		αv=	0.240	In Vertical direction				

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1			1822.500		196.830	131.220	0.500	911.250	65.610	1177.958		0.000	0.000	1638.216
SIDL except Wearing Course	1			96.000		10.368	6.912	0.500	48.000	3.456	1178.772		0.000	0.000	94.732
Wearing Course	1			178.200		19.246	12.830	0.500	89.100	6.415	1178.323		0.000	0.000	167.206
				2096.700		**226.444**	**150.962**		**1048.350**	**75.481**				**0.000**	**1900.153**
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1	25	5.123	128.081	20.749	13.833	9.222	-0.150	-19.212	-1.383	1177.691	167.145	0.000	0.000	111.430
Dirt Wall-Tapered portion	1	25	-0.629	-15.719	-2.546	-1.698	-1.132	-0.150	2.358	0.170	1177.136	-19.100	0.000	0.000	-12.734
Bracket - Uniform portion	1	25	1.215	30.375				-0.450	-13.669						
Bracket - Tapered portion	1	25	0.608	15.188				-0.400	-6.075						
Cap - (uniform portion)	1	25	6.480	162.000	26.244	17.496	11.664	0.500	81.000	5.832	1176.907	190.846	0.000	0.000	127.231
Cap - (corbel portion)	1	25	5.218	130.441	21.131	14.088	9.392	0.500	65.220	4.696	1176.607	147.328	0.000	0.000	98.219
Cantilever Return Wall-Rectangle p	1	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1178.323	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle port	1	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1178.323	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1			28.000				-0.150	-4.200				0.000	0.000	
Aproach Slab	1	25	7.088	177.188				-0.450	-79.734				0.000	0.000	
				655.553	**65.578**	**43.719**	**29.146**		**25.688**	**9.314**		**486.219**		**0.000**	**324.146**
Substructure & Foundation -Portion 2															
Solid Return wall	1	25	31.752	793.800	128.596	85.730	57.154	-2.000	-1587.600	-114.307	1174.432	616.889	0.000	0.000	411.259
Abutment Shaft	1	25	71.847	1796.175	181.576	121.050	80.700	0.500	898.088	40.350	1174.547	891.809	0.000	0.000	594.539
Back filling over heel slab	1	20	420.215	8404.290	0.000	0.000	0.000	-2.021	-16988.580	0.000	1174.432	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1	20	91.165	1823.310				2.444	4457.025				0.000	0.000	
Side filling between heel and toe	1	20	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	25	40.500	1012.500				-1.778	-1800.000				0.000	0.000	
Toe slab	1	25	30.375	759.375				2.333	1771.875				0.000	0.000	
portion between heel & toe	1	25	13.500	337.500				0.500	168.750				0.000	0.000	
Vertical component of active earth pressure	1			1036.192				-4.000	-4144.768				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			534.451				-4.000	-2137.806				0.000	0.000	
				16497.593	**310.171**	**206.781**	**137.854**		**-19363.016**	**-73.957**		**1508.698**		**0.000**	**1005.799**
Total =				**19249.846**	**375.749**	**476.943**	**317.962**		**-18288.978**	**10.839**		**1994.917**		**0.000**	**3230.098**
							-317.962			-10.839					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure								
Dead Load	0.95			1731.375	124.659	-3.500	-6059.813	-436.307
SIDL except Wearing Course	0.95			91.200	6.566	-3.500	-319.200	-22.982
Wearing Course	1.00			178.200	12.830	-3.500	-623.700	-44.906
				2000.775	**144.056**		**-7002.713**	**-504.195**

For Overturning or Sliding Effect

Load Factor	FL = αh x P (kN)	C.g. of Force (m)	MLs due to FL

Substructure & Foundation -Portion 1												
Dirt Wall-Uniform portion	0.95	25	5.123	121.677	8.761	-4.150	-504.960	-36.357	1.0	20.749	1177.691	167.145
Dirt Wall-Tapered portion	0.95	25	-0.629	-14.933	-1.075	-4.150	61.972	4.462	1.0	-2.546	1177.136	-19.100
Bracket - Uniform portion	0.95	25	1.215	28.856								
Bracket - Tapered portion	0.95	25	0.608	14.428								
Cap - (uniform portion)	0.95	25	6.480	153.900	11.081	-3.500	-538.650	-38.783	1.0	26.244	1176.907	190.846
Cap - (corbel portion)	0.95	25	5.218	123.919	8.922	-3.500	-433.715	-31.228	1.0	21.131	1176.607	147.328
Cantilever Return Wall-Rectangle p	0.95	25	0.000	0.000	0.000	-4.000	0.000	0.000	1.0	0.000	1178.323	0.000
Cantilever Return Wall-Traingle port	0.95	25	0.000	0.000	0.000	-4.000	0.000	0.000	1.0	0.000	1178.323	0.000
RCC Railing or Crash Barrier	0.95			26.600		-4.150	-110.390					
Aproach Slab	0.95	25	7.088	168.328		-4.450	-749.060					
				622.775	**27.689**		**-2274.804**	**-101.905**		**65.578**		**486.219**
Substructure & Foundation -Portion 2												
Abutment Shaft	0.95	25	71.847	1706.366	74.234	-3.500	-5972.282	-259.819	1.0	175.818	1174.547	863.528
Solid Return wall	0.95	25	31.752	754.110	54.296	-6.000	-4524.660	-325.776	1.0	128.596	1174.432	616.889
Back filling over heel slab	0.95	20	420.215	7984.076	0.000	-6.021	-48075.453	0.000	1.0	0.000	1174.432	0.000
Front Filling over Pile Cap	0.95	20	91.165	1732.144		-1.556	-2694.404					
Side filling between heel and toe	0.95	20	0.000	0.000		0.000	0.000					
Heel slab	0.95	25	40.500	961.875		-5.778	-5557.500					
Toe slab	0.95	25	30.375	721.406		-1.667	-1202.344					
portion between heel & toe	0.95	25	13.500	320.625		-3.500	-1122.188					
Vertical component of active earth pressure	0.95			984.382		-8.000	-7875.059					
Vertical component of dynamic increment of earth pressure	0.95			507.729		-8.000	-4061.830					
				15672.714	**128.530**		**-81085.72**	**-585.595**		**304.413**		**1480.417**
Total =				**18296.264**	**300.274**		**-90363.24**	**-1191.696**		**369.991**		**1966.636**
					-300.274			1191.696				

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	226.444	1177.358	8096.407	1900.153
due to Substructure	1	375.749	250.500		1994.917	1329.945
due to Earth pressure	1	4315.307			16766.975	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	8096.41	0.00	0.00	0.00	0.00	226.44	1900.15
375.75	1994.92	0.00	0.00	0.00	0.00	250.50	1329.94
4315.31	16766.98						
5739.41	**26858.30**	**0.00**	**0.00**	**0.00**	**0.00**	**476.94**	**3230.10**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.66
due to Substructure	1.5	554.987		2949.95
due to Active Earth pressure	1.5	4270.371		15582.41
due to dynamic Earth pressure	1.5	2202.590		9568.05
		8155.445		**36808.080**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
554.99	2949.95	0.00	0.00
4270.371	15582.413	0.000	0.000
2202.590	9568.049	0.000	0.000
8155.45	**36808.08**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	19567.808	18931.884	KN
ML	8580.160	8558.483	kNm
MT	3230.098	3230.098	kNm

Summary of Restoring Forces

Vertical Load	17995.990	kN
Moment	-91554.932	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				2096.700		226.444	150.962		1048.350	75.481				0.000	1900.153

Forces from Substructure				17153.146	375.749	250.500	167.000		-19337.328	-64.643		1994.917		0.000	1329.945
CWLL-Max. Reaction case	0.20			191.50		20.682	13.788	0.500	95.751	6.894	1179.523		1.955	374.343	204.507
Vertical component of LL Surcharge	0.20			57.25				-4.000	-228.993				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			29.53				-4.000	-118.111				0.000	0.000	
Total =				**19528.125**	**375.749**	**497.625**	**331.750**		**-18540.330**	**17.733**		**1994.917**		**374.343**	**3434.605**
							-331.750			-17.733					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstucture				2000.775	144.056	0.000	-7002.71	-504.195
Forces from Substructure				16295.489	156.219	0.000	-83360.52	-687.500
CWLL-Max. Reaction case	0.00			0.00	0.000	-3.500	0.00	0.00
Vertical component of LL Surcharge	0.00			0.00		-8.000	0.00	
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.000	0.00	
Total =				**18296.264**	**300.274**		**-90363.24**	**-1191.696**
					-300.274			**1191.696**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	247.126	1177.358	8096.407	2104.660
due to Substructure	1	375.749	250.500		1994.917	1329.945
due to Earth pressure	1	4315.307			16766.975	
due to Live load surcharge	0.20	238.415			1155.495	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	8096.41	0.00	0.00	0.00	0.00	247.13	2104.66
375.75	1994.92	0.00	0.00	0.00	0.00	250.50	1329.94
4315.31	16766.98						
238.41	1155.49						
5977.82	**28013.79**	**0.00**	**0.00**	**0.00**	**0.00**	**497.63**	**3434.60**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Substructure	1.5	554.987		2949.954
due to Active Earth pressure	1.5	4270.371		15582.413
due to dynamic Earth pressure	1.5	2202.590		9568.0494
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		8155.445		**36808.080**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
554.99	2949.95	0.00	0.00
4270.371	15582.413		
2202.590	9568.049		
0.000	0.000		
0.000	0.000		
8155.45	**36808.08**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	19859.875	19196.375	KN
ML	9491.197	9455.731	kNm
MT	3808.948	3808.948	kNm

Summary of Restoring Forces

Vertical Load	17995.990	kN
Moment	-91554.932	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2096.700**		**226.444**	**150.962**		**1048.350**	**75.481**				**0.000**	**1900.153**

Substructure & Foundation -Portion 1				**655.553**	**65.578**	**43.719**	**29.146**		**25.688**	**9.314**		**486.219**		**0.000**	**324.146**
Substructure & Foundation -Portion 2															
Solid Return wall	1		31.75	793.80	128.596	85.730	57.154	-2.00	-1587.600	-114.307	1174.43	616.889	0.00	0.000	411.259
Shaft above HFL	1	25	38.084	952.088	154.238	102.825	68.550	0.500	476.044	34.275	1175.047	834.660	0.000	0.000	556.440
Shaft below HFL	1	15	33.763	506.452	-27.359	-18.240	-12.160	0.500	253.226	-6.080	1173.136	-95.785	0.000	0.000	-63.857
Back filling above HFL over heel sla	1	20	253.098	5061.960	820.038	546.692	364.461	-2.000	-10123.920	-728.922	1175.980	5202.73	0.000	0.000	3468.49
Back filling below HFL over heel sla	1	10	175.554	1755.540	-65.697	-43.798	-29.199	-2.051	-3601.080	59.895	1171.886	-147.85	0.000	0.000	-98.57
Front Filling over Pile Cap	1	10	91.165	911.655				2.444	2228.512				0.000	0.000	
Side filling between heel and toe	1	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1	15	40.500	607.500				-1.778	-1080.000				0.000	0.000	
Toe slab	1	15	30.375	455.625				2.333	1063.125				0.000	0.000	
portion between heel & toe	1	15	13.500	202.500				0.500	101.250				0.000	0.000	
Vertical component of active earth pressure	1			926.315				-4.000	-3705.259				0.000	0.000	
Vertical component of dynamic increment of earth pressure	1			477.778				-4.000	-1911.114				0.000	0.000	
				12651.213	**1009.814**	**673.210**	**448.806**		**-17886.815**	**-755.139**		**6410.640**		**0.000**	**4273.760**
Total =				**15403.466**	**1075.393**	**943.372**	**628.915**		**-16812.777**	**-670.344**		**6896.859**		**0.000**	**6498.059**
							-628.915			670.344					

Vertical Forces For Restoring or Resisting Effect / **For Overturning or Sliding Effect**

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv	Load Factor	FL = αh x P (kN)	C.g. of Force (m)	MLs due to FL
Superstructure				**2000.775**	**144.056**		**-7002.713**	**-504.195**				
Substructure & Foundation -Portion 1				**622.775**	**27.689**		**-2274.804**	**-101.905**		**65.578**		**486.219**
Substructure & Foundation -Portion 2												
Solid Return wall	0.95	25	31.752	754.110	54.296	-6.00	-4524.660	-325.776	1.0	128.596	1174.432	616.889
Shaft above HFL	0.95	25	38.084	904.483	65.123	-3.500	-3165.691	-227.930	1.0	154.238	1175.047	834.660
Shaft below HFL	0.95	15	33.763	481.130	-13.983	-3.500	-1683.955	48.940	1.0	-33.118	1173.136	-115.944
Back filling above HFL over heel sla	0.95	20	253.098	4808.862	0.000	-6.000	-28853.172	0.000	1.0	0.000	1175.980	0.000
Back filling below HFL over heel sla	0.95	10	175.554	1667.763	0.000	-6.051	-10092.078	0.000	1.0	0.000	1171.886	0.000
Front Filling over Pile Cap	0.95	10	91.165	866.072		-1.556	-1347.202					
Side filling between heel and toe	0.95	10	0.000	0.000		0.000	0.000					
Heel slab	0.95	15	40.500	577.125		-5.778	-3334.500					
Toe slab	0.95	15	30.375	432.844		-1.667	-721.406					
portion between heel & toe	0.95	15	13.500	192.375		-3.500	-673.313					
Vertical component of active earth pressure	0.95			879.999		-8.000	-7039.992					
Vertical component of dynamic increment of earth pressure	0.95			453.890		-8.000	-3631.116					
				12018.653	**105.436**		**-65067.085**	**-504.765**		**249.716**		**1335.605**
Total =				**14642.203**	**277.180**		**-74344.60**	**-1110.866**		**315.294**		**1821.824**
					-277.180			1110.866				

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	226.444	1177.358	8096.407	1900.153
due to Substructure	1	1075.393	716.928		6896.859	4597.906
due to Earth pressure	1	3857.714			12557.259	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	8096.41	0.00	0.00	0.00	0.00	226.44	1900.15
1075.39	6896.86	0.00	0.00	0.00	0.00	716.93	4597.91
3857.71	12557.26						
5981.46	**27550.52**	**0.00**	**0.00**	**0.00**	**0.00**	**943.37**	**6498.06**

Horizontal Forces For Overturning or Sliding Effect

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Substructure	1.5	472.942		2732.736
due to Active Earth pressure	1.5	3817.543		12267.924
due to dynamic Earth pressure	1.5	1969.028		6567.964
		7387.011		**30276.287**

FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
472.94	2732.74	0.00	0.00
3817.543	12267.924		
1969.028	6567.964		
7387.01	**30276.29**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	16032.381	14774.552	KN
ML	10067.403	11408.091	kNm
MT	6498.059	6498.059	kNm

Summary of Restoring Forces

Vertical Load	14365.023	kN
Moment	-75455.466	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2096.700		226.444	150.962		1048.350	75.481				0.000	1900.153
Forces from Substructure				13306.766	1075.393	716.928	477.952		-17861.127	-745.825		6896.859		0.000	4597.906
CWLL-Max. Reaction case	0.20			88.22		9.527	6.352	0.500	44.109	3.176	1179.523		2.633	232.273	94.208
Vertical component of LL Surcharge	0.20			57.25				-4.000	-228.993				0.000	0.000	
Vertical component of dynamic increment LL Surcharge	0.20			29.53				-4.000	-118.111				0.000	0.000	
Total =				**15578.459**	**1075.393**	**952.899**	**635.266**		**-17115.772**	**-667.168**		**6896.859**		**232.273**	**6592.267**
							-635.266			667.168					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Forces from Superstructure				2000.775	144.056		-7002.713	-504.195
Forces from Substructure				12641.428	133.124		-67341.888	-606.670
CWLL-Max. Reaction case	0.00			0.00	0.00		-3.50	0.00
Vertical component of LL Surcharge	0.00			0.00		-3.500	0.00	0.00
Vertical component of dynamic increment LL Surcharge	0.00			0.000		-8.000	0.000	0.000
Total =				**14642.203**	**277.180**		**-74348.10**	**-1110.866**
					-277.180			**1110.866**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	235.971	1177.358	8096.407	1994.361
due to Substructure	1	1075.393	716.928		6896.859	4597.906
due to Earth pressure	1	3857.714			12557.259	
due to Live load surcharge	0.20	238.415			1148.446	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	8096.41	0.00	0.00	0.00	0.00	235.97	1994.36
1075.39	6896.86	0.00	0.00	0.00	0.00	716.93	4597.91
3857.71	12557.26						
238.41	1148.45						
6219.87	**28698.97**	**0.00**	**0.00**	**0.00**	**0.00**	**952.90**	**6592.27**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00

due to Substructure	1.5	472.942		2732.73565
due to Active Earth pressure	1.5	3817.543		12267.924
due to dynamic Earth pressure	1.5	1969.028238		6567.96417
due to Live load surcharge	0	0		0
due to dynamic increment of live load surcharge	0	0		0
		7387.011		30276.287

472.94	2732.74	0.00	0.00
3817.543	12267.924		
1969.028	6567.964		
0.000	0.000		
0.000	0.000		
7387.01	**30276.29**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	16213.725	14943.193	KN
ML	10916.031	12250.367	kNm
MT	6824.540	6824.540	kNm

Summary of Restoring Forces

Vertical Load	14365.023	kN
Moment	-75458.966	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2096.700**		**754.812**	**150.962**		**1048.350**	**75.481**				**0.000**	**6333.845**
Substructure & Foundation -Portion 1				**655.553**	**19.673**	**145.729**	**29.146**		**25.688**	**9.314**		**145.866**		**0.000**	**1080.487**
Substructure & Foundation -Portion 2				**16497.593**	**93.051**	**689.270**	**137.854**		**-19363.016**	**-73.957**		**452.609**		**0.000**	**3352.662**
Total =				**19249.846**	**112.725**	**1589.811**	**317.962**		**-18288.978**	**10.839**		**598.475**		**0.000**	**10766.994**
							-317.962			-10.839					

Vertical Forces For Restoring or Resisting Effect

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure				**2000.775**	**144.056**		**-7002.71**	**-504.195**
Substructure & Foundation -Portion 1				**622.775**	**27.689**		**-2274.80**	**-101.905**
Substructure & Foundation -Portion 2				**15672.714**	**128.530**		**-81085.72**	**-585.595**
Total =				**18296.264**	**300.274**		**-90363.24**	**-1191.696**
					-300.274			1191.696

For Overturning or Sliding Effect

Load Factor	FL = 0.3 x αh x P (kN)	C.g. of Force (m)	MLs due to FL
	65.578		**486.219**
	304.413		**1480.417**
	369.991		**1966.636**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	754.812	1177.358	8096.407	6333.845
due to Substructure	1	112.725	834.999		598.475	4433.149
due to Earth pressure	1	4315.307			16766.975	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	8096.41	0.00	0.00	0.00	0.00	754.81	6333.84
112.72	598.48	0.00	0.00	0.00	0.00	835.00	4433.15
4315.31	16766.98						
5476.38	**25461.86**	**0.00**	**0.00**	**0.00**	**0.00**	**1589.81**	**10766.99**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.663
due to Substructure	1.5	554.987		2949.95417
due to Active Earth pressure	1.5	4270.371		15582.4134
due to dynamic Earth pressure	1.5	660.777		2870.41482
		6613.632		**30110.446**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
554.99	2949.95	0.00	0.00
4270.371	15582.413		
660.777	2870.415		
6613.63	**30110.45**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward

Summary of Restoring Forces

Vertical Load	17995.990	kN

P	19567.808	18931.884	KN
ML	7183.718	7162.041	kNm
MT	10766.994	10766.994	kNm

Moment	-91554.932	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	**19528.125**	**331.750**	**-18540.33**	**17.733**	**374.343**
		-331.750		-17.733	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL2	MLs due to Fv
Total =	**18296.264**	**300.274**	**-90363.24**	**-1191.696**
		-300.274		**1191.696**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	823.753	1177.358	8096.407	7015.533
due to Substructure	1	112.725	834.999		598.475	4433.149
due to Earth pressure	1	4315.307			16766.975	
due to Live load surcharge	0.2	238.415			1155.495	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	8096.41	0.00	0.00	0.00	0.00	823.75	7015.53
112.72	598.48	0.00	0.00	0.00	0.00	835.00	4433.15
4315.31	16766.98						
238.41	1155.49						
5714.80	**26617.35**	**0.00**	**0.00**	**0.00**	**0.00**	**1658.75**	**11448.68**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.50	1177.358	8707.663
due to Substructure	1.5	166.50		884.986
due to Active Earth pressure	1.5	4270.37		15582.413
due to dynamic Earth pressure	1.5	660.78		2870.415
due to Live load surcharge	0	0.00		0.000
due to dynamic increment of live load surcharge	0	0.00		0.000
		6225.14		**28045.478**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
166.50	884.99	0.00	0.00
4270.371	15582.413		
660.777	2870.415		
0.000	0.000		
0.000	0.000		
6225.14	**28045.48**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	19859.875	19196.375	KN
ML	8094.754	8059.289	kNm
MT	11823.026	11823.026	kNm

Summary of Restoring Forces

Vertical Load	17995.990	kN
Moment	-91554.932	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads		Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure		**2096.700**	**150.962**	**1048.350**	**75.481**	**0.000**
Substructure & Foundation -Portion 1		**655.553**	**29.146**	**25.688**	**9.314**	**0.000**
Substructure & Foundation -Portion 2		**12651.213**	**448.806**	**-17886.815**	**-755.139**	**0.000**
Total =		**15403.466**	**628.915**	**-16812.777**	**-670.344**	**0.000**
			-628.915		670.344	

Vertical Forces For Restoring or Resisting Effect

Loads		Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Superstructure		**2000.775**	**144.056**		**-7002.713**	**-504.195**
Substructure & Foundatic		**622.775**	**27.689**		**-2274.804**	**-101.905**
Substructure & Foundatic		**12018.653**	**105.436**		**-65067.085**	**-504.765**
Total =		**14642.203**	**277.180**		**-74344.601**	**-1110.866**
			-277.180			1110.866

Horizontal Forces For SBC Calculation

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.35	754.81	1177.36	8096.41	6333.84
due to Substructure	1	322.62	2389.76		2069.06	15326.35
due to Earth pressure	1	3857.71			12557.26	

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	8096.41	0.00	0.00	0.00	0.00	754.81	6333.84
322.62	2069.06	0.00	0.00	0.00	0.00	2389.76	15326.35
3857.71	12557.26						
5228.68	**22722.72**	**0.00**	**0.00**	**0.00**	**0.00**	**3144.57**	**21660.20**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.498	1177.358	8707.66
due to Substructure	1.5	141.882		819.82
due to Active Earth pressure	1.5	3817.543		12267.92
due to dynamic Earth pressure	1.5	590.708		1970.39
		5677.632		**23765.80**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
141.88	819.82	0.00	0.00
3817.543	12267.924		
590.708	1970.389		
5677.63	**23765.80**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	16032.381	14774.552	KN
ML	5239.602	6580.290	kNm
MT	21660.198	21660.198	kNm

Summary of Restoring Forces

Vertical Load	14365.023	kN
Moment	-75455.466	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Vertical Forces For SBC Calculation

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	**15578.459**	**635.266**	**-17115.77**	**-667.168**	**232.273**
		-635.266		667.168	

Vertical Forces For Restoring or Resisting Effect

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL2) @ Toe (m)	ML = PxeL2	MLs due to Fv
Total =	**14642.203**	**277.180**		**-74348.10**	**-1110.866**
		-277.180			**1110.866**

Horizontal Forces For SBC Calculation

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure	1	1048.350	786.5701983	1177.358	8096.407	6647.86977
due to Substructure	1	322.618	2389.761157		2069.058	15326.3531
due to Earth pressure	1	3857.714			12557.259	
due to Live load surcharge	0.2	238.415			1148.446	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1048.35	8096.41	0.00	0.00	0.00	0.00	786.57	6647.87
322.62	2069.06	0.00	0.00	0.00	0.00	2389.76	15326.35
3857.71	12557.26						
238.41	1148.45						
5467.10	**23871.17**	**0.00**	**0.00**	**0.00**	**0.00**	**3176.33**	**21974.22**

Horizontal Forces For Overturning or Sliding Effect

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1127.50	1177.358	8707.66
due to Substructure	1.5	141.88		819.82
due to Active Earth pressure	1.5	3817.54		12267.92
due to dynamic Earth pressure	1.5	590.71		1970.39
due to Live load surcharge	0	0.00		0.00
due to dynamic increment of live load surcharge	0	0.00		0.00
		5677.63		**23765.80**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1127.50	8707.66	0.00	0.00
141.88	819.82	0.00	0.00
3817.543	12267.924		
590.708	1970.389		
0.000	0.000		
0.000	0.000		
5677.63	**23765.80**	**0.00**	**0.00**

Summary of Forces For SBC

	Downward	Upward	
P	16213.725	14943.193	KN
ML	6088.229	7422.566	kNm
MT	22206.496	22206.496	kNm

Summary of Restoring Forces

Vertical Load	14365.023	kN
Moment	-75458.966	kNm

	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.523 - 1169.635) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.523 - 1169.635) = 0.000 kNm

Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT

Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

	SAFE BEARING CAPACITY CHECK									SLIDING CHECK			OVERTURNING CHECK		
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D	Max. Base Pressure	Min. Base Pressure	Sliding Force	Restoring Force= μP + c.A + Fp	FOS	Overturning moment	Restoring Moment = ΣP.eToe+Mp	FOS
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN	kN		kNm	kNm	
Case 1 : DL+SIDL-Normal Dry Case	18715.395	2333.510	0.000	157.086	189.496	157.086	189.496	189.496	157.086	5397.869	12451.975	2.31	24290.077	86493.30	3.56
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	19959.150	5083.600	1871.716	157.207	227.812	141.802	212.407	227.812	141.802	6341.597	12451.975	1.96	28389.633	88668.73	3.12
Case 2A : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case-SV Load Case	19784.244	4996.148	234.783	149.458	218.849	147.526	216.917	218.849	147.526	6341.597	12451.975	1.96	28389.633	88668.73	3.12
								SAFE	SAFE			SAFE			SAFE
Normal HFLCase															
Case 3 : DL+SIDL-Normal HFL Case	14925.688	1373.360	0.000	128.664	147.738	128.664	147.738	147.738	128.664	4945.041	9931.819	2.01	20975.587	70905.38	3.38
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	15653.015	3865.236	1161.363	122.873	176.557	113.314	166.998	176.557	113.314	5888.769	10122.169	1.72	25075.144	73080.81	2.91
Case 4A : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case-SV Load Case	15869.320	3973.389	197.217	120.157	175.343	118.534	173.720	175.343	118.534	5888.769	10122.169	1.72	25075.144	73080.81	2.91
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic Dry Case															
Case 5 : DL+SIDL-Long. Seismic Dry Case	19567.808	8580.160	3230.098	134.892	254.060	108.306	227.475	254.060	108.306	8155.445	12597.193	1.54	36808.080	91554.93	2.49
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	19859.875	9491.197	3808.948	133.651	265.474	102.302	234.124	265.474	102.302	8155.445	12597.193	1.54	36808.080	91554.93	2.49
								SAFE	SAFE			SAFE			SAFE
Longitudinal Seismic HFL Case															

Case 7 : DL+SIDL-Long. Seismic HFL Case	16032.381	11408.091	6498.059	95.966	254.412	42.484	200.930	254.412	42.484	7387.011	10055.516	1.36	30276.287	75455.47	2.49
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	16213.725	12250.367	6824.540	93.140	263.284	36.971	207.115	263.284	36.971	7387.011	10055.516	1.36	30276.287	75458.97	2.49
								SAFE	**SAFE**			**SAFE**			**SAFE**
Transverse Seismic Dry Case															
Case 9 : DL+SIDL-Trans. Seismic Dry Case	19567.808	7183.718	10766.994	175.605	275.379	86.988	186.762	275.379	86.988	6613.632	12597.193	1.90	30110.446	91554.93	3.04
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	19859.875	8094.754	11823.026	176.329	288.756	79.020	191.447	288.756	79.020	6225.142	12597.193	2.02	28045.478	91554.93	3.26
								SAFE	**SAFE**			**SAFE**			**SAFE**
Transverse Seismic HFL Case															
Case 11 : DL+SIDL-Trans. Seismic HFL Case	16032.381	6580.290	21660.198	191.888	283.281	13.615	105.008	283.281	13.615	5677.632	10055.516	1.77	23765.797	75455.47	3.17
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	16213.725	7422.566	22206.496	189.966	293.057	7.197	110.288	293.057	7.197	5677.632	10055.516	1.77	23765.797	75458.97	3.18
								SAFE	**SAFE**			**SAFE**			**SAFE**

DESIGN OF FOUNDATION

Foundation Lvl = 1169.635 m

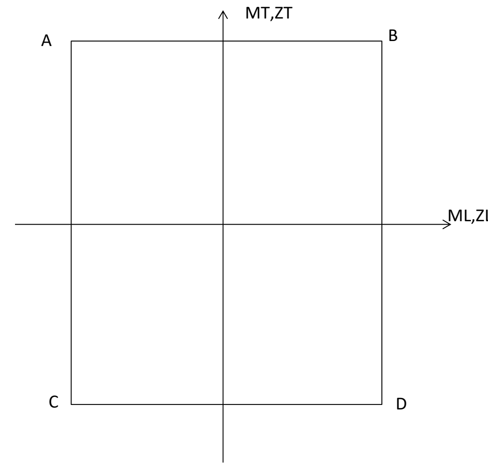
Properties of Footing Base:

A	=	108.000	m^2
ZL	=	144.000	m^3
ZT	=	243.000	m^3

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.35			2460.375	0.500	1230.188	0.000	0.000
SIDL except Wearing Course	1.35			129.600	0.500	64.800	0.000	0.000
Wearing Course	1.75			311.850	0.500	155.925	0.000	0.000
				2901.825		**1450.913**		**0.000**
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1.35	25	5.123	172.910	-0.150	-25.936	0.000	0.000
Dirt Wall-Tapered portion	1.35	25	-0.629	-21.221	-0.150	3.183	0.000	0.000
Bracket - Uniform portion	1.35	25	1.215	41.006	-0.450	-18.453	0.000	0.000
Bracket - Tapered portion	1.35	25	0.608	20.503	-0.400	-8.201	0.000	0.000
Cap - (uniform portion)	1.35	25	6.480	218.700	0.500	109.350	0.000	0.000
Cap - (corbel portion)	1.35	25	5.218	176.095	0.500	88.048	0.000	0.000
Cantilever Return Wall-Rectangle p	1.35	25	0.000	0.000	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle por	1.35	25	0.000	0.000	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier or Crash Barrier	1.35			37.800	-0.150	-5.670	0.000	0.000
Aproach Slab	1.35	25	7.088	239.203	-0.450	-107.641	0.000	0.000
				884.996		**34.679**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.35	25	31.752	1071.630	-2.000	-2143.260	0.000	0.000
Abutment Shaft	1.35	25	71.847	2424.836	0.500	1212.418	0.000	0.000
Back filling over heel slab	1.35	20	420.215	11345.792	-2.021	-22934.583	0.000	0.000
Front Filling over toe slab	1.35	20	91.165	2461.468	2.444	6016.984	0.000	0.000
Side filling between heel and toe	1.35	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.35	25	40.500	1366.875	-1.778	-2430.000	0.000	0.000
Toe slab	1.35	25	30.375	1025.156	2.333	2392.031	0.000	0.000
portion between heel & toe	1.35	25	13.500	455.625	0.500	227.813	0.000	0.000
Vertical Components of active earth pressure	1.5			1554.288	-4.000	-6217.152	0.000	0.000
				21705.670		**-23875.749**		**0.000**
Total				**25492.492**		**-22390.158**		**0.000**



Summary of Forces About C.G. OF Footing

P	25492.492	KN
ML	4397.653	kNm
MT	0.000	kNm

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.358	11205.397
due to Earth pressure	1.5	4270.371		15582.413

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	11205.40	0.00	0.00
4270.37	15582.41	0.00	0.00
5721.284	**26787.811**	**0.000**	**0.000**

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		25492.492		-22390.158		0.000
CWLL-Max. Reaction case	1.5	1436.271	0.500	718.135	1.955	2807.573
Vertical Components of LL Surcharge	1.2	343.489	-4.000	-1373.956	0.000	0.000
Total		**27272.252**		**-23045.979**		**2807.573**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.358	11205.397
due to Earth pressure	1.5	4270.371		15582.413
due to Live load surcharge	1.2	943.728		4099.556
		6665.012		**30887.367**

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	11205.40	0.00	0.00
4270.37	15582.41		
943.73	4099.56		
6665.012	**30887.367**	**0.000**	**0.000**

Summary of Forces About C.G. OF Footing

P	27272.252	KN
ML	7841.388	kNm
MT	2807.573	kNm

Case 3 : DL+SIDL-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				**2901.825**		**1450.913**		**0.000**
Substructure & Foundation -Portion 1				**884.996**		**34.679**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.35	25	31.752	1071.630	-2.000	-2143.260	0.000	0.000
Shaft above HFL	1.35	25	38.084	1285.318	0.500	642.659	0.000	0.000
Shaft below HFL	1.35	15	33.763	683.711	0.500	341.855	0.000	0.000
Back filling above HFL over heel slab	1.35	20	253.098	6833.646	-2.000	-13667.292	0.000	0.000
Back filling below HFL over heel slab	1.35	10	175.554	2369.979	-2.051	-4861.458	0.000	0.000
Front Filling over toe slab	1.35	10	91.165	1230.734	2.444	3008.492	0.000	0.000
Side filling between heel and toe	1.35	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.35	15	40.500	820.125	-1.778	-1458.000	0.000	0.000
Toe slab	1.35	15	30.375	615.094	2.333	1435.219	0.000	0.000
Portion between Heel & Toe	1.35	15	13.500	273.375	0.500	136.688	0.000	0.000
Vertical Components of active earth pressure	1.5			1389.472	-4.000	-5557.889	0.000	0.000
				16573.084		**-22122.986**		**0.000**
Total				**20359.906**		**-20637.395**		**0.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.358	11205.397
due to Earth pressure	1.5	3817.543		12267.924

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	11205.40	0.00	0.00
3817.54	12267.92		
5268.456	**23473.321**	**0.000**	**0.000**

Summary of Forces About C.G. OF Footing

P	20359.906	KN
ML	2835.927	kNm

MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		20359.906		-20637.395		0.000
CWLL-Min. Reaction case	1.5	661.629	0.500	330.815	2.633	1742.045
Vertical Components of LL Surcharge	1.2	343.489	-4.000	-1373.956	0.000	0.000
Total		**21365.024**		**-21680.536**		**1742.045**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.358	11205.397
due to Earth pressure	1.5	3817.543		12267.924
due to Live load surcharge	1.2	943.728		4099.556

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	11205.40	0.00	0.00
3817.54	12267.92		
943.73	4099.56		
6212.184	**27572.878**	**0.000**	**0.000**

Summary of Forces About C.G. OF Footing

P	21365.024	KN
ML	5892.341	kNm
MT	1742.045	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1.50 αh= 0.162 In Longitudinal direction Weight of shaft below Ground level = 675.34 KN
αh= 0.360 In Transverse direction Weight of back fill below Ground level = 2161.08 KN
αv= 0.240 In Vertical direction

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1.35			2460.375		295.245	196.830	0.500	1230.188	98.415	1177.958		0.000	0.000	2457.324
SIDL except Wearing Course	1.35			129.600		15.552	10.368	0.500	64.800	5.184	1178.772		0.000	0.000	142.097
Wearing Course	1.75			311.850		28.868	19.246	0.500	155.925	9.623	1178.323		0.000	0.000	250.809
				2901.825		**339.665**	**226.444**		**1450.913**	**113.222**				**0.000**	**2850.230**
Substructure & Foundation -Portion 1															
Dirt Wall-Uniform portion	1.35	25	5.123	172.910	31.124	20.749	13.833	-0.150	-25.936	-2.075	1177.691	250.717	0.000	0.000	167.145
Dirt Wall-Tapered portion	1.35	25	-0.629	-21.221	-3.820	-2.546	-1.698	-0.150	3.183	0.255	1177.136	-28.650	0.000	0.000	-19.100
Bracket - Uniform portion	1.35	25	1.215	41.006				-0.450	-18.453						
Bracket - Tapered portion	1.35	25	0.608	20.503				-0.400	-8.201						
Cap - (uniform portion)	1.35	25	6.480	218.700	39.366	26.244	17.496	0.500	109.350	8.748	1176.907	286.270	0.000	0.000	190.846
Cap - (corbel portion)	1.35	25	5.218	176.095	31.697	21.131	14.088	0.500	88.048	7.044	1176.607	220.992	0.000	0.000	147.328
Cantilever Return Wall-Rectangle p	1.35	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1178.323	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle por	1.35	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1178.323	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1.35			37.800				-0.150	-5.670				0.000	0.000	
Aproach Slab	1.35	25	7.088	239.203				-0.450	-107.641				0.000	0.000	
				884.996	**98.367**	**65.578**	**43.719**		**34.679**	**13.972**		**729.329**		**0.000**	**486.219**
Substructure & Foundation -Portion 2															
Solid Return wall	1.35	25	31.752	1071.630	192.893	128.596	85.730	-2.000	-2143.260	-171.461	1174.432	925.334	0.000	0.000	616.889
Abutment Shaft	1.35	25	71.847	2424.836	314.910	209.940	139.960	0.500	1212.418	69.980	1174.547	1546.679	0.000	0.000	1031.120
Back filling over heel slab	1.35	20	420.215	11345.792	0.000	0.000	0.000	-2.021	-22934.583	0.000	1174.432	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1.35	20	91.165	2461.468				2.444	6016.984				0.000	0.000	
Side filling between heel and toe	1.35	20	0.000	0.000				0.000	0.000				0.000	0.000	

Heel slab	1.35	25	40.500	1366.875				-1.778	-2430.000				0.000	0.000	
Toe slab	1.35	25	30.375	1025.156				2.333	2392.031				0.000	0.000	
portion between heel & toe	1.35	25	13.500	455.625				0.500	227.813				0.000	0.000	
Vertical component of active earth pressure	1.00			1036.192				-4.000	-4144.768						
Vertical component of dynamic increment of earth pressure	1.50			801.677				-4.000	-3206.708						
				21989.252	**507.803**	**338.535**	**225.690**		**-25010.074**	**-101.481**		**2472.013**		**0.000**	**1648.009**
Total =				**25776.073**	**606.170**	**743.779**	**495.853**		**-23524.482**	**25.712**		**3201.342**		**0.000**	**4984.458**
							-495.853			-25.712					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	339.665	1177.358	11205.397	2850.230
due to Substructure		606.170	404.114		3201.342	2134.228
due to Active Earth pressure	1.00	2846.914			10388.276	
due to dynamic increment of EP	1.50	2202.590			9568.049	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	11205.40	0.00	0.00	0.00	0.00	339.67	2850.23
606.17	3201.34	0.00	0.00	0.00	0.00	404.11	2134.23
2846.91	10388.28						
2202.59	9568.05						
7106.59	**34363.06**	**0.00**	**0.00**	**0.00**	**0.00**	**743.78**	**4984.46**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	26271.926	25280.220	KN
ML	10864.294	10812.869	kNm
MT	4984.458	4984.458	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				2901.825		339.665	226.444		1450.913	113.222				0.000	2850.230
Forces from Substructure				22874.248	606.170	404.114	269.409		-24975.395	-87.509		3201.342		0.000	2134.228
CWLL-Max. Reaction case	0.75			718.14		116.338	77.559	0.500	359.068	38.779	1179.523		1.955	1403.787	1150.350
Vertical component of LL Surcharge	0.20			57.248				-4.000	-228.993						
Vertical component of dynamic increment LL Surcharge	1.50			221.458				-4.000	-885.831						
Total =				**26772.914**	**606.170**	**860.117**	**573.411**		**-24280.238**	**64.492**		**3201.342**		**1403.787**	**6134.808**
							-573.411			-64.492					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	456.003	1177.358	11205.397	4000.580
due to Substructure		606.170	404.114		3201.342	2134.228
due to Active Earth pressure	1	2846.914			10388.276	
due to dynamic increment of EP	1.50	2202.590			9568.049	
due to Live load surcharge	0.20	157.288			683.259	
due to dynamic increment of Surcharge	1.50	608.450			3541.764	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	11205.40	0.00	0.00	0.00	0.00	456.00	4000.58
606.17	3201.34	0.00	0.00	0.00	0.00	404.11	2134.23
2846.91	10388.28						
2202.59	9568.05						
157.29	683.26						
608.45	3541.76						
7872.32	**38588.09**	**0.00**	**0.00**	**0.00**	**0.00**	**860.12**	**6134.81**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	27346.326	26199.503	KN
ML	14372.341	14243.357	kNm
MT	7538.594	7538.594	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2901.825**		**339.665**	**226.444**		**1450.913**	**113.222**				**0.000**	**2850.230**
Substructure & Foundation -Portion 1				**884.996**	**98.367**	**65.578**	**43.719**		**34.679**	**13.972**		**729.329**		**0.000**	**486.219**
Substructure & Foundation -Portion 2															
Solid Return wall	1.35	25	31.752	1071.630	192.893	128.596	85.730	-2.000	-2143.260	-171.461	1174.432	925.334	0.000	0.000	616.889
Shaft above HFL	1.35	25	38.084	1285.318	231.357	154.238	102.825	0.500	642.659	51.413	1175.047	1251.990	0.000	0.000	834.660
Shaft below HFL	1.35	15	33.7635	683.711	1.507	1.005	0.670	0.500	341.855	0.335	1173.136	5.277	0.000	0.000	3.518
Back filling above HFL over heel slab	1.35	20	253.098	6833.646	0.000	0.000	0.000	-2.000	-13667.292	0.000	1175.980	0.000	0.000	0.000	0.000
Back filling below HFL over heel slab	1.35	10	175.554	2369.979	0.000	0.000	0.000	-2.051	-4861.458	0.000	1171.886	0.000	0.000	0.000	0.000
Front Filling over Pile Cap	1.35	10	91.165	1230.734				2.444	3008.492				0.000	0.000	
Side filling between heel and toe	1.35	10	0.000	0.000				0.000	0.000				0.000	0.000	
Heel slab	1.35	15	40.500	820.125				-1.778	-1458.000				0.000	0.000	
Toe slab	1.35	15	30.375	615.094				2.333	1435.219				0.000	0.000	
portion between heel & toe	1.35	15	13.500	273.375				0.500	136.688				0.000	0.000	
Vertical component of active earth pressure	1.00			926.315				-4.000	-3705.259						
Vertical component of dynamic increment of earth pressure	1.50			716.668				-4.000	-2866.671						
				16826.594	**425.758**	**283.839**	**189.226**		**-23137.027**	**-119.713**		**2182.600**		**0.000**	**1455.067**
Total =				**20613.416**	**524.125**	**689.082**	**459.388**		**-21651.436**	**7.480**		**2911.929**		**0.000**	**4791.516**
							-459.388			-7.480					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	339.665	1177.358	11205.397	2850.230
due to Substructure		524.125	349.417		2911.929	1941.286
due to Active Earth pressure	1.00	2545.029			8178.616	
due to dynamic increment of EP	1.50	1969.028			6567.964	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	11205.40	0.00	0.00	0.00	0.00	339.67	2850.23
524.12	2911.93	0.00	0.00	0.00	0.00	349.42	1941.29
2545.03	8178.62						
1969.03	6567.96						
6489.09	**28863.91**	**0.00**	**0.00**	**0.00**	**0.00**	**689.08**	**4791.52**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	21072.804	20154.028	KN
ML	7219.951	7204.990	kNm
MT	4791.516	4791.516	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT

Forces from Superstructure				2901.825		339.665	226.444		1450.913	113.222				0.000	2850.230
Forces from Substructure				17711.591	524.125	349.417	232.944		-23102.348	-105.742		2911.929		0.000	1941.286
CWLL-Min. Reaction case	0.75			330.81		53.592	35.728	0.500	165.407	17.864	1179.523		2.633	871.023	529.917
Vertical component of LL Surcharge	0.20			57.248				-4.000	-228.993						
Vertical component of dynamic increment LL Surcharge	1.50			221.458				-4.000	-885.831						
Total =				**21222.936**	**524.125**	**742.674**	**495.116**		**-22600.852**	**25.344**		**2911.929**		**871.023**	**5321.433**
							-495.116			-25.344					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)	Forces along Long. Axis FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	Forces along Trans. Axis FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
due to Superstructure		1450.913	393.257	1177.358	11205.397	3380.147	1450.91	11205.40	0.00	0.00	0.00	0.00	393.26	3380.15
due to Substructure		524.125	349.417		2911.929	1941.286	524.12	2911.93	0.00	0.00	0.00	0.00	349.42	1941.29
due to Active Earth pressure	1	2545.029			8178.616		2545.03	8178.62						
due to dynamic increment of EP	1.50	1969.028			6567.964		1969.03	6567.96						
due to Live load surcharge	0.20	157.288			683.259		157.29	683.26						
due to dynamic increment of Surcharge	1.50	608.450			3488.902		608.45	3488.90						
							7254.83	**33036.07**	**0.00**	**0.00**	**0.00**	**0.00**	**742.67**	**5321.43**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	21718.052	20727.820	KN
ML	10460.560	10409.871	kNm
MT	6192.456	6192.456	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = 0.3 x αh x P (kN)	FT = αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				**2901.825**		**1132.218**	**226.444**		**1450.913**	**113.222**				**0.000**	**9500.767**
Substructure & Foundation -Portion 1				**884.996**	**29.510**	**218.594**	**43.719**		**34.679**	**13.972**		**218.799**		**0.000**	**1620.730**
Substructure & Foundation -Portion 2				**21989.252**	**152.341**	**1128.452**	**225.690**		**-25010.074**	**-101.481**		**741.604**		**0.000**	**5493.362**
Total =				**25776.073**	**181.851**	**2479.263**	**495.853**		**-23524.482**	**25.712**		**960.403**		**0.000**	**16614.860**
							-495.853			-25.712					

Forces due to Horizontal Load

		FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)	Forces along Long. Axis FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	Forces along Trans. Axis FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
due to Superstructure		1450.913	1132.218	1177.358	11205.397	9500.767	1450.91	11205.40	0.00	0.00	0.00	0.00	1132.22	9500.77
due to Substructure		181.851	1347.045		960.403	7114.093	181.85	960.40	0.00	0.00	0.00	0.00	1347.05	7114.09
due to Active Earth pressure		2846.914			10388.276		2846.91	10388.28						
due to dynamic increment of EP		660.777			2870.415		660.78	2870.41						
							5140.45	**25424.49**	**0.00**	**0.00**	**0.00**	**0.00**	**2479.26**	**16614.86**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	26271.926	25280.220	KN
ML	1925.720	1874.295	kNm

MT	16614.860	16614.860	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**26772.914**	**573.411**	**-24280.238**	**64.492**	**1403.787**
					-573.411		-64.492	

Forces due to Horizontal Load

		FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1520.011	1177.358	11205.397	13335.2656
due to Substructure		181.851	1347.045		960.403	7114.09288
due to Earth pressure		2846.914			10388.276	
due to dynamic increment of EP		660.777			2870.415	
due to Live load surcharge		157.288			683.259	
due to dynamic increment of Surcharge		182.535			1062.529	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	11205.40	0.00	0.00	0.00	0.00	1520.01	13335.27
181.85	960.40	0.00	0.00	0.00	0.00	1347.05	7114.09
2846.91	10388.28						
660.78	2870.41						
157.29	683.26						
182.54	1062.53						
5480.28	**27170.28**	**0.00**	**0.00**	**0.00**	**0.00**	**2867.06**	**20449.36**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	27346.326	26199.503	KN
ML	2954.532	2825.549	kNm
MT	21853.145	21853.145	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Superstructure				**2901.825**	**226.444**	**1450.913**	**113.222**	**0.000**
Substructure & Foundation -Portion 1				**884.996**	**43.719**	**34.679**	**13.972**	**0.000**
Substructure & Foundation -Portion 2				**16826.594**	**189.226**	**-23137.027**	**-119.713**	**0.000**
Total =				**20613.416**	**459.388**	**-21651.436**	**7.480**	**0.000**
					-459.388		-7.480	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1132.218	1177.358	11205.397	9500.76706
due to Substructure		157.237	1164.722		873.579	6470.953
due to Active Earth pressure	1.00	2545.029			8178.616	
due to dynamic increment of EP	1.50	590.708			1970.389	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	11205.40	0.00	0.00	0.00	0.00	1132.22	9500.77
157.24	873.58	0.00	0.00	0.00	0.00	1164.72	6470.95
2545.03	8178.62						
590.71	1970.39						
4743.89	**22227.98**	**0.00**	**0.00**	**0.00**	**0.00**	**2296.94**	**15971.72**

Summary of Forces About C.G. OF Footing

	Downward	Upward	
P	21072.804	20154.028	KN
ML	584.026	569.065	kNm
MT	15971.720	15971.720	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Forces due to Vertical Load

Loads	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =	**21222.936**	**495.116**	**-22600.852**	**25.344**	**871.023**
		-495.116		-25.344	

Forces due to Horizontal Load

		FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1310.858	1177.358	11205.397	11267.158
due to Substructure		157.237	1164.722		873.579	6470.95332
due to Earth pressure		2545.029			8178.616	
due to dynamic increment of EP		590.708			1970.389	
due to Live load surcharge		157.288			683.259	
due to dynamic increment of Surcharge		182.535			1046.671	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	11205.40	0.00	0.00	0.00	0.00	1310.86	11267.16
157.24	873.58	0.00	0.00	0.00	0.00	1164.72	6470.95
2545.03	8178.62						
590.71	1970.39						
157.29	683.26						
182.54	1046.67						
5083.71	**23957.91**	**0.00**	**0.00**	**0.00**	**0.00**	**2475.58**	**17738.11**

Summary of Forces About C.G. OF Footing

	Seismic Downward	Seismic Upward	
P	21718.052	20727.820	KN
ML	1382.403	1331.715	kNm
MT	18609.134	18609.134	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.50 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.523 - 1169.635) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.75 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.523 - 1169.635) = 0.000 kNm

	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

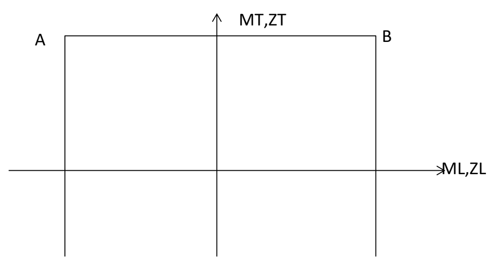
Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT

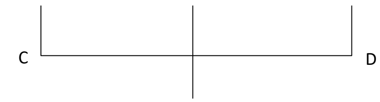
Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

Summary of Design Base Pressure

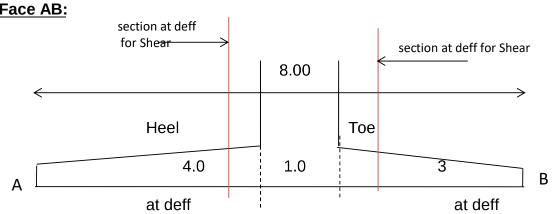
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2
Case 1 : DL+SIDL-Normal Dry Case	25492.492	4397.653	0.000	205.502	266.581	205.502	266.581
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	27272.252	7841.388	2807.573	209.621	318.529	186.513	295.421
Normal HFLCase							
Case 3 : DL+SIDL-Normal HFL Case	20359.906	2835.927	0.000	168.824	208.212	168.824	208.212
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	21365.024	5892.341	1742.045	164.074	245.912	149.736	231.574
Longitudinal Seismic Dry Case							



Case 5 : DL+SIDL-Long. Seismic Dry Case	26271.926	10864.294	4984.458	188.324	339.217	147.300	298.193
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	27346.326	14372.341	7538.594	184.422	384.038	122.376	321.992
Longitudinal Seismic HFL Case							
Case 7 : DL+SIDL-Long. Seismic HFL Case	21072.804	7219.951	4791.516	164.698	264.975	125.262	225.539
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	21718.052	10460.560	6192.456	153.934	299.219	102.967	248.252
Transverse Seismic Dry Case							
Case 9 : DL+SIDL-Trans. Seismic Dry Case	26271.926	1925.720	16614.860	298.259	325.006	161.512	188.258
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	27346.326	2954.532	21853.145	322.620	363.655	142.758	183.794
Transverse Seismic HFL Case							
Case 11 : DL+SIDL-Trans. Seismic HFL Case	21072.804	584.026	15971.720	256.790	264.902	125.336	133.447
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	21718.052	1382.403	18609.134	268.074	287.274	114.912	134.112



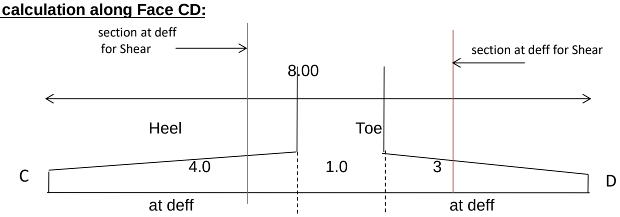
Pressure calculation along Face AB:



		at deff			at deff	
Case : 1	205.502	229.056	236.04	243.676	250.662	266.581
Case : 2	209.621	251.618	264.07	277.688	290.145	318.529
Case : 3	168.824	184.013	188.52	193.441	197.946	208.212
Case : 4	164.074	195.633	204.99	215.223	224.583	245.912
Case : 5	188.324	246.512	263.77	282.632	299.891	339.217
Case : 6	184.422	261.399	284.23	309.182	332.013	384.038
Case : 7	164.698	203.368	214.84	227.371	238.841	264.975
Case : 8	153.934	209.959	226.58	244.737	261.354	299.219
Case : 9	298.259	308.573	311.63	314.976	318.035	325.006
Case : 10	322.620	338.444	343.14	348.267	352.960	363.655
Case : 11	256.790	259.918	260.85	261.860	262.787	264.902
Case : 12	268.074	275.478	277.67	280.074	282.270	287.274

Average MAX Base Pressure for Design of Heel Slab-along Face AB = 332.879 kN/m^2
Average MIN Base Pressure for Design of Heel Slab-along Face AB = 178.671 kN/m^2
Average MAX Base Pressure for Design of Toe Slab-along Face AB = 355.961 kN/m^2
Max. Base Pressure at deff for Design of Toe Slab-along Face AB = 352.960 kN/m^2
Max. Base Pressure at deff for Design of Heel Slab-along Face AB = 338.444 kN/m^2

Pressure calculation along Face CD:



		at deff			at deff	
Case : 1	205.502	229.056	236.04	243.676	250.662	266.581
Case : 2	186.513	228.511	240.97	254.581	267.037	295.421
Case : 3	168.824	184.013	188.52	193.441	197.946	208.212
Case : 4	149.736	181.295	190.66	200.885	210.245	231.574
Case : 5	147.300	205.488	222.75	241.608	258.866	298.193
Case : 6	122.376	199.353	222.18	247.136	269.967	321.992
Case : 7	125.262	163.931	175.40	187.935	199.404	225.539
Case : 8	102.967	158.993	175.61	193.770	210.387	248.252
Case : 9	161.512	171.826	174.88	178.228	181.287	188.258
Case : 10	142.758	158.583	163.28	168.405	173.099	183.794
Case : 11	125.336	128.464	129.39	130.405	131.333	133.447
Case : 12	114.912	122.316	124.51	126.912	129.108	134.112

Average MAX Base Pressure for Design of Heel Slab-along Face CD = 220.772 kN/m^2
Average MIN Base Pressure for Design of Heel Slab-along Face CD = 119.712 kN/m^2
Average Base Pressure for Design of Toe Slab-along Face CD = 284.564 kN/m^2
Max. Base Pressure at deff for Design of Toe Slab-along Face CD = 269.967 kN/m^2
Max. Base Pressure at deff for Design of Heel Slab-along Face CD = 229.056 kN/m^2

Calculation of Moment and Shear Force Along Traffic Direction:

Case 1 : Maximum Base Pressure Case (Dry Case)
Heel Slab - Maximum Moment Calculation

Max Average Base Pressure for Design of Heel Slab = 332.879 kN/m^2

Upward moment due to Base pressure = 2663.029 kNm/m

Downward moment due to backfill = factor 1.35 x 420.215 / 13.500 x 20 x 2.000

	=	1680.858	kNm/m							
Downward moment due to self weight of Heel slab	=	1.35	x	40.500	/	13.500	x	25	x	1.778
	=	180.000	kNm/m							
Net Moment at face of shaft	=	2663.029	-1680.858	-180.000 =		802.171	kNm/m	**Tension at Bottom of Heel Slab**		

Case 2 : Minimum Base Pressure Case (HFL Case)

Heel Slab - Maximum Moment Calculation

Min Average Base Pressure for Design of Heel Slab	=	119.712	kN/m^2							
Upward moment due to Base pressure	=	957.698	kNm/m							
		factor								
Downward moment due to backfill	=	1.35	x	420.215	/	13.500	x	10	x	2.000
	=	840.429	kNm/m							
Downward moment due to self weight of Heel slab	=	1.35	x	40.500	/	13.500	x	15	x	1.778
	=	108.000	kNm/m							
Net Moment at face of shaft	=	957.698	-840.429	-108.000 =		9.269	kNm/m	**Tension at Bottom of Heel Slab**		

Heel Slab - Shear Calculation at deff from face of Wall

Depth of slab at critical section	=	0.886	m					
effective depth at critical section	=	0.801	m					
Base pressure at deff from face of wall	=	338.444	kN/m^2					
Shear Force due to upward pressure at deff from face of wall	=	330.532	x	3.085 x	13.500	=	13765.826	KN
		factor						
Downward Force due to backfill	=	1.35	x	420.215 x	20	=	11345.792	KN
Downward Force due to self weight of Heel slab	=	1.35	x	40.500 x	25	=	1366.875	KN
Net Shear Force	=	13765.826		-11345.792	-1366.875	=	1053.159	KN
Net Shear Force / unit meter	=	1053.159	/	13.500		=	78.012	KN/m

Toe Slab - Moment Calculation

Maximum Average Base Pressure for Design of Toe Slab	=	355.961	kN/m^2							
Upward moment due to Base pressure	=	1601.824	kNm/m							
Downward moment due to self weight of Toe slab	=	1.35	x	30.375	/	13.500	x	25	x	1.333
	=	101.2500	kNm/m							
Net Moment at face of shaft	=	1601.824		-101.250 =		1500.574	kNm/m	**Tension at Bottom of Toe Slab**		

Toe Slab - Shear Calculation at deff from Face of Wall

For shear, critical section is assumed to be located at a distance equal to effective depth from face of wall

Depth of slab at critical section	=	0.848	m						
effective depth at critical section	=	0.760	m						
Base pressure at deff from face of wall	=	352.960	kN/m^2						
upward shear force due to base pressure	=	358.308	x	2.085 x		13.500	=	10085.462	KN
C.g. Of base pressure	=	0.953	m						
moment due to upward pressure at critical section	=	9610.285	kNm						
$\tan\beta$	=	0.167							
reduction in shear force (V_{ccd})	=	$\frac{M \tan\beta}{d}$	=	1889.928	KN				
Downward force due to self weight of toe slab	=	1.35	x	0.674	x	2.085	x	13.500	x 25
	=	640.048	KN						
Net Shear Force at deff	=	10085.462	-	640.048	-	1889.928	=	7555.486	KN
Net Shear Force / unit meter	=	7555.486	/	13.500			=	559.666	KN/m

Design Input :

Design length	=	1000	mm
Clear Cover For Foundation	=	75	mm
Grade of Concrete for Footing	=	M	**35**

fck	=	35.00 N/mm^2	
fctm	=	2.77 N/mm^2	
Grade of Reinforcement Steel	=	Fe 500D	(HYSD Bars)
fy or fyk	=	500.00 N/mm^2	
fyd	=	434.78 N/mm^2	(fy/1.15)
Es	=	200000.00 N/mm^2	

Flexural Reinforcement Calculation:

		Along Traffic Direction	
		Heel Slab	**Toe Slab**
Ultimate bending moment,Mu (kNm/m)	**=**	**802.17**	**1500.57**
Effective depth required (dreq) (mm)	=	370.46	506.68
Effective depth provided (dpro) (mm)	=	915.00	915.00
Check for provided depth	**=**	**SAFE**	**SAFE**
R = Mu/(b d2)	**=**	**0.96**	**1.79**
Total depth provided (mm)	=	1000.00	1000.00
Limiting depth of neutral axis (mm)	=	564.43	564.43
Actual depth of neutral axis (mm)	=	108.41	169.38
Check for Neutral axis depth	**=**	**OK**	**OK**
Lever arm (z) , mm	=	869.90	844.54
Moment of Resistance w.r.to steel	=	1188.21	1802.44
Check for Moment Capacity	**=**	**SAFE**	**SAFE**
Ast reqd (mm2 / m)	=	2276.80	4396.70
cl. 16.6.1 (2) of IRC :112-2011			
$A_{s,min}$ = 0.26 f_{ctm} b_t d / f_{yk} >= 0.0013 b_t d	=	1318.57	1318.57
Governing Ast (mm2 / m)	=	2276.80	4396.70
Tension Reinforcement			
Dia (mm)	=	**20.00**	**25.00**
Spacing (mm)	=	**200.00**	**200.00**
+ Dia (mm)	=	**20.00**	**25.00**
Spacing (mm)	=	**200.00**	**200.00**
Ast provided (mm2 / m)	=	3141.59	4908.74
Check for Ast provided	**=**	**OK**	**OK**
As per Clause 16.6.1.1. of IRC:112-2011 , Secondary Reinforcement shall be at least			
Secondary Reinforcement (mm2/m)	=	628.32	981.75
Dia (mm)	=	16.00	16.00
Spacing (mm)	=	200.00	150.00
Ast provided (mm2 /m)	=	1005.31	1340.41
Check for Ast provided	**=**	**OK**	**OK**

Shear Reinforcement Calculation:

		Along Traffic Direction		
		Heel Slab	**Toe Slab**	
Ultimate Shear Force (V_{Ed})	=	**78.012**	**559.666**	kN/m
Ast provided	=	3141.593	4908.74	mm2/m
Depth of slab at critical section	=	**885.625**	**847.500**	mm
Effective depth at critical section	=	800.625	760.000	mm
Percentage of steel provided (ρ1)	=	0.0035	0.0058	
cl. 10.3.1 of IRC :112-2011				
ρ1 = $A_{sl}/(b_w$ d) <= 0.02	=	OK	OK	
Actual shear stress=v_{ED} = (V_{Ed}/b*0.9d)	**=**	**0.108**	**0.818**	N/mm^2
Max shear capacity, 0.135 fck(1-fck/310)	=	4.192	4.192	N/mm^2
Depth Check for Shear Resistance	**=**	**SAFE**	**SAFE**	
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010				
K = 1+Sqrt(200/d) <= 2.0	=	1.500	1.513	

cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010				
ν_{min} = 0.031 $K^{3/2}$ $fck^{1/2}$	=	0.337	0.341	N/mm^2
0.12 K (80 ρ1 f_{ck})$^{0.33}$	=	0.384	0.455	N/mm^2
σ_{cp} = N_{Ed} / A_c <= 0.2 f_{cd}	=	0.000	0.000	N/mm^2
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2011				
$V_{Rd.c}$ = [0.12K(80ρ1 f_{ck})$^{0.33}$ + 0.15σ_{cp}]b_wd subjected to minimum (ν_{min} + 0.15 σ_{cp}) b_w d	=	351.290	416.614	kN
Check for Shear Reinforcement		**OK, No shear reinf. Req.**	**Provide Shear Reinf.**	
Balance Shear Force= $V_{Rd,s}$ = V_{Ed} - $V_{Rd,c}$	=	0.000	143.051	KN/m
b	=	13.500	13.500	m
Total Shear Force	=	0.000	1931.191	kN
θ = 0.5 x sin^-1 [vEd / (0.18 fck (1- fck/250))]		0.572	4.343	
cot θ = (< 1 cotθ <2.5)	=	2.500	2.500	
fywd = 0.8 x fy/1.15	=	347.826	347.826	N/mm^2
Provide Shear Reinforcement				
Legged	=	**0**	**20**	
Dia	=	**0**	**12**	mm
Area of Shear Reinf, Asw	=	0.000	2261.947	mm^2
z = 0.9 * d	=	720.563	684.000	mm
Spacing of shear Reinforcement required				
S = Asw*z* fywd* cotθ / V_{Rd}	=	0.000	696.651	mm
As per Clause 10.3.3.5 of IRC:112-2011				
Asw/ (b S) = $\rho_{w,min}$ = (0.072 $f_{ck}^{0.5}$) / f_{yk}	=	0.001	0.001	
Spacing of shear Reinforcement required	=	0.000	196.676	mm
As per Clause 16.5.2 , eq. 16.6 of IRC:112-2011				
S_{max} = 0.75 d	=	600.469	570.000	mm
Governing Spacing of Shear Reinf.	=	**0.000**	**196.676**	mm
Provided Spacing of Shear Reinf.	=	**200**	**150**	mm

SLS CHECK OF FOUNDATION

Foundation Lvl = 1169.635 m

Properties of Footing Base:

A	=	108.000	m^2
ZL	=	144.000	m^3
ZT	=	243.000	m^3

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.00			1822.500	0.500	911.250	0.000	0.000
SIDL except Wearing Course	1.00			96.000	0.500	48.000	0.000	0.000
Wearing Course	1.20			213.840	0.500	106.920	0.000	0.000
				2132.340		**1066.170**		**0.000**
Substructure & Foundation -Portion 1								
Dirt Wall-Uniform portion	1.00	25	5.123	128.081	-0.150	-19.212	0.000	0.000
Dirt Wall-Tapered portion	1.00	25	-0.629	-15.719	-0.150	2.358	0.000	0.000
Bracket - Uniform portion	1.00	25	1.215	30.375	-0.450	-13.669	0.000	0.000
Bracket - Tapered portion	1.00	25	0.608	15.188	-0.400	-6.075	0.000	0.000
Cap - (uniform portion)	1.00	25	6.480	162.000	0.500	81.000	0.000	0.000
Cap - (corbel portion)	1.00	25	5.218	130.441	0.500	65.220	0.000	0.000
Cantilever Return Wall-Rectangle portion	1.00	25	0.000	0.000	0.000	0.000	0.000	0.000
Cantilever Return Wall-Traingle portion	1.00	25	0.000	0.000	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier or Crash Barrier	1.00	25		28.000	-0.150	-4.200	0.000	0.000
Aproach Slab	1.00	25	7.088	177.188	-0.450	-79.734	0.000	0.000
				655.553		**25.688**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.00	25	31.752	793.800	-2.000	-1587.600	0.000	0.000
Abutment Shaft	1.00	25	71.847	1796.175	0.500	898.088	0.000	0.000
Back filling over heel slab	1.00	20	420.215	8404.290	-2.021	-16988.580	0.000	0.000
Front Filling over toe slab	1.00	20	91.165	1823.310	2.444	4457.025	0.000	0.000
Side filling between heel and toe	1.00	20	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.00	25	40.500	1012.500	-1.778	-1800.000	0.000	0.000
Toe slab	1.00	25	30.375	759.375	2.333	1771.875	0.000	0.000
portion between heel & toe	1.00	25	13.500	337.500	0.500	168.750	0.000	0.000
Vertical Components of active earth pressure	1.00			1036.192	-4.000	-4144.768	0.000	0.000
				15963.142		**-17225.210**		**0.000**
Total				**18751.035**		**-16133.353**		**0.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1066.170	1177.358	8234.031
due to Earth pressure	1.00	2846.914		10388.276

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1066.17	8234.03	0.00	0.00
2846.91	10388.28		
3913.084	**18622.307**	**0.000**	**0.000**

Summary of Forces

P	18751.035	KN
ML	2488.954	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		18751.035		-16133.353		0.000
CWLL-Max. Reaction case	1.00	957.514	0.500	478.757	1.955	1871.716
Vertical Components of LL Surcharge	0.80	228.993	-4.000	-915.971	0.000	0.000
Total		**19937.542**		**-16570.566**		**1871.716**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1066.170	1177.358	8234.031
due to Earth pressure	1.00	2846.914		10388.276
due to Live load surcharge	0.80	629.152		2733.038

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1066.17	8234.03	0.00	0.00
2846.91	10388.28		
629.15	2733.04		

4542.236	21355.344	0.000	0.000

Summary of Forces

P	19937.542	KN
ML	4784.778	kNm
MT	1871.716	kNm

Case 3 : DL+SIDL-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				**2132.340**		**1066.170**		**0.000**
Substructure & Foundation -Portion 1				**655.553**		**25.688**		**0.000**
Substructure & Foundation -Portion 2								
Solid Return wall	1.00	25	31.752	793.800	-2.000	-1587.600	0.000	0.000
Shaft above HFL	1.00	25	38.084	952.088	0.500	476.044	0.000	0.000
Shaft below HFL	1.00	15	33.763	506.452	0.500	253.226	0.000	0.000
Back filling above HFL over heel slab	1.00	20	253.098	5061.960	-2.000	-10123.920	0.000	0.000
Back filling below HFL over heel slab	1.00	10	175.554	1755.540	-2.051	-3601.080	0.000	0.000
Front Filling over toe slab	1.00	10	91.165	911.655	2.444	2228.512	0.000	0.000
Side filling between heel and toe	1.00	10	0.000	0.000	0.000	0.000	0.000	0.000
Heel slab	1.00	15	40.500	607.500	-1.778	-1080.000	0.000	0.000
Toe slab	1.00	15	30.375	455.625	2.333	1063.125	0.000	0.000
Portion between Heel & Toe	1.00	15	13.500	202.500	0.500	101.250	0.000	0.000
Vertical Components of active earth pressure	1.00			926.315	-4.000	-3705.259	0.000	0.000
				12173.435		**-15975.702**		**0.000**
Total				**14961.328**		**-14883.844**		**0.000**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	Moment @ FND. (kNm)
due to Superstructure		1066.170	1177.358	8234.031
due to Earth pressure	1.00	2545.029		8178.616

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1066.17	8234.03	0.00	0.00
2545.03	8178.62		
3611.199	**16412.647**	**0.000**	**0.000**

Summary of Forces

P	14961.328	KN
ML	1528.803	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Forces due to Vertical load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		14961.328		-14883.844		0.000
CWLL-Min. Reaction case	1.00	441.086	0.500	220.543	2.633	1161.363
Vertical Components of LL Surcharge	0.80	228.993	-4.000	-915.971	0.000	0.000
Total		**15631.406**		**-15579.271**		**1161.363**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	Moment @ FND. (kNm)
due to Superstructure		1066.170	1177.358	8234.031
due to Earth pressure	1.00	2545.029		8178.616
due to Live load surcharge	0.80	629.152		2733.038

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1066.17	8234.03	0.00	0.00
2545.03	8178.62		
629.15	2733.04		
4240.351	**19145.684**	**0.000**	**0.000**

Summary of Forces

P	15631.406	KN
ML	3566.413	kNm
MT	1161.363	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.00 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.523 - 1169.635)

= 0.000 kNm

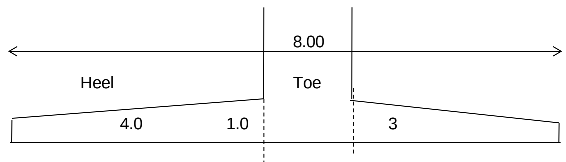
Base pressure on corner A = σ_A = P/A - ML/ZL + MT/ZT

Base pressure on corner B = σ_B = P/A + ML/ZL + MT/ZT

Base pressure on corner C = σ_C = P/A - ML/ZL - MT/ZT
Base pressure on corner D = σ_D = P/A + ML/ZL - MT/ZT

	Design Base Pressure						
LOAD CASES	P	ML	MT	σ_A	σ_B	σ_C	σ_D
Normal Dry Case	kN	kNm	kNm	kN/m^2	kN/m^2	kN/m^2	kN/m^2
Case 1 : DL+SIDL-Normal Dry Case	18751.035	2488.954	0.000	156.336	190.905	156.336	190.905
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	19937.542	4784.778	1871.716	159.082	225.537	143.677	210.132
Normal HFLCase							
Case 3 : DL+SIDL-Normal HFL Case	14961.328	1528.803	0.000	127.914	149.148	127.914	149.148
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	15631.406	3566.413	1161.363	124.748	174.281	115.189	164.723

Pressure calculation along Face AB:



Case 1 :	156.336	173.62	177.942	190.905
Case 2:	159.082	192.31	200.616	225.537
Case 4:	127.914	138.53	141.185	149.148
Case 5:	124.748	149.51	155.706	174.281

For Rare Combination

Average Base Pressure for Design of Heel Slab-along Face AB = 175.696 kN/m^2

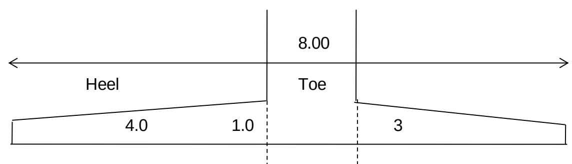
Average Base Pressure for Design of Toe Slab-along Face AB = 213.077 kN/m^2

For Quasi Permenant Combination

Average Base Pressure for Design of Heel Slab-along Face AB = 164.978 kN/m^2

Average Base Pressure for Design of Toe Slab-along Face AB = 184.423 kN/m^2

Pressure calculation along Face CD:



Case 1 :	156.336	173.62	177.942	190.905
Case 2:	143.677	176.90	185.211	210.132
Case 4:	127.914	138.53	141.185	149.148
Case 5:	115.189	139.96	146.148	164.723

For Rare Combination

Average Base Pressure for Design of Heel Slab-along Face CD = 164.978 kN/m^2

Average Base Pressure for Design of Toe Slab-along Face CD = 197.672 kN/m^2

For Quasi Permenant Combination

Average Base Pressure for Design of Heel Slab-along Face CD = 164.978 kN/m^2

Average Base Pressure for Design of Toe Slab-along Face CD = 184.423 kN/m^2

Moment Calculation

	Rare Combination		Quasi-Parmenant		
	Heel Slab	Toe Slab	Heel Slab	Toe Slab	
Max Average Base Pressure	175.70	213.08	164.98	184.42	kN/m^2
Upward moment due to Base pressure	1405.56	958.84	1319.83	829.91	kNm/m
Downward moment due to backfill	1245.08	0.00	1245.08	0.00	kNm/m
Downward moment due to self weight of slab	133.33	75.00	133.33	75.00	kNm/m
Net Moment	**27.15**	**883.84**	**-58.59**	**754.91**	kNm/m
	Tension at Bottom of Heel Slab	**Tension at Bottom of Toe Slab**	**Tension at Top of Slab**	**Tension at Bottom of Toe Slab**	

Check For Stresses in Rare and Quasi-Permanent Load Combination

Creep Coeff	=	1.2		
Ecm	=	32308.25 N/mm^2		
Es	=	200000.00 N/mm^2		
Eceff	=	$\frac{Ecm}{(1+\phi)}$	=	1.47E+04
Modular Ratio (m)	=	Es/ Eceff	=	13.62

		Rare Combination		Quasi Permanent Comb.		
		Heel Slab	Toe Slab	Heel Slab	Toe Slab	
Working bending moment, M	**=**	**27.15**	**883.84**	**-58.59**	**754.91**	kNm/m
Dx	**=**	**1.00**	**1.00**			m
Dy	**=**	**1.00**	**1.00**			m
Section Modulus (ZL) of uncracked sect	**=**	**0.17**	**0.17**			m^3
Bending Stress (M/ZL)	=	0.163	5.303			N/mm^2
Tensile stress of concrete , fctm	=	2.771	2.771			N/mm^2
Cracked or Uncracked Section	=	Uncracked	Cracked			
Section properties of Cracked section:						
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.						
Clear Cover, c	=	75.000	75.000			mm
Maximum dia used, ϕ	=	20.000	25.000			mm
Effective Depth deff (dy)	=	915.000	915.000			mm
Ast provided	=	3141.593	4908.739			mm^2/m
Percentage of steel , pt	=	0.0034	0.0054			
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.263	0.316			
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	240.282	289.248			mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	674.718	625.752			mm
Depth of neutral axis from c.g. Of tesnion steel (ys)	=	589.718	538.252			mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2				
Icr	=	2.410E+10	3.424E+10			mm^4
Maximum compressive stress in concrete	=	**0.271**	**7.466**	**-0.584**	**6.377**	**< 16.8, SAFE**
Maximum Tensile stress in steel	=	**9.047**	**189.202**	**-19.522**	**161.601**	**< 300, SAFE**

Check For Crack Width in Quasi-Permanent Load Combination

Crack width , Wk = Sr max (εsm - εcm)

Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+φ/2)

5*(c+φ/2)	=	425.000	437.500	mm
Provided Spacing	=	100.000	100.000	mm
Check for Applicability of Formula	=	OK	OK	
Maximum crack spacing , $S_{r\,max}$	=	3.4 c +	$\frac{0.425\,k1\,k2\,\varphi}{\rho_{\rho\,eff}}$	
K1	=	0.800	0.800	for deformed bars
K2	=	0.500	0.500	for bending
depth of neutral axis , yc	=	240.282	289.248	mm
$\rho_{\rho\,eff}$ = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.		
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	212.500	212.500	mm
Ac, eff = Dx * hc,eff	=	212500.000	212500.000	mm
$\rho_{\rho\,eff}$ = As/Ac eff	=	0.015	0.023	
Maximum crack spacing , $S_{r\,max}$	=	484.979	438.983	mm
$(\varepsilon_{sm} - \varepsilon_{cm})$	=	$\frac{\sigma_{sc} - k_t f_{ct\,eff} (1 + \alpha_e \rho_{\rho\,eff})}{\rho_{\rho\,eff}}$	/ Es	
tensile stress in steel, ,σsc	=	-19.522	161.601	N/mm^2
Kt	=	0.500	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.771	2.771	N/mm^2
αe = Es/Ecm	=	6.190	6.190	
(εsm - εcm)	=	-0.00006	0.0005	
Crack width , Wk=Sr max (εsm - εcm)	=	**0.000**	**0.213**	mm
Check	=	**SAFE**	**SAFE**	

CALCULATION OF ULS FORCES FOR DESIGN OF ABUTMENT SHAFT

Abutment shaft bottom lvl = 1170.635 m

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1.35			2460.375	0.000	0.000	0.000	0.000
SIDL except Wearing Course	1.35			129.600	0.000	0.000	0.000	0.000
Wearing Course	1.75			311.850	0.000	0.000	0.000	0.000
				2901.825		**0.000**		**0.000**
Substructure-Portion 1								
Dirt Wall-Uniform portion	1.35	25	5.123	172.910	-0.650	-112.391	0.000	0.000
Dirt Wall-Tapered portion	1.35	25	-0.629	-21.221	-0.650	13.793	0.000	0.000
Bracket - Uniform portion	1.35	25	1.215	41.006	-0.950	-38.956	0.000	0.000
Bracket - Tapered portion	1.35	25	0.608	20.503	-0.900	-18.453	0.000	0.000
Cap - (uniform portion)	1.35	25	6.480	218.700	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1.35	25	5.218	176.095	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier	1.35	25		37.800	-0.650	-24.570	0.000	0.000
Aproach Slab	1.35	25	7.088	239.203	-0.950	-227.243	0.000	0.000
				884.996		**-407.820**		**0.000**
Substructure-Portion 2								
Abutment Shaft	1.35	25	71.847	2424.836	0.000	0.000	0.000	0.000
Total				**6211.658**		**-407.820**		**0.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.91	1177.358	9754.48
due to Earth pressure	1.5	3343.90		10797.31

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	9754.48	0.00	0.00
3343.90	10797.31	0.00	0.00
4794.81	**20551.79**	**0.000**	**0.000**

Summary of Forces

P	6211.66	KN
ML	20143.97	kNm
MT	0.00	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		6211.658		-407.820		0.000
CWLL-Max. Reaction case	1.5	1436.271	0.000	0.000	1.955	2807.573
Total		**7647.929**		**-407.820**		**2807.573**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.358	9754.485
due to Earth pressure	1.5	3343.896		10797.306
due to Live load surcharge	1.2	835.104		3210.140

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	9754.48	0.00	0.00
3343.90	10797.31		
835.10	3210.14		
5629.912	**23761.931**	**0.000**	**0.000**

Summary of Forces

P	7647.929	KN
ML	23354.111	kNm
MT	2807.573	kNm

Case 3 : DL+SIDL-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2901.825		0.000		0.000
Substructure-Portion 1				884.996		-407.820		0.000
Substructure-Portion 2								
Shaft above HFL	1.35	25.000	38.084	1285.318	0.000	0.000	0.000	0.000
Shaft below HFL	1.35	23.500	33.763	1071.147	0.000	0.000	0.000	0.000
Total				**6143.287**		**-407.820**		**0.000**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.358	9754.485
due to Earth pressure	1.5	3089.138		8819.298

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	9754.48	0.00	0.00
3089.14	8819.30	0.00	0.00
4540.050	**18573.783**	**0.000**	**0.000**

Summary of Forces

P	6143.287	KN
ML	18165.963	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		6143.287		-407.820		0.000
CWLL-Max. Reaction case	1.5	661.629	0.000	0.000	2.633	1742.045
Total		**6804.916**		**-407.820**		**1742.045**

Forces due to Horizontal Load

	load factor	FL (KN)	R.L. of Force (m)	ML (kNm)
due to Superstructure		1450.913	1177.358	9754.485
due to Earth pressure	1.5	3089.138		8819.298
due to Live load surcharge	1.2	835.104		3210.140

Forces along Long. Axis		Forces along Trans. Axis	
FL Cosθ	ML Cosθ	FL Sinθ	ML Sin θ
1450.91	9754.48	0.00	0.00
3089.14	8819.30		
835.10	3210.14		
5375.154	**21783.923**	**0.000**	**0.000**

Summary of Forces

P	6804.916	KN
ML	21376.103	kNm
MT	1742.045	kNm

Case 5 : DL+SIDL-Long. Seismic Dry Case

Seismic Effect Factor = 1.50 αh= 0.120 In Longitudinal direction

Weight of shaft below Ground level = 675.3 KN

αh= 0.360 In Transverse direction
αv= 0.240 In Vertical direction

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure															
Dead Load	1.35			2460.375		295.245	196.830	0.000	0.000	0.000	1177.958		0.000	0.000	2162.079
SIDL except Wearing Course	1.35			129.600		15.552	10.368	0.000	0.000	0.000	1178.772		0.000	0.000	126.545
Wearing Course	1.75			311.850		28.868	19.246	0.000	0.000	0.000	1178.323		0.000	0.000	221.940
				2901.825		**339.665**	**226.444**		**0.000**	**0.000**				**0.000**	**2510.565**
Substructure-Portion 1															
Dirt Wall-Uniform portion	1.35	25	5.123	172.910	23.055	20.749	13.833	-0.650	-112.391	-8.991	1177.691	162.662	0.000	0.000	146.396
Dirt Wall-Tapered portion	1.35	25	-0.629	-21.221	-2.829	-2.546	-1.698	-0.650	13.793	1.103	1177.136	-18.393	0.000	0.000	-16.554
Bracket - Uniform portion	1.35	25	1.215	41.006				-0.950	-38.956						
Bracket - Tapered portion	1.35	25	0.608	20.503				-0.900	-18.453						
Cap - (uniform portion)	1.35	25	6.480	218.700	29.160	26.244	17.496	0.000	0.000	0.000	1176.907	182.892	0.000	0.000	164.602
Cap - (corbel portion)	1.35	25	5.218	176.095	23.479	21.131	14.088	0.000	0.000	0.000	1176.607	140.219	0.000	0.000	126.197
RCC Railing or Crash Barrier	1.35	25		37.800				-0.650	-24.570				0.000		
Aproach Slab	1.35	25	7.088	239.203				-0.950	-227.243				0.000		
				884.996	**72.865**	**65.578**	**43.719**		**-407.820**	**-7.888**		**467.379**		**0.000**	**420.641**
Substructure-Portion 2															
Abutment Shaft	1.35	25	71.847	**2424.836**	**233.267**	**209.940**	**139.960**	**0.000**	**0.000**	**0.000**	**1174.547**	**912.422**	**0.000**	**0.000**	**821.180**
Total =				**6211.658**	**306.131**	**615.183**	**410.122**		**-407.820**	**-7.888**		**1379.801**		**0.000**	**3752.385**
							-410.122			7.888					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	339.665	1177.358	9754.485	2510.565
due to Substructure		306.131	275.518		1379.801	1241.821
due to Active Earth pressure	1.00	2229.264			7198.204	
due to dynamic increment of EP	1.50	1724.728			6629.856	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	9754.48	0.00	0.00	0.00	0.00	339.67	2510.56
306.13	1379.80	0.00	0.00	0.00	0.00	275.52	1241.82
2229.26	7198.20						
1724.73	6629.86						
5711.04	**24962.35**	**0.00**	**0.00**	**0.00**	**0.00**	**615.18**	**3752.39**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6621.780	5801.535	KN
ML	24546.638	24562.414	kNm
MT	3752.385	3752.385	kNm

Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstucture				2901.825		339.665	226.444		0.000	0.000				0.000	2510.565
Forces from Substructure				3309.833	306.131	275.518	183.679		-407.820	-7.888		1379.801		0.000	1241.821
CWLL-Max. Reaction case	0.20			191.50		31.023	20.682	0.000	0.000	0.000	1179.523		1.955	374.343	275.736
Total =				**6403.160**	**306.131**	**646.207**	**430.805**		**-407.820**	**-7.888**		**1379.801**		**374.343**	**4028.122**
							-430.805			7.888					

Forces due to Horizontal Load

Forces along Long. Axis	Forces along Trans. Axis

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	370.689	1177.358	9754.485	2786.301
due to Substructure		306.131	275.518		1379.801	1241.821
due to Active Earth pressure	1.00	2229.264			7198.204	
due to dynamic increment of EP	1.50	1724.728			6629.856	
due to Live load surcharge	0.20	139.184			535.023	
due to dynamic increment of Surcharge	1.50	538.417			2773.363	

FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	9754.48	0.00	0.00	0.00	0.00	370.69	2786.30
306.13	1379.80	0.00	0.00	0.00	0.00	275.52	1241.82
2229.26	7198.20						
1724.73	6629.86						
139.18	535.02						
538.42	2773.36						
6388.64	**28270.73**	**0.00**	**0.00**	**0.00**	**0.00**	**646.21**	**4028.12**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6833.965	5972.356	KN
ML	27855.025	27870.801	kNm
MT	4402.465	4402.465	kNm

Case 7 : DL+SIDL-Long. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Superstructure				2901.825		339.665	226.444		0.000	0.000				0.000	2510.565
Substructure-Portion 1				884.996	72.865	65.578	43.719		-407.820	-7.888		467.379		0.000	420.641
Substructure-Portion 2															
Shaft above HFL	1.350	25.000	38.084	1285.318	171.376	154.238	102.825	0.000	0.000	0.000	1175.047	756.024	0.000	0.000	680.422
Shaft below HFL	1.350	23.500	33.763	1071.147	52.775	47.497	31.665	0.000	0.000	0.000	1173.136	131.989	0.000	0.000	118.790
				2356.465	**224.150**	**201.735**	**134.490**		**0.000**	**0.000**		**888.013**		**0.000**	**799.212**
Total =				**6143.287**			**404.653**		**-407.820**	**-7.888**				**0.000**	
							-404.653			7.888					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	339.665	1177.358	9754.485	2510.565
due to Substructure		297.015	267.313		1355.392	1219.853
due to Active Earth pressure	1.00	2059.425			5879.532	
due to dynamic increment of EP	1.50	1593.328			4789.218	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	9754.48	0.00	0.00	0.00	0.00	339.67	2510.56
297.01	1355.39	0.00	0.00	0.00	0.00	267.31	1219.85
2059.43	5879.53						
1593.33	4789.22						
5400.68	**21778.63**	**0.00**	**0.00**	**0.00**	**0.00**	**606.98**	**3730.42**

Summary of Forces

	Downward	Upward	
P	6547.939	5738.63	KN
ML	21362.919	21378.70	kNm
MT	3730.418	3730.42	kNm

Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	FL = αh x P (kN)	FT = 0.3 x αh x P (kN)	Fv = 0.3 x αv x P (kN)	Long. Ecc. (eL1) (m)	ML = PxeL1	MLs due to Fv	C.g. of Force (m)	MLs due to FL	Transv. Ecc. (eT) (m)	MT = PxeT	MTs due to FT
Forces from Superstructure				2901.825		339.665	226.444		0.000	0.000				0.000	2510.565
Forces from Substructure				3241.462	297.015	267.313	178.209		-407.820	-7.888		1355.392		0.000	1219.853
CWLL-Min. Reaction case	0.20			88.22		14.291	9.527	0.000	0.000	0.000	1179.523		2.633	232.273	127.020
Total =				**6231.504**	**297.015**	**621.270**	**414.180**		**-407.820**	**-7.888**		**1355.392**		**232.273**	**3857.438**
							-414.180			7.888					

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	353.957	1177.358	9754.48	2637.585
due to Substructure		297.015	267.313		1355.39	1219.853
due to Active Earth pressure	1.00	2059.425			5879.53	
due to dynamic increment of EP	1.50	1593.328			4789.22	
due to Live load surcharge	0.20	139.184			535.02	
due to dynamic increment of Surcharge	1.50	538.417			2731.97	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	9754.48	0.00	0.00	0.00	0.00	353.96	2637.58
297.01	1355.39	0.00	0.00	0.00	0.00	267.31	1219.85
2059.43	5879.53						
1593.33	4789.22						
139.18	535.02						
538.42	2731.97						
6078.28	**25045.62**	**0.00**	**0.00**	**0.00**	**0.00**	**621.27**	**3857.44**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6645.684	5817.324	KN
ML	24629.913	24645.688	kNm
MT	4089.711	4089.711	kNm

Case 9 : DL+SIDL-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**6211.658**	**410.122**	**-407.820**	**-7.888**	**0.000**
					-410.122		7.888	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1132.218	1177.358	9754.485	8368.54906
due to Substructure		91.839	918.393085		413.940	4139.40257
due to Active Earth pressure	1.00	2229.264			7198.204	
due to dynamic increment of EP	1.50	517.419			1988.957	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	9754.48	0.00	0.00	0.00	0.00	1132.22	8368.55
91.84	413.94	0.00	0.00	0.00	0.00	918.39	4139.40
2229.26	7198.20						
517.42	1988.96						
4289.43	**19355.59**	**0.00**	**0.00**	**0.00**	**0.00**	**2050.61**	**12507.95**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6621.780	5801.535	KN
ML	18939.878	18955.654	kNm
MT	12507.952	12507.952	kNm

Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**6403.160**	**430.805**	**-407.820**	**-7.888**	**374.343**
					-430.805		7.888	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1235.6295	1177.358	9754.485	9287.6705
due to Substructure		91.839	918.393085		413.940	4139.403
due to Earth pressure	1.00	2229.264			7198.204	
due to dynamic increment of EP	1.50	517.419			1988.957	
due to Live load surcharge	0.20	139.184			535.023	
Surcharge	1.50	161.525			832.009	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	9754.48	0.00	0.00	0.00	0.00	1235.63	9287.67
91.84	413.94	0.00	0.00	0.00	0.00	918.39	4139.40
2229.26	7198.20						
517.42	1988.96						
139.18	535.02						
161.53	832.01						
4590.14	**20722.62**	**0.00**	**0.00**	**0.00**	**0.00**	**2154.02**	**13427.07**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6833.965	5972.356	KN
ML	20306.911	20322.686	kNm
MT	13801.416	13801.416	kNm

Case 11 : DL+SIDL-Trans. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**6143.287**	**404.653**	**-407.820**	**-7.888**	**0.000**
					-404.653		7.888	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1132.218	1177.358	9754.485	8368.549
due to Substructure		89.104	891.04465		406.618	4066.177
due to Active Earth pressure	1.00	2059.425			5879.532	
due to dynamic increment of EP	1.50	477.998			1436.765	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	9754.48	0.00	0.00	0.00	0.00	1132.22	8368.55
89.10	406.62	0.00	0.00	0.00	0.00	891.04	4066.18
2059.43	5879.53						
478.00	1436.77						
4077.44	**17477.40**	**0.00**	**0.00**	**0.00**	**0.00**	**2023.26**	**12434.73**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6547.939	5738.634	KN
ML	17061.692	17077.468	kNm
MT	12434.726	12434.726	kNm

Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Fv = 0.3 x αv x P (kN)	ML = PxeL1	MLs due to Fv	MT = PxeT
Total =				**6231.504**	**414.180**	**-407.820**	**-7.888**	**232.273**
					-414.180		7.888	

Forces due to Horizontal Load

	load factor	FL (KN)	FT (KN)	R.L. of Force (m)	ML (kNm)	MT (kNm)
due to Superstructure		1450.913	1179.8553	1177.358	9754.485	8791.94936
due to Substructure		89.104	891.04465		406.618	4066.177
due to Earth pressure	1.00	2059.425			5879.532	
due to dynamic increment of EP	1.50	477.998			1436.765	
due to Live load surcharge	0.20	139.184			535.023	
Surcharge	1.50	161.525			819.591	

Forces along Long. Axis				Forces along Trans. Axis			
FL Cosθ	ML Cosθ	FT Sinθ	MT Sinθ	FL Sinθ	ML Sin θ	FT Cosθ	MT Cosθ
1450.91	9754.48	0.00	0.00	0.00	0.00	1179.86	8791.95
89.10	406.62	0.00	0.00	0.00	0.00	891.04	4066.18
2059.43	5879.53						
478.00	1436.77						
139.18	535.02						
161.53	819.59						
4378.15	**18832.01**	**0.00**	**0.00**	**0.00**	**0.00**	**2070.90**	**12858.13**

Summary of Forces

	Seismic Downward	Seismic Upward	
P	6645.68	5817.32	KN
ML	18416.31	18432.08	kNm
MT	13090.40	13090.40	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.) = 1.50 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.523 - 1170.635) = 0.000 kNm

Centrifugal Force : Seismic Case

Centrifugal Force (C.F.) = 0.20 x 0.00 = 0.000 KN

Transverse Moment due to C.F. = 0.000 x (1179.523 - 1170.635) = 0.000 kNm

	Forces along Long. Axis		Forces along Trans. Axis	
	FT Cosθ	MT Cosθ	FT Sinθ	MT Sin θ
Normal	0.00	0.00	0.00	0.00
Seismic	0.00	0.00	0.00	0.00

Summary of ULS Forces for Design of Abutment Shaft

LOAD CASES		Total forces at bottom of abutment shaft P	ML	MT
Normal Dry Case		kN	kNm	kNm
Case 1 : DL+SIDL-Normal Dry Case		6211.658	20143.971	0.000
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case		7647.929	23354.111	2807.573
Normal HFLCase				
Case 3 : DL+SIDL-Normal HFL Case		6143.287	18165.963	0.000
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case		6804.916	21376.103	1742.045
Longitudinal Seismic Dry Case				

Case 5 : DL+SIDL-Long. Seismic Dry Case	DN	6621.780	24546.638	3752.385
	UP	5801.535	24562.414	3752.385
Case 6 : DL+SIDL+LL-(Maximum Reaction Case)-Long. Seismic Dry Case	DN	6833.965	27855.025	4402.465
	UP	5972.356	27870.801	4402.465
Longitudinal Seismic HFL Case				
Case 7 : DL+SIDL-Long. Seismic HFL Case	DN	6547.939	21362.919	3730.418
	UP	5738.634	21378.695	3730.418
Case 8 : DL+SIDL+LL- (Minimum Reaction Case)-Long. Seismic HFL Case	DN	6645.684	24629.913	4089.711
	UP	5817.324	24645.688	4089.711
Transverse Seismic Dry Case				
Case 9 : DL+SIDL-Trans. Seismic Dry Case	DN	6621.780	18939.878	12507.952
	UP	5801.535	18955.654	12507.952
Case 10 : DL+SIDL+LL-(Maximum Reaction Case)-Trans. Seismic Dry Case	DN	6833.965	20306.911	13801.416
	UP	5972.356	20322.686	13801.416
Transverse Seismic HFL Case				
Case 11 : DL+SIDL-Trans. Seismic HFL Case	DN	6547.939	17061.692	12434.726
	UP	5738.634	17077.468	12434.726
Case 12 : DL+SIDL+LL- (Minimum Reaction Case)-Trans. Seismic HFL Case	DN	6645.684	18416.307	13090.399
	UP	5817.324	18432.082	13090.399
	MAX =	**7647.93**	**27870.80**	**13801.42**

Design of Wall:

Material Property:

Grade of Concrete	=	M 35
fck	=	35 N/mm^2
fcd	=	15.633 N/mm^2
Grade of steel	=	Fe 500
fy	=	500 N/mm^2
fyd	=	434.783 N/mm^2
Es	=	200000.00 N/mm^2

Cross section of Wall:

Thickness of Wall (B)	=	1.000 m
Depth of Wall (D)	=	13.500 m
Area of Concrete (Ac)	=	13.500 m^2
Clear Cover to earth faces	=	75 mm
Clear Cover to non earth faces	=	50 mm
Maximum Dia of Vertical Reinf.	=	32 mm
Dia of Horizontal Reinf.	=	16 mm
Effective cover	=	123 mm

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = **7647.93** kN

0.1 fcd Ac = 0.1 x 15.63 x 13500000
= 21105000 N
= **21105.00** kN

Since Axial Force is less than axial capacity of section , Section will design as bending element . Neglecting axial force

PART 1: LONGITUDINAL MOMENT : VERTICAL REINFORCEMENT ON EARTH FACE

Ultimate Design bending moment (ML) = 27870.80 kNm = **2064.504 kNm/m**

Check For Depth of Wall :

Mult = 0.165 x fck x b x d^2
= 2064.50 kNm/m

b = 1000.00 mm

Effective Depth Required (dreq) = $SQRT\left(\frac{2064.50 \times 1000000}{0.165 \times 35.00 \times 1000}\right)$

(dreq) = 597.905 mm

Total Depth Required (Dreq)	=	704.90 mm	
Total Depth Provided (Dprov)	=	1000.00 mm	OK
Effective depth provided(deff)	=	877.00 mm	

R= Mu/(b d^2) = **2.68**

Minimum Longitudinal Reinforcement in wall on each face
= 0.0012 x b x D
Ast min = **1200.00** mm^2/m

Area of Steel Required:

$\frac{pt}{} = \frac{Ast_{req}}{} = \frac{fck \{ 1 - sqrt(1- 4.598 R/fck) \}}{}$

100 b D 2 fy

= 0.0068

Ast_{req} = 6839.210 mm^2/m

Ast required = max(Astmin, Astreq) = **6839.21** mm^2/m

Total are of steel required in full length v = **92329.34** mm^2

Provide	32	mm dia	@	200.00	mm c/c	=	8042.48	mm^2/m	OK
Provide	32	mm dia	@	200.00	mm c/c	=			

Effective length of shaft = 13254 mm

Calculation of reinforcement in numbers

Provide	32	mm dia	-	66.00	nos	=	106964.95	mm^2	OK
Provide	32	mm dia	-	67.00	nos	=			

Percentage of steel = **0.792** %

Check for Moment of Resistance of Section due to Steel

Limiting Depth of Neutral Axis , Xm $= \dfrac{0.0035 \cdot d}{(0.0035 + fyd/Es)}$

$= \dfrac{0.0035 \times 877.00}{0.0035 + 0.0022}$

= 540.98 mm

Depth of Neutral Axis , X $= \dfrac{fyd \cdot Ast}{0.36 \cdot fck \cdot b}$

$= \dfrac{434.78 \times 8042.48}{0.36 \times 35.00 \times 1000.00}$

= 277.52 mm **OK**

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X

= 877.00 - 115.45

= 761.55 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 8042.48 x 761.55

= 2.66E+09 Nmm /m

= 2662.94 kNm/m > 2064.50 kNm/m

Moment of Resistance of Wall is More than Design Bending Moment , HENCE Wall IS SAFE IN BENDING

LONGITUDINAL REINFORCEMENT ON NON EARTH FACE

Minimum Longitudinal Reinforcement in wall on each face

= 0.0012 x b x D

Ast min = **1200.00** mm^2/m

= **16200.00** mm^2

Provide	20	mm dia	@	200.00	mm c/c	=	1570.80 mm^2/m	OK

Calculation of reinforcement in numbers

Provide	20 mm dia	@	66.00	nos	=	20734.51 mm^2	OK

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

maximum of following = 0.2500 x 9613.27 = 2403.318 As per IRC: 112-2011 , Clause 16.3.2
= 0.001 x 1.00E+06 = 1000.000

Maximum Horizontal Reinf. **2403** mm^2 per meter

Min dia of bar = 0.250 x 32 = 8 mm
or 8 mm

Maximum Spacing between l <= 300 mm c/c

2 Legged	16 dia	@	150 c/c	=	2680.826 mm^2	OK

Confinement Reinforcement

As per Clause 17.2.1.3 (Note 2)of IRC:112-2011
Distance between links or ties (ST) = 1/3 x 843 = 281.000
or 200.00 mm

Governing Spacing = 200.00 mm

As per Clause 17.2.1.3 (Note 1)of IRC:112-2011
The Spacing of hoops and ties in the longitudinal direction (SL)
SL = 5 x 32 = 160 mm
or 1/5 x 843 = 168.6 mm
Min = 100 mm

2 Legged	16 dia	@	100 c/c	=	4021.239 mm^2	OK
24 Legged	10 dia	@	100 c/c	=	18849.556 mm^2	
40 links	10 dia	@	100 c/c	=	31415.927 mm^2	
					54286.721 mm^2	

Minimum Confinement Reinforrcement:

nk = $\frac{NED}{Ak\ fck}$ = $\frac{7647928.58}{472500000}$ = 0.0162
AC = 13.500 mm^2
ACC = 0.875 x 13.400 = 11.725 mm^2
ρ L = 0.00794 per meter
ρ L = 0.10718
fyd = 434.783
fcd = 15.633

$$\boxed{\omega_{wd.req} = 0.37\frac{A_C}{A_{CC}}\eta_k + 0.13\frac{f_{yd}}{f_{cd}}(\rho_L - 0.01)}$$

$\omega_{wd.req}$ = 0.3582
ω_{wd} = max ($\omega_{wd,req}$, 0.12) = 0.3582

As per Clause 17.2.1.1 (4) of IRC:112-2011

Confined Reinforcement = $\omega_{wd} = \rho_w f_{yd} / f_{cd}$ where , $\rho_w = \frac{A_{sw}}{S_L . b}$

Volumetric ratio,

Asw	=	54286.721	mm^2
SL	=	100.000	mm
b	=	843.000	mm
ρw	=	0.644	
$\omega_{wd.c}$	=	17.910	

$\omega_{wd,c}$ ≥ ω_{wd} as per equation 17.7 of IRC:112-2011

$\omega_{wd,c}$ = 17.91 OK

Length of Potential Plastic Hinges Refer clause 17.2.1.4 of IRC:112-2011

$$nk = \frac{NED}{Ak\ fck} = 0.0162 < 0.30$$

CALCULATION OF SLS FORCES FOR DESIGN ABUTMENT SHAFT

Abutment shaft bottom lvl = 1170.635 m

Case 1 : DL+SIDL-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure								
Dead Load	1			1822.500	0.000	0.000	0.000	0.000
SIDL except Wearing Course	1			96.000	0.000	0.000	0.000	0.000
Wearing Course	1			178.200	0.000	0.000	0.000	0.000
				2096.700		**0.000**		**0.000**
Substructure-Portion 1								
Dirt Wall-Uniform portion	1	25	5.123	128.081	-0.650	-83.253	0.000	0.000
Dirt Wall-Tapered portion	1	25	-0.629	-15.719	-0.650	10.217	0.000	0.000
Bracket - Uniform portion	1	25	1.215	30.375	-0.950	-28.856	0.000	0.000
Bracket - Tapered portion	1	25	0.608	15.188	-0.900	-13.669	0.000	0.000
Cap - (uniform portion)	1	25	6.480	162.000	0.000	0.000	0.000	0.000
Cap - (corbel portion)	1	25	5.218	130.441	0.000	0.000	0.000	0.000
RCC Railing or Crash Barrier or Crash Barrier	1	25		28.000	-0.650	-18.200	0.000	0.000
Aproach Slab	1	25	7.088	177.188	-0.950	-168.328	0.000	0.000
				655.553		**-302.089**		**0.000**
Substructure-Portion 2								
Abutment Shaft	1	25	71.847	1796.175	0.000	0.000	0.000	0.000
Total				**4548.428**		**-302.089**		**0.000**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	Moment @ Shaft (kNm)
due to Superstructure		1066.170	1177.358	7167.861
due to Earth pressure	1	2229.264		7198.204
				14366.065

Summary of Forces at Bottom of abutment shaft

P	4548.428	KN
ML	14063.976	kNm
MT	0.000	kNm

Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		4548.428		-302.089		0.000
CWLL-Max. Reaction case	1	957.514	0.000	0.000	1.955	1871.716
Total		**5505.942**		**-302.089**		**1871.716**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	ML @ Shaft (kNm)
due to Superstructure		1066.170	1177.358	7167.861
due to Earth pressure	1	2229.264		7198.204
due to Live load surcharge	0.8	556.736		2140.093
				16506.158

Summary of Forces at Bottom of abutment shaft

P	5505.942	KN
ML	16204.070	kNm
MT	1871.716	kNm

Case 3 : DL+SIDL-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Superstructure				2096.700		0.000		0.000
Substructure-Portion 1				655.553		-302.089		0.000

Substructure-Portion 2								
Shaft above HFL	1.000	25.000	38.084	952.088	0.00	0.00	0.00	0.00
Shaft below HFL	1.000	23.500	33.763	793.442	0.00	0.00	0.00	0.00
				4497.783		**-302.089**		**0.000**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	Moment @ Shaft (kNm)
due to Superstructure		1066.170	1177.358	7167.861
due to Earth pressure	1	2059.425		5879.532
				13047.393

Summary of Forces at Bottom of abutment shaft

P	4497.783	KN
ML	12745.304	kNm
MT	0.000	kNm

Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case

Forces due to Vertical Load

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Trans. Ecc (eT) (m)	MT = PxeT (kNm)
Forces from Case :DL+SIDL		4497.783		-302.089		0.000
CWLL-Max. Reaction case	1	441.086	0.000	0.000	2.633	1161.363
Total		**4938.869**		**-302.089**		**1161.363**

Forces due to Horizontal Load

	load factor	Horizontal Force (KN)	R.L. of Force (m)	ML @ Shaft (kNm)
due to Superstructure		1066.170	1177.358	7167.861
due to Earth pressure	1	2059.425		5879.532
due to Live load surcharge	0.8	556.736		2140.093
				15187.486

Summary of Forces at Bottom of abutment shaft

P	4938.869	KN
ML	14885.398	kNm
MT	1161.363	kNm

Centrifugal Force : Normal Case

Centrifugal Force (C.F.)	=	1.00	x	0.00	=	0.000	KN
Transverse Moment due to C.F.	=	0.000	x (	1179.523 - 1170.635)	=	0.000	kNm

Summary of SLS Forces for Design of Abutment Shaft

LOAD CASES	Total forces at bottom of abutment shaft		
Normal Dry Case	P	ML	MT
	kN	kNm	kNm
Case 1 : DL+SIDL-Normal Dry Case	4548.428	14063.976	0.000
Case 2 : DL+SIDL+LL-(Maximum Reaction Case)-Normal Dry Case	5505.942	16204.070	1871.716
Normal HFLCase			
Case 3 : DL+SIDL-Normal HFL Case	4497.783	12745.304	0.000
Case 4 : DL+SIDL+LL- (Minimum Reaction Case)-Normal HFL Case	4938.869	14885.398	1161.363

IN RARE COMBINATION

Max SLS Moment	=	16204.070	kNm
Max Moment per meter	=	1200.301	kNm/m

IN QUASI-PERMANENT

Max SLS Moment	=	14063.976	kNm
Max Moment per meter	=	1041.776	kNm/m

Check For Stresses in Rare and Quasi-Permanent Load Combination

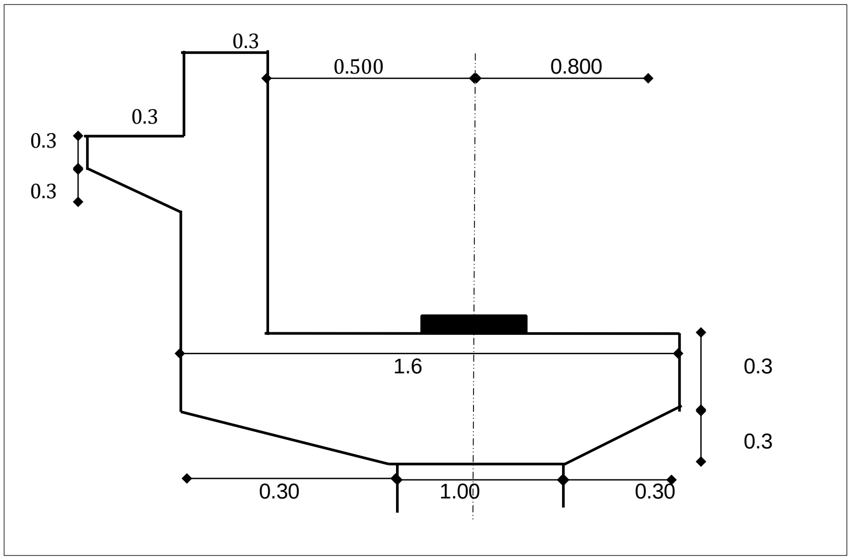
Creep Coeff = 1.2

		Rare Combination		Quasi permanent	
		Short term	Long Term		
Working bending moment, M	=	1200.30	1200.30	1041.78	kNm/m
Dx (unit width of shaft)	=	1.00	1.00	1.00	m
Dy (Thickness of shaft)	=	1.00	1.00	1.00	m
Section Modulus (ZL) of uncrack	=	0.17	0.17	0.17	m^3
Bending Stress (M/ZL)	=	7.202	7.202	6.251	N/mm^2
Tensile stress of concrete , fctm	=	2.771	2.771	2.771	N/mm^2
Cracked or Uncracked Section	=	**Cracked**	**Cracked**	**Cracked**	
Section properties of Cracked section:					
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.					
Es	=	200000.00	200000.00	200000.00	N/mm^2
Ecm	=	32308.25	32308.25	32308.25	N/mm^2
Eceff	=	32308.25	14685.57	14685.57	N/mm^2
Modular Ratio (m)	=	6.19	13.62	13.62	
Clear Cover, c	=	75.000	75.000	75.00	mm
Maximum dia used, ϕ	=	32.000	32.000	32.00	mm
Effective Depth deff (dy)	=	877.000	877.000	877.00	mm
Ast provided	=	8042.477	8042.477	8042.48	mm^2/m
Percentage of steel , pt	=	0.0079	0.0079	0.0079	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m		0.268	0.369	0.369	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	235.012	323.628	323.628	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	641.988	553.372	553.372	mm
Depth of neutral axis from c.g. Of tension steel (ys)	=	550.988	462.372	462.372	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2			
Icr	=	2.485E+10	4.484E+10	4.484E+10	mm^4
Maximum compressive stress in concrete	=	**11.353**	**8.663**	**7.519**	**< 16.8, SAFE**
Maximum tensile stress in concrete	=	31.014	14.813	12.857	
Maximum Tensile stress in steel	=	**164.777**	**168.566**	**146.303**	**< 300, SAFE**

Check For Crack Width in Quasi-Permanent Case

Crack width , Wk	=	Sr max (εsm - εcm)	
Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+φ/2)			
5*(c+φ/2)	=	455.000	mm
Provided Spacing	=	200.000	mm
Check for Applicability of Formula	=	OK	
Maximum crack spacing , $S_{r\,max}$	=	3.4 c +	$\frac{0.425\ k1\ k2\ \varphi}{\rho_{\rho\,eff}}$
K1	=	0.800	for deformed bars
K2	=	0.500	for bending
depth of neutral axis , yc	=	323.628	mm
$\rho_{\rho\,eff}$ = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.	
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	307.500	mm
Ac, eff = Dx * hc,eff	=	307500.000	mm
$\rho_{\rho\,eff}$ = As/Ac eff	=	0.026	
Maximum crack spacing , $S_{r\,max}$	=	462.996	mm
$(\varepsilon_{sm} - \varepsilon_{cm})$	=	$\frac{\sigma_{sc} - k_t f_{ct\,eff} (1 + \alpha_e \rho_{\rho\,eff})}{\rho_{\rho\,eff}}$	/ Es
tensile stress in steel, ,σsc	=	146.303	N/mm^2
Kt	=	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.771	N/mm^2
αe = Es/Ecm	=	13.619	
(εsm - εcm)	=	0.00044	
Crack width , Wk=Sr max (εsm -	=	**0.203**	**mm**
Check	=	**< 0.3 ,SAFE**	

DESIGN OF ABUTMENT CAP



As the cap is fully supported on the abutment. Minimum thickness of the cap required as per cl. 710.8.7 of IRC : 78-2014 is 225 mm.

Assuming a cap thickness of	=	225	mm				
Volume of abutment cap	=	225	x	1600	x	13500	
	=	4.86E+09	mm^3				

as per cl. 710.8.7 of IRC : 78- 2014

Quantity of steel = 1 % of volume

$$= \frac{1}{100} \times 4.86E{+}09 = 4.86E{+}07\ mm^3$$

(a) Longitudinal steel

Quantity of steel to be provided in longitudinal direction

= 2.43E+07 mm^3

Clear cover = 50 mm

Length of bar = 13500 -100 = 13400 mm

Area of steel required in longitudinal directi = $\frac{2.43E+07}{13400}$ = 1813.433 mm^2 (top +Bottom)

Provide	12	Nos. of	12	mm dia bar as longitudinal steel on top & Bottom face of abutment cap.

Provided steel = 1357 mm^2

(b) Transverse steel

Volume of steel to be provided in transverse direction = 2.43E+07 mm^3

Volume of steel required per meter = $\frac{2.43E+07}{13.50}$ = 1.80E+06 mm^3/m

Provide	**2 L**	**12 mm dia bar @**	**150**	**mm c/c stirrups**

Length of each stirrups = 1600 -100 -12 = 1488 mm

Volume of steel provided per meter = 2.24E+06 mm^3/m **OK**

DESIGN OF DIRT WALL

Dirt wall will be designed as a vertical cantilever.

1.) NORMAL CASE

1a. Dead Load

Self Weight of Dirt Wall	=	4.494	m^3 x	25.00	=	112.362 kN
Self Weight of Dirt Wall/ m	=	112.362 /		13.50	=	8.323 kN

1b. Live Load

Assuming Class 70R Boggie load, One Axle is Directly over Dirt Wall

Vertical Load on Dirt Wall = 200 kN

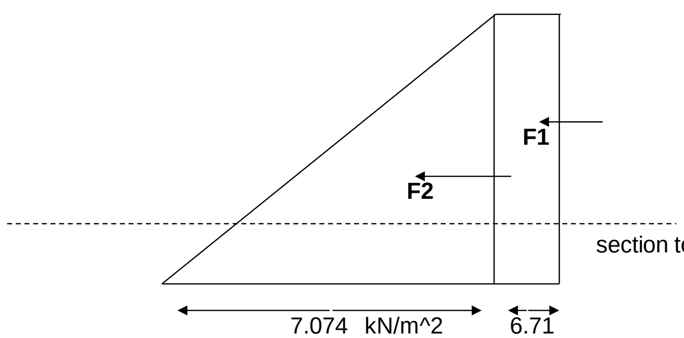
Braking Load

Assuming 20% braking Force i.e. 0.2 *200 = 40.000 kN acting at 1.2 m above deck

Effective Width = 2.79 m

Moment (due to Breaking) = $\dfrac{40.000 \times 2.466}{2.79}$ = 35.355 kNm/m

1c. EARTH PRESSURE



Height of dirt wall = 1.266 m

section to check Shear stress

Normal Earth Pressure

Earth Pressure Diagram

Intensity for rectangular portion	=	0.279	x 20	x 1.2	=	6.705	kN/m^2	
F1	=	6.705	x 1.27	x 1.00	=	8.489	kN/m	
Intensity for triangular portion	=	0.2794	x 20	x 1.266	=	7.074	kN/m^2	
F2	=	0.50	x 7.07	x 1.266	x 1.00	=	4.478	kN/m

Moment @ RL **1177.06** m (at dirt wall base)

M1 = 8.489 x 0.633 = 5.373 kN.m/m

(Centre of pressure considered at an elevation of 0.42 x the height of the wall as per cl. 217.1 of IRC:6-2014)

M2 = 4.478 x 0.532 = 2.381 kN.m/m

Design Horizontal Forces (Normal Case):

Load Factor For Live Load Surcharge = 1.2
Ultimate Moment due to Live Load Surcharge = 6.448 kN.m/m

Load Factor For Earth Pressure = 1.5
Ultimate Moment due to Earth Pressure = 3.571 kN.m/m

Load Factor For Braking Force = 1.5
Ultimate Moment due to Braking Force = 53.032 kN.m/m

Total Ultimate Moment = 63.052 kN.m/m

Material Property:

Grade of Concrete = M 35
Characteristic Strength of Concrete,fck = 35.00 Mpa at 28 days
Grade of Reinforcement = Fe 500
Yield Strength of Reinforcement, fy or fyk = 500 N/mm^2
Design Yield Strength of Reinforcement, fyd = 434.783 N/mm^2
Modulus of Elasticity of Steel (Es) = 200000 N/mm^2

(a) Vertical steel on earth face — As per Clause 16.3.1 of IRC:112-2011
Adorting clear cover on either face = 50 mm
Minimum Dia of Reinforcement = 12 mm
Maximum Spacing of Steel = 150 mm
Thickness of dirtwall = 0.300 m
Available effective depth = 300 -50 -6 = 244 mm

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 63.05 kNm/m

Effective Depth of Cap Required (dreq) = SQRT($\frac{63.05 \times 1000000}{0.165 \times 35.00 \times 1000}$) = 104.490 mm

Total Depth Required (Dreq) = 160.49 mm
Total Depth Provided (Dprov) = 300.00 mm **OK**

R= Mu/(b d^2) = 1.059

Area of Steel Required:

$$\frac{pt}{100} = \frac{Ast_{req}}{b\,d} = \frac{fck\,\{1 - \mathrm{sqrt}(1- 4.598\, R/fck)\}}{2\,fy} = 0.003$$

Ast_{req} = 616.322 mm^2/m
As per Clause 16.3.1 of IRC:112-2011
Minimum Reinforcement = 0.12/100 b x D = 360 mm^2/m
Maximum (Ast_{req}, Ast_{min}) = 616.322 mm^2/m

Provide 12 mm dia bar @ 150 mm c/c as vertical steel at earth face.

Provide Ast = 754 mm^2/m) OK

Percentage of Steel Provided = 0.309 %

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\frac{0.0035\,.\,d}{(0.0035 + fyd/\,Es)}$ = $\frac{0.0035 \times 244}{0.0035 + 0.00217}$
= 150.5134 mm

Depth of Neutral Axis , = $\frac{fyd\,.\,Ast}{0.36\,.\,fck\,.\,b}$

= $\frac{435 \times 754}{0.36 \times 35.00 \times 1000}$ = 26.030 mm **OK**

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z	=	d	-	0.416 . X	=	244	-	10.829
	=	233.171	mm					

Moment of Resistance of Section w.r.t. Steel (MR)

MR	=	fyd . Ast . z		=	434.78	x		754	x	233.17	
	=	7.6E+07	Nmm	=	76.438	kNm/m	>			63.05	kNm/m
								SAFE			

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

(b) Horizontal steel Refer Clause 16.3.2 of IRC:112-2011

Adopting distribution steel bars Dia.	=	10	mm			
Minimum Area of Steel	=	0.001x 0.5 x b x D OR 25% of Ast on Vertical Face				
0.001x0.5xbxD	=	150	mm^2/m	OR	154.080	mm^2/m
Governing Ast	=	154.080	mm^2/m			
Maximum Spacing of Bars	=	300	mm			

Provide 10 mm dia bar @ 200 mm c/c horizontal steel at non earth face.

Provided Ast = **393 mm^2/m)** **OK**

(c) Vertical steel on other face

As per Clause 16.3.1 of IRC:112-2011

Minimum Reinforcement	=	0.12/100	b x D	=	360	mm^2/m

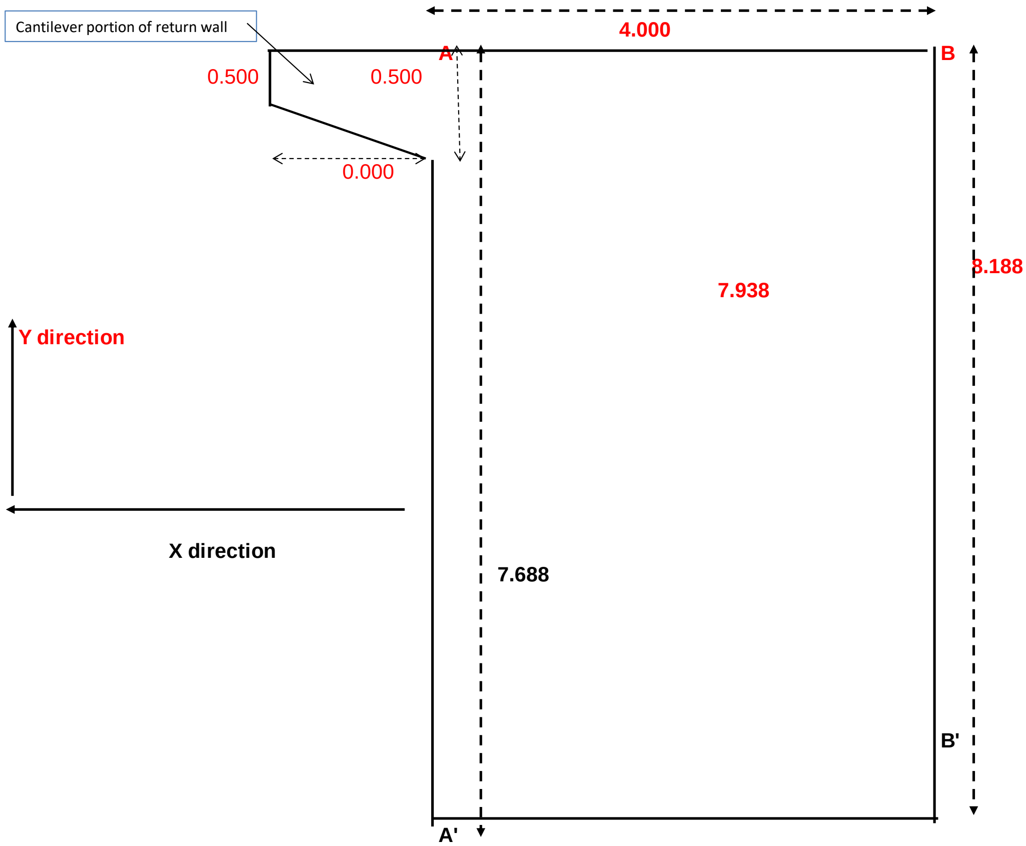
Provide 10 mm dia bar @ 150 mm c/c as vertical steel at earth face.

Provided Ast= 524 mm^2/m) OK

Design of Solid Return wall

THICKNESS OF SOLID RETURN WALL = 0.500 m

THICKNESS OF CANTILEVER RETURN WALL = 0.500 m



Width of Solid Return	**a**	=	4.00	m
Avg. Heigth of Solid Return	**b**	=	7.938	m

a) Design of Solid Return wall

For design of return wall Load case 11.a & 11.d and their formulae given by Roark have been used.

Here, a/b = 0.504

a/b	=	0.5	$\beta1$ =	0.631	$\beta2$	=	0.632
a/b	=	0.75	$\beta1$ =	1.246	$\beta2$	=	1.186

For uniformly distributed load over entire plate

For, a/b = 0.504 $\beta1$ = 0.641

$\beta2$ = 0.641

Live Load Surcharge Intensity:

q = 0.2794 x 20.00 x 1.200 = 6.705 kN/m^2

Max. $$.\sigma b = \frac{\beta1 \times q \times b^2}{(t1)^2}$$

$$.\sigma a = \frac{\beta2 \times q \times b^2}{(t2)^2}$$

$$.\sigma b = \frac{0.641 \times 6.705 \times 63.012}{0.250}$$

At bottom edge = 1082.645 kN/m2 = **1.083 MPa**

For 1000 mm of width , Z = $\frac{1000 \times 250000}{6}$

= 4.17E+07 mm^3

Hence Moment /m width along Y direction -

My /m width = 1.083 x 4.167E+07

= 45110205 Nmm/m = **45.110 kN.m/m**

.σ a = $\frac{0.641 \times 6.705 \times 63.012}{0.250}$

= 1083 = **1.0827 MPa**

For 1000 mm of height , Z = $\frac{1000 \times 250000}{6}$

= 4.167E+07 mm^3

Hence, Moment /m height along X direction -

Mx /m height = 1.0827 x 4.167E+07 = 4.511E+07 Nmm/m

= **45.114 kN.m/m**

For triangular loading due to Earth Pressure

Refer Load case No. 11 d

a/b =	0.500	β1 =	0.328	β2 =	0.200
a/b =	0.75	β1 =	0.537	β2 =	0.276

For, a/b = 0.504 **β1 = 0.331**

β2 = 0.201

q = 0.279 x 20.00 x 7.94

= 44.355 kN/m^2

Max. .σ b = $\frac{\beta 1 \times q \times b^2}{(t1)^2}$

.σ a = $\frac{\beta 2 \times q \times b^2}{(t2)^2}$

σ b = $\frac{0.331 \times 44.355 \times 63.012}{0.25}$

= 3703.39 kN/m^2

= **3.703 MPa**

For 1000 mm of width , Z = $\frac{1000 \times 250000}{6}$

= 4.167E+07 mm^3

Hence Moment /m width along Y direction -

My /m width = 3.703 x 4.167E+07

= 154307946 Nmm/m = **154.308 kN.m/m**

.σ a = $\frac{0.201 \times 44.355 \times 63.012}{0.25}$

= 2249.2 kN/m^2 = 2.249 MPa

For 1000 mm of height , Z = $\frac{1000 \times 250000}{6}$

= 4.167E+07 mm^3

Hence Moment /m height along X direction -

Mx /m height = 2.249 x 4.167E+07 = 9.372E+07 Nmm/m

= **93.716 kN.m/m**

Total Moment in Solid Return Wall / m height = 138.829 kN.m/m

Total Moment in Solid Return Wall / m width = 199.418 kN.m/m

Final Design Moments:

Load Factor for Earth pressure	=	1.50	
Load Factor for live load surcharge	=	1.20	
Total Moment(Mx) in Solid Return Wall / m height	=	195	kN.m/m
Total Moment(My) in Solid Return Wall / m width	=	286	kN.m/m

Material Property:

- Refer Table No 6.5 of IRC : 112-2011

Grade of Concrete	=	M 35	
Characteristic Strength of Concrete,fck	=	35.00	Mpa at 28 days
Grade of Reinforcement	=	Fe 500	
Yield Strength of Reinforcement, fy or fyk	=	500.00	Mpa
Design Yield Strength of Reinforcement, fyd	=	434.78	Mpa (1/1.15 * fy)
Modulus of Elasticity of Steel (Es)	=	200000.00	Mpa

1. Design of Face BB'

Moment in Solid Return /m height (including cantilever moment) =

= 194.710 + 0.00

= 194.71 kN.m / m

Adorting clear cover on either face	=	75	mm	
Minimum Dia of Reinforcement	=	16	mm	
Maximum Spacing of Steel	=	150	mm	
Thickness of wall	=	0.500	m	
Available effective depth	=	500	-75	-8
	=	417	mm	

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 194.71 kNm/m

Effective Depth of Cap Required (dreq) = SQRT($\dfrac{194.71 \times 1000000}{0.165 \times 35.00 \times 1000}$)

Effective Depth of Cap Required (dreq) = 183.619 mm

Total Depth Required (Dreq) = 266.62 mm

Total Depth Provided (Dprov) = 500.00 mm **OK**

R= Mu/(b d^2) = 1.12

Area of Steel Required:

$\dfrac{pt}{100} = \dfrac{Ast_{req}}{b\,d} = \dfrac{fck\,\{1 - sqrt(1 - 4.598\,R/fck)\}}{2\,fy}$

= 0.003

Ast_{req} = 1116.153 mm^2/m

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011

= 600 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 1116.153 mm^2/m

Provide 16 mm dia bar @ 150 mm c/c as Horizontal steel at earth face.

Provide Ast= 1340 mm^2/m) OK

Percentage of Steel Provided = 0.321 %

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm = $\dfrac{0.0035\,.\,d}{(0.0035 + fyd/Es)}$

= $\dfrac{0.0035 \times 417}{0.0035 + 0.00217}$

= 257.230 mm

Depth of Neutral Axis , X = $\frac{fyd \,.\, Ast}{0.36 \,.\, fck \,.\, b}$

= $\frac{434.78 \times 1340}{0.36 \times 35.00 \times 1000}$

= 46.253 mm **OK**

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X
= 417 - 19.241
= 397.759 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 1340 x 397.759

= 2.32E+08 Nmm

= 231.809 kNm/m > 194.71 kNm/m

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

Provide 10 mm dia bar @ 150 mm c/c as Horizontal steel at non earth face.

Provided Ast = **524 mm^2/m)**

2. Design for Face A'B'

Moment in Solid Return /m width = 285.59 kN.m / m

Adorting clear cover on either face	=	75	mm		
Minimum Dia of Reinforcement	=	20	mm		
Maximum Spacing of Steel	=	150	mm		
Thickness of wall	=	0.500	m		
Available effective depth	=	500	-75	-16	-10
	=	399	mm		

Check for Depth:

Mult = 0.165 x fck x b x d^2 = 285.59 kNm/m

Effective Depth of Cap Required (dreq) = SQRT($\frac{285.59 \times 1000000}{0.165 \times 35.00 \times 1000}$)

Effective Depth of Cap Required (dreq) = 222.382 mm

Total Depth Required (Dreq) = 307.38 mm
Total Depth Provided (Dprov) = 500.00 mm **OK**

R= Mu/(b d^2) = 1.79

Area of Steel Required:

$\frac{pt}{100} = \frac{Ast_{req}}{b\,d} = \frac{fck \{ 1 - sqrt(1- 4.598 R/fck) \}}{2\,fy}$

= 0.004

Ast_{req} = 1755.964 mm^2/m

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011
= 600 mm^2/m

Maximum (Ast_{req}, Ast_{min}) = 1755.964 mm^2/m

Provide 20 mm dia bar @ 150 mm c/c as vertical steel at earth face.

Provide Ast= 2094 mm^2/m) OK

Percentage of Steel Provided = 0.5249 %

Provide	**12 mm dia bar @**	**150**	**mm c/c as Vertical steel at non earth face.**

Check for Moment of Resistance of section due to steel

Limiting Depth of Neutral Axis , Xm $= \dfrac{0.0035 \,.\, d}{(0.0035 + fyd/\,Es)}$

$= \dfrac{0.0035 \times 399}{0.0035 + 0.00217}$

= 246.13 mm

Depth of Neutral Axis , X $= \dfrac{fyd \,.\, Ast}{0.36 \,.\, fck \,.\, b}$

$= \dfrac{434.78 \times 2094}{0.36 \times 35.00 \times 1000}$

= 72.270 mm OK

Lever Arm (z) between Compressive Force (C) and Tensile Force (T)

z = d - 0.416 . X
= 399 - 30.064
= 368.94 mm

Moment of Resistance of Section w.r.t. Steel (MR)

MR = fyd . Ast . z

= 434.78 x 2094 x 368.936

= 3.36E+08 Nmm

= 335.955 kNm/m > 285.59 kNm/m

Moment of Resistance of Shaft is More than Design Bending Moment , HENCE SHAFT IS SAFE IN BENDING

b) Cantilever Portion of Return Wall

Self-weight of cantilever portion of return wall	=	6	kN/m
Crash Barrier weight	=	10.0	kN/m
Total Load	=	16	kN/m
Moment at Cantilever Face	=	0	kNm
Load Factor	=	1.35	
Design Moment	=	0	kNm
Effective Depth	=	442.000	mm

R= Mu/(b d^2) = 0.00

Area of Steel Required:

$\dfrac{pt}{100} = \dfrac{Ast_{req}}{b\,d} = \dfrac{fck\,\{1 - sqrt(1 - 4.598\,R/fck)\}}{2\,fy}$

= 0.000

Ast_{req} = 0.000 mm^2

Minimum Reinforcement = 0.12/100 b x D As per Clause 16.3.1 of IRC:112-2011
= 265.2 mm^2

Maximum (Ast_{req}, Ast_{min}) = 265.2000 mm^2

Provide	**16**	**2**	**=**	**402**	**mm^2**

ANNEXURE-I (LOAD CALCULATION-CARRIAGEWAY LIVE LOAD)

Nos. of Lane for design purpose = 3 LANE

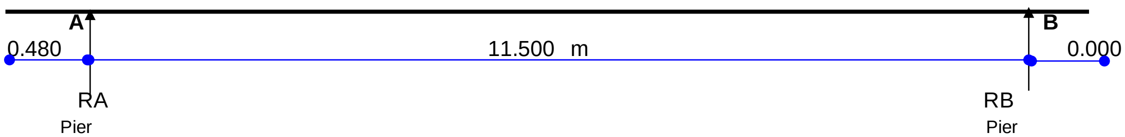
Maximum Live Load Reaction Case

Due to Class A 1-Lane , 2-Lanes, 3-Lanes & 4-Lanes

Considering **114.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	**=**	**11.50 m**
Projection beyond cL of bearing at Abut. end	=	0.480 m
Projection beyond cL of bearing at far end	=	0.000 m
Total length including Overhangs	=	11.98 m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support A in metres	Total Moment of all Loads @ Support A in kN-m	Reaction at Support A in kN	Reaction at Support B in kN
Ist Train	Total Load	500.0kN				
					251.583	**248.417**
114.000	3.200	**0.000**	0.000	0.000		
114.000	1.200	1.200	1.200	136.800		
68.000	4.300	5.500	5.500	374.000		
68.000	3.000	8.500	8.500	578.000		
68.000	3.000	11.500	11.500	782.000		
68.000	3.000	14.500	14.500	986.000		

Reactions (without Impact) for 1 Lane

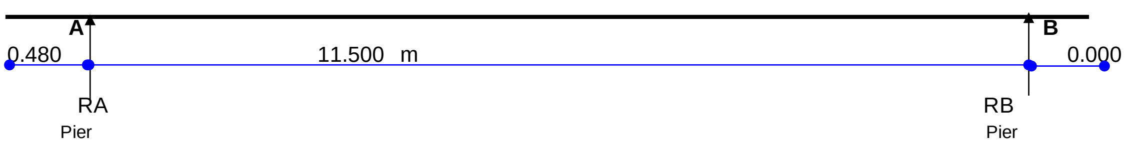
Description		At Supp-A RA	At Supp-B RB
Reaction	in kN	251.583	248.417

Due to Class 70R Wheeled

Considering **170.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	**=**	**11.50 m**
Projection beyond cL of bearing at Abut. end	=	0.480 m
Projection beyond cL of bearing at far end	=	0.000 m
Total length including Overhangs	=	11.98 m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support **A** in metres	Total Moment of all Loads @ Support **A** in kN-m	Reaction at Support **A** in kN	Reaction at Support **B** in kN
Ist Train	Total Load	1000.0kN				
170.000		**0.000**	-0.480	-81.600	**596.191**	**403.809**
170.000	1.370	1.370	0.890	151.300		
170.000	3.050	4.420	3.940	669.800		
170.000	1.370	5.790	5.310	902.700		
120.000	2.130	7.920	7.440	892.800		
120.000	1.520	9.440	8.960	1075.200		
80.000	3.960	13.400	12.920	1033.600		

Reactions (without Impact) for 70R Wheeled

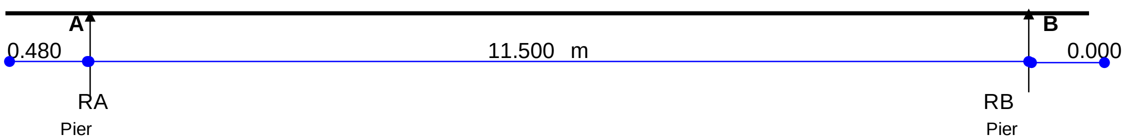
Description		At Supp-A RA	At Supp-B RB
Reaction	in kN	596.191	403.809

Due to Class A 1-Lane/2-Lane (along with Class 70R)

Considering **68.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	=	**11.50**	**m**
Projection beyond cL of bearing at Abut. end	=	0.480	m
Projection beyond cL of bearing at far end	=	0.000	m
Total length including Overhangs	=	11.98	m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support **A** in metres	Total Moment of all Loads @ Support **A** in kN-m	Reaction at Support **A** in kN	Reaction at Support **B** in kN
Ist Train	Total Load	554.0kN				
68.000		**0.000**	0.000	0.000	**86.287**	**467.713**
68.000	3.000	3.000	3.000	204.000		
68.000	3.000	6.000	6.000	408.000		
68.000	3.000	9.000	9.000	612.000		
114.000	4.300	13.300	13.300	1516.200		
114.000	1.200	14.500	14.500	1653.000		
27.000	3.200	17.700	17.700	477.900		
27.000	1.100	18.800	18.800	507.600		

Reactions (without Impact) for 1 Lane

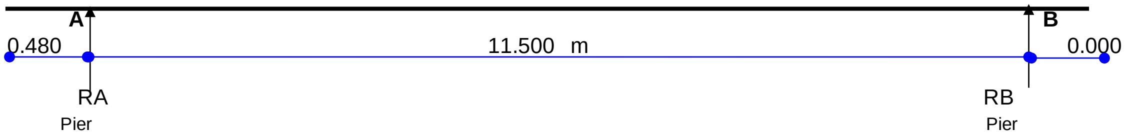
Description		At Supp-A RA	At Supp-B RB
Reaction	in kN	467.713	86.287

Due to Class SV Loading

Considering **180.00** kN

(I.e. **0.000m** from extreme Left End)

Length of the Span	**=**	**11.50**	**m**
Projection beyond cL of bearing at Abut. end	=	0.480	m
Projection beyond cL of bearing at far end	=	0.000	m
Total length including Overhangs	=	11.98	m



Axle Load in kN	Spacing between two successive axles in metres	Distance of the axles from Extreme Left Node in metres	Distance of the axles from the Support **A** in metres	Total Moment of all Loads @ Support **A** in kN-m	Reaction at Support **A** in kN	Reaction at Support **B** in kN
Ist Train	Total Load	1440.0kN				
180.000		**0.000**	0.000	0.000		
180.000	1.500	1.500	1.500	270.000	**782.609**	**657.391**
180.000	1.500	3.000	3.000	540.000		
180.000	1.500	4.500	4.500	810.000		
180.000	1.500	6.000	6.000	1080.000		
180.000	1.500	7.500	7.500	1350.000		
180.000	1.500	9.000	9.000	1620.000		
180.000	1.500	10.500	10.500	1890.000		
0.000	1.500	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		
0.000	0.000	0.000	0.000	0.000		

Reactions for SV Loading

Description	At Supp-**A** **RA**	At Supp-**B** **RB**
Reaction in kN	782.609	657.391

Deck Width = **13.500** m

SV LOAD

transverse ecc.	=	0.300	m				
Maximum Reaction (RA)	=	782.609	KN	Corr. MT	=	234.783	kNm
Minimum Reaction (RB)	=	657.391	KN	Corr. MT	=	197.217	kNm

1-CLASS A

transverse ecc.	=	6.75		-0.5	-0.4	-0.9	0	0	=	4.95	m
Maximum Reaction (RA)	=	251.583	KN	Corr. MT	=		1245.334	kNm			
Minimum Reaction (RB)	=	248.417	KN	Corr. MT	=		1229.666	kNm			

2-CLASS A													
transverse ecc.	=	6.75	-0.5	-0.4	-1.8	-0.85	0	=	3.20 m				
Maximum Reaction (RA)	=	503.165 KN		Corr. MT	=	1610.129 kNm							
Minimum Reaction (RB)	=	496.835 KN		Corr. MT	=	1589.871 kNm							
3-CLASS A													
transverse ecc.	=	6.75	-0.5	-0.4	-1.8	-1.7	-0.9	=	1.45 m				
Maximum Reaction (RA)	=	754.748 KN		Corr. MT	=	1094.384 kNm							
Minimum Reaction (RB)	=	745.252 KN		Corr. MT	=	1080.616 kNm							
4-CLASS A													
transverse ecc.	=	6.75	-0.5	-0.4	-1.8	-1.7	-1.8	-0.85	=	-0.3 m			
Maximum Reaction (RA)	=	1006.330 KN		Corr. MT	=	-301.899 kNm							
Minimum Reaction (RB)	=	993.670 KN		Corr. MT	=	-298.101 kNm							
1- 70RW													
Transverse Ecc.	for 70RW	=		6.75	-0.5	-1.2	-1.395	=	3.655 m				
Maximum Reaction (RA)	=	596.191 KN		Corr. MT	=	2179 kNm							
Minimum Reaction (RB)	=	403.809 KN		Corr. MT	=	1476 kNm							
1-CLASS A + 1-70RW		3 LANE											
Transverse Ecc.	for Class A	=	6.75	-0.5	-0.4	-0.9	=	4.95 m					
	for 70RW	=	6.75	-0.5	-0.4	-1.8	-0.25	-2.8	-1.395	=	-0.395		
Maximum Reaction (RA)	=	1063.904 KN		Corr. MT	=	467.71 x	4.95 +	596.19 x	-0.395	=	2080		
Minimum Reaction (RB)	=	490.096 KN		Corr. MT	=	86.287	4.95 +	403.809	-0.395	=	268		
2-CLASS A + 1-70RW		4 LANE											
Transverse Ecc.	for 1st Class A	=	4.95 m										
	for 2nd Class A	=	4.95	-0.90	-0.85	0	=	3.2 m					
	for 70RW	=	3.2	-0.85		-1.8	-0.25	-1.2	-1.395	=	-2.295		
Maximum Reaction (RA)	=	1531.617 KN		Corr. MT	=	467.71 x	4.95 +	467.71 x	3.200	=	2444		
							+	596.19 x	-2.295				
Minimum Reaction (RB)	=	576.383 KN		Corr. MT	=	86.287	4.95 +	86.29 x	3.200	=	-224		
							+	403.81 x	-2.295				
1- 70RW + 1-CLASS A	-	3 LANE											
Transverse Ecc.	for 70RW	=	6.75	-0.5	-1.2	-1.395	=	3.655 m					
	for Class A	=	6.75	-0.5	-7.25	-0.25	-0.9 =		-2.150 m				
Maximum Reaction (RA)	=	1063.904 KN		Corr. MT	=	596.19 x	3.655 +	467.71 x	-2.150	=	1173		
Minimum Reaction (RB)	=	490.096 KN		Corr. MT	=	403.809	3.655 +	86.287	-2.150	=	1290		
1- 70RW + 2-CLASS A	-	4 LANE											