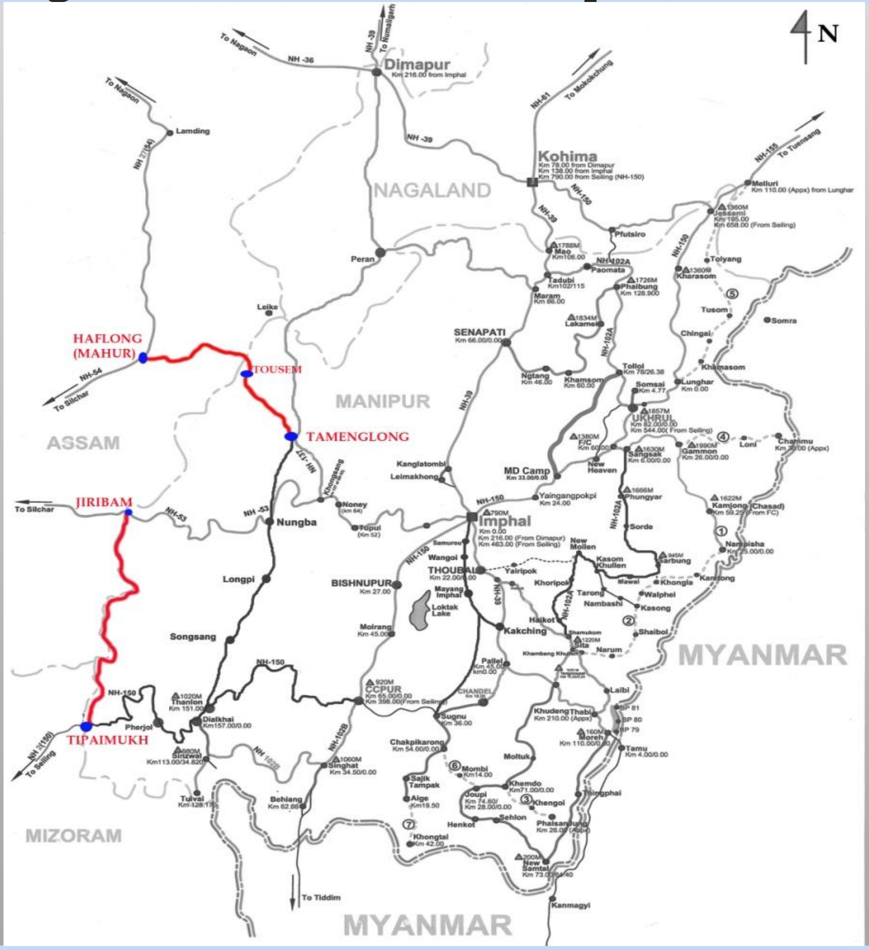
NATIONAL HIGHWAY INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

Consultancy Services for preparation of Feasibility Study and Detailed Project Report for Two Lane with Paved Shoulders of Tamenglong-Tousem-Haflong Road in the State of Manipur and Assam.



DRAFT DETAILED PROJECT REPORT
VOL-II DESIGN REPORT
PKG-10 P.LEIKUL- MAHUR(BOROWAPU) SECTION
(FROM KM 156+489 TO KM 176+581) LENGTH-20.092KM

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FINAL DESIGN REPORT

1.0 HIGHWAY & STRUCTURE DESIGN

Following is a summary of the recommended design standards proposed to be adopted for the project road other than service road and intersections:

Table 6.1: Draft Design Standards

Sr. No.	Element	Terrain		
		Rural (Non Urban)	**Urban Area**	**Hilly**
1	Width of Carriageway (m)	Intermediate Lane : 5.5 2-Lane : 7.0	2-Lane : 7 2-Lane+ Paved Shoulder : 10	2-Lane : 7 2-Lane+ Paved Shoulder : 10
2	Shoulders (Earthen)	2-Lane : 2.50		2-Lane : Valley Side 1.0
		2-Lane+Paved Shoulders 12.0		2-Lane+ Paved Shoulders : Valley Side 1.0
3	Formation Width (m)	Intermediate Lane : 10.0 2-Lane : 14.0	2-Lane+Paved Shoulder : 13.0 (inclusive 2X1.5m of Drain/Foot path)	Intermediate Lane: : 10 2-Lane+ Paved Shoulders : 11
4	Camber/ Cross Fall	Bituminous : 2.5% Concrete Pavement : 2.5% Earthen Shoulder : 3.5% (min)	Bituminous :2.5% Concrete Pavement :2.5%	Bituminous: : 2.5% Concrete Pavement : 2.5% Earthen : 3.5% Shoulder : Min
5	Design Speed (km/h)	<u>Plain Rolling</u> Ruling 100 Mm: 80	Ruling : 60 Minimum : 40	Ruling : 60 Minimum : 40

1.1 Geometric Design

1.1.1 General

Geometric design of a highway is the process whereby the layout of the road in specific terrain is designed to meet the needs of the road users keeping in view the road function, type and volume of traffic, potential traffic hazards and safety as well as convenience of the road users. The principal areas of control for fulfilment of this objective are the horizontal alignment, vertical alignment and the road cross-section.

The Consultants have referred to the latest IRC publications and MoRT&H circulars regarding design standards to be applied for state highways in India. After careful review of all available data and requirements of the project road the proposed Design Standards for adoption on the project road have been recommended.

1.1.2 Design Speed

The project road passes through plain, rolling and hilly terrain. For geometric design of the highway, design speed is used as an index which links road function, traffic flow and terrain. An appropriate design speed should correspond to general topography and adjacent land use. The speed selected for design should also cater to travel needs and behaviour of the road users. Rural highways, except expressways, are normally designed for speed of 80 km/hr, however depending on terrain and whether the design is for new alignment or reconstruction of an existing facility, the design speed is determined to the site requirement.

The ruling design speed corresponding to the type of terrain as per IRC:SP 73-2018, are as follows:

Table 6.2: Design Speed Standards

Terrain	IRC SP:73:2018
Plain/Rolling	80-100
Mountainous	40-60

Assuming a diverse mix of traffic on the project roads, a ruling design speed of 80-100 km/h for plain, rolling terrain and 40-60 km/h for hilly terrain is proposed to be adopted. Use of speed regulatory sign is proposed at locations such as hairpin bends, urban areas and other sharp curves where design speed cannot be maintained.

1.1.3 Levels of Service (LOS)

The Level of Service (LOS) characterizes the operating conditions on the roadway in terms of traffic performance measures related to speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience. The levels of service range from level-of-service A (least congested) to level-of-service F (most congested). The Highways Capacity Manual (HCM) provides the following levels of service definitions:

Table 6.3: Standards for Level of Service

Level of Service (LOS)	General Operating Conditions
A	Free flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Considering the importance of the highway Level of Service (LOS) 'B' is proposed.

1.1.4 Cross Sectional Elements

1.1.4.1 Roadway Width for Multilane Highways

Adequate roadway width will be provided for the requisite number of traffic lanes besides the shoulders and a central median dividing the traffic flow directions. As specified in the IRC 73-2018, in general, for multilane highways, the shoulder width should be 2.5 m and lane width 3.5 m per lane. Based on a comparative review of international standards and safety, the values proposed to be adopted for the roadway elements by the Consultants for the project highway are as follows:

Table 6.4: Road Cross Section

Item	Two-Lane with Earthen Shoulder	Two-Lane with Paved Shoulder	
		Plain/Rolling Terrain	Hilly Terrain
Carriageways	2 X 3.5 m	2 X 3.5 m	2 X 3.5 m
Paved shoulder	N.A.	2 X 1.5m	2 X 1.5
Unpaved shoulder Plain/ rolling terrain Hilly terrain : Hill Side Valley Side	2 X 2.5 m 2 X 1.0 m 2 X 2.0 m	2 X 2	 1x 1.0m
Total Formation width Plain/rolling terrain Hilly terrain	12 m 10 m	14m	 11m
Total Formation width in Urban Area(inclusive Foot path/Drain)	13 m (Inclusive of 2X1.5m of Footpath/Drain)	14m	11m

As the proposed road is a national highway, total carriageway width of 7.0 m i.e. two lane with 1.5m Paved shoulders & 2.0m earthen shoulders has been proposed with the formation width of 14m in plain/rolling terrain and 7.0m carriageway with 1.5m paved shoulder and 1.0m valley side earthen shoulder has been proposed with the formation width of 11m in hilly terrain.

1.1.4.2 Lane Width

Lane width has a significant influence on the safety and comfort of the road. The capacity of a roadway is markedly affected by the lane width. In general, safety increases with wider lanes up to a width of about 3.5 m. **The lane width as per IRC:SP 73-2018 is 3.5 m.**

1.1.4.3 Shoulders

Shoulders are a critical element of the roadway cross section. Shoulders provide recovery area for errant vehicles; a refuge for stopped or disabled vehicles; and access for emergency and maintenance vehicles. Shoulders can also provide an opportunity to improve sight distance through cut sections.
IRC: SP 73-2018 recommends a paved outer shoulder of 1.5 m together with an earthen shoulder of 2.0 m for multilane highways. For mountainous terrain, the recommended earthen shoulder width is 1.0 m valley side.

1.1.4.4 Pavement Camber (Cross-fall)

IRC:SP 73-2018 recommends the following camber for various surface types:

Table 6.5: Provision for Cross-fall

Surface type	Camber
High Type Bituminous Surfacing	1.7% - 2.0 %
Thin Bituminous Surfacing	2.0 % - 2.5 %
Water Bound Macadam, Gravel	2.5 % - 3.0 %
Earth	3.0 % - 4.0 %

Considering the bituminous surfacing (bituminous concrete) the Consultants propose to provide a camber of 2.5 % for the main carriageway as well as paved shoulders and 3.5 % for the unpaved shoulder (granular).

1.1.4.5 Embankment Slopes

The side slope shall not be steeper than 2H:1V unless soil is retained by suitable soil retaining by structure.

1.1.5 Typical Cross-sections

The proposed cross-section in rural sections consists of two lane with paved shoulder configuration during the service life of the project. Concentric widening is proposed to minimize land acquisition issues and to ensure maximum utilisation of existing carriageway.

1.1.6 Horizontal Alignment

1.1.6.1 General

For balance in highway design, all geometrical elements should be determined for consistent operation under the design speed in general. A horizontal alignment should be as smooth and consistent as possible with the surrounding topography. To achieve that, an appropriate blending with the natural contours is preferable to the one with long tangents through the terrain.

1.1.6.2 Sight Distances

Sight distance is a direct function of the design speed. Safe stopping distances corresponding to various design speeds are given below:

Table 6.6: Sight Stopping Distance Criteria

Design Speed Km/h	IRC SP:73:2018
100	180
80	120
60	90
40	45

It is desirable to design the highway for more liberal values for operational convenience. An appropriate allowance would be considered to take care of the effect of adverse incidents. The value recommended by IRC & guidelines are proposed to be adopted in design.

1.1.6.3 Horizontal Curve

The minimum horizontal curve radius is the limiting value of curvature for a given design speeds and is determined from the maximum rate of super elevation and the side friction factor. As per the IRC: 73 - 2018 the minimum ruling radii of Horizontal curve for National Highways corresponding to different terrain conditions are as follows:

Table 6.7: Horizontal Radii Criteria

Type of Terrain	Minimum Radii of Horizontal Curve	
	Two Lane	
	Ruling Minimum	Absolute Minimum
Plain	400	150
Rolling	400	150
Mountainous	150	75

Absolute minimum and ruling minimum radii are corresponding to the minimum design speed and the ruling design speeds respectively.

On new roads, horizontal curves are designed with liberal radius provision that blends well the overall geometry and topography. However, for locations with constraints and to make use of available roadway, it is proposed to keep minimum radius in accordance with the IRC recommendations.

Table 6.8: Adopted Horizontal Radii

Speed (km/h)	Absolute Minimum Radius Two lane (m)
80	250
65	150
40	75

1.1.6.4 Transition (Spiral) Curves

The purpose of a transition (spiral) curve is to provide a smooth and aesthetically pleasing transition from a tangent and a circular curve. In addition the transition curves provide the necessary length for attainment of super-elevation runoff.

It is proposed to adopt transition curve lengths provided above for minimum recommended moves.

1.1.6.5 Super-elevation

The IRC: SP 73-2018 design standards propose a maximum super-elevation rate of 7 % for plain and rolling terrains, and 10% for the mountainous terrain.

The limiting value of the super-elevation on the project road in both plain/rolling and hilly terrain is proposed to be 7%.

1.1.7 Vertical Alignment

1.1.7.1 General

The vertical alignment should produce a smooth longitudinal profile consistent with standard of the road and of the terrain. Horizontal and Vertical curvature should be so combined that the safety and operational efficiency of the road is enhanced.

1.1.7.2 Gradients

The IRC: SP 73-2018 geometric design standards propose ruling vertical grades of 3.3% to 5.0% for plain and rolling terrains; and 5.0% to 6.0% for hilly terrain.

Table 6.9 : Vertical Gradient

Terrain	Ruling (%)	Limiting (%)
Plain/Rolling	2.5%	3.3%
Hilly	5.0%	6.0%
Steep	6.0%	7.0%

To ensure adequate drainage, roadways typically have a minimum longitudinal grade of 0.5% to 0.6%, depending on the terrain. The minimum longitudinal grades as per IRC: SP 73-2018 design standards are 0.5% for lined side ditches, and 1.0% for unlined side ditches.

1.1.7.3 Vertical Curves

As per IRC: SP 73-2015 design standards, the minimum lengths of vertical curves are 60 m and 50 m for design speeds of 100 km/h and 80 km/h respectively The length of a vertical curve is calculated using the following equation:

L = K x A,

Where L = Length of vertical curve in metres;

K = Coefficient, a measure of the flatness of a vertical curve; and
A = Algebraic difference of grade lines (%)

Summit or Crest Curves

According to AASHTO (2001) design guidelines, the minimum K values for stopping sight distance requirements are 52, 26 and 7 for design speeds of 100 km/hr, 80 km/h and 50 km/hr respectively.

According to TAC (1999) design guidelines, the minimum K valves for stopping sight distance requirements are 45 to 80, 24 to 36 and 6 to 16 for design speeds of 100 km/hr, 80 km/hr and 50 km/hr respectively.

As per IRC-SP-23-1993 design Guidelines the Consultant propose minimum summit curve K values of 75, 45, and 25 for design speeds of 100 km/hr, 80 km/hr, 65 km/hr respectively.

Valley or Sag Curves

The minimum K values for valley or sag curves, in accordance with AASHTO (2001) design guidelines are 45, 30 and 13 for design speeds of 100 km/hr, 80 km/hr and 50 km/hr respectively. The minimum K values for valley or sag curves, in accordance with TAC (1999) design guidelines are 37 to 50, 25 to 32 and 7 to 16 for design speeds of 100 km/hr, 80 km/hr, 50 km/hr and 40 km/hr respectively.

As per IRC-SP-23-1993 design Guidelines the Consultant propose minimum valley curve K values of 42, 26 and 15 for design speeds of 100 km/hr, 80 km/hr, 65 km/hr respectively.

1.2 Bridges and Cross Drainage Structures

1.2.1 General

The bridge having total length more than 60 m is termed as major bridge and bridge length between 6 m to 60 m as minor bridge. The culvert is the structure having length less than 6 m between inner faces of dirt wall or extreme vent way boundaries measured at right angles thereto.

1.2.1.1 Bridges and Culvert

For major and minor bridges the minimum overall width between the outermost faces of the bridge shall be equal to 16m comprising of 13m carriageway and 0.45m RCC barrier on each side. Width of culverts shall be equal to 12m.

1.3 Hydrological and Hydraulic Investigations

Hydrological Data

The hydraulic condition of each structure was assessed thoroughly by visual observations and details are collected from the local offices of PWD, Tripura and BRO department, wherever available to collect the available hydrological data.

For the existing major and minor bridges the Topographic maps obtained from Survey of India has been utilized for the Hydrological Calculations.

Topographic maps, obtained from Survey of India, on 1:50,000 scales, have been utilized for the hydrological study in the corridor, accordingly for entire project Corridor, are prepared and attached as Annexure 5.5 "Abstract of Hydraulic Calculations".

1.4 Hydrological Design Methodology

For the calculation of discharge of the stream by the Area-Velocity method, topographical survey including leveling surveys have been carried out across and along the water courses to determine the cross-section and the slope. A number of cross-sections have been taken at regular intervals on both upstream and downstream side of the structure, including one at the proposed location of the structure in accordance with IRC specifications.

The following assumptions have been made during peak discharge calculation:

For locations where water spreads over the banks, the cross-sections were extended up to the HFL, in order to calculate the effective cross-section of flow.

The longitudinal section to determine the bed slope have been taken at an approximate regular interval of 100 m following the channel course extending on both the upstream and the downstream sides of the structure. Caution is taken by following the curved flow line for longitudinal gradient, rather than a straight line.

1.4.1.1 Assessment of Peak Discharge

The peak discharge and the HFL have been calculated by the following methods.

Dickens Method to find discharge from catchment, and Area velocity methods at the bridge site, the upstream and the downstream sections.

Dickens Method

Dickens's Formula is proposed as Empirical formulae in entire road stretch, which is as below.

Q = CM (0.75)

Where,

Q = the peak run-off in cu.m/sec.

M Is the catchment area in sq.km and

C = 11-14, where the annual rainfall is 60-120 cm;

14-19, in Madhya Pradesh; and

32, in Western Ghats.

Area – Velocity Method (Manning's Formula)

Q = A x V

= A x [(1/n) x (R)2/3 x (S)1/2]

Where, Q = the discharge in cumecs ;

A = Area of the cross section in sq. m.;

V = Velocity in m/sec;

R = Hydraulic mean depth in m. = A / P;

P = Wetted perimeter of the stream in m.;

S = Bed slope of the stream; and

n = Rugosity Co-efficient.

The Design Discharge has been taken as the maximum of peak discharges at different cross sections.

1.4.1.2 Hydraulic Analysis for Design HFL

In hydraulic analysis, the Design HFL has been calculated corresponding to the Design Discharge by Manning's Equation at the bridge site, as described above.

1.4.1.3 Afflux Calculation

When the waterway area of the opening of a bridge is less than the unobstructed natural waterway area of the stream, i.e. when bridge contracts the stream, afflux occurs. The afflux will be calculated using Molesworth's formula as given below: -

$$h = \left(\frac{V2}{17.88} + 0.01524 \right) \{(A/a)2 - 1\}$$

Where, h = Afflux in meters;

V = Average velocity of water in the river prior to construction in m/sec;

A = Unobstructed sectional area of the river at proposed site in sq m; and

a = Constricted area of the river at the bridge in sq m.

1.4.1.4 Scour Depth Calculation

To provide an adequate margin of safety for design of foundation, a further increase by 30% has been made over the design discharge as per IRC: 78-2000, thus obtaining the final design discharge for the design of foundation.

By IRC: 5-1998 / IRC: 78-2000

As per IRC: 5-1998 or IRC: 78-2000, the mean depth of scour below the highest flood level, Dsm, will be given by the following equation:

Dsm = 1.34 x (Db2 / Ksf) 1/3

Where, Db = the discharge in cumecs per meter width and Ksf = Silt Factor.

The value of 'Db' shall be the total design discharge divided by the effective linear waterway between abutments.

For most of the bridges, the silt factor, Ksf, has been calculated as per guidelines given in IRC-78: 2000 (Clause 703.2) otherwise it has been assumed as 1.5 due to absence of soil distribution curve.

1.4.1.5 Maximum Depth of Scour for Design of Foundation

The maximum depth of scour below the Highest Flood Level (HFL) for the design of piers (dsmp) and abutments (dsma), having individual foundations without any floor protection are as follows:

In the vicinity of pier:	dsmp = 2 x Dsm
In the vicinity of abutment:	dsma = 1.27 x Dsm

For the design of floor protection works for rafts or open foundations, the following values of maximum scour depth may be adopted:

In a straight reach:	1.27 x Dsm
In a bend:	1.50 x Dsm

For the RCC Box type structures proper scour protection is given in the form of floor apron and flexible apron both on the up-stream and downstream sides. No scour will be allowed to occur in the RCC Box type structures.

1.4.1.6 Additional Balancing Culvert on Main Carriage Way

Additional balancing culvert on Main Carriage Way has been provided if it is required for planning of adequate drainage system. Also additional culvert of 1.2m diameter HP (NP-4) for field channel (farm) shall be provided at bypasses to allow the water to pass from one side to other side, if the lands on both side of the road belong to the same owner.

1.4.1.7 Pipe Culvert

The existing pipe culverts that are hydraulically adequate and functional will be widened to full formation width. Pipe culverts having less than 0.90 m dia pipe will be replaced. Based on proposed finish levels if pipe culverts do not have adequate cushion, they shall be encased all round in M15 grade cement concrete with 200 mm thick slab and in M20 grade cement concrete over top of the pipe.

1.4.1.8 Various Codes and Publication to be adopted

The bridges shall be designed as per various IRC codes and special publications wherever required. For conditional cases, if IRC code does not specify anything then relevant BIS code will be followed. The following IRC codes shall be adopted for bridge design.

IRC: 5-1998	General features of design
IRC: 6-2014	Loads and Stresses
IRC: 18-2000	Design criteria for PSC Road Bridges
IRC: 21-2000	Cement concrete plain and reinforced
IRC: 22-2008	Composite Construction
IRC: 40-2002	Brick, stone and block masonry
IRC: 45-2015	Design of well foundation of bridges
IRC: 54-2000	Lateral and Vertical clearances at underpasses
IRC: 78-2000	Foundation and substructure
IRC: 83-1999	(Part I) Metallic Bearings
IRC: 83-1987	(Part II) Elastomeric Bearings
IRC: 83-2002	(Part III) POT PTFE Bearings
IRC: 89-1997	Guidelines for river training and control works
IRC: SP: 13:2004	Guidelines for the design of small bridges and culverts
IS 2911-2010	code of practice for design and construction of pile foundations

1.4.1.9 Design Live Load

The two-lane with paved shoulder carriageway shall be designed with loading combination of Class A, Class 2A, Class 3A and 70R two-lane load or IRC 70 R single lane whichever produces severe effects.

1.4.1.10 Vertical Load

The various components of bridge will be designed for self weight of structure as well as live load with buoyancy effect through pore pressure as well as uplift at base of foundation with appropriate factors depending upon the founding strata.

1.4.1.11 Longitudinal Forces

The bridge will be designed for longitudinal forces on account of tractive and braking action, wind force, seismic force as well as forces due to longitudinal movement of superstructure generated due to creep, shrinkage or temperature. All longitudinal forces will be considered as stipulated in various IRC codes.

1.4.1.12 Seismic Zone

The project road is located in a seismic zone V. It is proposed to design the bridges for seismic forces as mentioned in modified clause 222 of IRC: 6-2000.

1.4.1.13 Condition of Exposure

Since the project road is away from marine environment, a moderate condition of exposure will be adopted.

1.4.1.14 Grade of Concrete

The following minimum grade of concrete will be adopted for major and minor bridges as well as ROB, Flyover and Underpass.

Sr. No.	Type of Concreting	Major Bridge/	Minor Bridge and Culverts
1	Plain Cement Concrete (PCC)	M-20	M-20
2	Reinforced Cement Concrete (RCC)	M-35	M-30/M-35

1.5 Miscellaneous

1.5.1 Road Signs

Road signs are proposed to be placed according to IRC: 67:2012. The signs are to be placed on embankment such that extreme edge of sign would be 2.0m away from the edge of the carriageway. The location of each sign is to be decided in accordance with the guidelines therein.
The sheeting shall be provided of Super High Intensity Micro Prismatic sheets Type IX as per ASTM D 4956 for all types of road sign boards as well as Over Head Signs.

1.5.2 Road Markings

Road markings will be made for centre and edge lines using reflective thermoplastic paints. Appropriate road markings will also be provided at junctions and crossings.

1.5.3 Traffic Barriers

Traffic barriers are protective devices that are placed between traffic and a potential hazard off the roadway, with the intention of reducing the severity of a collision when an errant vehicle leaves the travelled portion of the roadway. Barriers are to be provided at high embankments, sharp curves and bridge approaches. The barrier is to be located in unpaved shoulders.

1.5.4 River Training work

River training works will be provided in accordance with IRC 89-1997 and designed as per forces and loads stipulated for respective components as per the site specific requirements.

2.0 PAVEMENT DESIGN

2.1 General

2.1.1 Objectives

The main objective of this Project is preparation of Detailed Project Report for the improvement of the given set of roads in Manipur, based on the investigations, studies and analysis.

The studies are to be carried out with a view to upgrade the road geometrics and to improve the pavement structure. However, only minor re-alignments to improve the road geometry are envisaged. In general the existing single-lane road pavements are to be widened Intermediate pavement. The road stretches which need further widening based on the traffic requirement are to be identified. On the stretches where the traffic during the design period exceed the capacity of two-lane carriageway.

There are road stretches with inadequate height of road formation with reference to the high flood level or level of adjoining irrigated fields or general ground level or water table. These stretches are likely to be submerged under water during monsoon or be subjected to water-logging conditions resulting in extensive damages to the road structure, year after year. Also there are number of locations where the streams cross the road at low level causeways, limiting the un-interrupted traffic movement along these roads. Thus there is a need to identify the stretches where

The formation is to be re-constructed due to minor re-alignment to improve the road geometry.

The formation height is to be raised to prevent the problem of submergence or water-logging or over flowing of water from the crossing streams.

On the re-aligned stretches of the road and the stretches where the formation is to be raised, there will be need to construct new pavement, starting from the subgrade level.
While considering various design alternatives and specifications for pavement layers and materials, it is very important to make full use of experience in this country. Therefore the accepted methods of investigations, design and specifications as given in the Guidelines of the Indian Roads Congress (IRC) and the MOST Specifications for Roads and Bridges have been generally followed during the investigation and design of pavements.

2.1.2 Scope

Basically the "Pavement Design" chapter of this report deals with two categories of design work:
Design of Flexible Pavement Overlays, to strengthen existing stretches of flexible pavement
Design of new flexible pavement, for construction of new pavement and for widening of existing pavement including construction of paved shoulders.

Apart from the above, a typical design for the CC pavement is also presented so that if required, this may be considered as a possible option at least at some problematic stretches.

2.2 Analysis Of Data For Pavement Design

2.2.1 General

The pavement condition survey data are made use of to identify the stretches, which need different types of pavement improvement measures mentioned above. The analysis of traffic study data are made use of to work out the initial volume of classified traffic and their growth during the design life. The analysis of Axle load studies are needed to work out the values of Vehicle Damage Factor (VDF) of different categories of commercial / heavy vehicles on different corridors and the values of Cumulative Standard Axle Load (CSA) for design of pavements. The spectrum of wheel loads also are made use of for the design of CC pavements. The results of Benkelman Beam Deflection (BBD) studies and the analysis are needed for the structural evaluation of flexible pavements which need strengthening and for the design of overlays. The analysis of soil test results and the soaked CBR values are made use for the design of new flexible pavements including pavement widening.

2.2.2 Pavement Condition Study Data

Preliminary pavement condition survey was carried out on the entire length of Morvan-jawad road, before starting the actual deflection studies using Benkelman beam. The stretches of the existing road pavement were subdivided into sub-stretches based on the type and extent of cracking, rutting and other pavement distress as per the IRC Guidelines, IRC : 81 - 1997. The sub-stretches with uniform pavement condition which could be strengthened by suitable overlays were identified in order to carry out Benkelman beam rebound deflection studies.

Based on the analysis of pavement condition studies, the road corridors and the different sections there-of have been sub-divided into set of sub- stretches with fairly uniform characteristics. These have been re-grouped into the following four categories for the purpose of proposing the different types of pavement improvement programmers.

Sub-stretches for strengthening of the existing pavement by suitable Overlays

Sub-stretches for widening of carriageway including shoulders, using pavement layers as per "Design of New Pavements"

Sub-stretches for the construction of new pavement layers starting from the subgrade, as per "Design of New Pavements" on the stretches needing

"Reconstruction" and newly constructed formation, due to raising or re-alignment.

2.2.3 Classified Traffic Volume Data

2.2.3.1 Vehicle Classes Considered for Pavement Design

The consolidated values Classified Traffic Volume Studies and the analysis of data are presented in Chapter 4 of main report and the relevant annexure. The following vehicle classes have been considered and suitably re-grouped for the determination of CSA values and design of pavements :

Heavy Commercial vehicles consisting of heavy trucks with two axles
Heavy Commercial vehicles consisting of heavy trucks with rigid body and tandem axles
Heavy Commercial Vehicles, such as tractor-trailer units with Multiple Axles and agricultural tractors with trailers and other heavy vehicles , Buses , Light Commercial Vehicles of gross weight exceeding 3 t and mini-buses.
The average volume of the above groups of vehicles on different sections of each corridor as on the year 2014 were made use of for determining the initial traffic by the year 2017, when the pavement improvement works of the project roads are expected to be completed.

2.2.3.2 Traffic Growth Rate

The mean growth rate of the above groups of vehicle classes for the Manipur as a whole have been worked out and presented in Chapter 4, "Traffic Survey Analysis and Forecast". It was observed that the traffic growth rates were different for the periods
As already mentioned, it was decided to consider the initial traffic as on the year 2017 for pavement design. The fifteen year design period considered for design of flexible pavement overlays and for the design of new flexible pavement is :
20 years life, for the period 2020 to 2040
Therefore the weighted average growth rates were worked out for the above five vehicle groups in order to work out the CSA values of each vehicle class during the respective design periods.

2.2.5 Design C.S.A. Values

The CSA values were calculated using the relationship given below :
Ns = [365 A D F{ (1 + r)x - 1 }/r] ¸ msa

Design CSA on the design - lane = Tf. Ns, msa
Where,
Ns = Cumulative Standard Axles (CSA) on the road section during the design period (2014to 2029), msa
A = the initial traffic (number of the particular vehicle class per day) on the road section under consideration by the year 2009
r = the rate of growth of the vehicle class during the design life of 15 years
x = design life, years (15 years)
F = Vehicle Damage Factor (VDF) determined from axle load studies on the respective corridor
D = Lane Distribution Factor
Tf = Traffic Distribution Factor on the design lane
= 0.75 for intermediate-lane, two-way traffic road

Axle Load Survey has been carried out in order to estimate vehicle damage factor (VDF) for using in design of overlay on existing pavement and new pavement design for additional lanes

2.3.2 Calculation of VDF

The vehicle damage factor is a multiplier for converting the number of commercial vehicles of different axle loads to the number of standard axle load repetitions. Design of new pavement for additional lane or strengthening of existing pavement is based upon the cumulative number of 8.17 tonne equivalent standard axles (ESA) that will pass over during the 15 year design period. The classes of traffic which lead to significant axle loads (or damage) to the pavement and accordingly considered for design are: LCVs, two / three axle and multi axle trucks. Cumulative standard axles (CSA) are calculated in accordance with the guidelines provided in IRC: 37 – 2019 and IRC: 81 - 1997. The overloaded vehicles have serious adverse impact on performance of pavement. It has been ascertained that the damaging effect of axles on flexible pavement is approximately proportional to the fourth power of the axle load.

Equivalency factors as recommended by IRC have been used to convert the axle load spectrum into an equivalent number of standard axles. The computations of VDF for each type of vehicle in each direction are given in tabular forms in Annexure of this report.

Equivalency factors as recommended by IRC have been used to convert the axle load spectrum into an equivalent number of standard axles. The equivalency factors are derived for each axle load category from the fourth power rule. The product of frequency of axles for each axle load category and corresponding equivalency factors gives the ESA for corresponding axle load category. The VDF is calculated by dividing the total number of ESA by the number of vehicles weighed.

2.3.3 Computation of design traffic

The design traffic is considered in terms of the CSA to be carried during the design life on the road. MSA for new pavement design is worked out considering that the construction of the project road would be completed by the year 2016 and traffic will start using the facility from the year 2017 onwards. The MSA for overlay design is worked out considering the present traffic on existing pavement and projected traffic based on growth rates. Its computation involves the initial volume of commercial vehicles per day, lateral distribution of traffic, the growth rate, the design life in years and the vehicle damage factor (number of standard axle per commercial vehicle) to convert commercial vehicles to standard axles.

The following equation has been used to calculate the cumulative number of standard axles in accordance with IRC: 81 – 1997 and IRC: 37 – 2012.

$$N_s = \frac{365 \times A\left[(1+r)^x - 1\right]F}{r}$$ ………………………………………..Eqn. 5.1

Where

Ns = the cumulative number of standard axles to be catered for in the design.

A = Initial traffic, in the year of completion of construction, in terms of the number of commercial vehicles per day duly modified to account for lane distribution.

r = Annual growth rate of commercial vehicles, %

x = Design life in years

F = Vehicle Damage Factor (number of standard axles per commercial vehicle)

The Million Standard Axles (MSA) for the base year 2016 and horizon year for commercial traffic has been estimated using VDF values derived from axle load survey for LCV, 3 and multi axle trucks.

1.6 PAVEMENT DESIGN OF PROJECT ROAD

To comprehensively appreciate the traffic and travel characteristics on the project corridor from Tamenglong-Haflong Via Tousem & Lisang. The type of surveys, locations and duration, as identified at the inception stage of the study have been followed during data collection exercise with minor modifications on account of the project corridor.

The traffic characteristics on the project road for the base year are essential for formulating improvement programs. The objectives of the traffic study are:

- Traffic estimation in terms of volume on various sections.
- Growth factor estimation for traffic forecasting.
- Capacity assessment based on traffic forecasting for next 30 years.
- Pavement and intersection design

1.7 Average Annual Daily Traffic and it Composition

The Average Annual Daily Traffic (AADT) obtained from the volume count surveys for all the locations are given in **Table no. 1.4.** To study the variation in the intensity of traffic, consultants have analyzed the variation of traffic along the project road. The following observations are made from the analysis for each location along the project stretch.

Table 1.4: Annual Average Daily Traffic (AADT)

Categories	PCU Factor	Km. 0+300 at Tamenglong town Location-1		Km. 136+650 Near Mahur town Location-2		Average of all locations	
		Vehicles	PCUs	Vehicles	PCUs	Vehicles	PCUs
Car/Jeep/Van	1.0	109	109	634	634	372	372
3 Wheeler	1.0	127	127	710	710	419	419
Mini Bus	1.5	7	11	13	20	10	15

Standard Bus	3.0	5	15	13	39	9	27
LCV / Tempo	1.5	43	64	124	186	84	126
2-Axle	3.0	42	126	35	105	39	117
3-Axle	3.0	0	0	11	33	6	18
MAV (4-6)	4.5	0	0	0	0	0	0
Two Wheeler	0.5	109	54	682	341	396	198
Animal Cart	6.0	0	0	0	0	0	0
Cycle	0.5	46	23	138	69	92	46
Tractor with trolly	4.5	0	0	0	0	0	0
Tractor	1.5	0	0	0	0	0	0
Hand Cart	6.0	0	0	0	0	0	0
EME/HCV	4.5	2	9	6	27	4	18
Total Traffic		490	538	2366	2164	1431	1356

Traffic growth rate during the design life in percentage

As per IRC SP 48:1998 Hill road Manual 7.5 per cent growth rate is considered for hill road.

Hence traffic growth rate is adopted 7.5% for projection of present traffic.

Vehicle Damage Factor

Summary of VDF

LOCATION	DIRECTION	LCV	Bus	2 AXLE	3 AXLE
KM - 136+650	**Mahur- Lisang**	0.001	0.157	1.207	3.531
	Lisang- Mahur	0.009	0.337	2.696	8.848
	Adopted VDF	**0.009**	**0.337**	**2.696**	**8.848**

Cumulative Mean Standard Axles (CMSA)

Summary of CMSA		
Year	**Pkg-1**	**Design year**
2017 to 2021	Project Clearance & Construction Period	
2022	**0.23**	1
2023	**0.49**	2
2024	**0.76**	3
2025	**1.05**	4
2026	**1.36**	5
2027	**1.70**	6

2028	**2.06**	7
2029	**2.45**	8
2030	**2.87**	9
2031	**3.32**	10
2032	**3.80**	**11**
2033	**4.32**	12
2034	**4.88**	13
2035	**5.48**	14
2036	**6.13**	15
2037	**6.82**	16
2038	**7.57**	17
2039	**8.37**	18
2040	**9.23**	19
2041	**10.16**	20

Adopted MSA is 20 as per IRC SP 73:2018

For Details of Traffic Surveys and Analysis Please refer Chapter-5

1.4. PAVEMENT DESIGN

As per plate No.-44 of IRC-37:2018 the Pavement Design is:-

Design crust thickness for the flexible pavement for 20 years as arrived is given below in **table 1.5**

Table 1.5

Homogenous Section (Km)			**CBR (%)**	**MSA**	**Adopted Pavement Composition (mm)**			
From	**To**	**Length (in Km)**		**Adopted**	**BC**	**DBM**	**WWM**	**CTSB**
156+489	176+581	20.092	8	20	30	50	150	200

As Per test results the average CBR Varies from 9-36%. So, the value of adopted CBR is 8%.

DESIGN OF CULVERTS

Design note
for
RCC BOX OF SIZE 1 x 2 x 2

	Project		Designed by:	KB
	Client		Checked by:	
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	

Index

1.0 Design Report

The following report represents the design note of RCC BOX of clear span 1 x 2 x 2

1.1 Introduction:-

Design is presented consistently in SI units; the following apply unless mentioned specifically otherwise:

Length	m
Force	kN
Stress	MPa
Bearing Pressure	kN/m2
Hog Mom/Com Str	-ve
Sag Mom/Ten Str	+ve

1.2 Reference documents :-

1 IRC codes /guidelines/special publications
2 MORTH specification
3 Specialised literature as relevant

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

1 Structure is designed for per metre width.
2 On top slab 75 mm thick wearing coat is considerd for SIDL.
3 Deck width taken 12 m
4 Carriageway width- 11 m
5 Modulus of subgrade reaction (Assumed) - 2500 KN/m3
6 Shear value is taken at dist. 0.15m from the face of the slab.
7 In case of load dispersion wearing coat thickness, fill thickness and top slab thickness is considered wherever applicable.
8 In case of design sheet under summary of moments, only magnitude of force has been considered.
9 In case of earth pressure and LL surcharge governing case out of Normal earth pressure, Fluid pressure and Normal earth pressure + hydrostatic fluid pressure is taken.
10 Structure is designed for standard earth pressure without weep holes.

1.4 Loads:-

The different types of loads used as per IRC 6 : 2014 are.

1 Dead load.
2 In SIDL fill, crash barrier, and wearing coat load is considered.
3 Normal Earth pressure with hydrostatic pressure.
4 Live load -70R Track, 40 T Boggie, 70R Wheel load in case of top slab.
5 Live load surcharge.
6 Braking load is taken as 20% of the live load on top slab.
7 1.25 of Impact factor is considered.
8 Temperature loading for uniform rise and temperature gradient is considered.
9 The Earth pressure coefficient at rest 0.5 is considered.

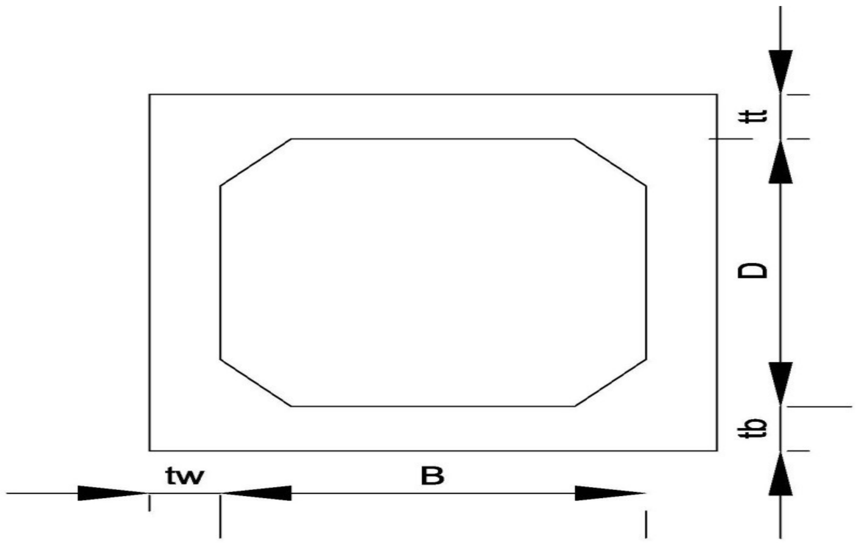
1.5 Load combinations

Load combinations as per IRC 6: 2014 have been considered in staad load combination.

1.6 Material properties

1 Grade of Concrete M30
2 Grade of Steel Fe 500.

BOX (1 Cell 2m wide x 2m height)



2.1 Dimensions of Box

No. of Cell	=	1	Clear Width of cell	=	2.00 m
Top Slab Thick. (tt)	=	0.300 m	Clear Height of Cell	=	2.00 m
Bot. Slab Thick. (tb)	=	0.325 m	C/C Width of structure	=	2.300 m
Side Wall Thick. (tw)	=	0.300 m	C/C Height of structure	=	2.313 m
Int. wall Thickness (ti)	=	0.000 m	Total length of Structure at top =		2.600 m
Total Deck width	=	12.00 m	Total length of Structure at bottom =		2.600 m
Carrriageway Width	=	11.00 m	Total Height of Structure	=	2.63 m
water above bott. Slab	=	1.375 m	Footpath Dimensions	=	0.00 m
			Crash barrier width	=	0.50 m
Wearing coat for SIDL	=	75mm		Height of fill =	0.00 m
Haunch size	=	150mm	x150mm		

SIDL (Top Slab)

Crash barrier	=		10	kN/m^2
Due to earth fill	=	0 x20 =	0	kN/m^2
			10	kN/m^2
Due to wearing coat	=	0.075 x 22 =	1.65	kN/m^2

2.2 Basic Parameters

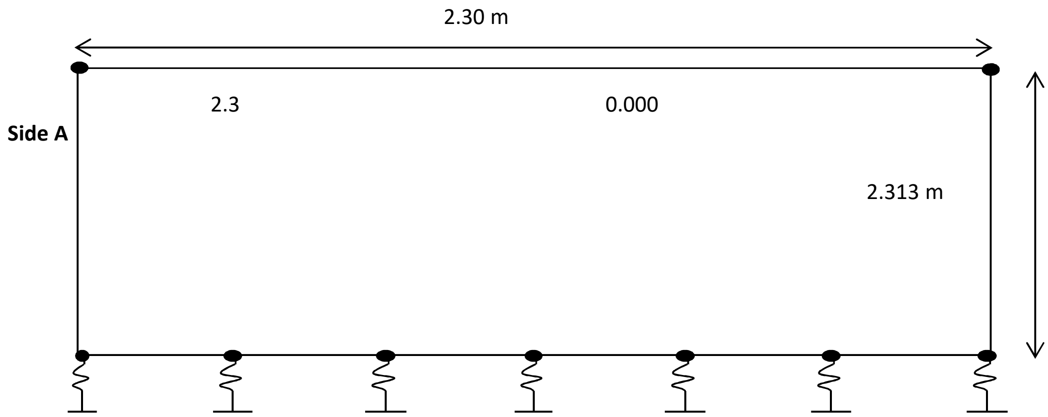
Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpres:	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge	=	1.2	m

Safe Bearing Pressure = 100 kN/m^2

Fluid Pressure as per cl. 214.1 of IRC 6 2010 4.71 kN/m^2

2.3 <u>Idealised Structure for Staad Analysis</u>

(Analysis is done for 1m Strip)



Nos. of beam for one span at bottom	=	10
Spacing between Springs	=	0.230 m
Modulus of Subgrade Reactiom (Assumed)	=	2500 kN/m^3
Spring Constant at End Support	=	288 kN/m
Spring Constant at intermediate Support	=	575 kN/m

3.1 <u>Earth Pressure and Live Load Calculation</u>

1) a Earth Pressure (Normal Condition)

Earth Pressure	Height
0.84 kN/m^2	0.150 m
13.74 kN/m^2	2.463 m

1) b Fluid Pressure

Fluid Pressure	Height
0.71 kN/m^2	0.150 m
11.60 kN/m^2	2.463 m

1) c Earth Pressure (Normal Condition+Full hydrostatic pressure)

Earth Pressure	Height
1.92	0.15
31.50	2.463 m

1) d Earth Pressure at rest K_0 = (1-sinf) = 0.5

LWL **Earth Pressure**	HFL **Earth Pressure**	**Height**
1.50	2.25	0.150 m
24.63	36.94	2.463 m

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

2) b Live Load Surcharge (Fluid Pressure) as per cl. 214.1 of IRC 6 2014

Live Load Surcharge = 5.651 kN/m

2) c Live Load Surcharge (Normal Condition+Full hydrostatic pressure)

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

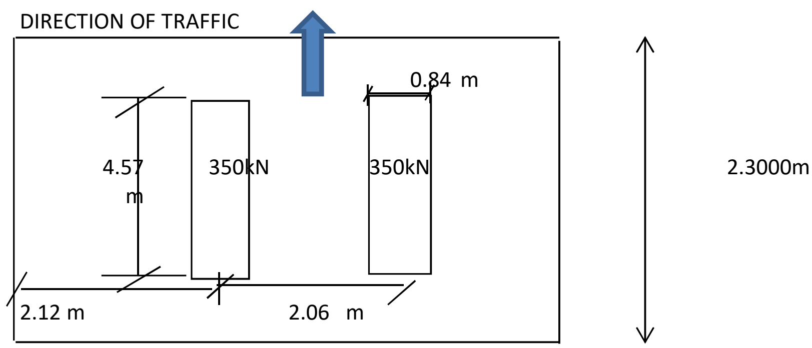
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 13.75 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



Total Load	=	**700kN**	4.57	2.3000m
		153.17 KN/m		
		352.3 KN		

<u>Effective width of Loading</u>

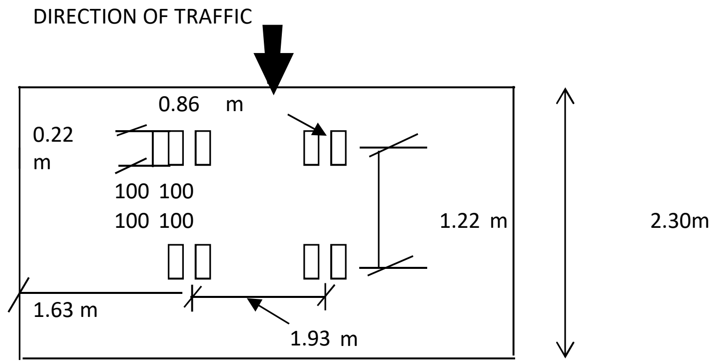
a	=	1.15	m
b1	=	0.99	m
b/lo	=	5.22	
a	=	2.60	
beff	=	2.49	m

2.06<2.49 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	4.55	m
Width along span	=	2.3	m
Load Intensity	=	33.66	kN/m^2
Increase due to impact	=	42.08	kN/m^2
	Say	**42.10**	kN/m^2

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

B) 40T Boggie Load at Mid Span



Total Load = 400kN

Effective width of Loading

a	=	1.15 m
b1	=	1.01 m
b/lo	=	5.22
a	=	2.60
beff	=	2.51 m

1.93<2.51 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	4.44 m
Width along span	=	2.19 m
Load Intensity	=	41.14 kN/m^2
Increase due to impact	=	51.43 kN/m^2
	Say	**51.50** kN/m^2

C) 40T Boggie Load at Support

Effective width of Loading

a	=	0.61 m
b1	=	1.01 m
b/lo	=	5.22
a	=	2.60
beff	=	2.18 m

1.93<2.18 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	4.11 m
Width along span	=	1.815 m
Load Intensity	=	53.62 kN/m^2
Increase due to impact	=	67.03 kN/m^2
	Say	**67.10** kN/m^2

D) 70R Track at Support

Effective width of Loading

a	=	1.15 m
b1	=	0.99 m
b/lo	=	5.22
a	=	2.60
beff	=	2.49 m

2.06<2.49 ***Therefore overlapping due to load dispersion occurs***

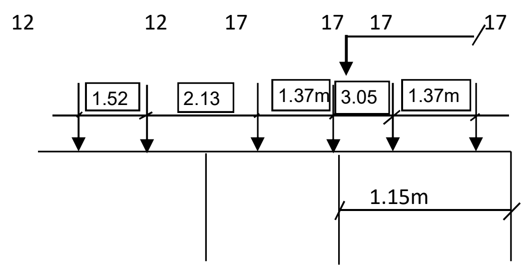
Effective width	=	4.55 m
Width along span	=	2.300 m
Load Intensity	=	33.66 kN/m^2

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Increase due to impact = 42.08 kN/m^2

Say **42.10** kN/m^2

F) 70R Wheel Case 1

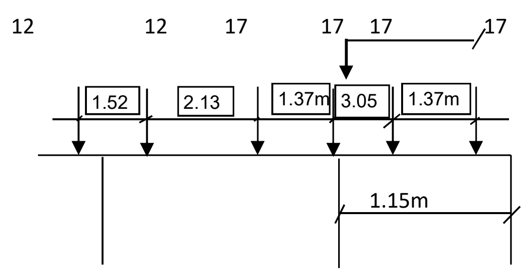


0.86m 1.93m 0.86m

Width along span = 0.970m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.49m	2.60	2.01m	Yes	3.94m	43.7 kN/sqm	55 kN/sqm
2	166.77	0.45m	2.60	1.94m	Yes	3.87m	44.4 kN/sqm	55 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm

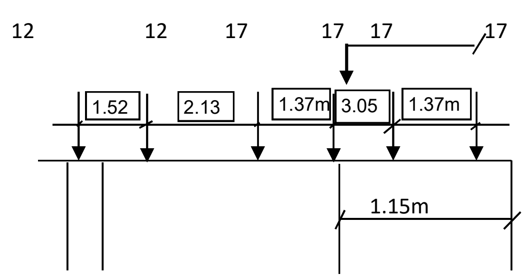
F) 70R Wheel Case 2



Width along span = 0.970m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.485	2.60	2.01m	Yes	3.94m	43.7 kN/sqm	55 kN/sqm
2	166.77	0.445	2.60	1.94m	Yes	3.87m	44.4 kN/sqm	55 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm

G) 70R Wheel Case 3



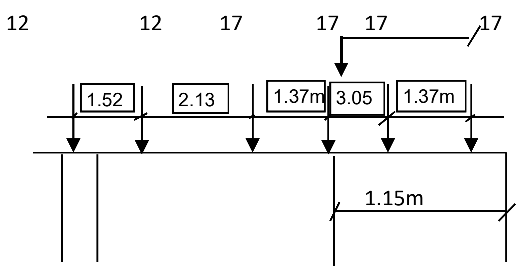
Width along span = 0.970m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.485	2.60	2.01m	Yes	3.94m	43.7 kN/sqm	55 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0.0 kN/sqm	0 kN/sqm

H) 70R Wheel Case 4



Width along span = 0.970m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.000	2.60	1.01m	No	1.01m	85.1 kN/sqm	106 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0.0 kN/sqm	0 kN/sqm

G) Braking load		20%	Av. Eff. Width	Load per meter
Load on the span 70R Wheel	334 kN	67 kN	3.90m	17 kN/m
Load on the span 70R Track	352 kN	70 kN	4.55m	15 kN/m
Max. force				**17 kN/m**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

3.2 Temperature load calculation

Effective Bridge Temperature

Maximum Air Shade temperature	=	47.9	/oC (as per Annexure F of IRC:6-2014)
Minimum Air Shade temperature	=	0.2	/^{o}C (as per Annexure F of IRC:6-2014)
Mean of max and min temperature	=	23.85	/^{o}C (as per clause 215.2 of IRC:6-2014)
Bridge temperature to be assumed	=	33.85	
TEMPERATURE RISE		**33.85**	
TEMPERATURE FALL		**-34.05**	

Effect of temperature gradient

The box has been checked for temperature differential.

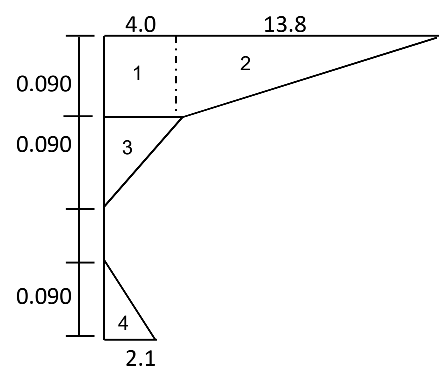
F = E_c aDt A

E_c = Modulus of Elasticity of Concrete	=	3.21E+06	t/m^2
a = Coefficient of Thermal expansion	=	1.20E-05	/^{o}C (as per IRC:6)

Dt = Temperature differential
A = X sectional Area of section where temperature differential is Dt

Average thickness of Deck slab = 300 mm

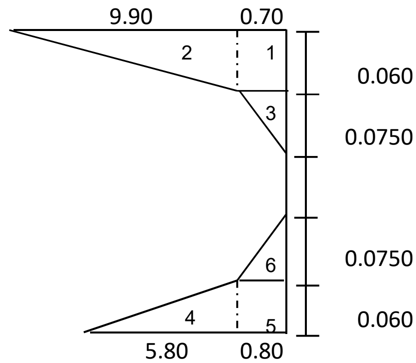
EFFECT OF TEMPERATURE RISE



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	4.0	1.0	0.090	0.090	13.88	0.045 m from top	0.105
2	13.8 / 2	1.0	0.100	0.100	26.60	0.033 m from top	0.117
3	4.0 / 2	1.0	0.090	0.090	6.94	0.120 m from top	0.030
4	2.1 / 2	1.0	0.090	0.090	3.64	0.030m from bottom	-0.120
				SF =	51.07	M =	4.332

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

EFFECT OF TEMPERATURE FALL



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	0.70	1.0	0.060	0.060	1.62	0.03 m from top	0.120
2	9.90 / 2	1.0	0.060	0.060	11.45	0.020 m from top	0.130
3	0.70 / 2	1.0	0.0750	0.0750	1.01	0.085 m from top	0.065
4	5.80 / 2	1.0	0.060	0.060	6.71	0.020 m from bottom	-0.130
5	0.80	1.0	0.060	0.060	1.85	0.030 m from bottom	-0.120
6	0.80 / 2	1.0	0.0750	0.0750	1.16	0.085 m from bottom	-0.065
				SF =	23.80	M =	0.579

	Project	0
	Client	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2

3.3 Summary of factored moments

Grade of Concrete = M30

Grade of Steel = Fe500

Summary of factored moments

	Top slab			Bottom slab			Outer wall			
Load Case	Moment in Mid-Span	Moment at End Suppor	Top slab shear at	Moment in Mid-Span	Moment at End Suppor	Bottom slab shear	Min. Axial force	Moment at top	Moment at bottom	Wall shear at deff
	kN-m	kN-m	kN	kN-m	kN-m	kN	KN	kN-m	kN-m	kN
Basic Combination (33 - 62)	48.3	57	30	-	-	-	17	55	80	93
Rare Combination (63 -122)	33	42	206	43	65		14	39	62	70
Frequent Combinatio (123 - 182)	-	-	-	-	-	-	-	-	-	-
Quasi Static (183 - 186)	10	15		6	15			14	13	
Combination 1	-	-	-	65	86	123	-	-	-	-
Combination 2	-	-	-	58	80	122	-	-	-	-
	-	-	-	58	80	122	-	-	-	-

4.0 Partial Safety Factors

Material Parameters

Concrete **Refer Table 6.5, IRC:112-2011**

Grade		=	**M30**	
Cube strength of concrete at 28 days	f_{ck}	=	30	MPa
Design value of concrete compressive strength	f_{cd}	=	$\alpha f_{ck} / \gamma_m$	
Refer cl. 6.4.2.8 of IRC:112-2011			a =	0.67
	f_{ctm}	=	2.5	MPa
For Basic Combination	f_{cd}	=	13.40	MPa
For Accidental Combination	f_{cd}	=	16.75	MPa
For Seismic Combination	f_{cd}	=	13.40	MPa
Modulus of Elasticity	E_c	=	31000	MPa
Mean value of axial tensile strength of concrete	f_{ctm}	=	2.5	MPa
Density		=	2.50	t/m^3
Grade		=	Fe500	
Characteristics yield strength	f_{yk}	=	500	MPa
Design yield strength	f_{yd}	=	f_{yk} / γ_m	
For Basic Combination	f_{yd}	=	434.78	MPa
For Accidental Combination	f_{yd}	=	500	MPa
For Seismic Combination	f_{yd}	=	434.78	MPa
Modulus of Elasticity	E_s	=	2.0E+05	MPa
Density		=	7.85	t/m^3

Partial Safety Factor for Materials

Material	Partial Safety Factor g_m			
	Basic Combination	Accidental Combination	Seismic Combination	
Concrete	1.5	1.2	1.5	Cl 6.4.2.8, IRC:112-2011
Steel	1.15	1	1.15	Cl 6.2.2, IRC:112-2011

Partial Safety Factor for Loads

Ultimate Limit State

Partial Safety for Verification of Structural Strength **Table 3.1, Annex B, IRC:6-2014**

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
(1)	(2)	(3)	(4)	(5)	(4)	(3)
	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect
Permanent Loads:	1.05	0.95	1.00	1.00	1.05	0.95
Dead Load, SIDL except surfacing, Backfill Weight, Settlement, Creep and shrinkage effect						
Surfacing	1.35	1.00	1.00	1.00	1.35	1.00
Earth Pressure due to Backfill	1.50	0.00	1.00	0.00	1.00	0.00
Variable Loads:						
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:						
a) Leading Load	1.50	0.00	0.75	0.00	0.00	0.00
b) Accompanying Load	1.15	0.00	0.20	0.00	0.20	0.00
c) Construction Live Load	1.35	0.00	1.00	0.00	1.00	0.00
Thermal Loads						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	0.90	0.00	0.50	0.00	0.50	0.00
Wind						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	0.90	0.00	0.00	0.00	0.00	0.00
Live Load Surcharge (as accompanying load)	1.20	0.00	0.00	0.00	0.00	0.00
Accidental Effects:						
i) Vehicle Collision ii) Barge Impact iii) Impact due to floating bodies	0.00	0.00	1.00	0.00	0.00	0.00
Seismic Effect						
a) During Service	0.00	0.00	0.00	0.00	1.50	0.00
b) During Construction	0.00	0.00	0.00	0.00	0.75	0.00
Construction Condition:						
Counter Weights:						
a) When density or self weight is well defined	0.00	0.90	0.00	1.00	0.00	1.00
b) When density or self weight is not well defined	0.00	0.80	0.00	1.00	0.00	1.00
c) Erection effects	1.05	0.95	0.00	0.00	0.00	0.00
Wind						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	1.20	0.00	0.00	0.00	0.00	0.00
Hydraulic Loads:						
(Accompanying Load):						
Water Current Forces	1.00	0.00	1.00	0.00	1.00	0.00
Wave Pressure	1.00	0.00	1.00	0.00	1.00	0.00
Hydrodynamic Effect	0.00	0.00	0.00	0.00	1.00	0.00
Buoyancy	1.00	0.00	1.00	0.00	1.00	0.00

Partial Safety for Verification of Structural Strength **Table 3.2, Annex B, IRC:6-2014**
Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
(1)	(2)	(3)	(4)
Permanent Loads:			
Dead Load			
SIDL except surfacing			
a) Adding to the effect of variable loads	1.35	1.00	1.35
b) Relieving the effect of variable loads	1.00	1.00	1.00
Surfacing:			
a) Adding to the effect of variable loads	1.75	1.00	1.75
b) Relieving the effect of variable loads	1.00	1.00	1.00
Backfill Weight	1.50	1.00	1.00
Earth Pressure due to Backfill			
a) Leading Load	1.50	0.00	1.00
b) Accompanying Load	1.00	1.00	1.00
Variable Loads:			
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.50	0.75	0.00
b) Accompanying Load	1.15	0.20	0.20
c) Construction Live Load	1.35	1.00	1.00
Wind during service and construction			
a) Leading Load	1.50	0.00	0.00
b) Accompanying Load	0.90	0.00	0.00
Live Load Surcharge (as accompanying load)	1.20	0.20	0.20
Erection effects	1.00	1.00	1.00
Accidental Effects:			
i) Vehicle Collision			
ii) Barge Impact	0.00	1.00	0.00
iii) Impact due to floating bodies			
Seismic Effect			
a) During Service	0.00	0.00	1.50
b) During Construction	0.00	0.00	0.75
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	1.00
Wave Pressure	1.00	1.00	1.00
Hydrodynamic Effect	0.00	0.00	1.00
Buoyancy	0.15	0.15	0.15

Serviceability Limit State

Partial Safety for Verification of Serviceability Limit State **Table 3.3, Annex B, IRC:6-2014**

Loads	Partial Safety Factor		
	Rare Combination	Frequent Combination	Quasi-permanent
(1)	(2)	(3)	(4)
Permanent Loads:			
Dead Load	1.00	1.00	1.00
SIDL including surfacing	1.00	1.00	1.00
Backfill Weight	1.00	1.00	1.00
Shrinkage and Creep Effects	1.00	1.00	1.00
Earth Pressure due to Backfill	1.00	1.00	1.00
Settlement Effects			
a) Adding to the permanent loads	1.00	1.00	1.00
b) Opposing the permanent loads	0.00	0.00	0.00
Variable Loads:			
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.00	0.75	0.00
b) Accompanying Load	0.75	0.20	0.00
Thermal Loads:			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load			
Wind			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load	0.60	0.50	0.00
Live Load Surcharge (Accompanying load)	0.80	0.00	0.00
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	0.00
Wave Pressure	1.00	1.00	0.00
Buoyancy	0.15	0.15	0.15

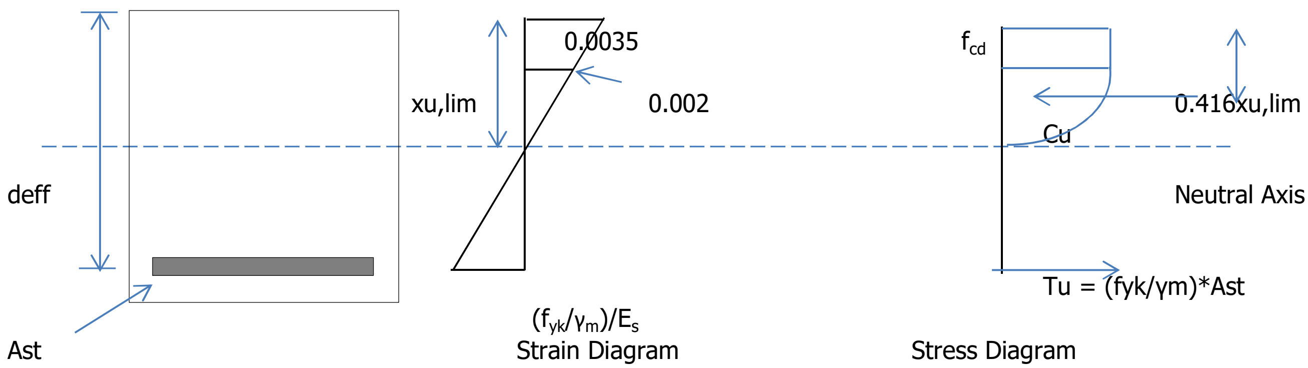
Combination for Base Pressure and Design of Foundation

Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor			
	Combination (1)	Combination (2)	Seismic Combination	Accidental Combination
(1)	(2)	(3)	(4a)	(4b)
Permanent Loads:				
Dead Load, SIDL except surfacing, Backfill earth filling	1.35	1.00	1.35	1.00
SIDL Surfacing	1.75	1.00	1.75	1.00
Settlement Effect	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Earth Pressure due to Backfill				
a) Leading Load	1.50	1.30	0.00	0.00
b) Accompanying Load	1.00	0.85	1.00	1.00
Variable Loads:				
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:				
a) Leading Load	1.50	1.30	(0.75 if applicable) or 0	(0.75 if applicable) or 0
b) Accompanying Load	1.15	1.00	0.20	0.20
Thermal Loads as accompanying load	0.90	0.80	0.50	0.50
Wind				
a) Leading Load	1.50	1.30	0.00	0.00
b) Accompanying Load	0.90	0.80	0.00	0.00
Live Load Surcharge (as accompanying load if applicable)	1.20	1.00	0.20	0.20
Accidental Effects or Seismic Effect:				
a) During Service	0.00	0.00	1.50	1.00
b) During Construction	0.00	0.00	0.75	0.50
Erection effects	1.00	1.00	1.00	1.00
Hydraulic Loads:				
Water Current	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Wave Pressure	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Hydrodynamic Effect	0.00	0.00	1.0 or 0	1.0 or 0
Buoyancy:				
For Base Pressure	1.00	1.00	1.00	1.00
For Structural Design	0.15	0.15	0.15	0.15

5.1.1 Verification of structural strength for top slab



ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	13.40	N/mm^2	For Basic Combination
	f_{cd}	=	16.75	N/mm^2	For Accidental Combination
	f_{cd}	=	13.40	N/mm^2	For Seismic Combination
	E_c	=	31000	MPa	
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	435	N/mm^2	For Basic Combination
	f_{Yd}	=	500	N/mm^2	For Accidental Combination
	f_{Yd}	=	435	N/mm^2	For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

E_c = 31000 MPa

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
xu,$_{lim}$/d	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

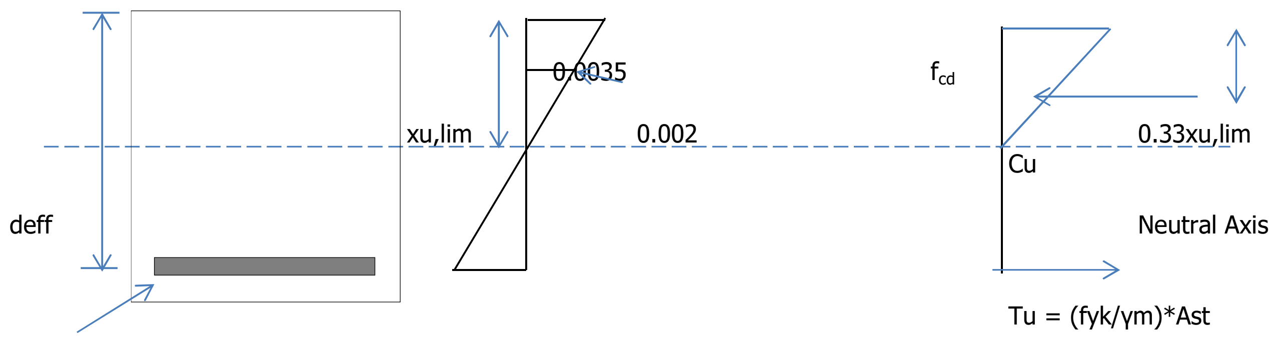
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	57.0			48.3		
b	1000			1000		
D	300			300		
c	50			50		
d	232.0			233.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			4.97		
$M_{u,Lim}$ (KNm)	268			270		
	OK			**OK**		
Ast Req.	590			494		
Dia of bar (main tension) (mm)	12			10		
Spacing (mm)	140			140		
+ dia of bar (main tension) (mm)	12			10		
Spacing (mm)	140			140		
Ast provided (sq mm)	1616			1122		
Dia of bar (main compresion) (mm)	10			12		
Spacing (mm)	140			140		
Area of main compresion (mm^2)	561			808		
f_{ctm}	2.5			2.5		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	347			348		
A_{ct}	235240			255028		
$f_{ct,eff}$	2.9			2.9		
$k_c = 0.4\ \{ 1 - s_c / (k_1\ f_{ct,eff}\ h/h^*) \} <= 1$	0.4			0.4		
For Bending or bending combined with axial force						
k	1.0000			1.0000		
s_s	435			435		
As.max = 0.025 Ac (main tension)	7500			7500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**			**OK**		
As.max = 0.04 Ac (tension + compresion)	12000			12000		
x (mm)	65			45		
x/d	0.279			0.193		
	OK			**OK**		
z (mm)	205			214		
MR (KNm)	144			105		
	OK			**OK**		

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Shear on the section	**Top slab Top End support**		
Actual shear V_{Ed} (KN)	30.0		
Actual shear stress (N/mm2)	0.144		
Max shear capacity, 0.135 fck(1-fck/310)	3.7		
	OK.		
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		
Θ = 0.5 x $\sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.928		
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$n_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.455		
cl. 10.3.1 of IRC :112-2011			
r1 = $A_{sl}/(b_w\ d)$ <= 0.02	0.007		
	OK		
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.586		
Axial compressive force N_{Ed} (KN)	0		
$s_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (KN)	105		
	OK.		
Min shear stress	0.455		
Min shear force for providing reinf., V_E (N)	94945.5		
No. of link for shear reinf.	4		
Dia. of bar for shear reinf.	12		
S = Asw x 0.9 x d x cot Θ x fy / V_E	1081		
A_{SW}	452		
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011			
$S_{l.max}$ = 0.75 d	174		
Spacing provided in Long. Direction (mm)	**174.0**		
cl. 16.5.2(9) Eq. 16.8 of IRC :112-2011			
$S_{t.max}$ = 0.75 d <= 600mm	174		
Spacing provided in Trans. Direction, $S_{t.}$ mm	**150**		
	OK		

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

5.1.2 Verification for serviceability limit state for top slab



$(f_{yk}/\gamma_m)/E_s$

Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	For Rare Combination
	f_{cd}	=	14.40	N/mm^2	For Frequent Combination
	f_{cd}	=	10.80	N/mm^2	For Quasi-Perma. Combination
As per clause 12.2.2, IRC:112-2011					
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	300	N/mm^2	For Rare Combination
	f_{Yd}	=	300	N/mm^2	For Frequent Combination
	f_{Yd}	=	300	N/mm^2	For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011
For steel reinforcement, simplified bilinear diagram is used
Minimum strain in steel reinforcement = 0.87 fy / Es
Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu
= 0.5 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.33 xu
Tu = fyd*Ast

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section d	=	300	mm
Clear cover	=	40	

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

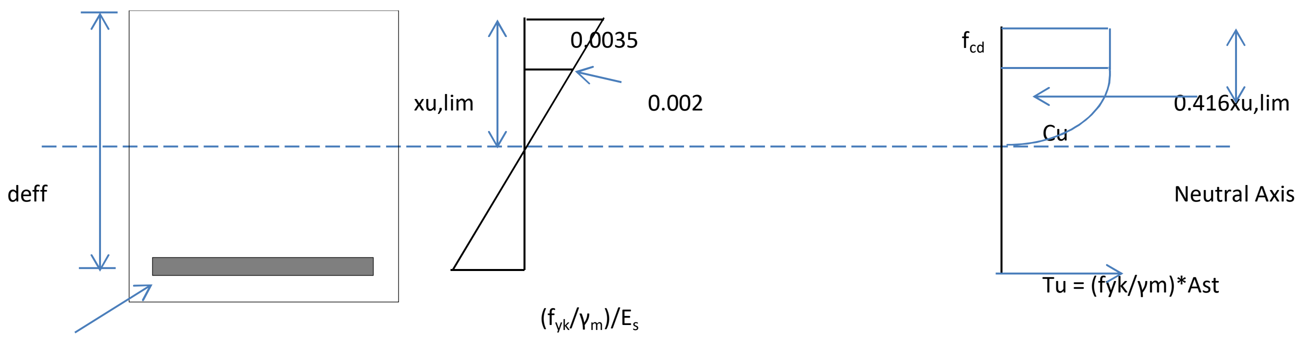
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	243.0		243.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	227		170	229		172
	OK		**OK**	**OK**		**OK**
Ast Req.	599		210	465		139
Dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	140		140	140		140
+ dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	140		140	140		140
Ast provided (sq mm)	1616		1616	1122		1122
Dia of bar (main compresion) (mm)	10		10	12		12
Spacing (mm)	140		140	140		140
Area of main compresion (mm^2)	561		561	808		808
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	67.3		89.8	46.7		62.3
x/d	0.278		0.371	0.192		0.257
	OK		**OK**	**OK**		**OK**
z (mm)	220		212	228		222
MR_{sls} (KNm)	107		103	77		75
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	118		44	129		40
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095\ z\ b\ x_u)$	5.68		1.57	6.20		1.44
	OK		**OK**	**OK**		**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Calculation of crack width	**Top slab Top End support**			**Top slab Bottom Mid Span**		
n_1			7			7
n_2			7			7
$f_{eq} = (n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1 + n_2 f_2)$			12			10
cl. 12.3.4 (3) of IRC :112-2011						
c			40			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$r_{p.eff} = A_s / A_{c,eff}$			0.014			0.010
$S_{r,max} = \{ 3.4\ c + (0.425\ k_1\ k_2\ f) / r_{p.eff} \}$			281			306
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			31000
$a_e = E_s / E_{cm}$			6.45			6.45
$(e_{sm}-e_{cm})=(s_{sc}-k_t\ f_{ct,eff}(1+a_e\ r_{p,eff})/r_{p,eff})/E_s$ $>=0.6 s_{sc}/E_s$			0.0001			0.0001
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max}\ (e_{sm} - e_{cm})$			0.037			0.04
cl. 12.3.4 (1) of IRC :112-2011						
			OK	**OK**	**OK**	**OK**
Calculation of deflection						
Span (mm)					2300	
span/800					2.9	
cl. 12.4.1 (2) of IRC :112-2011						
Short term elastic deflection from STAAD					0.2	
					OK	

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

5.2.1 Verification of structural strength for bottom slab



Strain Diagram   Stress Diagram

ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd}	=	13.40	N/mm^2	Combination (1)
f_{cd}	=	16.75	N/mm^2	Accidental Combi.
f_{cd}	=	13.40	N/mm^2	Combination (2)
E_c	=	31000	MPa	

Grade of steel

f_Y	=	500	N/mm^2	
f_{Yd}	=	435	N/mm^2	Combination (1)
f_{Yd}	=	500	N/mm^2	Accidental Combi.
f_{Yd}	=	435	N/mm^2	Combination (2)

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
xu,$_{lim}$/d	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 325 mm

Clear cover at bott. = 75   Clear cover at top = 40

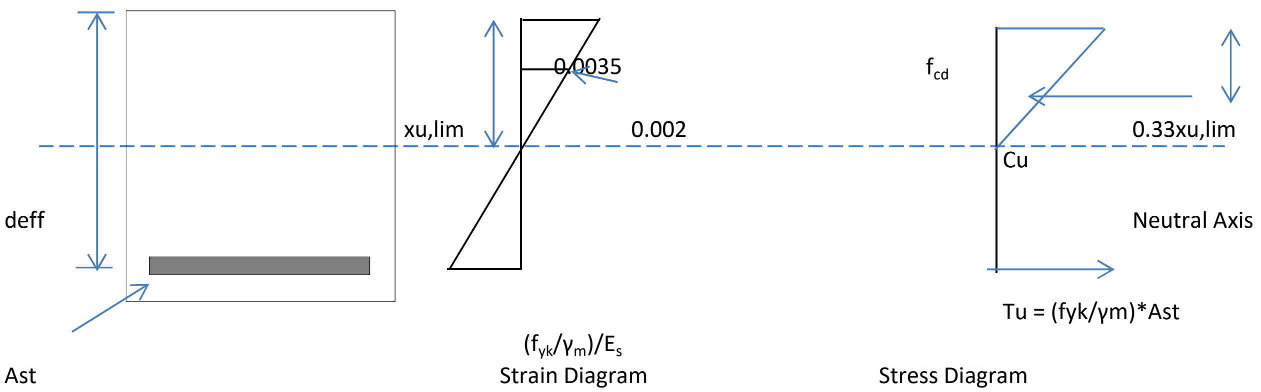
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Moment on the section	**Bottom End support**			**Top Mid Span**		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	86.0		80.0	65.0		58.0
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435		435	435		435
$xu_{,lim}/d$	0.62		0.62	0.62		0.62
$R_{sls} = M_{u,sls}/bd^2$	4.97		4.97	4.97		4.97
$M_{u,Lim}$ (KNm)	268		268	357		357
	OK		**OK**	**OK**		**OK**
Ast Req.	912		844	579		514
Dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	140		140	140		140
+ dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	140		140	140		140
Ast provided (sq mm)	1616		1616	1122		1122
Dia of bar (main compresion) (mm)	10		10	12		12
Spacing (mm)	140		140	140		140
Area of main compresion (mm^2)	561		561	808		808
f_{ctm}	2.5		2.5	2.5		2.5
f_{yk}	435		435	435		435
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26 f_{ctm} b_t d / f_{yk} >= 0.0013 b_t d$	347		347	401		401
A_{ct}	260240		260240	280028		280028
$f_{ct,eff}$	2.9		2.9	2.9		2.9
$k_c = 0.4 \{ 1 - s_c / (k_1 f_{ct,eff} h/h^*) \} <= 1$	0.4		0.4	0.4		0.4
For Bending or bending combined with axial force						
k	0.9825		0.9825	0.9825		0.9825
s_s	435		435	435		435
As.max = 0.025 Ac (main tension)	8125		8125	8125		8125
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**		**OK**	**OK**		**OK**
As.max = 0.04 Ac (tension + compresion)	13000		13000	13000		13000
x (mm)	65		65	45		45
x/d	0.279		0.279	0.168		0.168
	OK		**OK**	**OK**		**OK**
z (mm)	205		205	249		249
MR (KNm)	144		144	122		122
	OK		**OK**	**OK**		**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Shear on the section	**Bottom End support**		
Actual shear V_{Ed} (KN)	123.0		122.0
Actual shear stress (N/mm2)	0.589		0.584
Max shear capacity, 0.135 fck(1-fck/310)	3.7		3.7
	OK.		**OK.**
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		2.5
$\Theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.928		1.928
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$n_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.455		0.455
cl. 10.3.1 of IRC :112-2011			
$r1 = A_{sl}/(b_w\ d) <= 0.02$	0.007		0.007
	OK		**OK**
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.586		0.6
Axial compressive force N_{Ed} (KN)	0		0
$s_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (KN)	105		105
	Provide Shear Reinf.		**Provide Shear Reinf.**

5.2.2 Verification for serviceability limit state for bottom slab



SERVICEABILITY LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 12.2.1, IRC:112-2011

f_{cd}	=	14.40	N/mm^2	For Rare Combination
f_{cd}	=	14.40	N/mm^2	For Frequent Combination
f_{cd}	=	10.80	N/mm^2	For Quasi-Perma. Combination

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

f_{Yd}	=	300	N/mm^2	For Rare Combination
f_{Yd}	=	300	N/mm^2	For Frequent Combination
f_{Yd}	=	300	N/mm^2	For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 325 mm

Clear cover at bott. = 75

Clear cover at top = 40

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

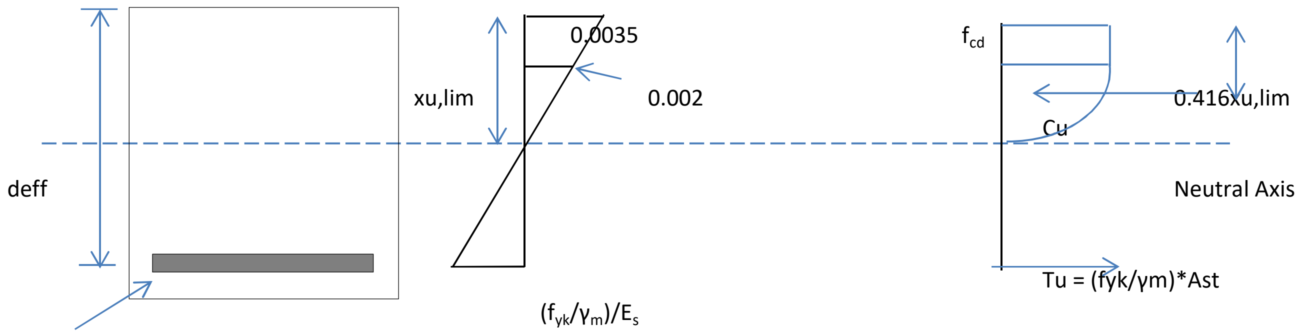
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	65.0		15.0	43		6
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	209		156	278		209
	OK		**OK**	**OK**		**OK**
Ast Req.	992		219	550		75
Dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	140		140	140		140
+ dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	140		140	140		140
Ast provided (sq mm)	1616		1616	1122		1122
Dia of bar (main compresion) (mm)	10		10	12		12
Spacing (mm)	140		140	140		140
Area of main compresion (mm^2)	561		561	808		808
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	67.3		89.8	46.7		62.3
x/d	0.290		0.387	0.174		0.233
	OK		**OK**	**OK**		**OK**
z (mm)	210		202	253		247
MR_{sls} (KNm)	102		98	85		83
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	192		46	152		22
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095\ z\ b\ x_u)$	9.21		1.65	7.28		0.78
	OK		**OK**	**OK**		**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Calculation of crack width	**Bottom End support**			**Top Mid Span**		
n_1			7			7
n_2			7			7
$f_{eq} = (n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1 + n_2 f_2)$			12			10
cl. 12.3.4 (3) of IRC :112-2011						
c			75			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer						
$r_{p.eff} = A_s / A_{c,eff}$			0.010			0.010
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 f) / r_{p.eff} \}$			460			306
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			31000
$a_e = E_s / E_{cm}$			6.45			6.45
$(e_{sm}-e_{cm})=(s_{sc}-k_t f_{ct,eff}(1+a_e r_{p,eff})/r_{p,eff})/E_s >=0.6 s_{sc}/E_s$			0.0001			0.0001
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (e_{sm} - e_{cm})$			0.06			0.02
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

5.3.1 Verification of structural strength for outer wall



Strain Diagram

Stress Diagram

ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd} = 13.40 N/mm^2 For Basic Combination

f_{cd} = 16.75 N/mm^2 For Accidental Combination

f_{cd} = 13.40 N/mm^2 For Seismic Combination

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 435 N/mm^2 For Basic Combination

f_{Yd} = 500 N/mm^2 For Accidental Combination

f_{Yd} = 435 N/mm^2 For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
xu,$_{lim}$/d	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

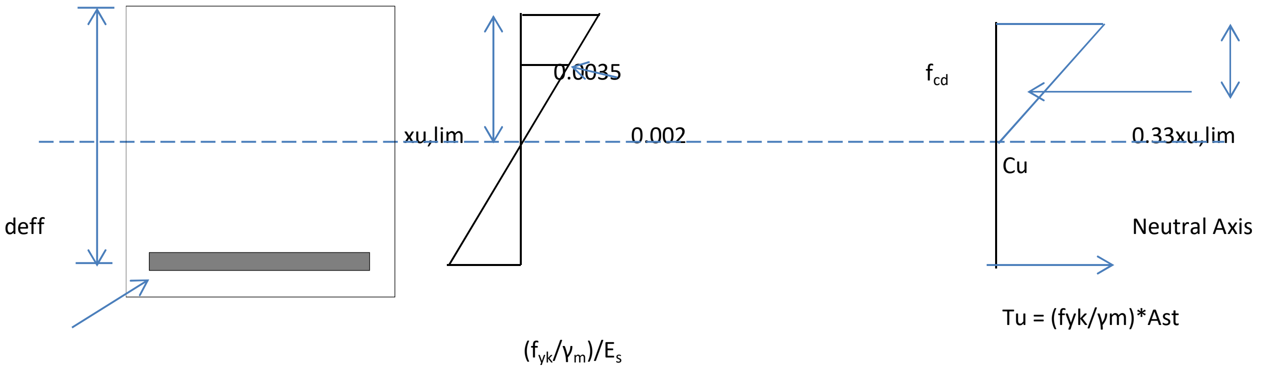
Depth of section D = 300 mm

Clear cover = 75

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Moment on the section	Bottom End support			Top End support		
	Basic Comb			Basic Comb		
Actual moment (KNm)	80.0			55.0		
b	1000			1000		
D	300			300		
c	75			75		
d	207.0			207.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			4.97		
$M_{u,Lim}$ (KNm)	213			213		
	OK			**OK**		
Ast Req.	964			645		
Dia of bar (main tension) (mm)	12			12		
Spacing (mm)	140			140		
+ dia of bar (main tension) (mm)	12			12		
Spacing (mm)	140			140		
Ast provided (sq mm)	1616			1616		
Dia of bar (main compresion) (mm)	10			10		
Spacing (mm)	140			140		
Area of main compresion (mm^2)	561			561		
f_{ctm}	2.5			2.5		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	309			309		
A_{ct}	235240			235240		
$f_{ct,eff}$	2.9			2.9		
$k_c = 0.4 \{ 1 - s_c / (k_1 f_{ct,eff}\ h/h^*) \} <= 1$	0.4			0.4		
For Bending or bending combined with axial force						
k	1.0000			1.0000		
s_s	435			435		
As.max = 0.025 Ac (main tension)	7500			7500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**			**OK**		
As.max = 0.04 Ac (tension + compresion)	12000			12000		
x (mm)	65			65		
x/d	0.313			0.313		
	OK			**OK**		
z (mm)	180			180		
MR (KNm)	126			126		
	OK			**OK**		

5.3.2 Verification for serviceability limit state for outer wall



Ast　　Strain Diagram　　Stress Diagram

SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	For Rare Combination
	f_{cd}	=	14.40	N/mm^2	For Frequent Combination
	f_{cd}	=	10.80	N/mm^2	For Quasi-Perma. Combination
As per clause 12.2.2, IRC:112-2011					
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	300	N/mm^2	For Rare Combination
	f_{Yd}	=	300	N/mm^2	For Frequent Combination
	f_{Yd}	=	300	N/mm^2	For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa　　E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu　　Refer Chaper 5 of Reinfroced Concrete

cg of compression block from top = 0.33 xu　　Limit State Design by Ashok K. Jain

Tu = fyd*Ast

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 75

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Moment on the section	**Bottom End support**			**Top End support**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	62.0		13.0	39		14
b	1000		1000	1000		1000
D	300		300	300		300
c	75		75	75		75
d	207.0		207.0	207.0		207.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	166		125	166		125
	OK		**OK**	**OK**		**OK**
Ast Req.	1075		213	657		230
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	140		140	140		140
+ dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	140		140	140		140
Ast provided (sq mm)	1616		1616	1616		1616
Dia of bar (main compresion) (mm)	10		10	10		10
Spacing (mm)	140		140	140		140
Area of main compresion (mm^2)	561		561	561		561
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	67.3		89.8	67.3		89.8
x/d	0.325		0.434	0.325		0.434
	OK		**OK**	**OK**		**OK**
z (mm)	185		177	185		177
MR_{sls} (KNm)	90		86	90		86
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	208		45	131		49
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095\ z\ b\ x_u)$	9.97		1.63	6.27		1.76
	OK		**OK**	**OK**		**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Calculation of crack width	**Bottom End support**			**Top End support**		
n_1			7			7
n_2			7			7
$f_{eq} =(n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1+n_2 f_2)$			12			12
cl. 12.3.4 (3) of IRC :112-2011						
c			75			75
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$r_{p.eff} = A_s / A_{c,eff}$			0.011			0.011
$S_{r,max}$ ={ 3.4 c + (0.425 k_1 k_2 f) / $r_{p.eff}$ }			444			444
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			29626
$a_e = E_s / E_{cm}$			6.45			6.75
$(e_{sm}-e_{cm})=(s_{sc}-k_t f_{ct,eff}(1+a_e r_{p,eff})/r_{p,eff})/E_s$ $>=0.6 s_{sc}/E_s$			0.0001			0.0001
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (e_{sm} - e_{cm})$			0.06			0.07
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

6.0 Summary of provided Reinforcement

Provided Reinforcement

Top Slab

At top of Mid Span					Required
Area of Steel Provided			=	807.8 mm^2/m	347
12mm dia	@	140mmc/c Top slab (Top main reinforcement)			
At bottom of Mid Span					
Area of Steel Provided			=	1122.0 mm^2/m	
10mm dia	@	140mmc/c Top slab (Bottom main reinforcement)			
10mm dia	@	140mmc/c Top slab (Bottom extra reinforcement)			OK
At top of End Support					
Area of Steel Provided			=	1615.7 mm^2/m	
12mm dia	@	140mmc/c Top slab (Top main reinforcement)			
12mm dia	@	140mmc/c Outer wall (Outer main reinforcement)			OK
0mm dia	@	140mmc/c Top corner extra reinforcement			
At bottom of End Support					
Area of Steel Provided			=	561.0 mm^2/m	
10mm dia	@	140mmc/c Top slab (Bottom main reinforcement)			OK
0mm dia	@	140mmc/c			

Bottom Slab

At top of Mid Span					
Area of Steel Provided			=	1122.0 mm^2/m	
10mm dia	@	140mmc/c Bottom slab (Top main reinforcement)			
10mm dia	@	140mmc/c Bottom slab (Top extra reinforcement)			OK
At bottom of Mid Span					
Area of Steel Provided			=	807.8 mm^2/m	
12mm dia	@	140mmc/c Bottom slab (Bottom main reinforcement)			
0mm dia	@	140mmc/c Bottom slab (Bottom extra reinforcement)			
At top of End Support					
Area of Steel Provided			=	561.0 mm^2/m	
10mm dia	@	140mmc/c Bottom slab (Top main reinforcement)			OK
0mm dia	@	140mmc/c			
At bottom of End Support					
Area of Steel Provided			=	1615.7 mm^2/m	
12mm dia	@	140mmc/c Bottom slab (Bottom main reinforcement)			
12mm dia	@	140mmc/c Outer wall (Outer main reinforcement)			OK
0mm dia	@	140mmc/c Bottom corner extra reinforcement			

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Outer Wall

At outer face of top end

Area of Steel Provided			=	1615.7	mm^2/m	
12mm dia	@	140mmc/c	Outer wall (Outer main reinforcement)			
12mm dia	@	140mmc/c	Top slab (Top main reinforcement)			OK
0mm dia	@	140mmc/c	Top corner extra reinforcement			

At inner face of top end

Area of Steel Required			=	313.8	mm^2/m	
Area of Steel Provided			=	561.0	mm^2/m	
10mm dia	@	140mmc/c	Outer wall (Inner main reinforcement)			OK

At outer face of bottom end

Area of Steel Provided			=	1615.7	mm^2/m	
12mm dia	@	140mmc/c	Bottom slab (Bottom main reinforcement)			
12mm dia	@	140mmc/c	Outer wall (Outer main reinforcement)			OK
0mm dia	@	140mmc/c	Bottom corner extra reinforcement			

At inner face of bottom end

Area of Steel Provided			=	561.0	mm^2/m
10mm dia	@	140mmc/c	Outer wall (Inner main reinforcement)		

Shear Reinforcement

Bottom Slab

12mm dia	225mmc/c	(Long. Direc	0	198.304	kN
12mm dia	140mmc/c	(Trans. Direction)			

Distribution Reinforcement As per cl. 16.6.1.1 (3) of IRC :112-2011

Top Slab

Req. Reinforcement			=	174	mm^2/m	
Provided Reinforcement			=			
12mm dia	@	225mmc/c		502.7	mm^2/m	OK

Bottom Slab

Req. Reinforcement			=	200.3	mm^2/m	
Provided Reinforcement			=			
12mm dia	@	225mmc/c		502.7	mm^2/m	OK

Outer Wall

Req. Reinforcement			=	192.7	mm^2/m	
Provided Reinforcement			=			
12mm dia	@	225mmc/c		502.7	mm^2/m	OK

7.0 Base Pressure

L/C	Node											Total Wt (KN/m)	Base Pressure (KN/m^{2})
	1	2	5	6	7	8	9	10	11	12	13		
299	10	11	21	21	21	21	21	21	21	21	14	203	78
300	12	12	24	24	24	24	24	25	25	25	13	232	89

Max	**89**
Min.	**78**
	OK

Bearing capacity = 100 KN/sqm

Design note
for
RCC BOX OF SIZE 1 x 3 x 3

	Project		Designed by:	KB
	Client		Checked by:	
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	

Index

1.0 Design Report

The following report represents the design note of RCC BOX of clear span 1 x 3 x 3

1.1 Introduction:-

Design is presented consistently in SI units; the following apply unless mentioned specifically otherwise:

Length	m
Force	kN
Stress	MPa
Bearing Pressure	kN/m2
Hog Mom/Com Str	-ve
Sag Mom/Ten Str	+ve

1.2 Reference documents :-

1 IRC codes /guidelines/special publications
2 MORTH specification
3 Specialised literature as relevant

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

1 Structure is designed for per metre width.
2 On top slab 75 mm thick wearing coat is considerd for SIDL.
3 Deck width taken 12 m
4 Carriageway width- 11 m
5 Modulus of subgrade reaction (Assumed) - 2500 KN/m3
6 Shear value is taken at dist. 0.15m from the face of the slab.
7 In case of load dispersion wearing coat thickness, fill thickness and top slab thickness is considered wherever applicable.
8 In case of design sheet under summary of moments, only magnitude of force has been considered.
9 In case of earth pressure and LL surcharge governing case out of Normal earth pressure, Fluid pressure and Normal earth pressure + hydrostatic fluid pressure is taken.
10 Structure is designed for standard earth pressure without weep holes.

1.4 Loads:-

The different types of loads used as per IRC 6 : 2014 are.

1 Dead load.
2 In SIDL fill, crash barrier, and wearing coat load is considered.
3 Normal Earth pressure with hydrostatic pressure.
4 Live load -70R Track, 40 T Boggie, 70R Wheel load in case of top slab.
5 Live load surcharge.
6 Braking load is taken as 20% of the live load on top slab.
7 1.25 of Impact factor is considered.
8 Temperature loading for uniform rise and temperature gradient is considered.
9 The Earth pressure coefficient at rest 0.5 is considered.

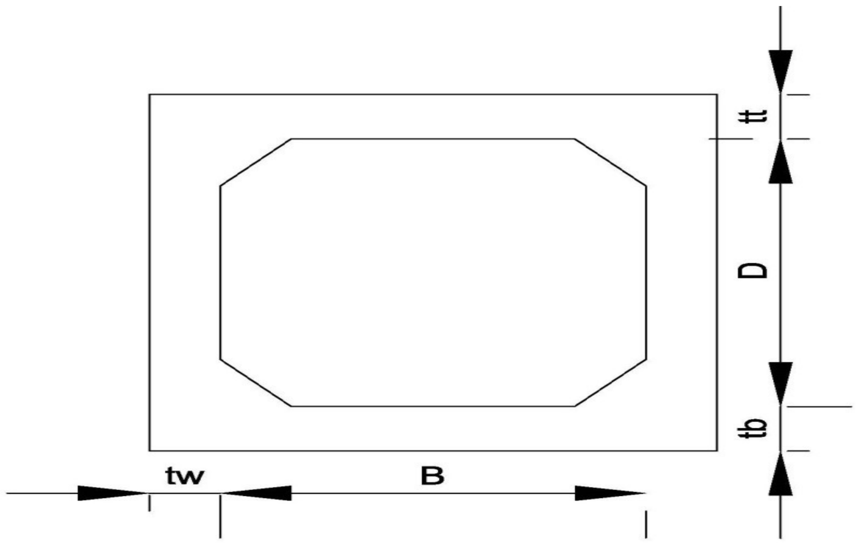
1.5 Load combinations

Load combinations as per IRC 6: 2014 have been considered in staad load combination.

1.6 Material properties

1 Grade of Concrete M30
2 Grade of Steel Fe 500.

BOX (1 Cell 3m wide x 3m height)



2.1 Dimensions of Box

No. of Cell	=	1	Clear Width of cell	=	3.00 m
Top Slab Thick. (tt)	=	0.420 m	Clear Height of Cell	=	3.00 m
Bot. Slab Thick. (tb)	=	0.420 m	C/C Width of structure	=	3.420 m
Side Wall Thick. (tw)	=	0.420 m	C/C Height of structure	=	3.420 m
Int. wall Thickness (ti)	=	0.000 m	Total length of Structure at top =		3.840 m
Total Deck width	=	12.00 m	Total length of Structure at bottom =		3.840 m
Carrriageway Width	=	11.00 m	Total Height of Structure	=	3.84 m
water above bott. Slab	=	2.495 m	Footpath Dimensions	=	0.00 m
			Crash barrier width	=	0.50 m
Wearing coat for SIDL	=	75mm		Height of fill =	0.00 m
Haunch size	=	150mm	x150mm		

SIDL (Top Slab)

Crash barrier	=		10	kN/m^2
Due to earth fill	=	0 x20 =	0	kN/m^2
			10	kN/m^2
Due to wearing coat	=	0.075 x 22 =	1.65	kN/m^2

2.2 Basic Parameters

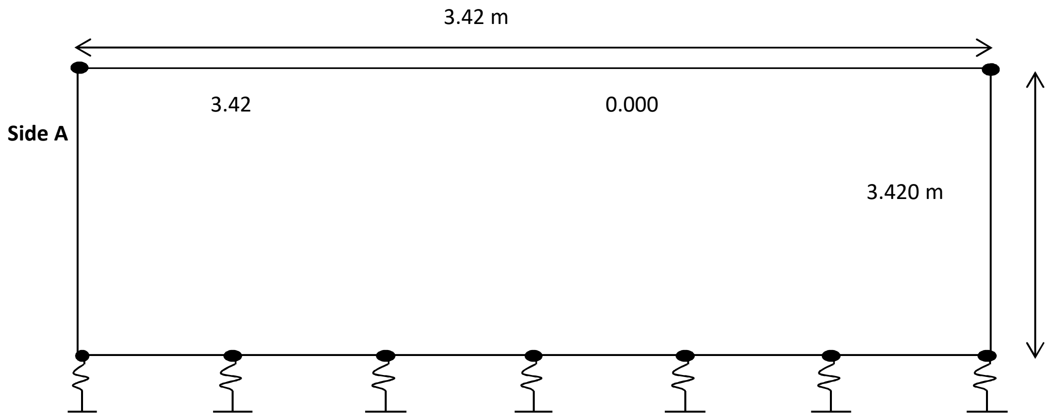
Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpres:	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge	=	1.2	m

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Safe Bearing Pressure	=	100	kN/m^2
Fluid Pressure as per cl. 214.1 of IRC 6 2010		4.71	kN/m^2

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



Nos. of beam for one span at bottom	=	10	
Spacing between Springs	=	0.342	m
Modulus of Subgrade Reactiom (Assumed)	=	2500	kN/m^3
Spring Constant at End Support	=	428	kN/m
Spring Constant at intermediate Support	=	855	kN/m

3.1 Earth Pressure and Live Load Calculation

1) a Earth Pressure (Normal Condition)

Earth Pressure	Height
1.17 kN/m^2	0.210 m
20.26 kN/m^2	3.630 m

1) b Fluid Pressure

Fluid Pressure	Height
0.99 kN/m^2	0.210 m
17.09 kN/m^2	3.630 m

1) c Earth Pressure (Normal Condition+Full hydrostatic pressure)

Earth Pressure	Height
2.69	0.21
46.43	3.630 m

1) d Earth Pressure at rest K_0 = (1-sinf) = 0.5

LWL Earth Pressure	HFL Earth Pressure	Height
2.10	3.15	0.210 m
36.30	54.45	3.630 m

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

2) b Live Load Surcharge (Fluid Pressure) as per cl. 214.1 of IRC 6 2014

Live Load Surcharge = 5.651 kN/m

2) c Live Load Surcharge (Normal Condition+Full hydrostatic pressure)

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

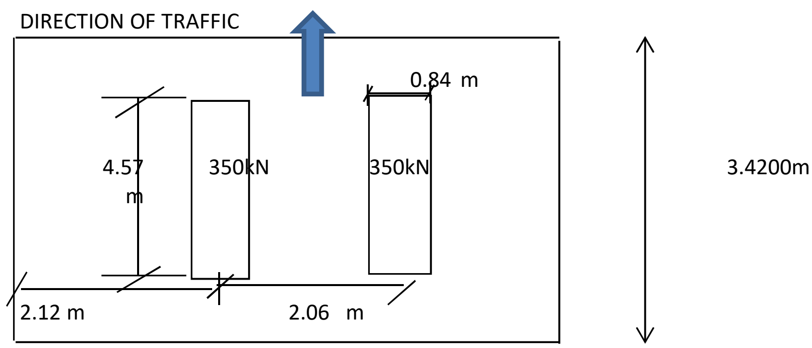
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 24.95 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



Total Load	=	**700kN**	4.57	3.4200m
		153.17 KN/m		
		523.9 KN		

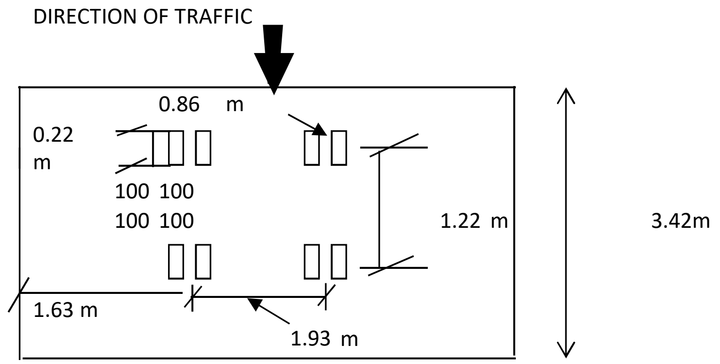
<u>Effective width of Loading</u>

a	=	1.71 m
b1	=	0.99 m
b/lo	=	3.51
a	=	2.60
beff	=	3.21 m

2.06<3.21 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	5.27 m
Width along span	=	3.42 m
Load Intensity	=	29.07 kN/m^2
Increase due to impact	=	36.34 kN/m^2
	Say	**36.40** kN/m^2

B) 40T Boggie Load at Mid Span



Total Load = 400kN

Effective width of Loading

a	=	1.71 m
b1	=	1.01 m
b/lo	=	3.51
a	=	2.60
beff	=	3.23 m

1.93<3.23 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	5.16 m
Width along span	=	2.43 m
Load Intensity	=	31.90 kN/m^2
Increase due to impact	=	39.88 kN/m^2
	Say	**39.90** kN/m^2

C) 40T Boggie Load at Support

Effective width of Loading

a	=	0.61 m
b1	=	1.01 m
b/lo	=	3.51
a	=	2.60
beff	=	2.31 m

1.93<2.31 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	4.24 m
Width along span	=	1.935 m
Load Intensity	=	48.75 kN/m^2
Increase due to impact	=	60.94 kN/m^2
	Say	**61.00** kN/m^2

D) 70R Track at Support

Effective width of Loading

a	=	1.71 m
b1	=	0.99 m
b/lo	=	3.51
a	=	2.60
beff	=	3.21 m

2.06<3.21 ***Therefore overlapping due to load dispersion occurs***

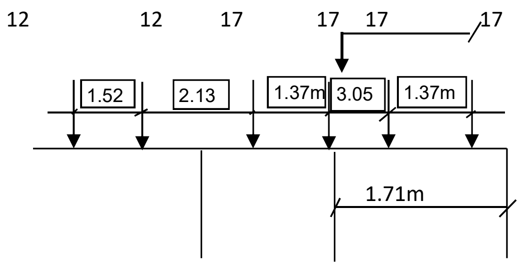
Effective width	=	5.27 m
Width along span	=	3.420 m
Load Intensity	=	29.07 kN/m^2

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Increase due to impact = 36.34 kN/m^2

Say **36.40** kN/m^2

F) 70R Wheel Case 1

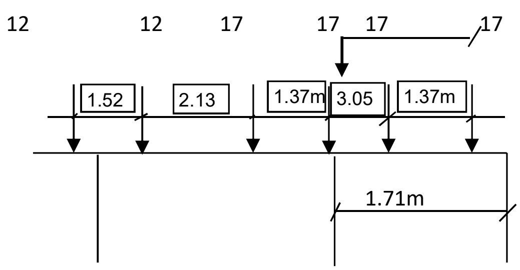


0.86m 1.93m 0.86m

Width along span = 1.210m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.61m	2.60	2.30m	Yes	4.23m	32.5 kN/sqm	41 kN/sqm
2	166.77	1.45m	2.60	3.18m	Yes	5.11m	27.0 kN/sqm	34 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.00m	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm

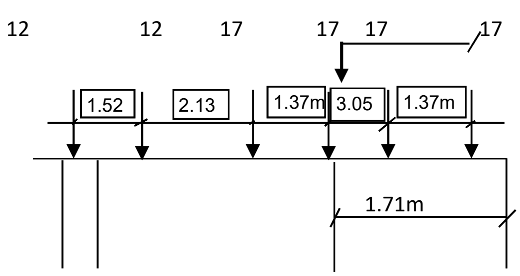
F) 70R Wheel Case 2



Width along span = 1.210m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	1.025	2.60	2.88m	Yes	4.81m	28.7 kN/sqm	36 kN/sqm
2	166.77	1.025	2.60	2.88m	Yes	4.81m	28.7 kN/sqm	36 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm

G) 70R Wheel Case 3



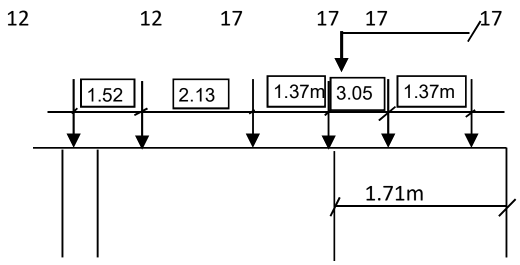
Width along span = 1.210m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.605	2.60	2.30m	Yes	4.23m	32.5 kN/sqm	41 kN/sqm
2	166.77	1.445	2.60	3.18m	Yes	5.11m	27.0 kN/sqm	34 kN/sqm

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0.0 kN/sqm	0 kN/sqm

H) 70R Wheel Case 4



Width along span = 1.210m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.685	2.60	2.43m	Yes	4.36m	31.6 kN/sqm	39 kN/sqm
2	166.77	1.365	2.60	3.14m	Yes	5.07m	27.2 kN/sqm	34 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0.0 kN/sqm	0 kN/sqm

G) Braking load		20%	Av. Eff. Width	Load per meter
Load on the span 70R Wheel	334 kN	67 kN	4.67m	14 kN/m
Load on the span 70R Track	524 kN	105 kN	5.27m	20 kN/m
Max. force				**20 kN/m**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

3.2 Temperature load calculation

Effective Bridge Temperature

Maximum Air Shade temperature	=	47.9	/oC (as per Annexure F of IRC:6-2014)
Minimum Air Shade temperature	=	0.2	/^{o}C (as per Annexure F of IRC:6-2014)
Mean of max and min temperature	=	23.85	/^{o}C (as per clause 215.2 of IRC:6-2014)
Bridge temperature to be assumed	=	33.85	
TEMPERATURE RISE		**33.85**	
TEMPERATURE FALL		**-34.05**	

Effect of temperature gradient

The box has been checked for temperature differential.

F = E_c aDt A

E_c = Modulus of Elasticity of Concrete = 3.21E+06 t/m^2

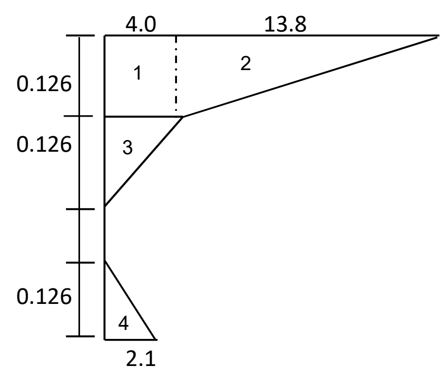
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

Dt = Temperature differential

A = X sectional Area of section where temperature differential is Dt

Average thickness of Deck slab = 420 mm

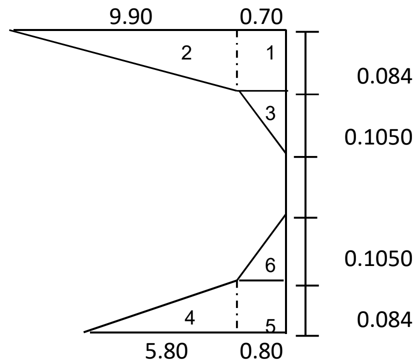
EFFECT OF TEMPERATURE RISE



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	4.0	1.0	0.126	0.126	19.43	0.063 m from top	0.147
2	13.8 / 2	1.0	0.126	0.126	33.52	0.042 m from top	0.168
3	4.0 / 2	1.0	0.126	0.126	9.72	0.168 m from top	0.042
4	2.1 / 2	1.0	0.126	0.126	5.10	0.042m from bottom	-0.168
				SF =	67.77	M =	8.039

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

EFFECT OF TEMPERATURE FALL



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	0.70	1.0	0.084	0.084	2.27	0.042m from top	0.168
2	9.90 / 2	1.0	0.084	0.084	16.03	0.028 m from top	0.182
3	0.70 / 2	1.0	0.1050	0.1050	1.42	0.119 m from top	0.091
4	5.80 / 2	1.0	0.084	0.084	9.39	0.028 m from bottom	-0.182
5	0.80	1.0	0.084	0.084	2.59	0.042m from bottom	-0.168
6	0.80 / 2	1.0	0.1050	0.1050	1.62	0.119 m from bottom	-0.091
				SF =	33.32	M =	1.136

3.3 Summary of factored moments

Grade of Concrete = M30

Grade of Steel = Fe500

Summary of factored moments

	Top slab			Bottom slab			Outer wall			
Load Case	Moment in Mid-Span	Moment at End Suppor	Top slab shear at	Moment in Mid-Span	Moment at End Suppor	Bottom slab shear	Min. Axial force	Moment at top	Moment at bottom	Wall shear at deff
	kN-m	kN-m	kN	kN-m	kN-m	kN	KN	kN-m	kN-m	kN
Basic Combination (33 - 62)	70	80	44	-	-	-	31	83	132	149
Rare Combination (63 -122)	53	68	206	77	91		31	68	91	118
Frequent Combinatio (123 - 182)	-	-	-	-	-	-	-	-	-	-
Quasi Static (183 - 186)	14	26		24	28			26	20	
Combination 1	-	-	-	111	130	187	-	-	-	-
Combination 2	-	-	-	93	107	162	-	-	-	-
	-	-	-	93	107	162	-	-	-	-

4.0 Partial Safety Factors

Material Parameters

Concrete **Refer Table 6.5, IRC:112-2011**

Grade		=	**M30**	
Cube strength of concrete at 28 days	f_{ck}	=	30	MPa
Design value of concrete compressive strength	f_{cd}	=	$\alpha f_{ck} / \gamma_m$	
Refer cl. 6.4.2.8 of IRC:112-2011			a =	0.67
	f_{ctm}	=	2.5	MPa
For Basic Combination	f_{cd}	=	13.40	MPa
For Accidental Combination	f_{cd}	=	16.75	MPa
For Seismic Combination	f_{cd}	=	13.40	MPa
Modulus of Elasticity	E_c	=	31000	MPa
Mean value of axial tensile strength of concrete	f_{ctm}	=	2.5	MPa
Density		=	2.50	t/m^3
Grade		=	Fe500	
Characteristics yield strength	f_{yk}	=	500	MPa
Design yield strength	f_{yd}	=	f_{yk} / γ_m	
For Basic Combination	f_{yd}	=	434.78	MPa
For Accidental Combination	f_{yd}	=	500	MPa
For Seismic Combination	f_{yd}	=	434.78	MPa
Modulus of Elasticity	E_s	=	2.0E+05	MPa
Density		=	7.85	t/m^3

Partial Safety Factor for Materials

Material	Partial Safety Factor g_m			
	Basic Combination	Accidental Combination	Seismic Combination	
Concrete	1.5	1.2	1.5	Cl 6.4.2.8, IRC:112-2011
Steel	1.15	1	1.15	Cl 6.2.2, IRC:112-2011

Partial Safety Factor for Loads

Ultimate Limit State

Partial Safety for Verification of Structural Strength **Table 3.1, Annex B, IRC:6-2014**

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
(1)	(2)	(3)	(4)	(5)	(4)	(3)
	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect
Permanent Loads:	1.05	0.95	1.00	1.00	1.05	0.95
Dead Load, SIDL except surfacing, Backfill Weight, Settlement, Creep and shrinkage effect						
Surfacing	1.35	1.00	1.00	1.00	1.35	1.00
Earth Pressure due to Backfill	1.50	0.00	1.00	0.00	1.00	0.00
Variable Loads:						
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:						
a) Leading Load	1.50	0.00	0.75	0.00	0.00	0.00
b) Accompanying Load	1.15	0.00	0.20	0.00	0.20	0.00
c) Construction Live Load	1.35	0.00	1.00	0.00	1.00	0.00
Thermal Loads						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	0.90	0.00	0.50	0.00	0.50	0.00
Wind						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	0.90	0.00	0.00	0.00	0.00	0.00
Live Load Surcharge (as accompanying load)	1.20	0.00	0.00	0.00	0.00	0.00
Accidental Effects:						
i) Vehicle Collision						
ii) Barge Impact	0.00	0.00	1.00	0.00	0.00	0.00
iii) Impact due to floating bodies						
Seismic Effect						
a) During Service	0.00	0.00	0.00	0.00	1.50	0.00
b) During Construction	0.00	0.00	0.00	0.00	0.75	0.00
Construction Condition:						
Counter Weights:						
a) When density or self weight is well defined	0.00	0.90	0.00	1.00	0.00	1.00
b) When density or self weight is not well defined	0.00	0.80	0.00	1.00	0.00	1.00
c) Erection effects	1.05	0.95	0.00	0.00	0.00	0.00
Wind						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	1.20	0.00	0.00	0.00	0.00	0.00
Hydraulic Loads:						
(Accompanying Load):						
Water Current Forces	1.00	0.00	1.00	0.00	1.00	0.00
Wave Pressure	1.00	0.00	1.00	0.00	1.00	0.00
Hydrodynamic Effect	0.00	0.00	0.00	0.00	1.00	0.00
Buoyancy	1.00	0.00	1.00	0.00	1.00	0.00

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Partial Safety for Verification of Structural Strength **Table 3.2, Annex B, IRC:6-2014**
Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
(1)	(2)	(3)	(4)
Permanent Loads:			
Dead Load			
SIDL except surfacing			
a) Adding to the effect of variable loads	1.35	1.00	1.35
b) Relieving the effect of variable loads	1.00	1.00	1.00
Surfacing:			
a) Adding to the effect of variable loads	1.75	1.00	1.75
b) Relieving the effect of variable loads	1.00	1.00	1.00
Backfill Weight	1.50	1.00	1.00
Earth Pressure due to Backfill			
a) Leading Load	1.50	0.00	1.00
b) Accompanying Load	1.00	1.00	1.00
Variable Loads:			
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.50	0.75	0.00
b) Accompanying Load	1.15	0.20	0.20
c) Construction Live Load	1.35	1.00	1.00
Wind during service and construction			
a) Leading Load	1.50	0.00	0.00
b) Accompanying Load	0.90	0.00	0.00
Live Load Surcharge (as accompanying load)	1.20	0.20	0.20
Erection effects	1.00	1.00	1.00
Accidental Effects:			
i) Vehicle Collision			
ii) Barge Impact	0.00	1.00	0.00
iii) Impact due to floating bodies			
Seismic Effect			
a) During Service	0.00	0.00	1.50
b) During Construction	0.00	0.00	0.75
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	1.00
Wave Pressure	1.00	1.00	1.00
Hydrodynamic Effect	0.00	0.00	1.00
Buoyancy	0.15	0.15	0.15

Serviceability Limit State

Partial Safety for Verification of Serviceability Limit State **Table 3.3, Annex B, IRC:6-2014**

Loads	Partial Safety Factor		
	Rare Combination	Frequent Combination	Quasi-permanent
(1)	(2)	(3)	(4)
Permanent Loads:			
Dead Load	1.00	1.00	1.00
SIDL including surfacing	1.00	1.00	1.00
Backfill Weight	1.00	1.00	1.00
Shrinkage and Creep Effects	1.00	1.00	1.00
Earth Pressure due to Backfill	1.00	1.00	1.00
Settlement Effects			
a) Adding to the permanent loads	1.00	1.00	1.00
b) Opposing the permanent loads	0.00	0.00	0.00
Variable Loads:			
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.00	0.75	0.00
b) Accompanying Load	0.75	0.20	0.00
Thermal Loads:			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load			
Wind			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load	0.60	0.50	0.00
Live Load Surcharge (Accompanying load)	0.80	0.00	0.00
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	0.00
Wave Pressure	1.00	1.00	0.00
Buoyancy	0.15	0.15	0.15

Combination for Base Pressure and Design of Foundation

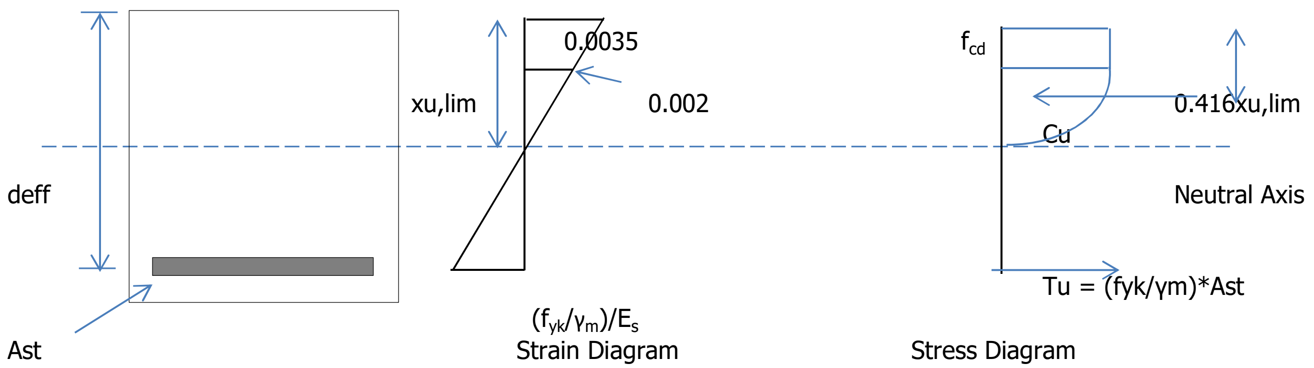
Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor			
	Combination (1)	Combination (2)	Seismic Combination	Accidental Combination
(1)	(2)	(3)	(4a)	(4b)
Permanent Loads:				
Dead Load, SIDL except surfacing, Backfill earth filling	1.35	1.00	1.35	1.00
SIDL Surfacing	1.75	1.00	1.75	1.00
Settlement Effect	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Earth Pressure due to Backfill				
a) Leading Load	1.50	1.30	0.00	0.00
b) Accompanying Load	1.00	0.85	1.00	1.00
Variable Loads:				
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:				
a) Leading Load	1.50	1.30	(0.75 if applicable) or 0	(0.75 if applicable) or 0
b) Accompanying Load	1.15	1.00	0.20	0.20
Thermal Loads as accompanying load	0.90	0.80	0.50	0.50
Wind				
a) Leading Load	1.50	1.30	0.00	0.00
b) Accompanying Load	0.90	0.80	0.00	0.00
Live Load Surcharge (as accompanying load if applicable)	1.20	1.00	0.20	0.20
Accidental Effects or Seismic Effect:				
a) During Service	0.00	0.00	1.50	1.00
b) During Construction	0.00	0.00	0.75	0.50
Erection effects	1.00	1.00	1.00	1.00
Hydraulic Loads:				
Water Current	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Wave Pressure	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Hydrodynamic Effect	0.00	0.00	1.0 or 0	1.0 or 0
Buoyancy:				
For Base Pressure	1.00	1.00	1.00	1.00
For Structural Design	0.15	0.15	0.15	0.15

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

5.1.1 Verification of structural strength for top slab



ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd} = 13.40 N/mm^2 For Basic Combination

f_{cd} = 16.75 N/mm^2 For Accidental Combination

f_{cd} = 13.40 N/mm^2 For Seismic Combination

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 435 N/mm^2 For Basic Combination

f_{Yd} = 500 N/mm^2 For Accidental Combination

f_{Yd} = 435 N/mm^2 For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

E_c = 31000 MPa

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
xu,$_{lim}$/d	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

Clear cover = 50

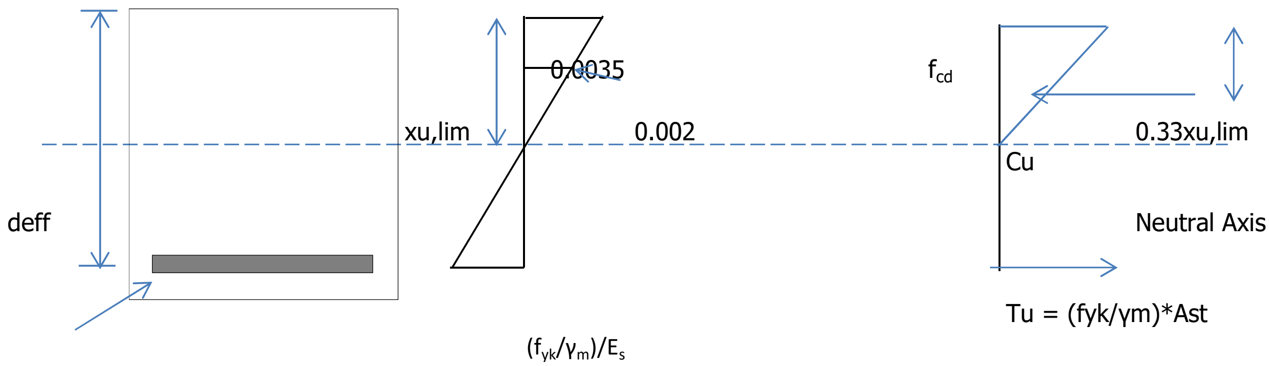
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Basic Comb			Basic Comb		
Actual moment (KNm)	80.0			70.0		
b	1000			1000		
D	420			420		
c	50			50		
d	352.0			353.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			4.97		
$M_{u,Lim}$ (KNm)	616			620		
	OK			**OK**		
Ast Req.	536			466		
Dia of bar (main tension) (mm)	12			10		
Spacing (mm)	150			150		
+ dia of bar (main tension) (mm)	12			10		
Spacing (mm)	150			150		
Ast provided (sq mm)	1508			1047		
Dia of bar (main compresion) (mm)	10			12		
Spacing (mm)	150			150		
Area of main compresion (mm^2)	524			754		
f_{ctm}	2.5			2.5		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26 f_{ctm} b_t d / f_{yk} >= 0.0013 b_t d$	526			528		
A_{ct}	359558			378026		
$f_{ct,eff}$	2.9			2.9		
$k_c = 0.4 \{ 1 - s_c / (k_1 f_{ct,eff} h/h^*) \} <= 1$	0.4			0.4		
For Bending or bending combined with axial force						
k	0.9160			0.9160		
s_s	435			435		
As.max = 0.025 Ac (main tension)	10500			10500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**			**OK**		
As.max = 0.04 Ac (tension + compresion)	16800			16800		
x (mm)	60			42		
x/d	0.172			0.119		
	OK			**OK**		
z (mm)	327			336		
MR (KNm)	214			153		
	OK			**OK**		

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Shear on the section	**Top slab Top End support**		
Actual shear V_{Ed} (KN)	44.0		
Actual shear stress (N/mm2)	0.139		
Max shear capacity, 0.135 fck(1-fck/310)	3.7		
	OK.		
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		
Θ = 0.5 x $\sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.754		
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$n_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.394		
cl. 10.3.1 of IRC :112-2011			
$r1 = A_{sl}/(b_w\ d) <= 0.02$	0.004		
	OK		
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.454		
Axial compressive force N_{Ed} (KN)	0		
$s_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (KN)	139		
	OK.		
Min shear stress	0.394		
Min shear force for providing reinf., V_E (N)	124930.8		
No. of link for shear reinf.	4		
Dia. of bar for shear reinf.	12		
S = Asw x 0.9 x d x cot Θ x fy / V_E	1247		
A_{SW}	452		
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011			
$S_{l.max}$ = 0.75 d	264		
Spacing provided in Long. Direction (mm)	**264.0**		
cl. 16.5.2(9) Eq. 16.8 of IRC :112-2011			
$S_{t.max}$ = 0.75 d <= 600mm	264		
Spacing provided in Trans. Direction,$S_{t.}$ mm	**150**		
	OK		

5.1.2 Verification for serviceability limit state for top slab



Strain Diagram

Stress Diagram

SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	For Rare Combination
	f_{cd}	=	14.40	N/mm^2	For Frequent Combination
	f_{cd}	=	10.80	N/mm^2	For Quasi-Perma. Combination
As per clause 12.2.2, IRC:112-2011					
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	300	N/mm^2	For Rare Combination
	f_{Yd}	=	300	N/mm^2	For Frequent Combination
	f_{Yd}	=	300	N/mm^2	For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu   Refer Chaper 5 of Reinfroced Concrete

cg of compression block from top = 0.33 xu   Limit State Design by Ashok K. Jain

Tu = fyd*Ast

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section d	=	420	mm
Clear cover	=	40	

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

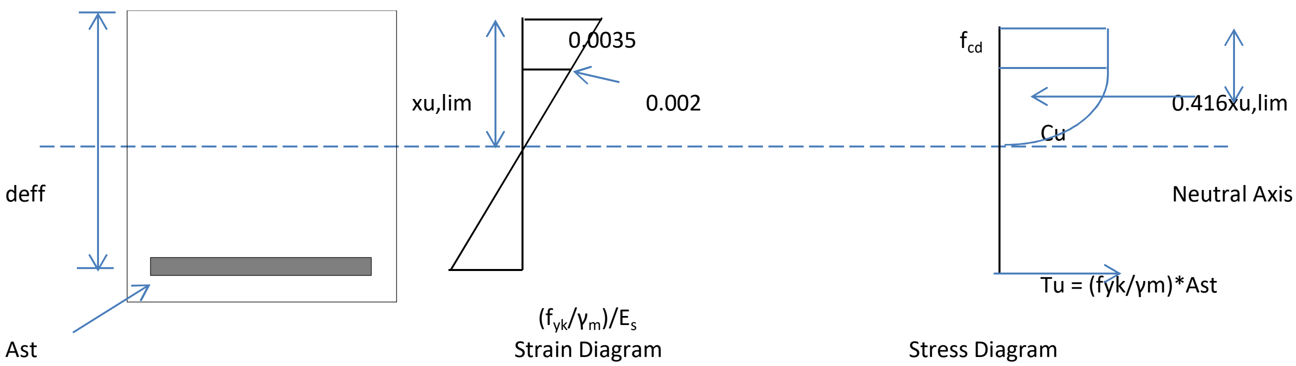
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	68.0		26.0	53		14
b	1000		1000	1000		1000
D	420		420	420		420
c	40		40	40		40
d	362.0		362.0	363.0		363.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	508		381	511		383
	OK		**OK**	**OK**		**OK**
Ast Req.	642		242	496		129
Dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	150		150	150		150
+ dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	150		150	150		150
Ast provided (sq mm)	1508		1508	1047		1047
Dia of bar (main compresion) (mm)	10		10	12		12
Spacing (mm)	150		150	150		150
Area of main compresion (mm^2)	524		524	754		754
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	62.8		83.8	43.6		58.2
x/d	0.174		0.231	0.120		0.160
	OK		**OK**	**OK**		**OK**
z (mm)	341		334	349		344
MR_{sls} (KNm)	154		151	110		108
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	132		52	145		39
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095 z b x_u)$	6.34		1.86	6.97		1.40
	OK		**OK**	**OK**		**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Calculation of crack width	**Top slab Top End support**			**Top slab Bottom Mid Span**		
n_1			7			7
n_2			7			7
$f_{eq} = (n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1 + n_2 f_2)$			12			10
cl. 12.3.4 (3) of IRC :112-2011						
c			40			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$r_{p.eff} = A_s / A_{c,eff}$			0.013			0.009
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 f) / r_{p.eff} \}$			292			319
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			31000
$a_e = E_s / E_{cm}$			6.45			6.45
$(e_{sm}-e_{cm})=(s_{sc}-k_t f_{ct,eff}(1+a_e r_{p,eff})/r_{p,eff})/E_s >=0.6 s_{sc}/E_s$			0.0002			0.0001
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (e_{sm} - e_{cm})$			0.045			0.04
cl. 12.3.4 (1) of IRC :112-2011						
			OK	**OK**	**OK**	**OK**
Calculation of deflection						
Span (mm)					3420	
span/800					4.3	
cl. 12.4.1 (2) of IRC :112-2011						
Short term elastic deflection from STAAD					0.2	
					OK	

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

5.2.1 Verification of structural strength for bottom slab



ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd} = 13.40 N/mm^2 Combination (1)

f_{cd} = 16.75 N/mm^2 Accidental Combi.

f_{cd} = 13.40 N/mm^2 Combination (2)

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 435 N/mm^2 Combination (1)

f_{Yd} = 500 N/mm^2 Accidental Combi.

f_{Yd} = 435 N/mm^2 Combination (2)

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = $fcd*b*(3/7xu_{,lim} + 2/3*4/7xu_{,lim})$

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.8095fcd*(xu_{lim}/d)*(1-0.416*xu_{lim}/d)$

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

Clear cover at bott. = 75 Clear cover at top = 40

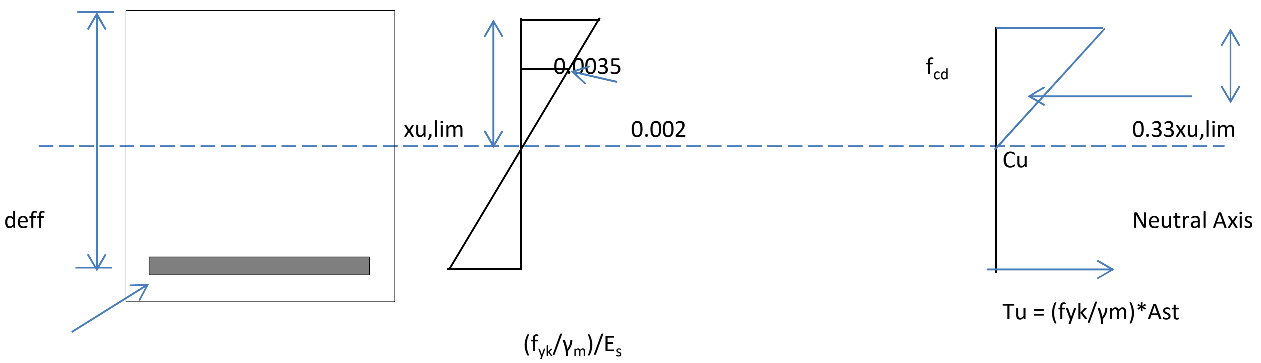
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Moment on the section	Bottom End support			Top Mid Span		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	130.0		107.0	111.0		93.0
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435		435	435		435
$xu_{,lim}/d$	0.62		0.62	0.62		0.62
$R_{sls} = M_{u,sls}/bd^2$	4.97		4.97	4.97		4.97
$M_{u,Lim}$ (KNm)	532		532	655		655
	OK		**OK**	**OK**		**OK**
Ast Req.	962		784	728		606
Dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	150		150	150		150
+ dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	150		150	150		150
Ast provided (sq mm)	1508		1508	1047		1047
Dia of bar (main compresion) (mm)	10		10	12		12
Spacing (mm)	150		150	150		150
Area of main compresion (mm^2)	524		524	754		754
f_{ctm}	2.5		2.5	2.5		2.5
f_{yk}	435		435	435		435
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	489		489	543		543
A_{ct}	359558		359558	378026		378026
$f_{ct,eff}$	2.9		2.9	2.9		2.9
$k_c = 0.4 \{ 1 - s_c / (k_1 f_{ct,eff} h/h^*) \} <= 1$	0.4		0.4	0.4		0.4
For Bending or bending combined with axial force						
k	0.9160		0.9160	0.9160		0.9160
s_s	435		435	435		435
As.max = 0.025 Ac (main tension)	10500		10500	10500		10500
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**		**OK**	**OK**		**OK**
As.max = 0.04 Ac (tension + compresion)	16800		16800	16800		16800
x (mm)	60		60	42		42
x/d	0.185		0.185	0.116		0.116
	OK		**OK**	**OK**		**OK**
z (mm)	302		302	346		346
MR (KNm)	198		198	157		157
	OK		**OK**	**OK**		**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Shear on the section	**Bottom End support**		
Actual shear V_{Ed} (KN)	187.0		162.0
Actual shear stress (N/mm2)	0.635		0.550
Max shear capacity, 0.135 fck(1-fck/310)	3.7		3.7
	OK.		**OK.**
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		2.5
Θ = 0.5 x $\sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.782		1.782
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$n_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.404		0.404
cl. 10.3.1 of IRC :112-2011			
$r1 = A_{sl}/(b_w\ d) <= 0.02$	0.005		0.005
	OK		**OK**
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.473		0.5
Axial compressive force N_{Ed} (KN)	0		0
$s_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (KN)	132		132
	Provide Shear Reinf.		**Provide Shear Reinf.**

5.2.2 Verification for serviceability limit state for bottom slab



Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 12.2.1, IRC:112-2011

f_{cd} = 14.40 N/mm^2 For Rare Combination

f_{cd} = 14.40 N/mm^2 For Frequent Combination

f_{cd} = 10.80 N/mm^2 For Quasi-Perma. Combination

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 300 N/mm^2 For Rare Combination

f_{Yd} = 300 N/mm^2 For Frequent Combination

f_{Yd} = 300 N/mm^2 For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 420 mm

Clear cover at bott. = 75 Clear cover at top = 40

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

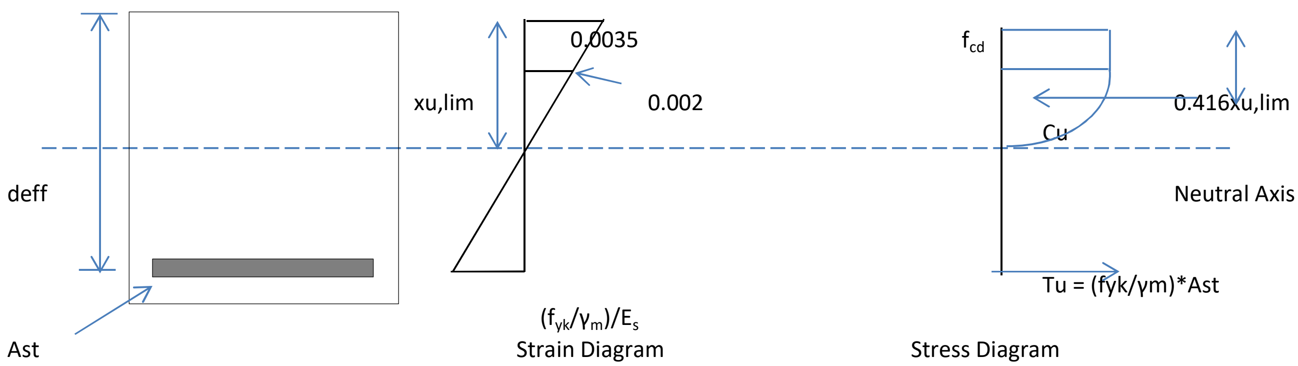
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	91.0		28.0	77		24
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	414		311	511		383
	OK		**OK**	**OK**		**OK**
Ast Req.	967		290	727		223
Dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	150		150	150		150
+ dia of bar (main tension) (mm)	12		12	10		10
Spacing (mm)	150		150	150		150
Ast provided (sq mm)	1508		1508	1047		1047
Dia of bar (main compresion) (mm)	10		10	12		12
Spacing (mm)	150		150	150		150
Area of main compresion (mm^2)	524		524	754		754
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	62.8		83.8	43.6		58.2
x/d	0.192		0.256	0.120		0.160
	OK		**OK**	**OK**		**OK**
z (mm)	306		299	349		344
MR_{sls} (KNm)	139		135	110		108
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	197		62	211		67
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095 z b x_u)$	9.46		2.23	10.12		2.40
	OK		**OK**	**OK**		**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Calculation of crack width	**Bottom End support**			**Top Mid Span**		
n_1			7			7
n_2			7			7
$f_{eq} = (n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1 + n_2 f_2)$			12			10
cl. 12.3.4 (3) of IRC :112-2011						
c			75			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer						
$r_{p.eff} = A_s / A_{c,eff}$			0.007			0.009
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 f) / r_{p.eff} \}$			529			319
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			31000
$a_e = E_s / E_{cm}$			6.45			6.45
$(e_{sm} - e_{cm}) = (s_{sc} - k_t f_{ct,eff}(1 + a_e r_{p,eff}) / r_{p,eff}) / E_s >= 0.6 s_{sc} / E_s$			0.0002			0.0002
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (e_{sm} - e_{cm})$			0.10			0.06
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

5.3.1 Verification of structural strength for outer wall



ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd} = 13.40 N/mm^2 For Basic Combination

f_{cd} = 16.75 N/mm^2 For Accidental Combination

f_{cd} = 13.40 N/mm^2 For Seismic Combination

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 435 N/mm^2 For Basic Combination

f_{Yd} = 500 N/mm^2 For Accidental Combination

f_{Yd} = 435 N/mm^2 For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
xu,$_{lim}$/d	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

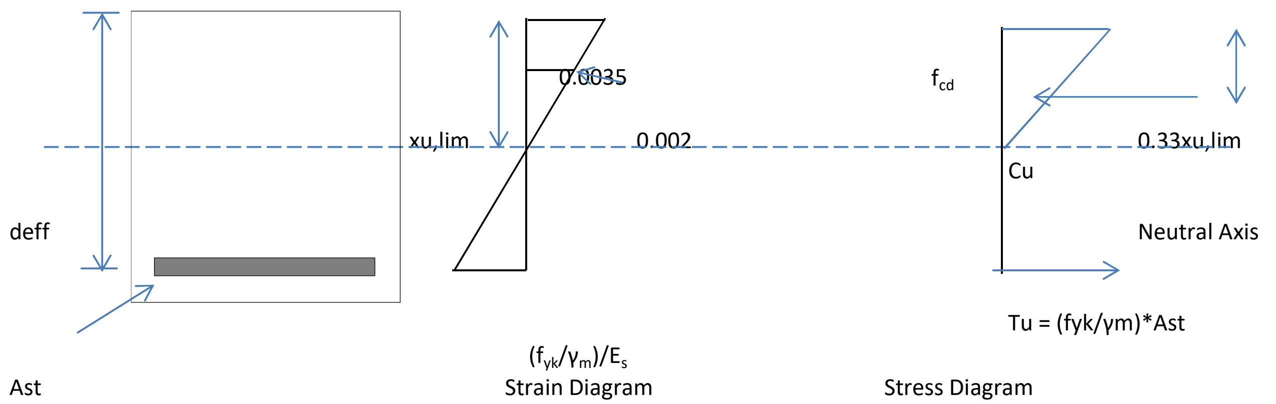
Clear cover = 75

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Moment on the section	**Bottom End support**			**Top End support**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	132.0			83.0		
b	1000			1000		
D	420			420		
c	75			75		
d	327.0			327.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			4.97		
$M_{u,Lim}$ (KNm)	532			532		
	OK			**OK**		
Ast Req.	977			602		
Dia of bar (main tension) (mm)	12			12		
Spacing (mm)	150			150		
+ dia of bar (main tension) (mm)	12			12		
Spacing (mm)	150			150		
Ast provided (sq mm)	1508			1508		
Dia of bar (main compresion) (mm)	10			10		
Spacing (mm)	150			150		
Area of main compresion (mm^2)	524			524		
f_{ctm}	2.5			2.5		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	489			489		
A_{ct}	359558			359558		
$f_{ct,eff}$	2.9			2.9		
$k_c = 0.4\ \{ 1 - s_c / (k_1 f_{ct,eff}\ h/h^*) \} <= 1$	0.4			0.4		
For Bending or bending combined with axial force						
k	0.9160			0.9160		
s_s	435			435		
As.max = 0.025 Ac (main tension)	10500			10500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**			**OK**		
As.max = 0.04 Ac (tension + compresion)	16800			16800		
x (mm)	60			60		
x/d	0.185			0.185		
	OK			**OK**		
z (mm)	302			302		
MR (KNm)	198			198		
	OK			**OK**		

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

5.3.2 Verification for serviceability limit state for outer wall



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	For Rare Combination
	f_{cd}	=	14.40	N/mm^2	For Frequent Combination
	f_{cd}	=	10.80	N/mm^2	For Quasi-Perma. Combination
As per clause 12.2.2, IRC:112-2011					
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	300	N/mm^2	For Rare Combination
	f_{Yd}	=	300	N/mm^2	For Frequent Combination
	f_{Yd}	=	300	N/mm^2	For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011
For steel reinforcement, simplified bilinear diagram is used
Minimum strain in steel reinforcement = 0.87 fy / Es
Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu
= 0.5 *fcd*b*xu
cg of compression block from top = 0.33 xu
Tu = fyd*Ast

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section d	=	420	mm
Clear cover	=	75	

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Moment on the section	**Bottom End support**			**Top End support**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	91.0		20.0	68		26
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	75		75
d	327.0		327.0	327.0		327.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	414		311	414		311
	OK		**OK**	**OK**		**OK**
Ast Req.	967		206	715		269
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	150		150	150		150
+ dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	150		150	150		150
Ast provided (sq mm)	1508		1508	1508		1508
Dia of bar (main compresion) (mm)	10		10	10		10
Spacing (mm)	150		150	150		150
Area of main compresion (mm^2)	524		524	524		524
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	62.8		83.8	62.8		83.8
x/d	0.192		0.256	0.192		0.256
	OK		**OK**	**OK**		**OK**
z (mm)	306		299	306		299
MR_{sls} (KNm)	139		135	139		135
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	197		44	147		58
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095\ z\ b\ x_u)$	9.46		1.59	7.07		2.07
	OK		**OK**	**OK**		**OK**

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Calculation of crack width	**Bottom End support**			**Top End support**		
n_1			7			7
n_2			7			7
$f_{eq} = (n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1 + n_2 f_2)$			12			12
cl. 12.3.4 (3) of IRC :112-2011						
c			75			75
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$r_{p.eff} = A_s / A_{c,eff}$			0.007			0.007
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 f) / r_{p.eff} \}$			529			529
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			29626
$a_e = E_s / E_{cm}$			6.45			6.75
$(e_{sm}-e_{cm})=(s_{sc}-k_t f_{ct,eff}(1+a_e r_{p,eff})/r_{p,eff})/E_s$ $>=0.6 s_{sc}/E_s$			0.0001			0.0002
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (e_{sm} - e_{cm})$			0.07			0.09
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

6.0 Summary of provided Reinforcement

Provided Reinforcement

Top Slab

At top of Mid Span						Required
Area of Steel Provided			=	754.0	mm^2/m	526
12mm dia	@	150mmc/c Top slab (Top main reinforcement)				
At bottom of Mid Span						
Area of Steel Provided			=	1047.2	mm^2/m	
10mm dia	@	150mmc/c Top slab (Bottom main reinforcement)				
10mm dia	@	150mmc/c Top slab (Bottom extra reinforcement)				OK
At top of End Support						
Area of Steel Provided			=	1508.0	mm^2/m	
12mm dia	@	150mmc/c Top slab (Top main reinforcement)				
12mm dia	@	150mmc/c Outer wall (Outer main reinforcement)				OK
0mm dia	@	150mmc/c Top corner extra reinforcement				
At bottom of End Support						
Area of Steel Provided			=	523.6	mm^2/m	
10mm dia	@	150mmc/c Top slab (Bottom main reinforcement)				OK
0mm dia	@	150mmc/c				

Bottom Slab

At top of Mid Span						
Area of Steel Provided			=	1047.2	mm^2/m	
10mm dia	@	150mmc/c Bottom slab (Top main reinforcement)				
10mm dia	@	150mmc/c Bottom slab (Top extra reinforcement)				OK
At bottom of Mid Span						
Area of Steel Provided			=	754.0	mm^2/m	
12mm dia	@	150mmc/c Bottom slab (Bottom main reinforcement)				
0mm dia	@	150mmc/c Bottom slab (Bottom extra reinforcement)				
At top of End Support						
Area of Steel Provided			=	523.6	mm^2/m	
10mm dia	@	150mmc/c Bottom slab (Top main reinforcement)				OK
0mm dia	@	150mmc/c				
At bottom of End Support						
Area of Steel Provided			=	1508.0	mm^2/m	
12mm dia	@	150mmc/c Bottom slab (Bottom main reinforcement)				
12mm dia	@	150mmc/c Outer wall (Outer main reinforcement)				OK
0mm dia	@	150mmc/c Bottom corner extra reinforcement				

	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Outer Wall

At outer face of top end

Area of Steel Provided				=	1508.0	mm^2/m	
12mm dia	@	150mmc/c	Outer wall (Outer main reinforcement)				
12mm dia	@	150mmc/c	Top slab (Top main reinforcement)				OK
0mm dia	@	150mmc/c	Top corner extra reinforcement				

At inner face of top end

Area of Steel Required				=	488.9	mm^2/m	
Area of Steel Provided				=	523.6	mm^2/m	
10mm dia	@	150mmc/c	Outer wall (Inner main reinforcement)				OK

At outer face of bottom end

Area of Steel Provided				=	1508.0	mm^2/m	
12mm dia	@	150mmc/c	Bottom slab (Bottom main reinforcement)				
12mm dia	@	150mmc/c	Outer wall (Outer main reinforcement)				OK
0mm dia	@	150mmc/c	Bottom corner extra reinforcement				

At inner face of bottom end

Area of Steel Provided				=	523.6	mm^2/m
10mm dia	@	150mmc/c	Outer wall (Inner main reinforcement)			

Shear Reinforcement

Bottom Slab

12mm dia	225mmc/c	(Long. Direc	0	185.295	kN
12mm dia	150mmc/c	(Trans. Direction)			

Distribution Reinforcement As per cl. 16.6.1.1 (3) of IRC :112-2011

Top Slab

Req. Reinforcement				=	264	mm^2/m	
Provided Reinforcement				=			
	12mm dia	@	225mmc/c		502.7	mm^2/m	OK

Bottom Slab

Req. Reinforcement				=	271.3	mm^2/m	
Provided Reinforcement				=			
	12mm dia	@	225mmc/c		502.7	mm^2/m	OK

Outer Wall

Req. Reinforcement				=	244.4	mm^2/m	
Provided Reinforcement				=			
	12mm dia	@	225mmc/c		502.7	mm^2/m	OK

7.0 Base Pressure

L/C	Node											Total Wt (KN/m)	Base Pressure (KN/m$^{2)}$
	1	2	5	6	7	8	9	10	11	12	13		
299	12	12	24	24	24	24	24	24	24	25	25	242	63
300	15	15	30	30	30	30	30	30	30	31	31	302	79

Max	**79**
Min.	**63**
	OK

Bearing capacity = 100 KN/sqm

DESIGN OF BRIDGES

AT Des Ch-165+270

Design note
for
RCC BOX OF SIZE 2 x 4.0 x 4.0

Index

1.0 Design Report

The following report represents the design note of RCC BOX of clear span 2 x 4.0 x 4.0

1.1 Introduction:-

Design is presented consistently in SI units; the following apply unless mentioned specifically otherwise:

Length	m
Force	kN
Stress	MPa
Bearing Pressure	kN/m2
Hog Mom/Com Str	-ve
Sag Mom/Ten Str	+ve

1.2 Reference documents :-

1 IRC codes /guidelines/special publications
2 MORTH specification
3 Specialised literature as relevant

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

1 Structure is designed for per metre width.
2 On top slab 50mm thick wearing coat is assumed for SIDL.
3 Deck width taken-16 m
4 Carriageway width- 11 m
5 Modulus of subgrade reaction (Assumed) - 2500 KN/m3
6 Shear value is taken at dist. 0.15m from the face of the slab.
7 In case of load dispersion wearing coat thickness, fill thickness and top slab thickness is considered wherever applicable.
8 In case of design sheet under summary of moments, only magnitude of force has been considered.
9 In case of earth pressure and LL surcharge governing case out of Normal earth pressure, Fluid pressure and Normal earth pressure + hydrostatic fluid pressure is taken.
10 Structure is designed for standard earth pressure without weep holes.

1.4 Loads:-

The different types of loads used as per IRC 6 : 2019 are.

1. Dead load.
2. In SIDL fill, crash barrier, and wearing coat load is considered.
3. Normal Earth pressure with hydrostatic pressure.
4. Live load -70R Track, 40 T Boggie, 70R Wheel load in case of top slab.
5. Live load surcharge.
6. Braking load is taken as 20% of the live load on top slab.
7. 1.25 of Impact factor is considered.
8. Temperature loading for uniform rise and temperature gradient is considered.
9. The Earth pressure coefficient at rest 0.5 is considered.

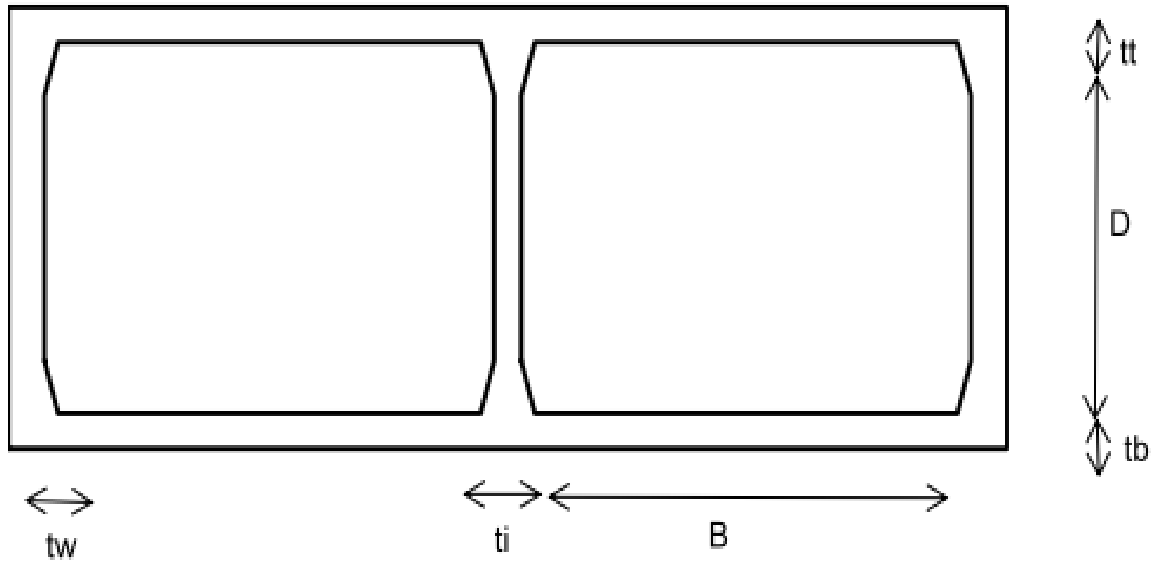
1.5 Load combinations

Load combinations as per IRC 6: 2014 have been considered in staad load combination.

1.6 Material properties

1. Grade of Concrete M30
2. Grade of Steel Fe 500.

MNB (2 Cell 4m wide x 4m height)



2.1 Dimensions of Box

No. of Cell	=	2	Clear Width of cell	=	4.00 m
Top Slab Thick. (tt)	=	0.500 m	Clear Height of Cell	=	4.00 m
Bot. Slab Thick. (tb)	=	0.550 m	C/C Width of structure	=	8.800 m
Side Wall Thick. (tw)	=	0.500 m	C/C Height of structure	=	4.525 m
Int. wall Thickness (ti)	=	0.300 m	Total length of Structure at top =		9.300 m
Total Deck width	=	16.00 m	Total length of Structure at bottom =		9.300 m
Carrriageway Width	=	11.00 m	Total Height of Structure	=	5.05 m
water above bott. Slab	=	2.900 m	Footpath Dimensions	=	0.00 m
			Crash barrier width	=	0.50 m
Wearing coat for SIDL	=	75mm		Height of fill =	0.00 m
Haunch size	=	150mm	x150mm		

SIDL (Top Slab)

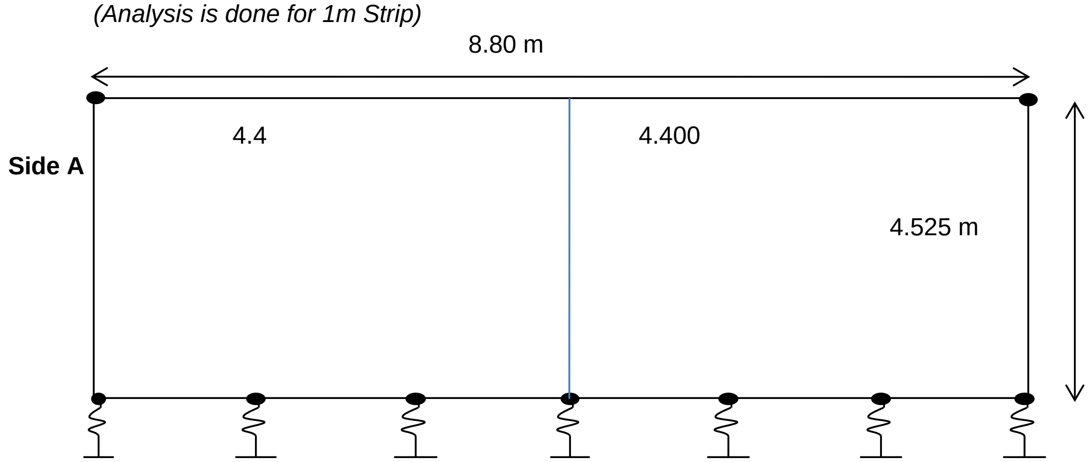
Crash barrier	=		1	kN/m^2
Due to earth fill	=	0 x20 =	0	kN/m^2
			1	kN/m^2
Due to wearing coat	=	0.075 x 22 =	1.65	kN/m^2

2.2 Basic Parameters

Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinϕ) =	=	0.5	
Factor of Earthpressure/Active earthpress	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge	=	1.2	m
Safe Bearing Pressure	=	220	kN/m^2
Fluid Pressure as per cl. 214.1 of IRC 6 2010		4.71	kN/m^2

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



Nos. of beam for one span at bottom	=	10	
Spacing between Springs	=	0.440	m
Modulus of Subgrade Reactiom (Assumed)	=	2500	kN/m^3
Spring Constant at End Support	=	550	kN/m
Spring Constant at intermediate Support	=	1100	kN/m

3.1 Earth Pressure and Live Load Calculation

1) a Earth Pressure (Normal Condition)

Earth Pressure	Height
1.40 kN/m^2	0.250 m
26.64 kN/m^2	4.775 m

1) b Fluid Pressure

Fluid Pressure	Height
1.18 kN/m^2	0.250 m
22.48 kN/m^2	4.775 m

1) c Earth Pressure (Normal Condition+Full hydrostatic pressure)

Earth Pressure	Height
3.20	0.25
61.07	4.775 m

1) d Earth Pressure at rest K_0 = (1-sinϕ) = 0.5

LWL Earth Pressure	HFL Earth Pressure	Height
2.50	3.75	0.250 m
47.75	71.63	4.775 m

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

2) b Live Load Surcharge (Fluid Pressure) as per cl. 214.1 of IRC 6 2014

Live Load Surcharge = 5.651 kN/m

2) c Live Load Surcharge (Normal Condition+Full hydrostatic pressure)

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

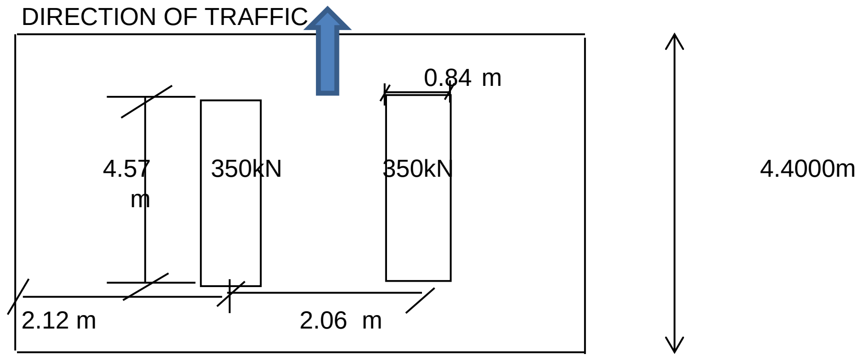
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 29.00 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



Total Load = **700kN**

674.0 KN

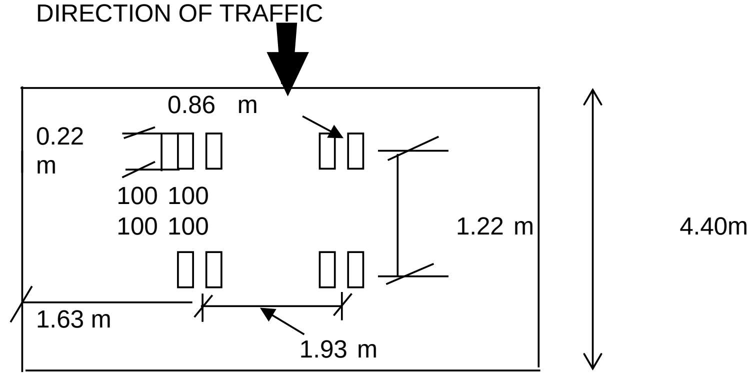
Effective width of Loading

a	=	2.20 m
b1	=	0.99 m
b/lo	=	3.64
α	=	2.60
beff	=	3.85 m

2.06<3.85 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	5.91 m
Width along span	=	4.4 m
Load Intensity	=	25.92 kN/m^2
Increase due to impact	=	32.40 kN/m^2
	Say	**32.40** kN/m^2

B) 40T Boggie Load at Mid Span



Total Load = 400kN

Effective width of Loading

a	=	1.59	m
b1	=	1.01	m
b/lo	=	3.64	
α	=	2.60	
beff	=	3.65	m

1.93<3.65 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	5.58	m
Width along span	=	2.59	m
Load Intensity	=	27.68	kN/m^2
Increase due to impact	=	34.60	kN/m^2
	Say	**34.60**	kN/m^2

C) 40T Boggie Load at Support

Effective width of Loading

a	=	0.61	m
b1	=	1.01	m
b/lo	=	3.64	
α	=	2.60	
beff	=	2.38	m

1.93<2.38 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	4.31	m
Width along span	=	2.015	m
Load Intensity	=	46.06	kN/m^2
Increase due to impact	=	57.58	kN/m^2
	Say	**57.60**	kN/m^2

D) 70R Track at Support

Effective width of Loading

a	=	2.20	m
b1	=	0.99	m
b/lo	=	3.64	
α	=	2.60	
beff	=	3.85	m

2.06<3.85 ***Therefore overlapping due to load dispersion occurs***

Effective width	=	5.91	m
Width along span	=	4.400	m
Load Intensity	=	25.92	kN/m^2
Increase due to impact	=	32.40	kN/m^2
	Say	**32.40**	kN/m^2

E) 70R Track at int side wall

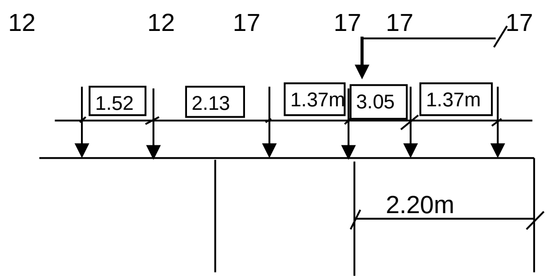
Effective width of Loading

a	1.14	m
b1	0.99	m
b/lo	3.64	
a	2.60	
beff	3.19	m

2.06<3.19 ***Therefore overlapping due to load dispersion occurs***

Effective width	5.25	m
Width along span	4.4	m
Load Intensity	29.18	kN/m^2
Increase due to impact	36.48	kN/m^2
Say	**36.50**	kN/m^2

F) 70R Wheel Case 1

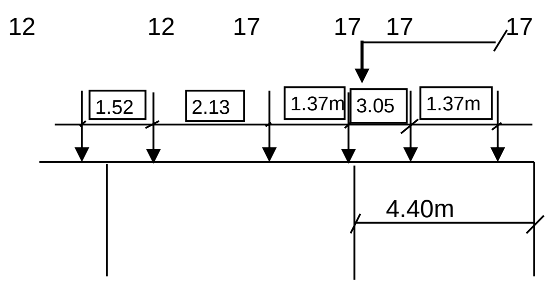


0.86m 1.93m 0.86m

Width along span = 1.370m

S.No.	Load	a	α	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.69m	2.60	2.51m	Yes	4.44m	27.4 kN/sqm	34 kN/sqm
2	166.77	2.06m	2.60	3.86m	Yes	5.79m	21.0 kN/sqm	26 kN/sqm

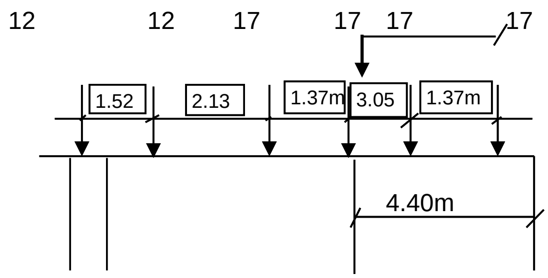
F) 70R Wheel Case 2



Width along span = 1.370m

S.No.	Load	a	α	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	1.515	2.60	3.59m	Yes	5.52m	22.0 kN/sqm	28 kN/sqm
2	166.77	1.515	2.60	3.59m	Yes	5.52m	22.0 kN/sqm	28 kN/sqm

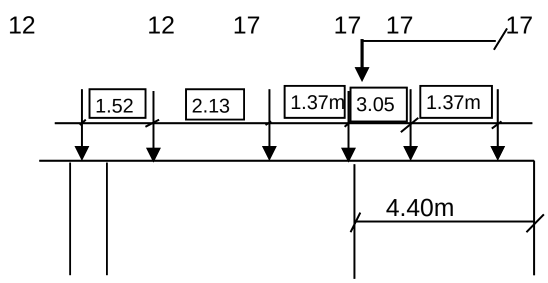
G) 70R Wheel Case 3



Width along span = 1.370m

S.No.	Load	a	α	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.685	2.60	2.51m	Yes	4.44m	27.4 kN/sqm	34 kN/sqm
2	166.77	2.055	2.60	3.86m	Yes	5.79m	21.0 kN/sqm	26 kN/sqm
3	166.77	0.705	2.60	2.55m	Yes	4.48m	27.2 kN/sqm	34 kN/sqm
4	166.77	2.075	2.60	3.86m	Yes	5.79m	21.0 kN/sqm	26 kN/sqm

H) 70R Wheel Case 4



Width along span = 1.370m

S.No.	Load	a	α	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	1.505	2.60	3.58m	Yes	5.51m	22.1 kN/sqm	28 kN/sqm
2	166.77	0.135	2.60	1.35m	No	1.35m	45.1 kN/sqm	56 kN/sqm
3	166.77	1.485	2.60	3.57m	Yes	5.50m	22.1 kN/sqm	28 kN/sqm

G) **Braking load**		20%	Av. Eff. Width	Load per meter
Load on the span 70R Wheel	334 kN	67 kN	5.12m	13 kN/m
Load on the span 70R Track	674 kN	135 kN	5.91m	23 kN/m
Max. force				**23 kN/m**

3.2 Temperature load calculation

Effective Bridge Temperature

Maximum Air Shade temperature	=	47.5	/^{o}C (as per Fig 8 of IRC:6-2014)
Minimum Air Shade temperature	=	0	/^{o}C (as per Fig 9 of IRC:6-2014)
Mean of max and min temperature	=	23.75	/^{o}C (as per clause 215.2 of IRC:6-2014)
Bridge temperature to be assumed	=	33.75	
TEMPERATURE RISE		**33.75**	
TEMPERATURE FALL		**-33.75**	

Effect of temperature gradient

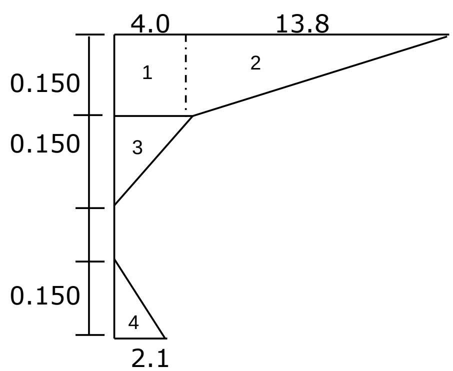
The box has been checked for temperature differential.

F = E_c aDt A

E_c = Modulus of Elasticity of Concrete = 3.21E+06 t/m^2
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)
Dt = Temperature differential
A = X sectional Area of section where temperature differential is Dt

Average thickness of Deck slab = 500 mm

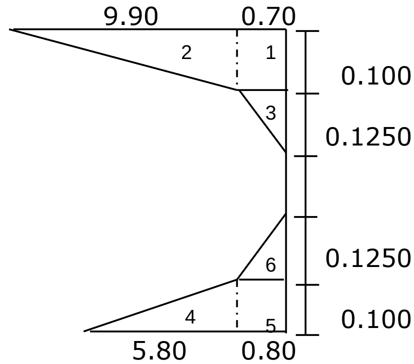
EFFECT OF TEMPERATURE RISE



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	4.0	1.0	0.150	0.150	23.13	0.075 m from top	0.175
2	13.8 / 2	1.0	0.150	0.150	39.91	0.050 m from top	0.200
3	4.0 / 2	1.0	0.150	0.150	11.57	0.200 m from top	0.050
4	2.1 / 2	1.0	0.150	0.150	6.07	0.050 m from bottom	-0.200
				SF =	80.68	M =	11.393

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

EFFECT OF TEMPERATURE FALL



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	0.70	1.0	0.100	0.100	2.70	0.05m from top	0.200
2	$\frac{9.90}{2}$	1.0	0.100	0.100	19.09	0.033m from top	0.217
3	$\frac{0.70}{2}$	1.0	0.1250	0.1250	1.69	0.142m from top	0.108
4	$\frac{5.80}{2}$	1.0	0.100	0.100	11.18	0.033m from bottom	-0.217
5	0.80	1.0	0.100	0.100	3.08	0.050m from bottom	-0.200
6	$\frac{0.80}{2}$	1.0	0.1250	0.1250	1.93	0.142m from bottom	-0.108
				SF =	39.66	M =	1.609

3.3 Staad input file (Without Fluid Pressure)

```
STAAD SPACE
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0
2 0 4.525 0
3 4.4 4.525 0
4 8.8 4.525 0

6 4.4 0 0
7 8.8 0 0

9 0.44 0 0
10 0.88 0 0
11 1.32 0 0
12 1.76 0 0
13 2.2 0 0
14 2.64 0 0
15 3.08 0 0
16 3.52 0 0
17 3.96 0 0
18 4.84 0 0
19 5.28 0 0
20 5.72 0 0
21 6.16 0 0
22 6.6 0 0
23 7.04 0 0
24 7.48 0 0
25 7.92 0 0
26 8.36 0 0
************************************
MEMBER INCIDENCES
1 1 2
2 2 3
3 3 4
6 3 6
7 4 7
8 1 9
9 9 10
10 10 11
11 11 12
12 12 13
13 13 14
14 14 15
15 15 16
16 16 17
17 17 6
18 6 18
19 18 19
20 19 20
21 20 21
22 21 22
23 22 23
24 23 24
25 24 25
26 25 26
27 26 7
```

```
**************************************
DEFINE MATERIAL START
ISOTROPIC CONCRETE1
E 32000000
POISSON 0.17
DENSITY 25
ALPHA 1.17e-005
DAMP 0.05
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
2 3 PRIS YD 0.5 ZD 1
1 7 PRIS YD 0.5 ZD 1
6 PRIS YD 0.3 ZD 1
8 18 PRIS YD 0.55 ZD 1
9 19 PRIS YD 0.55 ZD 1
10 20 PRIS YD 0.55 ZD 1
11 21 PRIS YD 0.55 ZD 1
12 22 PRIS YD 0.55 ZD 1
13 23 PRIS YD 0.55 ZD 1
14 24 PRIS YD 0.55 ZD 1
15 25 PRIS YD 0.55 ZD 1
16 26 PRIS YD 0.55 ZD 1
17 27 PRIS YD 0.55 ZD 1
*****************************************
CONSTANTS
MATERIAL CONCRETE1 ALL
SUPPORTS
1 7 FIXED BUT FZ MX MY MZ KFY 550
9 FIXED BUT FZ MX MY MZ KFY 1100
10 FIXED BUT FZ MX MY MZ KFY 1100
11 FIXED BUT FZ MX MY MZ KFY 1100
12 FIXED BUT FZ MX MY MZ KFY 1100
13 FIXED BUT FZ MX MY MZ KFY 1100
14 FIXED BUT FZ MX MY MZ KFY 1100
15 FIXED BUT FZ MX MY MZ KFY 1100
16 FIXED BUT FZ MX MY MZ KFY 1100
17 FIXED BUT FZ MX MY MZ KFY 1100
6 FIXED BUT FZ MX MY MZ KFY 1100
18 FIXED BUT FZ MX MY MZ KFY 550
19 FIXED BUT FZ MX MY MZ KFY 1100
20 FIXED BUT FZ MX MY MZ KFY 1100
21 FIXED BUT FZ MX MY MZ KFY 1100
22 FIXED BUT FZ MX MY MZ KFY 1100
23 FIXED BUT FZ MX MY MZ KFY 1100
24 FIXED BUT FZ MX MY MZ KFY 1100
25 FIXED BUT FZ MX MY MZ KFY 1100
26 FIXED BUT FZ MX MY MZ KFY 1100
********************************************
***DL***
LOAD 1 DL
SELFWEIGHT Y -1 ALL
***DL HFL CASE***
LOAD 2 DL HFL
SELFWEIGHT Y -1 LIST 2 3
SELFWEIGHT Y -0.85 LIST 1 6 TO 27
***SIDL+ Earth Fill****
LOAD 3 SIDL+ Earth Fill
MEMBER LOAD
```

```
2 3 UNI GY -1
8 TO 17 UNI GY -0
18 TO 27 UNI GY -0
**Surfacing (wearing coat)
LOAD 4 Surfacing (wearing coat)
MEMBER LOAD
2 3 UNI GY -1.65
****ACTIVE EARTH PRESSURE ****
LOAD 5  EARTH PRESSURE FROM RIGHT SIDE
MEMBER LOAD
7 TRAP GX -1.395 -26.645
LOAD 6  EARTH PRESSURE FROM LEFT SIDE
MEMBER LOAD
1 TRAP GX 26.645 1.395
*****LL SURCHARGE *****
LOAD 7 LL SURCHARGE RIGHT SIDE
MEMBER LOAD
7 UNI GX -6.696
LOAD 8 LL SURCHARGE LEFT SIDE
MEMBER LOAD
1 UNI GX 6.696
****ACTIVE EARTH PRESSURE HFL ****
LOAD 9  HFL EARTH PRESSURE FROM RIGHT SIDE
MEMBER LOAD
7 TRAP GX -3.198 -61.072
LOAD 10  HFL EARTH PRESSURE FROM LEFT SIDE
MEMBER LOAD
1 TRAP GX 61.072 3.198
*****HFL LL SURCHARGE *****
LOAD 11 HFL LL SURCHARGE RIGHT SIDE
MEMBER LOAD
7 UNI GX -15.348
LOAD 12 HFL LL SURCHARGE LEFT SIDE
MEMBER LOAD
1 UNI GX 15.348
****EARTH PRESSURE AT REST ****
LOAD 13  EARTH PRESSURE AT REST FROM RIGHT SIDE
MEMBER LOAD
7 TRAP GX -2.5 -47.75
LOAD 14  EARTH PRESSURE AT REST FROM LEFT SIDE
MEMBER LOAD
1 TRAP GX 47.75 2.5
**** HFL EARTH PRESSURE AT REST ****
LOAD 15  HFL EARTH PRESSURE AT REST FROM RIGHT SIDE
MEMBER LOAD
7 TRAP GX -3.75 -71.625
LOAD 16  HFL EARTH PRESSURE AT REST FROM LEFT SIDE
MEMBER LOAD
1 TRAP GX 71.625 3.75
*****LL SURCHARGE AT REST *****
LOAD 17 Wt. of water on bottom slab
MEMBER LOAD
8 TO 17 UNI GY -29
18 TO 27 UNI GY -29
****CLASS 70R (TOP SLAB AT MID SPAN)*******
LOAD 18 CLASS 70R (TOP SLAB AT MID SPAN)
JOINT LOAD
2 FX 22.81
```

```
MEMBER LOAD
2 UNI GY -32.4 0 4.4
******CLASS 40T (TOP SLAB AT MID SPAN)*********
LOAD 19 CLASS 40T (TOP SLAB AT MID SPAN)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -34.6 0.905 3.495
******************
LOAD 20 CLASS 40T AT SUPPORT (TOP SLAB AT SUPP.)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -57.6 0 2.015
*******
*******
*******
*******
*******
*******
******CLASS 70R AT SUPPORT (TOP SLAB AT SUPP.)**
LOAD 21 CLASS 70R AT SUPPORT (TOP SLAB AT SUPP.)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -32.4 0 4.4
****CLASS 70R Wheel Case 1(TOP SLAB AT SUPPORT)*******
LOAD 22 CLASS 70R Wheel Case 1(TOP SLAB AT SUPPORT)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -34.24 0 1.37
2 UNI GY -26.29 1.37 2.74
**
**
**
**
**
****CLASS 70R Wheel Case 2(TOP SLAB AT MID SPAN)*******
LOAD 23 CLASS 70R Wheel Case 2(TOP SLAB AT MID SPAN)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -27.55 0.83 2.2
2 UNI GY -27.55 2.2 3.57
**
**
**
**
**
********************
LOAD 24 CLASS 70R Wheel Case 3(TOP SLAB AT OUTER WALL)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -34.24 0 1.37
2 UNI GY -26.29 1.37 2.74
3 UNI GY -33.97 0.02 1.39
```

3 UNI GY -26.28 1.39 2.76
**
**
**
*******************Temperature Loading*********
*********Uniform increase****
LOAD 25 Temperature Loading (Rise)
TEMPERATURE LOAD
2 3 Temp 33.75
*********Uniform decrease****
LOAD 26 Temperature Loading (fall)
TEMPERATURE LOAD
2 3 Temp 33.75
***********Temperature gradient
LOAD 27 Temperature gradient (Rise)
JOINT LOAD
2 FX -791.46
4 FX 791.46
2 MZ 111.77
4 MZ -111.77
LOAD 28 Temperature gradient (fall)
JOINT LOAD
2 FX 389.11
4 FX -389.11
2 MZ -15.79
4 MZ 15.79
***Partial Safety for Verification of Structural Strength (Basic Combination)**
LOAD COMBINATION 29 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 18 1.15
LOAD COMBINATION 30 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 19 1.15
LOAD COMBINATION 31 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 20 1.15
LOAD COMBINATION 32 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 21 1.15
LOAD COMBINATION 33 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 22 1.15
LOAD COMBINATION 34 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 23 1.15
LOAD COMBINATION 35 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 24 1.15
LOAD COMBINATION 36 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 18 1.5
LOAD COMBINATION 37 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 19 1.5
LOAD COMBINATION 38 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 20 1.5
LOAD COMBINATION 39 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 21 1.5
LOAD COMBINATION 40 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 22 1.5
LOAD COMBINATION 41 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 23 1.5
LOAD COMBINATION 42 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 24 1.5
LOAD COMBINATION 43 BASIC COMBINATION STR. AT REST
1 1.35 3 1.35 4 1.75 13 1.5 14 1.5
***HFL Partial Safety for Verification of Structural Strength (Basic Combination)**

LOAD COMBINATION 44 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 18 1.15
LOAD COMBINATION 45 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 19 1.15
LOAD COMBINATION 46 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 20 1.15
LOAD COMBINATION 47 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 21 1.15
LOAD COMBINATION 48 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 22 1.15
LOAD COMBINATION 49 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 23 1.15
LOAD COMBINATION 50 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 24 1.15
LOAD COMBINATION 51 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 18 1.5
LOAD COMBINATION 52 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 19 1.5
LOAD COMBINATION 53 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 20 1.5
LOAD COMBINATION 54 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 21 1.5
LOAD COMBINATION 55 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 22 1.5
LOAD COMBINATION 56 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 23 1.5
LOAD COMBINATION 57 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 24 1.5
LOAD COMBINATION 58 BASIC COMBINATION STR. AT REST
2 1.35 3 1.35 4 1.75 15 1.5 16 1.5

***Partial Safety for Verification of Serviceability Limit State (Rare Combination)**

LOAD COMBINATION 59 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 18 1 25 0.6 27 0.6
LOAD COMBINATION 60 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 19 1 25 0.6 27 0.6
LOAD COMBINATION 61 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 20 1 25 0.6 27 0.6
LOAD COMBINATION 62 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 21 1 25 0.6 27 0.6
LOAD COMBINATION 63 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 22 1 25 0.6 27 0.6
LOAD COMBINATION 64 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 23 1 25 0.6 27 0.6
LOAD COMBINATION 65 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 24 1 25 0.6 27 0.6
LOAD COMBINATION 66 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 18 1 26 0.6 28 0.6
LOAD COMBINATION 67 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 19 1 26 0.6 28 0.6
LOAD COMBINATION 68 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 20 1 26 0.6 28 0.6
LOAD COMBINATION 69 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 21 1 26 0.6 28 0.6
LOAD COMBINATION 70 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 22 1 26 0.6 28 0.6
LOAD COMBINATION 71 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 23 1 26 0.6 28 0.6
LOAD COMBINATION 72 LL AS LEADING LOAD

1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 24 1 26 0.6 28 0.6
LOAD COMBINATION 73 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 18 0.75 25 1 27 1
LOAD COMBINATION 74 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 19 0.75 25 1 27 1
LOAD COMBINATION 75 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 20 0.75 25 1 27 1
LOAD COMBINATION 76 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 21 0.75 25 1 27 1
LOAD COMBINATION 77 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 22 0.75 25 1 27 1
LOAD COMBINATION 78 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 23 0.75 25 1 27 1
LOAD COMBINATION 79 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 24 0.75 25 1 27 1
LOAD COMBINATION 80 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 18 0.75 26 1 28 1
LOAD COMBINATION 81 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 19 0.75 26 1 28 1
LOAD COMBINATION 82 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 20 0.75 26 1 28 1
LOAD COMBINATION 83 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 21 0.75 26 1 28 1
LOAD COMBINATION 84 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 22 0.75 26 1 28 1
LOAD COMBINATION 85 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 23 0.75 26 1 28 1
LOAD COMBINATION 86 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 24 0.75 26 1 28 1
LOAD COMBINATION 87 THERMAL LOAD AT REST CONDITION
1 1 3 1 4 1 13 1 14 1 25 1 27 1
LOAD COMBINATION 88 THERMAL LOAD AT REST CONDITION
1 1 3 1 4 1 13 1 14 1 26 1 28 1
*** HFL Partial Safety for Verification of Serviceability Limit State (Rare Combination)**
LOAD COMBINATION 89 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 18 1 25 0.6 27 0.6
LOAD COMBINATION 90 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 19 1 25 0.6 27 0.6
LOAD COMBINATION 91 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 20 1 25 0.6 27 0.6
LOAD COMBINATION 92 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 21 1 25 0.6 27 0.6
LOAD COMBINATION 93 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 22 1 25 0.6 27 0.6
LOAD COMBINATION 94 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 23 1 25 0.6 27 0.6
LOAD COMBINATION 95 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 24 1 25 0.6 27 0.6
LOAD COMBINATION 96 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 18 1 26 0.6 28 0.6
LOAD COMBINATION 97 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 19 1 26 0.6 28 0.6
LOAD COMBINATION 98 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 20 1 26 0.6 28 0.6
LOAD COMBINATION 99 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 21 1 26 0.6 28 0.6
LOAD COMBINATION 100 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 22 1 26 0.6 28 0.6

LOAD COMBINATION 101 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 23 1 26 0.6 28 0.6
LOAD COMBINATION 102 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 24 1 26 0.6 28 0.6
LOAD COMBINATION 103 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 18 0.75 25 1 27 1
LOAD COMBINATION 104 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 19 0.75 25 1 27 1
LOAD COMBINATION 105 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 20 0.75 25 1 27 1
LOAD COMBINATION 106 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 21 0.75 25 1 27 1
LOAD COMBINATION 107 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 22 0.75 25 1 27 1
LOAD COMBINATION 108 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 23 0.75 25 1 27 1
LOAD COMBINATION 109 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 24 0.75 25 1 27 1
LOAD COMBINATION 110 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 18 0.75 26 1 28 1
LOAD COMBINATION 111 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 19 0.75 26 1 28 1
LOAD COMBINATION 112 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 20 0.75 26 1 28 1
LOAD COMBINATION 113 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 21 0.75 26 1 28 1
LOAD COMBINATION 114 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 22 0.75 26 1 28 1
LOAD COMBINATION 115 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 23 0.75 26 1 28 1
LOAD COMBINATION 116 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 24 0.75 26 1 28 1
LOAD COMBINATION 117 THERMAL LOAD AT REST CONDITION
2 1 3 1 4 1 15 1 16 1 25 1 27 1
LOAD COMBINATION 118 THERMAL LOAD AT REST CONDITION
2 1 3 1 4 1 15 1 16 1 26 1 28 1

***Partial Safety for Verification of Serviceability Limit State (Frequent Combination)**

LOAD COMBINATION 119 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 18 0.75 25 0.5 27 0.5
LOAD COMBINATION 120 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 19 0.75 25 0.5 27 0.5
LOAD COMBINATION 121 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 20 0.75 25 0.5 27 0.5
LOAD COMBINATION 122 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 21 0.75 25 0.5 27 0.5
LOAD COMBINATION 123 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 22 0.75 25 0.5 27 0.5
LOAD COMBINATION 124 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 23 0.75 25 0.5 27 0.5
LOAD COMBINATION 125 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 24 0.75 25 0.5 27 0.5
LOAD COMBINATION 126 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 18 0.75 26 0.5 28 0.5
LOAD COMBINATION 127 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 19 0.75 26 0.5 28 0.5
LOAD COMBINATION 128 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 20 0.75 26 0.5 28 0.5
LOAD COMBINATION 129 LL AS LEADING LOAD

1 1 3 1 4 1 5 1 6 1 21 0.75 26 0.5 28 0.5
LOAD COMBINATION 130 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 22 0.75 26 0.5 28 0.5
LOAD COMBINATION 131 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 23 0.75 26 0.5 28 0.5
LOAD COMBINATION 132 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 24 0.75 26 0.5 28 0.5
LOAD COMBINATION 133 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 18 0.2 25 0.6 27 0.6
LOAD COMBINATION 134 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 19 0.2 25 0.6 27 0.6
LOAD COMBINATION 135 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 20 0.2 25 0.6 27 0.6
LOAD COMBINATION 136 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 21 0.2 25 0.6 27 0.6
LOAD COMBINATION 137 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 22 0.2 25 0.6 27 0.6
LOAD COMBINATION 138 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 23 0.2 25 0.6 27 0.6
LOAD COMBINATION 139 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 24 0.2 25 0.6 27 0.6
LOAD COMBINATION 140 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 18 0.2 26 0.6 28 0.6
LOAD COMBINATION 141 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 19 0.2 26 0.6 28 0.6
LOAD COMBINATION 142 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 20 0.2 26 0.6 28 0.6
LOAD COMBINATION 143 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 21 0.2 26 0.6 28 0.6
LOAD COMBINATION 144 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 22 0.2 26 0.6 28 0.6
LOAD COMBINATION 145 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 23 0.2 26 0.6 28 0.6
LOAD COMBINATION 146 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 24 0.2 26 0.6 28 0.6
LOAD COMBINATION 147 THERMAL LOAD AT REST CONDITION
1 1 3 1 4 1 13 1 14 1 25 0.6 27 0.6
LOAD COMBINATION 148 THERMAL LOAD AT REST CONDITION
1 1 3 1 4 1 13 1 14 1 26 0.6 28 0.6
*** HFL Partial Safety for Verification of Serviceability Limit State (Frequent Combination)**
LOAD COMBINATION 149 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 18 0.75 25 0.5 27 0.5
LOAD COMBINATION 150 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 19 0.75 25 0.5 27 0.5
LOAD COMBINATION 151 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 20 0.75 25 0.5 27 0.5
LOAD COMBINATION 152 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 21 0.75 25 0.5 27 0.5
LOAD COMBINATION 153 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 22 0.75 25 0.5 27 0.5
LOAD COMBINATION 154 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 23 0.75 25 0.5 27 0.5
LOAD COMBINATION 155 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 24 0.75 25 0.5 27 0.5
LOAD COMBINATION 156 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 18 0.75 26 0.5 28 0.5
LOAD COMBINATION 157 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 19 0.75 26 0.5 28 0.5

LOAD COMBINATION 158 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 20 0.75 26 0.5 28 0.5
LOAD COMBINATION 159 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 21 0.75 26 0.5 28 0.5
LOAD COMBINATION 160 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 22 0.75 26 0.5 28 0.5
LOAD COMBINATION 161 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 23 0.75 26 0.5 28 0.5
LOAD COMBINATION 162 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 24 0.75 26 0.5 28 0.5
LOAD COMBINATION 163 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 18 0.2 25 0.6 27 0.6
LOAD COMBINATION 164 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 19 0.2 25 0.6 27 0.6
LOAD COMBINATION 165 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 20 0.2 25 0.6 27 0.6
LOAD COMBINATION 166 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 21 0.2 25 0.6 27 0.6
LOAD COMBINATION 167 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 22 0.2 25 0.6 27 0.6
LOAD COMBINATION 168 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 23 0.2 25 0.6 27 0.6
LOAD COMBINATION 169 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 24 0.2 25 0.6 27 0.6
LOAD COMBINATION 170 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 18 0.2 26 0.6 28 0.6
LOAD COMBINATION 171 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 19 0.2 26 0.6 28 0.6
LOAD COMBINATION 172 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 20 0.2 26 0.6 28 0.6
LOAD COMBINATION 173 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 21 0.2 26 0.6 28 0.6
LOAD COMBINATION 174 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 22 0.2 26 0.6 28 0.6
LOAD COMBINATION 175 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 23 0.2 26 0.6 28 0.6
LOAD COMBINATION 176 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 24 0.2 26 0.6 28 0.6
LOAD COMBINATION 177 THERMAL LOAD AT REST CONDITION
2 1 3 1 4 1 15 1 16 1 25 0.6 27 0.6
LOAD COMBINATION 178 THERMAL LOAD AT REST CONDITION
2 1 3 1 4 1 15 1 16 1 26 0.6 28 0.6
***Partial Safety for Verification of Serviceability Limit State (Quasi-permanent Combination)**
LOAD COMBINATION 179
1 1 3 1 4 1 13 1 14 1 25 0.5 27 0.5
LOAD COMBINATION 180
1 1 3 1 4 1 13 1 14 1 26 0.5 28 0.5
*** HFL Partial Safety for Verification of Serviceability Limit State (Quasi-permanent Combination)**
LOAD COMBINATION 181
2 1 3 1 4 1 15 1 16 1 25 0.5 27 0.5
LOAD COMBINATION 182
2 1 3 1 4 1 15 1 16 1 26 0.5 28 0.5
***Combination for Base Pressure and Design of Foundation (Combination 1)**
LOAD COMBINATION 183 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 18 1.15 25 0.9 27 0.9
LOAD COMBINATION 184 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 19 1.15 25 0.9 27 0.9
LOAD COMBINATION 185 EARTH PRESSURE AS LEADING LOAD

1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 20 1.15 25 0.9 27 0.9
LOAD COMBINATION 186 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 21 1.15 25 0.9 27 0.9
LOAD COMBINATION 187 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 22 1.15 25 0.9 27 0.9
LOAD COMBINATION 188 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 23 1.15 25 0.9 27 0.9
LOAD COMBINATION 189 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 24 1.15 25 0.9 27 0.9
LOAD COMBINATION 190 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 18 1.15 26 0.9 28 0.9
LOAD COMBINATION 191 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 19 1.15 26 0.9 28 0.9
LOAD COMBINATION 192 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 20 1.15 26 0.9 28 0.9
LOAD COMBINATION 193 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 21 1.15 26 0.9 28 0.9
LOAD COMBINATION 194 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 22 1.15 26 0.9 28 0.9
LOAD COMBINATION 195 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 23 1.15 26 0.9 28 0.9
LOAD COMBINATION 196 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 24 1.15 26 0.9 28 0.9
LOAD COMBINATION 197 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 18 1.5 25 0.9 27 0.9
LOAD COMBINATION 198 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 19 1.5 25 0.9 27 0.9
LOAD COMBINATION 199 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 20 1.5 25 0.9 27 0.9
LOAD COMBINATION 200 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 21 1.5 25 0.9 27 0.9
LOAD COMBINATION 201 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 22 1.5 25 0.9 27 0.9
LOAD COMBINATION 202 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 23 1.5 25 0.9 27 0.9
LOAD COMBINATION 203 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 24 1.5 25 0.9 27 0.9
LOAD COMBINATION 204 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 18 1.5 26 0.9 28 0.9
LOAD COMBINATION 205 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 19 1.5 26 0.9 28 0.9
LOAD COMBINATION 206 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 20 1.5 26 0.9 28 0.9
LOAD COMBINATION 207 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 21 1.5 26 0.9 28 0.9
LOAD COMBINATION 208 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 22 1.5 26 0.9 28 0.9
LOAD COMBINATION 209 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 23 1.5 26 0.9 28 0.9
LOAD COMBINATION 210 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 24 1.5 26 0.9 28 0.9

*** HFL Combination for Base Pressure and Design of Foundation (Combination 1)**

LOAD COMBINATION 211 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 18 1.15 25 0.9 27 0.9
LOAD COMBINATION 212 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 19 1.15 25 0.9 27 0.9
LOAD COMBINATION 213 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 20 1.15 25 0.9 27 0.9

LOAD COMBINATION 214 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 21 1.15 25 0.9 27 0.9
LOAD COMBINATION 215 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 22 1.15 25 0.9 27 0.9
LOAD COMBINATION 216 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 23 1.15 25 0.9 27 0.9
LOAD COMBINATION 217 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 24 1.15 25 0.9 27 0.9
LOAD COMBINATION 218 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 18 1.15 26 0.9 28 0.9
LOAD COMBINATION 219 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 19 1.15 26 0.9 28 0.9
LOAD COMBINATION 220 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 20 1.15 26 0.9 28 0.9
LOAD COMBINATION 221 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 21 1.15 26 0.9 28 0.9
LOAD COMBINATION 222 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 22 1.15 26 0.9 28 0.9
LOAD COMBINATION 223 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 23 1.15 26 0.9 28 0.9
LOAD COMBINATION 224 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 24 1.15 26 0.9 28 0.9
LOAD COMBINATION 225 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 18 1.5 25 0.9 27 0.9
LOAD COMBINATION 226 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 19 1.5 25 0.9 27 0.9
LOAD COMBINATION 227 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 20 1.5 25 0.9 27 0.9
LOAD COMBINATION 228 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 21 1.5 25 0.9 27 0.9
LOAD COMBINATION 229 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 22 1.5 25 0.9 27 0.9
LOAD COMBINATION 230 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 23 1.5 25 0.9 27 0.9
LOAD COMBINATION 231 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 24 1.5 25 0.9 27 0.9
LOAD COMBINATION 232 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 18 1.5 26 0.9 28 0.9
LOAD COMBINATION 233 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 19 1.5 26 0.9 28 0.9
LOAD COMBINATION 234 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 20 1.5 26 0.9 28 0.9
LOAD COMBINATION 235 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 21 1.5 26 0.9 28 0.9
LOAD COMBINATION 236 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 22 1.5 26 0.9 28 0.9
LOAD COMBINATION 237 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 23 1.5 26 0.9 28 0.9
LOAD COMBINATION 238 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 24 1.5 26 0.9 28 0.9

***Combination for Base Pressure and Design of Foundation (Combination 2)**

LOAD COMBINATION 239 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 18 1 25 0.8 27 0.8
LOAD COMBINATION 240 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 19 1 25 0.8 27 0.8
LOAD COMBINATION 241 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 20 1 25 0.8 27 0.8
LOAD COMBINATION 242 EARTH PRESSURE AS LEADING LOAD

1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 21 1 25 0.8 27 0.8
LOAD COMBINATION 243 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 22 1 25 0.8 27 0.8
LOAD COMBINATION 244 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 23 1 25 0.8 27 0.8
LOAD COMBINATION 245 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 24 1 25 0.8 27 0.8
LOAD COMBINATION 246 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 18 1 26 0.8 28 0.8
LOAD COMBINATION 247 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 19 1 26 0.8 28 0.8
LOAD COMBINATION 248 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 20 1 26 0.8 28 0.8
LOAD COMBINATION 249 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 21 1 26 0.8 28 0.8
LOAD COMBINATION 250 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 22 1 26 0.8 28 0.8
LOAD COMBINATION 251 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 23 1 26 0.8 28 0.8
LOAD COMBINATION 252 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 24 1 26 0.8 28 0.8
LOAD COMBINATION 253 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 18 1.3 25 0.8 27 0.8
LOAD COMBINATION 254 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 19 1.3 25 0.8 27 0.8
LOAD COMBINATION 255 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 20 1.3 25 0.8 27 0.8
LOAD COMBINATION 256 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 21 1.3 25 0.8 27 0.8
LOAD COMBINATION 257 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 22 1.3 25 0.8 27 0.8
LOAD COMBINATION 258 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 23 1.3 25 0.8 27 0.8
LOAD COMBINATION 259 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 24 1.3 25 0.8 27 0.8
LOAD COMBINATION 260 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 18 1.3 26 0.8 28 0.8
LOAD COMBINATION 261 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 19 1.3 26 0.8 28 0.8
LOAD COMBINATION 262 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 20 1.3 26 0.8 28 0.8
LOAD COMBINATION 263 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 21 1.3 26 0.8 28 0.8
LOAD COMBINATION 264 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 22 1.3 26 0.8 28 0.8
LOAD COMBINATION 265 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 23 1.3 26 0.8 28 0.8
LOAD COMBINATION 266 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 24 1.3 26 0.8 28 0.8
*** HFL Combination for Base Pressure and Design of Foundation (Combination 2)**
LOAD COMBINATION 267 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 18 1 25 0.8 27 0.8
LOAD COMBINATION 268 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 19 1 25 0.8 27 0.8
LOAD COMBINATION 269 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 20 1 25 0.8 27 0.8
LOAD COMBINATION 270 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 21 1 25 0.8 27 0.8

LOAD COMBINATION 271 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 22 1 25 0.8 27 0.8
LOAD COMBINATION 272 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 23 1 25 0.8 27 0.8
LOAD COMBINATION 273 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 24 1 25 0.8 27 0.8
LOAD COMBINATION 274 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 18 1 26 0.8 28 0.8
LOAD COMBINATION 275 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 19 1 26 0.8 28 0.8
LOAD COMBINATION 276 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 20 1 26 0.8 28 0.8
LOAD COMBINATION 277 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 21 1 26 0.8 28 0.8
LOAD COMBINATION 278 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 22 1 26 0.8 28 0.8
LOAD COMBINATION 279 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 23 1 26 0.8 28 0.8
LOAD COMBINATION 280 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 24 1 26 0.8 28 0.8
LOAD COMBINATION 281 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 18 1.3 25 0.8 27 0.8
LOAD COMBINATION 282 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 19 1.3 25 0.8 27 0.8
LOAD COMBINATION 283 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 20 1.3 25 0.8 27 0.8
LOAD COMBINATION 284 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 21 1.3 25 0.8 27 0.8
LOAD COMBINATION 285 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 22 1.3 25 0.8 27 0.8
LOAD COMBINATION 286 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 23 1.3 25 0.8 27 0.8
LOAD COMBINATION 287 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 24 1.3 25 0.8 27 0.8
LOAD COMBINATION 288 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 18 1.3 26 0.8 28 0.8
LOAD COMBINATION 289 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 19 1.3 26 0.8 28 0.8
LOAD COMBINATION 290 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 20 1.3 26 0.8 28 0.8
LOAD COMBINATION 291 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 21 1.3 26 0.8 28 0.8
LOAD COMBINATION 292 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 22 1.3 26 0.8 28 0.8
LOAD COMBINATION 293 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 23 1.3 26 0.8 28 0.8
LOAD COMBINATION 294 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 24 1.3 26 0.8 28 0.8
** For base pressure check only
LOAD COMBINATION 295 BASE PRESSURE CHECK FOR LWL CONDITION
1 1 3 1 4 1 5 1 6 1 7 1 8 1 24 1
LOAD COMBINATION 296 BASE PRESSURE CHECK FOR HFL CONDITION
2 1 3 1 4 1 5 1 6 1 7 1 8 1 24 1 17 1
PERFORM ANALYSIS
FINISH

3.3 Staad input file (With Fluid Pressure)

```
STAAD SPACE
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0
2 0 4.525 0
3 4.4 4.525 0
4 8.8 4.525 0

6 4.4 0 0
7 8.8 0 0

9 0.44 0 0
10 0.88 0 0
11 1.32 0 0
12 1.76 0 0
13 2.2 0 0
14 2.64 0 0
15 3.08 0 0
16 3.52 0 0
17 3.96 0 0
18 4.84 0 0
19 5.28 0 0
20 5.72 0 0
21 6.16 0 0
22 6.6 0 0
23 7.04 0 0
24 7.48 0 0
25 7.92 0 0
26 8.36 0 0
************************************
MEMBER INCIDENCES
1 1 2
2 2 3
3 3 4
6 3 6
7 4 7
8 1 9
9 9 10
10 10 11
11 11 12
12 12 13
13 13 14
14 14 15
15 15 16
16 16 17
17 17 6
18 6 18
19 18 19
20 19 20
21 20 21
22 21 22
23 22 23
24 23 24
25 24 25
26 25 26
27 26 7
```

```
**************************************
DEFINE MATERIAL START
ISOTROPIC CONCRETE1
E 32000000
POISSON 0.17
DENSITY 25
ALPHA 1.17e-005
DAMP 0.05
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
2 3 PRIS YD 0.5 ZD 1
1 7 PRIS YD 0.5 ZD 1
6 PRIS YD 0.3 ZD 1
8 18 PRIS YD 0.55 ZD 1
9 19 PRIS YD 0.55 ZD 1
10 20 PRIS YD 0.55 ZD 1
11 21 PRIS YD 0.55 ZD 1
12 22 PRIS YD 0.55 ZD 1
13 23 PRIS YD 0.55 ZD 1
14 24 PRIS YD 0.55 ZD 1
15 25 PRIS YD 0.55 ZD 1
16 26 PRIS YD 0.55 ZD 1
17 27 PRIS YD 0.55 ZD 1
*****************************************
CONSTANTS
MATERIAL CONCRETE1 ALL
SUPPORTS
1 7 FIXED BUT FZ MX MY MZ KFY 550
9 FIXED BUT FZ MX MY MZ KFY 1100
10 FIXED BUT FZ MX MY MZ KFY 1100
11 FIXED BUT FZ MX MY MZ KFY 1100
12 FIXED BUT FZ MX MY MZ KFY 1100
13 FIXED BUT FZ MX MY MZ KFY 1100
14 FIXED BUT FZ MX MY MZ KFY 1100
15 FIXED BUT FZ MX MY MZ KFY 1100
16 FIXED BUT FZ MX MY MZ KFY 1100
17 FIXED BUT FZ MX MY MZ KFY 1100
6 FIXED BUT FZ MX MY MZ KFY 1100
18 FIXED BUT FZ MX MY MZ KFY 550
19 FIXED BUT FZ MX MY MZ KFY 1100
20 FIXED BUT FZ MX MY MZ KFY 1100
21 FIXED BUT FZ MX MY MZ KFY 1100
22 FIXED BUT FZ MX MY MZ KFY 1100
23 FIXED BUT FZ MX MY MZ KFY 1100
24 FIXED BUT FZ MX MY MZ KFY 1100
25 FIXED BUT FZ MX MY MZ KFY 1100
26 FIXED BUT FZ MX MY MZ KFY 1100
********************************************
***DL***
LOAD 1 DL
SELFWEIGHT Y -1 ALL
***DL HFL CASE***
LOAD 2 DL HFL
SELFWEIGHT Y -1 LIST 2 3
SELFWEIGHT Y -0.85 LIST 1 6 TO 27
***SIDL+ Earth Fill****
LOAD 3 SIDL+ Earth Fill
MEMBER LOAD
```

2 3 UNI GY -1
8 TO 17 UNI GY -0
18 TO 27 UNI GY -0
**Surfacing (wearing coat)
LOAD 4 Surfacing (wearing coat)
MEMBER LOAD
2 3 UNI GY -1.65
****FLUID PRESSURE ****
LOAD 5 FLUID PRESSURE FROM RIGHT SIDE
MEMBER LOAD
7 TRAP GX -1.177 -22.485
LOAD 6 FLUID PRESSURE FROM LEFT SIDE
MEMBER LOAD
1 TRAP GX 22.485 1.177
*****LL SURCHARGE *****
LOAD 7 LL SURCHARGE RIGHT SIDE
MEMBER LOAD
7 UNI GX -5.651
LOAD 8 LL SURCHARGE LEFT SIDE
MEMBER LOAD
1 UNI GX 5.651
****ACTIVE EARTH PRESSURE HFL ****
LOAD 9 HFL EARTH PRESSURE FROM RIGHT SIDE
MEMBER LOAD
7 TRAP GX -3.198 -61.072
LOAD 10 HFL EARTH PRESSURE FROM LEFT SIDE
MEMBER LOAD
1 TRAP GX 61.072 3.198
*****HFL LL SURCHARGE *****
LOAD 11 HFL LL SURCHARGE RIGHT SIDE
MEMBER LOAD
7 UNI GX -15.348
LOAD 12 HFL LL SURCHARGE LEFT SIDE
MEMBER LOAD
1 UNI GX 15.348
****EARTH PRESSURE AT REST ****
LOAD 13 EARTH PRESSURE AT REST FROM RIGHT SIDE
MEMBER LOAD
7 TRAP GX -2.5 -47.75
LOAD 14 EARTH PRESSURE AT REST FROM LEFT SIDE
MEMBER LOAD
1 TRAP GX 47.75 2.5
**** HFL EARTH PRESSURE AT REST ****
LOAD 15 HFL EARTH PRESSURE AT REST FROM RIGHT SIDE
MEMBER LOAD
7 TRAP GX -3.75 -71.625
LOAD 16 HFL EARTH PRESSURE AT REST FROM LEFT SIDE
MEMBER LOAD
1 TRAP GX 71.625 3.75
*****LL SURCHARGE AT REST *****
LOAD 17 Wt. of water on bottom slab
MEMBER LOAD
8 TO 17 UNI GY -29
18 TO 27 UNI GY -29
****CLASS 70R (TOP SLAB AT MID SPAN)*******
LOAD 18 CLASS 70R (TOP SLAB AT MID SPAN)
JOINT LOAD
2 FX 22.81

```
MEMBER LOAD
2 UNI GY -32.4 0 4.4
******CLASS 40T (TOP SLAB AT MID SPAN)*********
LOAD 19 CLASS 40T (TOP SLAB AT MID SPAN)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -34.6 0.905 3.495
******************
LOAD 20 CLASS 40T AT SUPPORT (TOP SLAB AT SUPP.)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -57.6 0 2.015
*******
*******
*******
*******
*******
*******
******CLASS 70R AT SUPPORT (TOP SLAB AT SUPP.)**
LOAD 21 CLASS 70R AT SUPPORT (TOP SLAB AT SUPP.)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -32.4 0 4.4
****CLASS 70R Wheel Case 1(TOP SLAB AT SUPPORT)*******
LOAD 22 CLASS 70R Wheel Case 1(TOP SLAB AT SUPPORT)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -34.24 0 1.37
2 UNI GY -26.29 1.37 2.74
**
**
**
**
**
****CLASS 70R Wheel Case 2(TOP SLAB AT MID SPAN)*******
LOAD 23 CLASS 70R Wheel Case 2(TOP SLAB AT MID SPAN)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -27.55 0.83 2.2
2 UNI GY -27.55 2.2 3.57
**
**
**
**
**
********************
LOAD 24 CLASS 70R Wheel Case 3(TOP SLAB AT OUTER WALL)
JOINT LOAD
2 FX 22.81
MEMBER LOAD
2 UNI GY -34.24 0 1.37
2 UNI GY -26.29 1.37 2.74
3 UNI GY -33.97 0.02 1.39
```

3 UNI GY -26.28 1.39 2.76
**
**
**
*******************Temperature Loading*********
*********Uniform increase****
LOAD 25 Temperature Loading (Rise)
TEMPERATURE LOAD
2 3 Temp 33.75
*********Uniform decrease****
LOAD 26 Temperature Loading (fall)
TEMPERATURE LOAD
2 3 Temp 33.75
***********Temperature gradient
LOAD 27 Temperature gradient (Rise)
JOINT LOAD
2 FX -791.46
4 FX 791.46
2 MZ 111.77
4 MZ -111.77
LOAD 28 Temperature gradient (fall)
JOINT LOAD
2 FX 389.11
4 FX -389.11
2 MZ -15.79
4 MZ 15.79
***Partial Safety for Verification of Structural Strength (Basic Combination)**
LOAD COMBINATION 29 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 18 1.15
LOAD COMBINATION 30 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 19 1.15
LOAD COMBINATION 31 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 20 1.15
LOAD COMBINATION 32 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 21 1.15
LOAD COMBINATION 33 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 22 1.15
LOAD COMBINATION 34 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 23 1.15
LOAD COMBINATION 35 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 24 1.15
LOAD COMBINATION 36 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 18 1.5
LOAD COMBINATION 37 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 19 1.5
LOAD COMBINATION 38 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 20 1.5
LOAD COMBINATION 39 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 21 1.5
LOAD COMBINATION 40 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 22 1.5
LOAD COMBINATION 41 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 23 1.5
LOAD COMBINATION 42 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 24 1.5
LOAD COMBINATION 43 BASIC COMBINATION STR. AT REST
1 1.35 3 1.35 4 1.75 13 1.5 14 1.5
***HFL Partial Safety for Verification of Structural Strength (Basic Combination)**

LOAD COMBINATION 44 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 18 1.15
LOAD COMBINATION 45 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 19 1.15
LOAD COMBINATION 46 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 20 1.15
LOAD COMBINATION 47 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 21 1.15
LOAD COMBINATION 48 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 22 1.15
LOAD COMBINATION 49 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 23 1.15
LOAD COMBINATION 50 BASIC COMBINATION EARTH PRESSURE AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 24 1.15
LOAD COMBINATION 51 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 18 1.5
LOAD COMBINATION 52 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 19 1.5
LOAD COMBINATION 53 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 20 1.5
LOAD COMBINATION 54 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 21 1.5
LOAD COMBINATION 55 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 22 1.5
LOAD COMBINATION 56 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 23 1.5
LOAD COMBINATION 57 BASIC COMBINATION LIVE LOAD AS A LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 24 1.5
LOAD COMBINATION 58 BASIC COMBINATION STR. AT REST
2 1.35 3 1.35 4 1.75 15 1.5 16 1.5

***Partial Safety for Verification of Serviceability Limit State (Rare Combination)**

LOAD COMBINATION 59 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 18 1 25 0.6 27 0.6
LOAD COMBINATION 60 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 19 1 25 0.6 27 0.6
LOAD COMBINATION 61 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 20 1 25 0.6 27 0.6
LOAD COMBINATION 62 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 21 1 25 0.6 27 0.6
LOAD COMBINATION 63 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 22 1 25 0.6 27 0.6
LOAD COMBINATION 64 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 23 1 25 0.6 27 0.6
LOAD COMBINATION 65 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 24 1 25 0.6 27 0.6
LOAD COMBINATION 66 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 18 1 26 0.6 28 0.6
LOAD COMBINATION 67 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 19 1 26 0.6 28 0.6
LOAD COMBINATION 68 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 20 1 26 0.6 28 0.6
LOAD COMBINATION 69 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 21 1 26 0.6 28 0.6
LOAD COMBINATION 70 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 22 1 26 0.6 28 0.6
LOAD COMBINATION 71 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 23 1 26 0.6 28 0.6
LOAD COMBINATION 72 LL AS LEADING LOAD

1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 24 1 26 0.6 28 0.6
LOAD COMBINATION 73 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 18 0.75 25 1 27 1
LOAD COMBINATION 74 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 19 0.75 25 1 27 1
LOAD COMBINATION 75 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 20 0.75 25 1 27 1
LOAD COMBINATION 76 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 21 0.75 25 1 27 1
LOAD COMBINATION 77 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 22 0.75 25 1 27 1
LOAD COMBINATION 78 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 23 0.75 25 1 27 1
LOAD COMBINATION 79 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 24 0.75 25 1 27 1
LOAD COMBINATION 80 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 18 0.75 26 1 28 1
LOAD COMBINATION 81 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 19 0.75 26 1 28 1
LOAD COMBINATION 82 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 20 0.75 26 1 28 1
LOAD COMBINATION 83 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 21 0.75 26 1 28 1
LOAD COMBINATION 84 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 22 0.75 26 1 28 1
LOAD COMBINATION 85 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 23 0.75 26 1 28 1
LOAD COMBINATION 86 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 7 0.8 8 0.8 24 0.75 26 1 28 1
LOAD COMBINATION 87 THERMAL LOAD AT REST CONDITION
1 1 3 1 4 1 13 1 14 1 25 1 27 1
LOAD COMBINATION 88 THERMAL LOAD AT REST CONDITION
1 1 3 1 4 1 13 1 14 1 26 1 28 1
*** HFL Partial Safety for Verification of Serviceability Limit State (Rare Combination)**
LOAD COMBINATION 89 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 18 1 25 0.6 27 0.6
LOAD COMBINATION 90 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 19 1 25 0.6 27 0.6
LOAD COMBINATION 91 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 20 1 25 0.6 27 0.6
LOAD COMBINATION 92 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 21 1 25 0.6 27 0.6
LOAD COMBINATION 93 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 22 1 25 0.6 27 0.6
LOAD COMBINATION 94 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 23 1 25 0.6 27 0.6
LOAD COMBINATION 95 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 24 1 25 0.6 27 0.6
LOAD COMBINATION 96 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 18 1 26 0.6 28 0.6
LOAD COMBINATION 97 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 19 1 26 0.6 28 0.6
LOAD COMBINATION 98 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 20 1 26 0.6 28 0.6
LOAD COMBINATION 99 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 21 1 26 0.6 28 0.6
LOAD COMBINATION 100 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 22 1 26 0.6 28 0.6

LOAD COMBINATION 101 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 23 1 26 0.6 28 0.6
LOAD COMBINATION 102 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 24 1 26 0.6 28 0.6
LOAD COMBINATION 103 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 18 0.75 25 1 27 1
LOAD COMBINATION 104 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 19 0.75 25 1 27 1
LOAD COMBINATION 105 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 20 0.75 25 1 27 1
LOAD COMBINATION 106 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 21 0.75 25 1 27 1
LOAD COMBINATION 107 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 22 0.75 25 1 27 1
LOAD COMBINATION 108 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 23 0.75 25 1 27 1
LOAD COMBINATION 109 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 24 0.75 25 1 27 1
LOAD COMBINATION 110 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 18 0.75 26 1 28 1
LOAD COMBINATION 111 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 19 0.75 26 1 28 1
LOAD COMBINATION 112 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 20 0.75 26 1 28 1
LOAD COMBINATION 113 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 21 0.75 26 1 28 1
LOAD COMBINATION 114 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 22 0.75 26 1 28 1
LOAD COMBINATION 115 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 23 0.75 26 1 28 1
LOAD COMBINATION 116 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 11 0.8 12 0.8 17 1 24 0.75 26 1 28 1
LOAD COMBINATION 117 THERMAL LOAD AT REST CONDITION
2 1 3 1 4 1 15 1 16 1 25 1 27 1
LOAD COMBINATION 118 THERMAL LOAD AT REST CONDITION
2 1 3 1 4 1 15 1 16 1 26 1 28 1
***Partial Safety for Verification of Serviceability Limit State (Frequent Combination)**
LOAD COMBINATION 119 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 18 0.75 25 0.5 27 0.5
LOAD COMBINATION 120 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 19 0.75 25 0.5 27 0.5
LOAD COMBINATION 121 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 20 0.75 25 0.5 27 0.5
LOAD COMBINATION 122 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 21 0.75 25 0.5 27 0.5
LOAD COMBINATION 123 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 22 0.75 25 0.5 27 0.5
LOAD COMBINATION 124 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 23 0.75 25 0.5 27 0.5
LOAD COMBINATION 125 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 24 0.75 25 0.5 27 0.5
LOAD COMBINATION 126 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 18 0.75 26 0.5 28 0.5
LOAD COMBINATION 127 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 19 0.75 26 0.5 28 0.5
LOAD COMBINATION 128 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 20 0.75 26 0.5 28 0.5
LOAD COMBINATION 129 LL AS LEADING LOAD

1 1 3 1 4 1 5 1 6 1 21 0.75 26 0.5 28 0.5
LOAD COMBINATION 130 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 22 0.75 26 0.5 28 0.5
LOAD COMBINATION 131 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 23 0.75 26 0.5 28 0.5
LOAD COMBINATION 132 LL AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 24 0.75 26 0.5 28 0.5
LOAD COMBINATION 133 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 18 0.2 25 0.6 27 0.6
LOAD COMBINATION 134 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 19 0.2 25 0.6 27 0.6
LOAD COMBINATION 135 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 20 0.2 25 0.6 27 0.6
LOAD COMBINATION 136 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 21 0.2 25 0.6 27 0.6
LOAD COMBINATION 137 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 22 0.2 25 0.6 27 0.6
LOAD COMBINATION 138 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 23 0.2 25 0.6 27 0.6
LOAD COMBINATION 139 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 24 0.2 25 0.6 27 0.6
LOAD COMBINATION 140 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 18 0.2 26 0.6 28 0.6
LOAD COMBINATION 141 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 19 0.2 26 0.6 28 0.6
LOAD COMBINATION 142 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 20 0.2 26 0.6 28 0.6
LOAD COMBINATION 143 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 21 0.2 26 0.6 28 0.6
LOAD COMBINATION 144 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 22 0.2 26 0.6 28 0.6
LOAD COMBINATION 145 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 23 0.2 26 0.6 28 0.6
LOAD COMBINATION 146 THERMAL LOAD AS LEADING LOAD
1 1 3 1 4 1 5 1 6 1 24 0.2 26 0.6 28 0.6
LOAD COMBINATION 147 THERMAL LOAD AT REST CONDITION
1 1 3 1 4 1 13 1 14 1 25 0.6 27 0.6
LOAD COMBINATION 148 THERMAL LOAD AT REST CONDITION
1 1 3 1 4 1 13 1 14 1 26 0.6 28 0.6

*** HFL Partial Safety for Verification of Serviceability Limit State (Frequent Combination)**

LOAD COMBINATION 149 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 18 0.75 25 0.5 27 0.5
LOAD COMBINATION 150 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 19 0.75 25 0.5 27 0.5
LOAD COMBINATION 151 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 20 0.75 25 0.5 27 0.5
LOAD COMBINATION 152 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 21 0.75 25 0.5 27 0.5
LOAD COMBINATION 153 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 22 0.75 25 0.5 27 0.5
LOAD COMBINATION 154 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 23 0.75 25 0.5 27 0.5
LOAD COMBINATION 155 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 24 0.75 25 0.5 27 0.5
LOAD COMBINATION 156 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 18 0.75 26 0.5 28 0.5
LOAD COMBINATION 157 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 19 0.75 26 0.5 28 0.5

LOAD COMBINATION 158 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 20 0.75 26 0.5 28 0.5
LOAD COMBINATION 159 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 21 0.75 26 0.5 28 0.5
LOAD COMBINATION 160 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 22 0.75 26 0.5 28 0.5
LOAD COMBINATION 161 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 23 0.75 26 0.5 28 0.5
LOAD COMBINATION 162 LL AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 24 0.75 26 0.5 28 0.5
LOAD COMBINATION 163 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 18 0.2 25 0.6 27 0.6
LOAD COMBINATION 164 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 19 0.2 25 0.6 27 0.6
LOAD COMBINATION 165 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 20 0.2 25 0.6 27 0.6
LOAD COMBINATION 166 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 21 0.2 25 0.6 27 0.6
LOAD COMBINATION 167 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 22 0.2 25 0.6 27 0.6
LOAD COMBINATION 168 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 23 0.2 25 0.6 27 0.6
LOAD COMBINATION 169 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 24 0.2 25 0.6 27 0.6
LOAD COMBINATION 170 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 18 0.2 26 0.6 28 0.6
LOAD COMBINATION 171 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 19 0.2 26 0.6 28 0.6
LOAD COMBINATION 172 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 20 0.2 26 0.6 28 0.6
LOAD COMBINATION 173 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 21 0.2 26 0.6 28 0.6
LOAD COMBINATION 174 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 22 0.2 26 0.6 28 0.6
LOAD COMBINATION 175 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 23 0.2 26 0.6 28 0.6
LOAD COMBINATION 176 THERMAL LOAD AS LEADING LOAD
2 1 3 1 4 1 9 1 10 1 17 1 24 0.2 26 0.6 28 0.6
LOAD COMBINATION 177 THERMAL LOAD AT REST CONDITION
2 1 3 1 4 1 15 1 16 1 25 0.6 27 0.6
LOAD COMBINATION 178 THERMAL LOAD AT REST CONDITION
2 1 3 1 4 1 15 1 16 1 26 0.6 28 0.6
***Partial Safety for Verification of Serviceability Limit State (Quasi-permanent Combination)**
LOAD COMBINATION 179
1 1 3 1 4 1 13 1 14 1 25 0.5 27 0.5
LOAD COMBINATION 180
1 1 3 1 4 1 13 1 14 1 26 0.5 28 0.5
*** HFL Partial Safety for Verification of Serviceability Limit State (Quasi-permanent Combination)**
LOAD COMBINATION 181
2 1 3 1 4 1 15 1 16 1 25 0.5 27 0.5
LOAD COMBINATION 182
2 1 3 1 4 1 15 1 16 1 26 0.5 28 0.5
***Combination for Base Pressure and Design of Foundation (Combination 1)**
LOAD COMBINATION 183 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 18 1.15 25 0.9 27 0.9
LOAD COMBINATION 184 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 19 1.15 25 0.9 27 0.9
LOAD COMBINATION 185 EARTH PRESSURE AS LEADING LOAD

1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 20 1.15 25 0.9 27 0.9
LOAD COMBINATION 186 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 21 1.15 25 0.9 27 0.9
LOAD COMBINATION 187 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 22 1.15 25 0.9 27 0.9
LOAD COMBINATION 188 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 23 1.15 25 0.9 27 0.9
LOAD COMBINATION 189 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 24 1.15 25 0.9 27 0.9
LOAD COMBINATION 190 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 18 1.15 26 0.9 28 0.9
LOAD COMBINATION 191 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 19 1.15 26 0.9 28 0.9
LOAD COMBINATION 192 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 20 1.15 26 0.9 28 0.9
LOAD COMBINATION 193 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 21 1.15 26 0.9 28 0.9
LOAD COMBINATION 194 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 22 1.15 26 0.9 28 0.9
LOAD COMBINATION 195 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 23 1.15 26 0.9 28 0.9
LOAD COMBINATION 196 EARTH PRESSURE AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1.5 6 1.5 7 1.2 8 1.2 24 1.15 26 0.9 28 0.9
LOAD COMBINATION 197 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 18 1.5 25 0.9 27 0.9
LOAD COMBINATION 198 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 19 1.5 25 0.9 27 0.9
LOAD COMBINATION 199 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 20 1.5 25 0.9 27 0.9
LOAD COMBINATION 200 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 21 1.5 25 0.9 27 0.9
LOAD COMBINATION 201 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 22 1.5 25 0.9 27 0.9
LOAD COMBINATION 202 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 23 1.5 25 0.9 27 0.9
LOAD COMBINATION 203 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 24 1.5 25 0.9 27 0.9
LOAD COMBINATION 204 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 18 1.5 26 0.9 28 0.9
LOAD COMBINATION 205 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 19 1.5 26 0.9 28 0.9
LOAD COMBINATION 206 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 20 1.5 26 0.9 28 0.9
LOAD COMBINATION 207 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 21 1.5 26 0.9 28 0.9
LOAD COMBINATION 208 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 22 1.5 26 0.9 28 0.9
LOAD COMBINATION 209 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 23 1.5 26 0.9 28 0.9
LOAD COMBINATION 210 LIVE LOAD AS LEADING LOAD
1 1.35 3 1.35 4 1.75 5 1 6 1 7 1.2 8 1.2 24 1.5 26 0.9 28 0.9
*** HFL Combination for Base Pressure and Design of Foundation (Combination 1)**
LOAD COMBINATION 211 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 18 1.15 25 0.9 27 0.9
LOAD COMBINATION 212 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 19 1.15 25 0.9 27 0.9
LOAD COMBINATION 213 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 20 1.15 25 0.9 27 0.9

LOAD COMBINATION 214 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 21 1.15 25 0.9 27 0.9
LOAD COMBINATION 215 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 22 1.15 25 0.9 27 0.9
LOAD COMBINATION 216 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 23 1.15 25 0.9 27 0.9
LOAD COMBINATION 217 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 24 1.15 25 0.9 27 0.9
LOAD COMBINATION 218 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 18 1.15 26 0.9 28 0.9
LOAD COMBINATION 219 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 19 1.15 26 0.9 28 0.9
LOAD COMBINATION 220 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 20 1.15 26 0.9 28 0.9
LOAD COMBINATION 221 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 21 1.15 26 0.9 28 0.9
LOAD COMBINATION 222 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 22 1.15 26 0.9 28 0.9
LOAD COMBINATION 223 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 23 1.15 26 0.9 28 0.9
LOAD COMBINATION 224 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 24 1.15 26 0.9 28 0.9
LOAD COMBINATION 225 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 18 1.5 25 0.9 27 0.9
LOAD COMBINATION 226 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 19 1.5 25 0.9 27 0.9
LOAD COMBINATION 227 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 20 1.5 25 0.9 27 0.9
LOAD COMBINATION 228 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 21 1.5 25 0.9 27 0.9
LOAD COMBINATION 229 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 22 1.5 25 0.9 27 0.9
LOAD COMBINATION 230 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 23 1.5 25 0.9 27 0.9
LOAD COMBINATION 231 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 24 1.5 25 0.9 27 0.9
LOAD COMBINATION 232 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 18 1.5 26 0.9 28 0.9
LOAD COMBINATION 233 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 19 1.5 26 0.9 28 0.9
LOAD COMBINATION 234 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 20 1.5 26 0.9 28 0.9
LOAD COMBINATION 235 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 21 1.5 26 0.9 28 0.9
LOAD COMBINATION 236 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 22 1.5 26 0.9 28 0.9
LOAD COMBINATION 237 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 23 1.5 26 0.9 28 0.9
LOAD COMBINATION 238 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 24 1.5 26 0.9 28 0.9

***Combination for Base Pressure and Design of Foundation (Combination 2)**

LOAD COMBINATION 239 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 18 1 25 0.8 27 0.8
LOAD COMBINATION 240 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 19 1 25 0.8 27 0.8
LOAD COMBINATION 241 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 20 1 25 0.8 27 0.8
LOAD COMBINATION 242 EARTH PRESSURE AS LEADING LOAD

1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 21 1 25 0.8 27 0.8
LOAD COMBINATION 243 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 22 1 25 0.8 27 0.8
LOAD COMBINATION 244 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 23 1 25 0.8 27 0.8
LOAD COMBINATION 245 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 24 1 25 0.8 27 0.8
LOAD COMBINATION 246 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 18 1 26 0.8 28 0.8
LOAD COMBINATION 247 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 19 1 26 0.8 28 0.8
LOAD COMBINATION 248 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 20 1 26 0.8 28 0.8
LOAD COMBINATION 249 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 21 1 26 0.8 28 0.8
LOAD COMBINATION 250 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 22 1 26 0.8 28 0.8
LOAD COMBINATION 251 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 23 1 26 0.8 28 0.8
LOAD COMBINATION 252 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 24 1 26 0.8 28 0.8
LOAD COMBINATION 253 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 18 1.3 25 0.8 27 0.8
LOAD COMBINATION 254 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 19 1.3 25 0.8 27 0.8
LOAD COMBINATION 255 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 20 1.3 25 0.8 27 0.8
LOAD COMBINATION 256 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 21 1.3 25 0.8 27 0.8
LOAD COMBINATION 257 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 22 1.3 25 0.8 27 0.8
LOAD COMBINATION 258 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 23 1.3 25 0.8 27 0.8
LOAD COMBINATION 259 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 24 1.3 25 0.8 27 0.8
LOAD COMBINATION 260 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 18 1.3 26 0.8 28 0.8
LOAD COMBINATION 261 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 19 1.3 26 0.8 28 0.8
LOAD COMBINATION 262 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 20 1.3 26 0.8 28 0.8
LOAD COMBINATION 263 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 21 1.3 26 0.8 28 0.8
LOAD COMBINATION 264 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 22 1.3 26 0.8 28 0.8
LOAD COMBINATION 265 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 23 1.3 26 0.8 28 0.8
LOAD COMBINATION 266 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 24 1.3 26 0.8 28 0.8
*** HFL Combination for Base Pressure and Design of Foundation (Combination 2)**
LOAD COMBINATION 267 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 18 1 25 0.8 27 0.8
LOAD COMBINATION 268 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 19 1 25 0.8 27 0.8
LOAD COMBINATION 269 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 20 1 25 0.8 27 0.8
LOAD COMBINATION 270 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 21 1 25 0.8 27 0.8

LOAD COMBINATION 271 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 22 1 25 0.8 27 0.8
LOAD COMBINATION 272 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 23 1 25 0.8 27 0.8
LOAD COMBINATION 273 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 24 1 25 0.8 27 0.8
LOAD COMBINATION 274 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 18 1 26 0.8 28 0.8
LOAD COMBINATION 275 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 19 1 26 0.8 28 0.8
LOAD COMBINATION 276 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 20 1 26 0.8 28 0.8
LOAD COMBINATION 277 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 21 1 26 0.8 28 0.8
LOAD COMBINATION 278 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 22 1 26 0.8 28 0.8
LOAD COMBINATION 279 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 23 1 26 0.8 28 0.8
LOAD COMBINATION 280 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 24 1 26 0.8 28 0.8
LOAD COMBINATION 281 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 18 1.3 25 0.8 27 0.8
LOAD COMBINATION 282 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 19 1.3 25 0.8 27 0.8
LOAD COMBINATION 283 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 20 1.3 25 0.8 27 0.8
LOAD COMBINATION 284 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 21 1.3 25 0.8 27 0.8
LOAD COMBINATION 285 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 22 1.3 25 0.8 27 0.8
LOAD COMBINATION 286 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 23 1.3 25 0.8 27 0.8
LOAD COMBINATION 287 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 24 1.3 25 0.8 27 0.8
LOAD COMBINATION 288 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 18 1.3 26 0.8 28 0.8
LOAD COMBINATION 289 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 19 1.3 26 0.8 28 0.8
LOAD COMBINATION 290 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 20 1.3 26 0.8 28 0.8
LOAD COMBINATION 291 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 21 1.3 26 0.8 28 0.8
LOAD COMBINATION 292 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 22 1.3 26 0.8 28 0.8
LOAD COMBINATION 293 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 23 1.3 26 0.8 28 0.8
LOAD COMBINATION 294 LIVE LOAD AS LEADING LOAD
2 1 3 1 4 1 9 0.8 10 0.8 11 1 12 1 17 1 24 1.3 26 0.8 28 0.8
** For base pressure check only
LOAD COMBINATION 295 BASE PRESSURE CHECK FOR LWL CONDITION
1 1 3 1 4 1 5 1 6 1 7 1 8 1 24 1
LOAD COMBINATION 296 BASE PRESSURE CHECK FOR HFL CONDITION
2 1 3 1 4 1 5 1 6 1 7 1 8 1 24 1 17 1
PERFORM ANALYSIS
FINISH

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

3.4 Summary of factored moments

	Top slab			Bottom slab			Outer wall				Inner wall			
Load Case	Moment in Mid-Span	Moment at End Support	Top slab shear at deff	Moment in Mid-Span	Moment at End Support	Bottom slab shear at deff	Min. Axial force	Moment at top	Moment at bottom	Wall shear at deff	Min. Axial force	Moment at top	Moment at bottom	Wall shear at deff
	kN-m	kN-m	kN	kN-m	kN-m	kN	KN	kN-m	kN-m	kN	KN	kN-m	kN-m	kN
*Partial Safety for Verification of Structural Strength (Basic Combination) LC 29 TO 58	136	128	63	-	-	-	30	85	172	129	112	79	43	41
*Partial Safety for Verification of Serviceability Limit State (Rare Combination) LC 59 TO 118	55.3	128	63	109.4	132	137	30	92	137	129	112	58	32	41
*Partial Safety for Verification of Serviceability Limit State (Frequent Combination) LC 119 TO 178	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Partial Safety for Verification of Serviceability Limit State (Quasi-permanent Combination) LC 179 TO 182	11	52.2	63	56.4	54.7	137	30	34	46.2	129	112	1	1	41
*Combination for Base Pressure and Design of Foundation (Combination 1) LC 183 TO 238	-	-	-	187	169	137	-	-	-	-	-	-	-	-
*Combination for Base Pressure and Design of Foundation (Combination 2) LC 239 TO 294	-	-	-	152	131	137	-	-	-	-	-	-	-	-

4.0 Partial Safety Factors

Material Parameters

Concrete **Refer Table 6.5, IRC:112-2011**

Grade		=	**M30**	
Cube strength of concrete at 28 days	f_{ck}	=	**30**	MPa
Design value of concrete compressive strength	f_{cd}	=	$\alpha f_{ck} / \gamma_m$	
Refer cl. 6.4.2.8 of IRC:112-2011			α =	0.67
	f_{ctm}	=	2.5	MPa
For Basic Combination	f_{cd}	=	13.40	MPa
For Accidental Combination	f_{cd}	=	16.75	MPa
For Seismic Combination	f_{cd}	=	13.40	MPa
Modulus of Elasticity	E_c	=	31000	MPa
Mean value of axial tensile strength of concrete	f_{ctm}	=	2.5	MPa
Density		=	**2.50**	t/m^3
Grade		=	**Fe500**	
Characteristics yield strength	f_{yk}	=	500	MPa
Design yield strength	f_{yd}	=	f_{yk} / γ_m	
For Basic Combination	f_{yd}	=	434.78	MPa
For Accidental Combination	f_{yd}	=	500	MPa
For Seismic Combination	f_{yd}	=	434.78	MPa
Modulus of Elasticity	E_s	=	**2.0E+05**	MPa
Density		=	**7.85**	t/m^3

Partial Safety Factor for Materials

Material	Partial Safety Factor γ_m			
	Basic Combination	Accidental Combination	Seismic Combination	
Concrete	1.5	1.2	1.5	Cl 6.4.2.8, IRC:112-2011
Steel	1.15	1	1.15	Cl 6.2.2, IRC:112-2011

Partial Safety Factor for Loads

Ultimate Limit State

Partial Safety for Verification of Structural Strength   Table 3.1, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
(1)	(2)	(3)	(4)	(5)	(4)	(3)
	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect
Permanent Loads:	1.05	0.95	1.00	1.00	1.05	0.95
Dead Load, SIDL except surfacing, Backfill Weight, Settlement, Creep and shrinkage effect						
Surfacing	1.35	1.00	1.00	1.00	1.35	1.00
Earth Pressure due to Backfill	1.50	0.00	1.00	0.00	1.00	0.00
Variable Loads:						
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:						
a) Leading Load	1.50	0.00	0.75	0.00	0.00	0.00
b) Accompanying Load	1.15	0.00	0.20	0.00	0.20	0.00
c) Construction Live Load	1.35	0.00	1.00	0.00	1.00	0.00
Thermal Loads						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	0.90	0.00	0.50	0.00	0.50	0.00
Wind						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	0.90	0.00	0.00	0.00	0.00	0.00
Live Load Surcharge (as accompanying load)	1.20	0.00	0.00	0.00	0.00	0.00
Accidental Effects:						
i) Vehicle Collision ii) Barge Impact iii) Impact due to floating bodies	0.00	0.00	1.00	0.00	0.00	0.00
Seismic Effect						
a) During Service	0.00	0.00	0.00	0.00	1.50	0.00
b) During Construction	0.00	0.00	0.00	0.00	0.75	0.00
Construction Condition:						
Counter Weights:						
a) When density or self weight is well defined	0.00	0.90	0.00	1.00	0.00	1.00
b) When density or self weight is not well defin	0.00	0.80	0.00	1.00	0.00	1.00
c) Erection effects	1.05	0.95	0.00	0.00	0.00	0.00
Wind						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	1.20	0.00	0.00	0.00	0.00	0.00
Hydraulic Loads:						
(Accompanying Load):						
Water Current Forces	1.00	0.00	1.00	0.00	1.00	0.00
Wave Pressure	1.00	0.00	1.00	0.00	1.00	0.00
Hydrodynamic Effect	0.00	0.00	0.00	0.00	1.00	0.00
Buoyancy	1.00	0.00	1.00	0.00	1.00	0.00

Partial Safety for Verification of Structural Strength **Table 3.2, Annex B, IRC:6-2014**
Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
(1)	(2)	(3)	(4)
Permanent Loads:			
Dead Load			
SIDL except surfacing			
a) Adding to the effect of variable loads	1.35	1.00	1.35
b) Relieving the effect of variable loads	1.00	1.00	1.00
Surfacing:			
a) Adding to the effect of variable loads	1.75	1.00	1.75
b) Relieving the effect of variable loads	1.00	1.00	1.00
Backfill Weight	1.50	1.00	1.00
Earth Pressure due to Backfill			
a) Leading Load	1.50	0.00	1.00
b) Accompanying Load	1.00	1.00	1.00
Variable Loads:			
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.50	0.75	0.00
b) Accompanying Load	1.15	0.20	0.20
c) Construction Live Load	1.35	1.00	1.00
Wind during service and construction			
a) Leading Load	1.50	0.00	0.00
b) Accompanying Load	0.90	0.00	0.00
Live Load Surcharge (as accompanying load)	1.20	0.20	0.20
Erection effects	1.00	1.00	1.00
Accidental Effects:			
i) Vehicle Collision ii) Barge Impact iii) Impact due to floating bodies	0.00	1.00	0.00
Seismic Effect			
a) During Service	0.00	0.00	1.50
b) During Construction	0.00	0.00	0.75
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	1.00
Wave Pressure	1.00	1.00	1.00
Hydrodynamic Effect	0.00	0.00	1.00
Buoyancy	0.15	0.15	0.15

Serviceability Limit State

Partial Safety for Verification of Serviceability Limit St Table 3.3, Annex B, IRC:6-2014

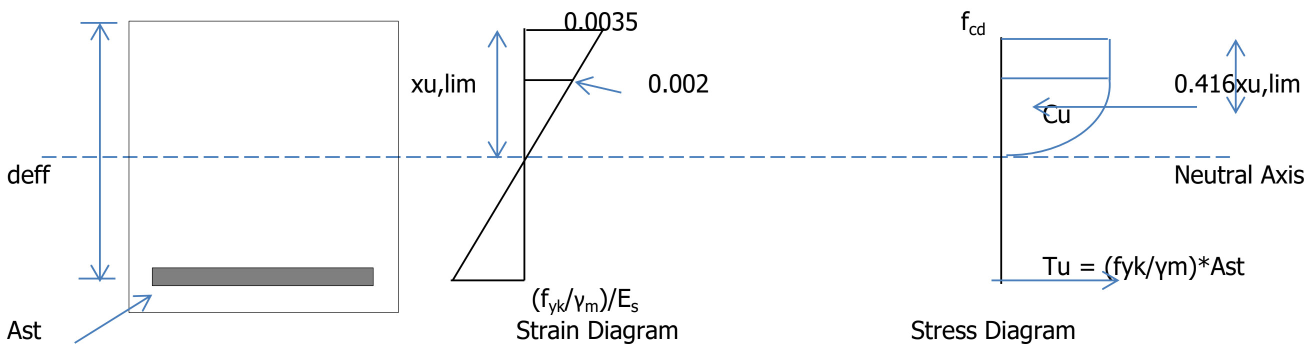
Loads	Partial Safety Factor		
	Rare Combination	Frequent Combination	Quasi-permanent
(1)	(2)	(3)	(4)
Permanent Loads:			
Dead Load	1.00	1.00	1.00
SIDL including surfacing	1.00	1.00	1.00
Backfill Weight	1.00	1.00	1.00
Shrinkage and Creep Effects	1.00	1.00	1.00
Earth Pressure due to Backfill	1.00	1.00	1.00
Settlement Effects			
a) Adding to the permanent loads	1.00	1.00	1.00
b) Opposing the permanent loads	0.00	0.00	0.00
Variable Loads:			
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.00	0.75	0.00
b) Accompanying Load	0.75	0.20	0.00
Thermal Loads:			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load			
Wind			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load	0.60	0.50	0.00
Live Load Surcharge (Accompanying load)	0.80	0.00	0.00
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	0.00
Wave Pressure	1.00	1.00	0.00
Buoyancy	0.15	0.15	0.15

Combination for Base Pressure and Design of Foundation
Table 3.4, Annex B, IRC:6-2014
Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor			
	Combination (1)	Combination (2)	Seismic Combination	Accidental Combination
(1)	(2)	(3)	(4a)	(4b)
Permanent Loads:				
Dead Load, SIDL except surfacing, Backfill earth filling	1.35	1.00	1.35	1.00
SIDL Surfacing	1.75	1.00	1.75	1.00
Settlement Effect	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Earth Pressure due to Backfill				
a) Leading Load	1.50	1.30	0.00	0.00
b) Accompanying Load	1.00	0.85	1.00	1.00
Variable Loads:				
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:				
a) Leading Load	1.50	1.30	(0.75 if applicable) or 0	(0.75 if applicable) or 0
b) Accompanying Load	1.15	1.00	0.20	0.20
Thermal Loads as accompanying load	0.90	0.80	0.50	0.50
Wind				
a) Leading Load	1.50	1.30	0.00	0.00
b) Accompanying Load	0.90	0.80	0.00	0.00
Live Load Surcharge (as accompanying load if applicable)	1.20	1.00	0.20	0.20
Accidental Effects or Seismic Effect:				
a) During Service	0.00	0.00	1.50	1.00
b) During Construction	0.00	0.00	0.75	0.50
Erection effects	1.00	1.00	1.00	1.00
Hydraulic Loads:				
Water Current	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Wave Pressure	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
Hydrodynamic Effect	0.00	0.00	1.0 or 0	1.0 or 0
Buoyancy:				
For Base Pressure	1.00	1.00	1.00	1.00
For Structural Design	0.15	0.15	0.15	0.15

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

5.1.1 Verification of structural strength for top slab



<u>ULTIMATE LIMIT STATE</u>

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	13.40	N/mm^2	For Basic Combination
	f_{cd}	=	16.75	N/mm^2	For Accidental Combination
	f_{cd}	=	13.40	N/mm^2	For Seismic Combination
	E_c	=	31000	MPa	
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	435	N/mm^2	For Basic Combination
	f_{Yd}	=	500	N/mm^2	For Accidental Combination
	f_{Yd}	=	435	N/mm^2	For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 500 mm

Clear cover = 40

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

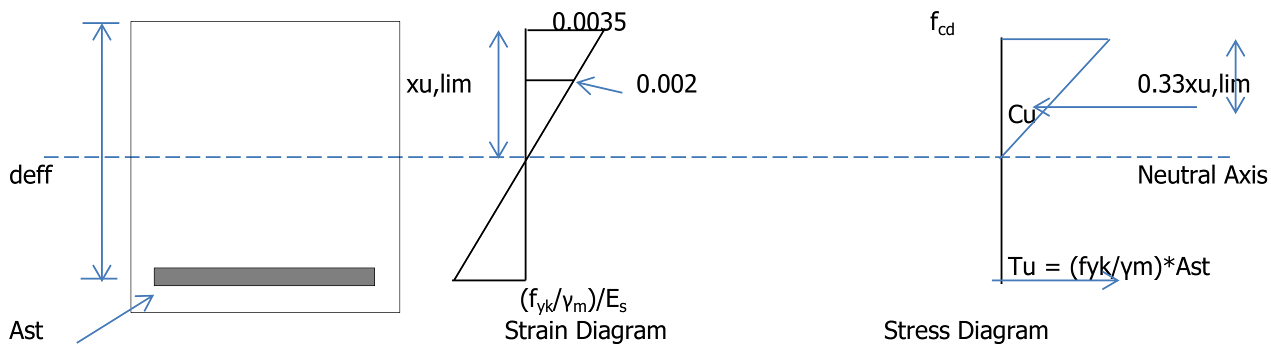
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	128.0			136.0		
b	1000			1000		
D	500			500		
c	40			40		
d	442.0			442.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			4.97		
$M_{u,Lim}$ (KNm)	972			972		
	OK			**OK**		
Ast Req.	684			728		
Dia of bar (main tension) (mm)	16			16		
Spacing (mm)	200			200		
+ dia of bar (main tension) (mm)	10			0		
Spacing (mm)	200			200		
Ast provided (sq mm)	1398			1005		
Dia of bar (main compresion) (mm)	0			10		
Spacing (mm)	200			200		
Area of main compresion (mm^2)	0			393		
f_{ctm}	2.5			2.5		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	661			661		
A_{ct}	443965			459705		
$f_{ct,eff}$	2.9			2.9		
$k_c = 0.4 \{ 1 - \sigma_c / (k_1 f_{ct,eff}\ h/h^*) \} <= 1$	0.4			0.4		
For Bending or bending combined with axial force						
k	0.8600			0.8600		
σ_s	435			435		
As.max = 0.025 Ac (main tension)	12500			12500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**			**OK**		
As.max = 0.04 Ac (tension + compresion)	20000			20000		
x (mm)	56			40		
x/d	0.127			0.091		
	OK			**OK**		
z (mm)	419			425		
MR (KNm)	254			186		
	OK			**OK**		

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

Shear on the section	**Top slab Top End support**
Actual shear V_{Ed} (KN)	63.0
Actual shear stress (N/mm2)	0.158
Max shear capacity, 0.135 fck(1-fck/310)	3.7
	OK.
Min shear capacity, 0.0924 fck(1-fck/310)	2.5
$\Theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	
Min angle of inclination, Θ (deg)	21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010	
K = 1+Sqrt(200/d) <= 2.0	1.673
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010	
$\nu_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.367
cl. 10.3.1 of IRC :112-2011	
$\rho 1 = A_{sl}/(b_w\ d) <= 0.02$	0.003
	OK
$0.12\ K\ (80\ \rho 1\ f_{ck})^{0.33}$	0.392
Axial compressive force N_{Ed} (KN)	0
$\sigma_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010	
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (\nu_{min} + 0.15\ \sigma_{cp})\ b_w\ d$ (KN)	162
	OK.

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

5.1.2 Verification for serviceability limit state for top slab



SERVICEABILITY LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 12.2.1, IRC:112-2011

f_{cd} = 14.40 N/mm^2 For Rare Combination

f_{cd} = 14.40 N/mm^2 For Frequent Combination

f_{cd} = 10.80 N/mm^2 For Quasi-Perma. Combination

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 300 N/mm^2 For Rare Combination

f_{Yd} = 300 N/mm^2 For Frequent Combination

f_{Yd} = 300 N/mm^2 For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 500 mm

Clear cover = 40

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

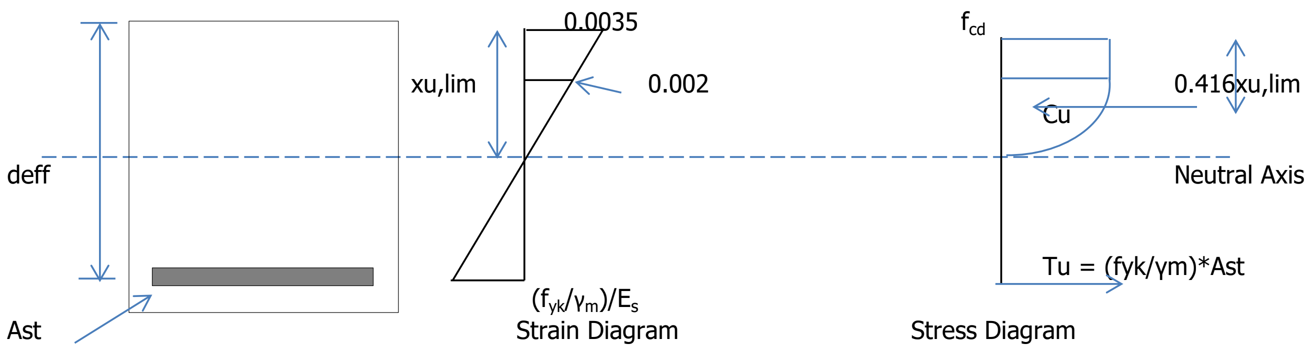
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	128.0		52.2	55.3		11
b	1000		1000	1000		1000
D	500		500	500		500
c	40		40	40		40
d	442.0		442.0	442.0		442.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	757		568	757		568
	OK		**OK**	**OK**		**OK**
Ast Req.	996		400	423		83
Dia of bar (main tension) (mm)	16		16	16		16
Spacing (mm)	200		200	200		200
+ dia of bar (main tension) (mm)	10		10	0		0
Spacing (mm)	200		200	200		200
Ast provided (sq mm)	1398		1398	1005		1005
Dia of bar (main compresion) (mm)	0		0	10		10
Spacing (mm)	200		200	200		200
Area of main compresion (mm^2)	0		0	393		393
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	58.3		77.7	41.9		55.9
x/d	0.132		0.176	0.095		0.126
	OK		**OK**	**OK**		**OK**
z (mm)	423		416	428		424
MR_{sls} (KNm)	177		175	129		128
	OK		**OK**	**OK**		**OK**
$\sigma_{sc} = M/(A_s z)$	217		90	128		26
	OK		**OK**	**OK**		**OK**
$\sigma_{ca} = M/(0.8095 z b x_u)$	10.40		3.23	6.17		0.93
	OK		**OK**	**OK**		**OK**

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

Calculation of crack width	**Top slab Top End support**			**Top slab Bottom Mid Span**		
n_1			5			5
n_2			5			5
$\phi_{eq} =(n_1\phi_1^2 + n_2\phi_2^2) / (n_1\phi_1+n_2\phi_2)$			14			16
cl. 12.3.4 (3) of IRC :112-2011						
c			40			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$\rho_{p.eff} = A_s / A_{c,eff}$			0.012			0.008
$S_{r,max} =\{ 3.4 c + (0.425 k_1 k_2 \phi) / \rho_{p.eff} \}$			336			461
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			31000
$\alpha_e = E_s / E_{cm}$			6.45			6.45
$(\varepsilon_{sm}-\varepsilon_{cm})=(\sigma_{sc}-k_t f_{ct,eff}(1+\alpha_e \rho_{p,eff})/\rho_{p,eff})/E_s >=0.6\sigma_{sc}/E_s$			0.0003			0.0001
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$			0.090			0.04
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**
Calculation of deflection						
Span (mm)					8800	
span/800					11.0	
cl. 12.4.1 (2) of IRC :112-2011						
Short term elastic deflection from STAAD					0.2	
					OK	

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

5.2.1 Verification of structural strength for bottom slab



ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd}	=	13.40	N/mm^2	Combination (1)
f_{cd}	=	16.75	N/mm^2	Accidental Combi.
f_{cd}	=	13.40	N/mm^2	Combination (2)

E_c = 31000 MPa

Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	435	N/mm^2	Combination (1)
	f_{Yd}	=	500	N/mm^2	Accidental Combi.
	f_{Yd}	=	435	N/mm^2	Combination (2)

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = $fcd*b*(3/7xu_{,lim} + 2/3*4/7xu_{,lim})$

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.8095fcd*(xu_{lim}/d)*(1-0.416*xu_{lim}/d)$

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 550 mm

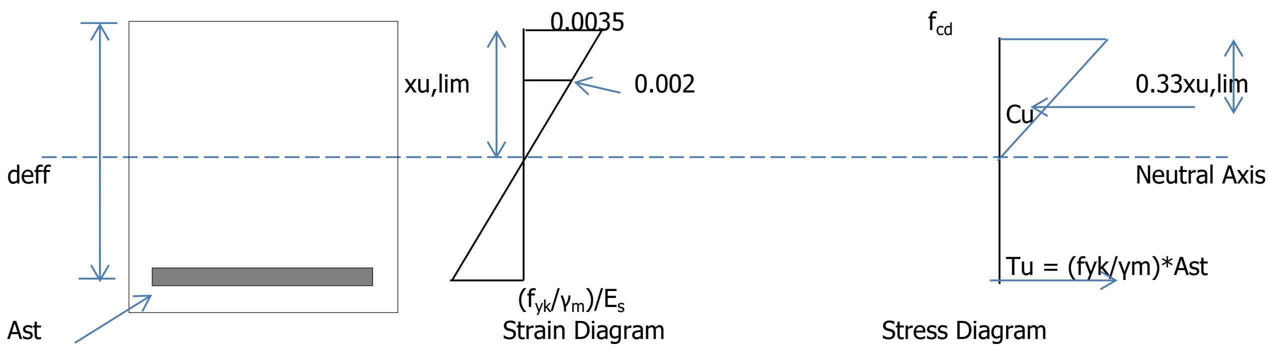
Clear cover at bott. = 75 Clear cover at top = 40

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

Moment on the section	**Bottom End support**			**Top Mid Span**		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	169.0		131.0	187.0		152.0
b	1000		1000	1000		1000
D	550		550	550		550
c	75		75	40		40
d	457.0		457.0	492.0		492.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435		435	435		435
$xu_{,lim}/d$	0.62		0.62	0.62		0.62
$R_{sls} = M_{u,sls}/bd^2$	4.97		4.97	4.97		4.97
$M_{u,Lim}$ (KNm)	1039		1039	1204		1204
	OK		**OK**	**OK**		**OK**
Ast Req.	879		676	902		729
Dia of bar (main tension) (mm)	16		16	16		16
Spacing (mm)	200		200	200		200
+ dia of bar (main tension) (mm)	10		10	0		0
Spacing (mm)	200		200	200		200
Ast provided (sq mm)	1398		1398	1005		1005
Dia of bar (main compresion) (mm)	0		0	10		10
Spacing (mm)	200		200	200		200
Area of main compresion (mm^2)	0		0	393		393
f_{ctm}	2.5		2.5	2.5		2.5
f_{yk}	435		435	435		435
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	683		683	736		736
A_{ct}	493965		493965	509705		509705
$f_{ct,eff}$	2.9		2.9	2.9		2.9
$k_c = 0.4 \{ 1 - \sigma_c / (k_1\ f_{ct,eff}\ h/h^*) \} <= 1$	0.4		0.4	0.4		0.4
For Bending or bending combined with axial force						
k	0.8250		0.8250	0.8250		0.8250
σ_s	435		435	435		435
As.max = 0.025 Ac (main tension)	13750		13750	13750		13750
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**		**OK**	**OK**		**OK**
As.max = 0.04 Ac (tension + compresion)	22000		22000	22000		22000
x (mm)	56		56	40		40
x/d	0.123		0.123	0.082		0.082
	OK		**OK**	**OK**		**OK**
z (mm)	434		434	475		475
MR (KNm)	264		264	208		208
	OK		**OK**	**OK**		**OK**

Shear on the section	**Bottom End support**		
Actual shear V_{Ed} (KN)	137.0		137.0
Actual shear stress (N/mm2)	0.333		0.333
Max shear capacity, 0.135 fck(1-fck/310)	3.7		3.7
	OK.		**OK.**
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		2.5
$\Theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.662		1.662
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$\nu_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.364		0.364
cl. 10.3.1 of IRC :112-2011			
$\rho1 = A_{sl}/(b_w\ d) <= 0.02$	0.003		0.003
	OK		**OK**
$0.12\ K\ (80\ \rho1\ f_{ck})^{0.33}$	0.385		0.4
Axial compressive force N_{Ed} (KN)	0		0
$\sigma_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (\nu_{min} + 0.15\ \sigma_{cp})\ b_w\ d$ (KN)	166		166
	OK.		**OK.**

5.2.2 Verification for serviceability limit state for bottom slab



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	For Rare Combination
	f_{cd}	=	14.40	N/mm^2	For Frequent Combination
	f_{cd}	=	10.80	N/mm^2	For Quasi-Perma. Combination
As per clause 12.2.2, IRC:112-2011					
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	300	N/mm^2	For Rare Combination
	f_{Yd}	=	300	N/mm^2	For Frequent Combination
	f_{Yd}	=	300	N/mm^2	For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 550 mm

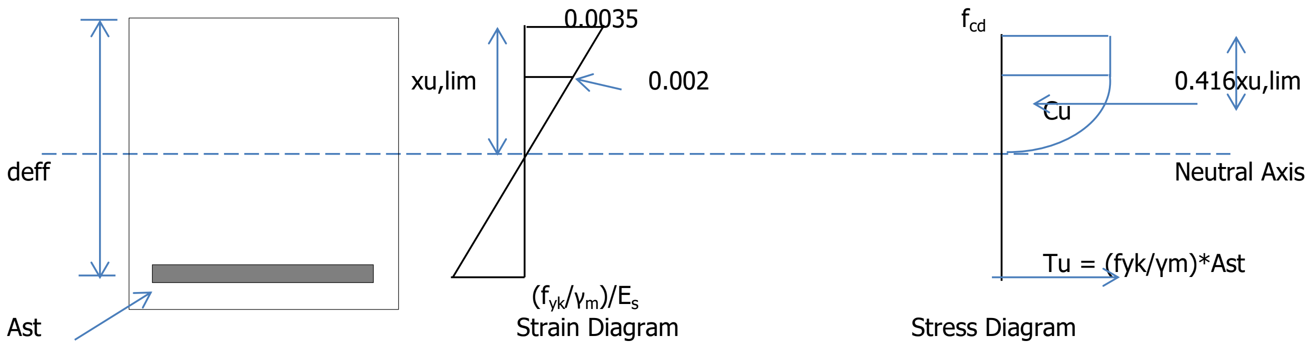
Clear cover at bott. = 75 Clear cover at top = 40

Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	132.0		54.7	109.4		56.4
b	1000		1000	1000		1000
D	550		550	550		550
c	75		75	40		40
d	457.0		457.0	492.0		492.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	809		607	938		704
	OK		**OK**	**OK**		**OK**
Ast Req.	992		406	757		388
Dia of bar (main tension) (mm)	16		16	16		16
Spacing (mm)	200		200	200		200
+ dia of bar (main tension) (mm)	10		10	0		0
Spacing (mm)	200		200	200		200
Ast provided (sq mm)	1398		1398	1005		1005
Dia of bar (main compresion) (mm)	0		0	10		10
Spacing (mm)	200		200	200		200
Area of main compresion (mm^2)	0		0	393		393
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	58.3		77.7	41.9		55.9
x/d	0.127		0.170	0.085		0.114
	OK		**OK**	**OK**		**OK**
z (mm)	438		431	478		474
MR_{sls} (KNm)	184		181	144		143
	OK		**OK**	**OK**		**OK**
$\sigma_{sc} = M/(A_s z)$	216		91	228		118
	OK		**OK**	**OK**		**OK**
$\sigma_{ca} = M/(0.8095\, z\, b\, x_u)$	10.35		3.27	10.92		4.26
	OK		**OK**	**OK**		**OK**

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

Calculation of crack width	**Bottom End support**			**Top Mid Span**		
n_1			5			5
n_2			5			5
$\phi_{eq} = (n_1\phi_1^2 + n_2 \phi_2^2) / (n_1\phi_1+n_2\phi_2)$			14			16
cl. 12.3.4 (3) of IRC :112-2011						
c			75			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer						
$\rho_{p.eff} = A_s / A_{c,eff}$			0.007			0.008
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 \phi) / \rho_{p.eff} \}$			600			461
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			31000
$\alpha_e = E_s / E_{cm}$			6.45			6.45
$(\varepsilon_{sm}-\varepsilon_{cm})=(\sigma_{sc}-k_t f_{ct,eff}(1+\alpha_e \rho_{p,eff})/\rho_{p,eff})/E_s >=0.6\sigma_{sc}/E_s$			0.0003			0.0004
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$			0.16			0.16
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

5.3.1 Verification of structural strength for outer wall



ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd} = 13.40 N/mm^2 For Basic Combination

f_{cd} = 16.75 N/mm^2 For Accidental Combination

f_{cd} = 13.40 N/mm^2 For Seismic Combination

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 435 N/mm^2 For Basic Combination

f_{Yd} = 500 N/mm^2 For Accidental Combination

f_{Yd} = 435 N/mm^2 For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
xu,$_{lim}$/d	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

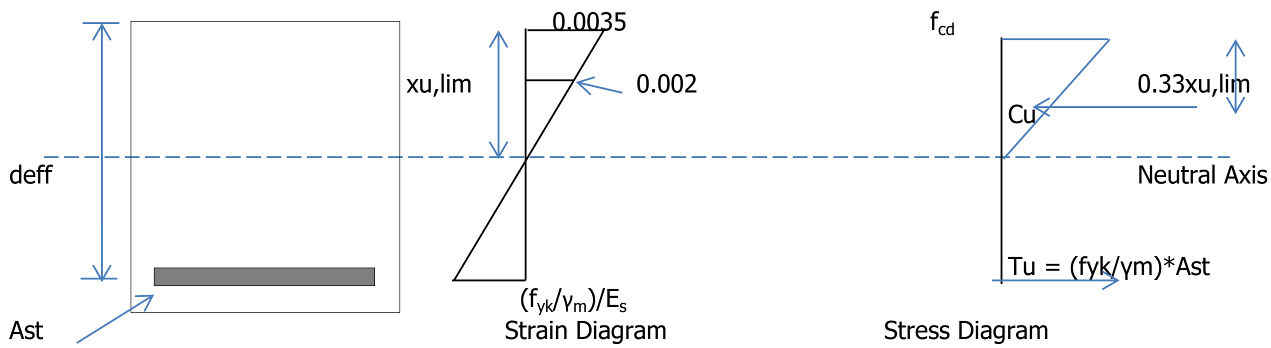
Depth of section D = 500 mm

Clear cover = 75

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

Moment on the section	**Bottom End support**			**Top End support**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	172.0			85.0		
b	1000			1000		
D	500			500		
c	75			75		
d	407.0			407.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			4.97		
$M_{u,Lim}$ (KNm)	824			824		
	OK			**OK**		
Ast Req.	1014			490		
Dia of bar (main tension) (mm)	16			16		
Spacing (mm)	200			200		
+ dia of bar (main tension) (mm)	10			10		
Spacing (mm)	200			200		
Ast provided (sq mm)	1398			1398		
Dia of bar (main compresion) (mm)	10			10		
Spacing (mm)	200			200		
Area of main compresion (mm^2)	393			393		
f_{ctm}	2.5			2.5		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	608			608		
A_{ct}	443965			443965		
$f_{ct,eff}$	2.9			2.9		
$k_c = 0.4\ \{\ 1 - \sigma_c\ /\ (\ k_1\ f_{ct,eff}\ h/h^*)\ \} <= 1$	0.4			0.4		
For Bending or bending combined with axial force						
k	0.8600			0.8600		
σ_s	435			435		
As.max = 0.025 Ac (main tension)	12500			12500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**			**OK**		
As.max = 0.04 Ac (tension + compresion)	20000			20000		
x (mm)	56			56		
x/d	0.138			0.138		
	OK			**OK**		
z (mm)	384			384		
MR (KNm)	233			233		
	OK			**OK**		

5.3.2 Verification for serviceability limit state for outer wall



SERVICEABILITY LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 12.2.1, IRC:112-2011

f_{cd} = 14.40 N/mm^2 For Rare Combination

f_{cd} = 14.40 N/mm^2 For Frequent Combination

f_{cd} = 10.80 N/mm^2 For Quasi-Perma. Combination

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 300 N/mm^2 For Rare Combination

f_{Yd} = 300 N/mm^2 For Frequent Combination

f_{Yd} = 300 N/mm^2 For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 500 mm

Clear cover = 75

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

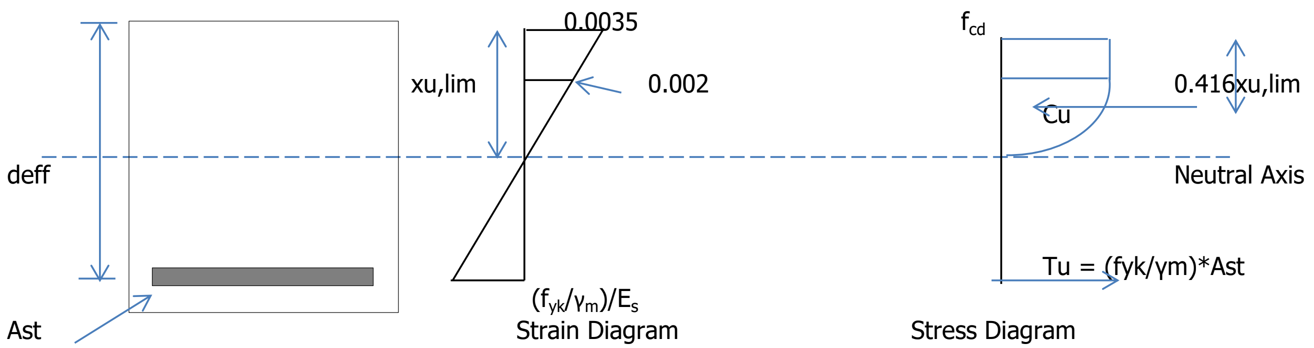
Moment on the section	**Bottom End support**			**Top End support**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	137.0		46.2	92		34
b	1000		1000	1000		1000
D	500		500	500		500
c	75		75	75		75
d	407.0		407.0	407.0		407.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	642		482	642		482
	OK		**OK**	**OK**		**OK**
Ast Req.	1168		385	774		282
Dia of bar (main tension) (mm)	16		16	16		16
Spacing (mm)	200		200	200		200
+ dia of bar (main tension) (mm)	10		10	10		10
Spacing (mm)	200		200	200		200
Ast provided (sq mm)	1398		1398	1398		1398
Dia of bar (main compresion) (mm)	10		10	10		10
Spacing (mm)	200		200	200		200
Area of main compresion (mm^2)	393		393	393		393
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	58.3		77.7	58.3		77.7
x/d	0.143		0.191	0.143		0.191
	OK		**OK**	**OK**		**OK**
z (mm)	388		381	388		381
MR_{sls} (KNm)	163		160	163		160
	OK		**OK**	**OK**		**OK**
$\sigma_{sc} = M/(A_s\ z)$	253		87	170		64
	OK		**OK**	**OK**		**OK**
$\sigma_{ca} = M/(0.8095\ z\ b\ x_u)$	12.13		3.12	8.15		2.30
	OK		**OK**	**OK**		**OK**

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

Calculation of crack width	**Bottom End support**			**Top End support**		
n_1			5			5
n_2			5			5
$\phi_{eq} = (n_1\phi_1^2 + n_2 \phi_2^2) / (n_1\phi_1+n_2\phi_2)$			14			14
cl. 12.3.4 (3) of IRC :112-2011						
c			75			75
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$\rho_{p.eff} = A_s / A_{c,eff}$			0.007			0.007
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 \phi) / \rho_{p.eff} \}$			600			600
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			29626
$\alpha_e = E_s / E_{cm}$			6.45			6.75
$(\varepsilon_{sm}-\varepsilon_{cm})=(\sigma_{sc}-k_t f_{ct,eff}(1+\alpha_e \rho_{p,eff})/\rho_{p,eff})/E_s >=0.6\sigma_{sc}/E_s$			0.0003			0.0002
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$			0.16			0.11
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

5.4.1 Verification of structural strength for inner wall



ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	13.40	N/mm^2	For Basic Combination
	f_{cd}	=	16.75	N/mm^2	For Accidental Combination
	f_{cd}	=	13.40	N/mm^2	For Seismic Combination
E_c		=	31000	MPa	
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	435	N/mm^2	For Basic Combination
	f_{Yd}	=	500	N/mm^2	For Accidental Combination
	f_{Yd}	=	435	N/mm^2	For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
xu,$_{lim}$/d	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

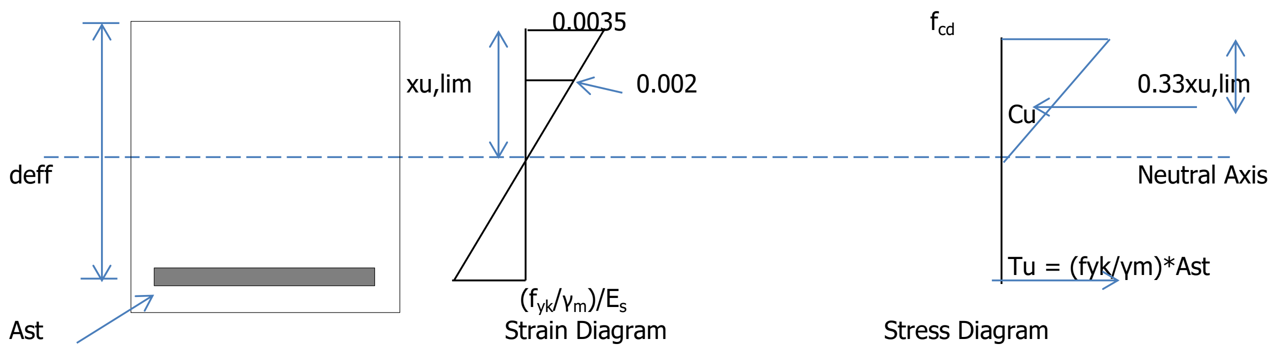
Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	40	

Moment on the section	**Bottom End support**			**Top End support**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	43.0			79.0		
b	1000			1000		
D	300			300		
c	40			40		
d	242.0			242.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			4.97		
$M_{u,Lim}$ (KNm)	291			291		
	OK			**OK**		
Ast Req.	421			794		
Dia of bar (main tension) (mm)	16			16		
Spacing (mm)	200			200		
+ dia of bar (main tension) (mm)	0			0		
Spacing (mm)	200			200		
Ast provided (sq mm)	1005			1005		
Dia of bar (main compresion) (mm)	0			0		
Spacing (mm)	200			200		
Area of main compresion (mm^2)	0			0		
f_{ctm}	2.5			2.5		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	362			362		
A_{ct}	259705			259705		
$f_{ct,eff}$	2.9			2.9		
$k_c = 0.4\ \{\ 1 - \sigma_c\ /\ (\ k_1\ f_{ct,eff}\ h/h^*)\ \} <= 1$	0.4			0.4		
For Bending or bending combined with axial force						
k	1.0000			1.0000		
σ_s	435			435		
As.max = 0.025 Ac (main tension)	7500			7500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**			**OK**		
As.max = 0.04 Ac (tension + compresion)	12000			12000		
x (mm)	40			40		
x/d	0.167			0.167		
	OK			**OK**		
z (mm)	225			225		
MR (KNm)	98			98		
	OK			**OK**		

5.4.2 Verification for serviceability limit state for inner wall



Strain Diagram

Stress Diagram

SERVICEABILITY LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 12.2.1, IRC:112-2011

f_{cd} = 14.40 N/mm^2 For Rare Combination

f_{cd} = 14.40 N/mm^2 For Frequent Combination

f_{cd} = 10.80 N/mm^2 For Quasi-Perma. Combination

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

f_{Yd} = 300 N/mm^2 For Rare Combination

f_{Yd} = 300 N/mm^2 For Frequent Combination

f_{Yd} = 300 N/mm^2 For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88	3.88	2.91

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 40

Moment on the section	**Bottom End support**			**Top End support**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	32.0		1.0	58		1
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	242.0		242.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.88		2.91	3.88		2.91
$M_{u,sls}$ (KNm)	227		170	227		170
	OK		**OK**	**OK**		**OK**
Ast Req.	452		14	839		14
Dia of bar (main tension) (mm)	16		16	16		16
Spacing (mm)	200		200	200		200
+ dia of bar (main tension) (mm)	0		0	0		0
Spacing (mm)	200		200	200		200
Ast provided (sq mm)	1005		1005	1005		1005
Dia of bar (main compresion) (mm)	0		0	0		0
Spacing (mm)	200		200	200		200
Area of main compresion (mm^2)	0		0	0		0
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	41.9		55.9	41.9		55.9
x/d	0.173		0.231	0.173		0.231
	OK		**OK**	**OK**		**OK**
z (mm)	228		224	228		224
MR_{sls} (KNm)	69		67	69		67
	OK		**OK**	**OK**		**OK**
$\sigma_{sc} = M/(A_s z)$	140		4	253		4
	OK		**OK**	**OK**		**OK**
$\sigma_{ca} = M/(0.8095\ z\ b\ x_u)$	6.70		0.16	12.14		0.16
	OK		**OK**	**OK**		**OK**

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

Calculation of crack width	**Bottom End support**			**Top End support**		
n_1			5			5
n_2			5			5
$\phi_{eq} = (n_1\phi_1^2 + n_2 \phi_2^2) / (n_1\phi_1+n_2\phi_2)$			16			16
cl. 12.3.4 (3) of IRC :112-2011						
c			40			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$\rho_{p.eff} = A_s / A_{c,eff}$			0.008			0.008
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 \phi) / \rho_{p.eff} \}$			461			461
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			31000			29626
$\alpha_e = E_s / E_{cm}$			6.45			6.75
$(\varepsilon_{sm}-\varepsilon_{cm})=(\sigma_{sc}-k_t f_{ct,eff}(1+\alpha_e \rho_{p,eff})/\rho_{p,eff})/E_s$ $>=0.6\sigma_{sc}/E_s$			0.0000			0.0000
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$			0.01			0.01
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

6.0 Summary of provided Reinforcement

Top Slab

At top of Mid Span

Area of Steel Provided = 392.7 mm^2/m

10mm dia @ 200mmc/c Top slab (Top main reinforcement)

At bottom of Mid Span

Area of Steel Provided = 1005.3 mm^2/m

16mm dia @ 200mmc/c Top slab (Bottom main reinforcement)

0mm dia @ 200mmc/c Top slab (Bottom extra reinforcement) OK

At top of End Support

Area of Steel Provided = 1398.0 mm^2/m

10mm dia @ 200mmc/c Top slab (Top main reinforcement)

16mm dia @ 200mmc/c Outer wall (Outer main reinforcement) OK

0mm dia @ 200mmc/c Top corner extra reinforcement

At bottom of End Support

Area of Steel Provided = 1005.3 mm^2/m

16mm dia @ 200mmc/c Top slab (Bottom main reinforcement) OK

0mm dia @ 200mmc/c

Bottom Slab

At top of Mid Span

Area of Steel Provided = 1005.3 mm^2/m

16mm dia @ 200mmc/c Bottom slab (Top main reinforcement)

0mm dia @ 200mmc/c Bottom slab (Top extra reinforcement) OK

At bottom of Mid Span

Area of Steel Provided = 392.7 mm^2/m

10mm dia @ 200mmc/c Bottom slab (Bottom main reinforcement)

0mm dia @ 200mmc/c Bottom slab (Bottom extra reinforcement)

At top of End Support

Area of Steel Provided = 1005.3 mm^2/m

16mm dia @ 200mmc/c Bottom slab (Top main reinforcement) OK

0mm dia @ 200mmc/c

At bottom of End Support

Area of Steel Provided = 1398.0 mm^2/m

10mm dia @ 200mmc/c Bottom slab (Bottom main reinforcement)

16mm dia @ 200mmc/c Outer wall (Outer main reinforcement) OK

0mm dia @ 200mmc/c Bottom corner extra reinforcement

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

Outer Wall

At outer face of top end

Area of Steel Provided = 1398.0 mm^2/m

16mm dia @ 200mmc/c Outer wall (Outer main reinforcement)
10mm dia @ 200mmc/c Top slab (Top main reinforcement) OK
0mm dia @ 200mmc/c Top corner extra reinforcement

At inner face of top end

Area of Steel Required = 608.5 mm^2/m

Area of Steel Provided = 1570.8 mm^2/m

20mm dia @ 200mmc/c Outer wall (Inner main reinforcement) OK

At outer face of bottom end

Area of Steel Provided = 1398.0 mm^2/m

10mm dia @ 200mmc/c Bottom slab (Bottom main reinforcement)
16mm dia @ 200mmc/c Outer wall (Outer main reinforcement) OK
0mm dia @ 200mmc/c Bottom corner extra reinforcement

At inner face of bottom end

Area of Steel Provided = 1570.8 mm^2/m

20mm dia @ 200mmc/c Outer wall (Inner main reinforcement)

Inner Wall

Area of Steel Provided = 1005.3 mm^2/m

16mm dia @ 200mmc/c Inner wall (main reinforcement)
0mm dia @ 200mmc/c Inner wall (main reinforcement) OK

Distribution Reinforcement As per cl. 16.6.1.1 (3) of IRC :112-2011

Top Slab

Req. Reinforcement = 330 mm^2/m

Provided Reinforcement =

10mm dia @ 200mmc/c 392.7 mm^2/m OK

Bottom Slab

Req. Reinforcement = 367.8 mm^2/m

Provided Reinforcement =

10mm dia @ 200mmc/c 392.7 mm^2/m OK

Outer Wall

Req. Reinforcement = 304.2 mm^2/m

Provided Reinforcement =

10mm dia @ 200mmc/c 392.7 mm^2/m OK

Inner Wall

Reinforcement Required = 180.9 mm^2/m

Provided Reinforcement =

10mm dia @ 200mmc/c 392.7 mm^2/m OK

7.0 Base Pressure

L/C	Node																					Total Wt (KN/m)	Base Pressure (KN/m$^{2)}$
	1	6	7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		
295	17	32	15	34	34	33	33	33	33	32	32	32	16	31	31	31	31	30	30	30	30	620	67
296	23	43	20	45	44	44	44	44	43	43	43	43	21	42	42	41	41	41	41	41	41	828	89

Max	**89**
Min.	**67**
	OK

Bearing capacity = 220 KN/sqm

AT Des Ch-157+500

Hydraulic calculation

Tamenglong- Mahur Road

Location - Des Ch- 157+500

1 Discharge:-

a) Discharge from catchment area

Dicken's Discharge 'Q' = C x $M^{3/4}$ as per SP-13-2004 Clause 4.2.

Where 'C' = 19 (Clause 4.2 of SP-13 ,C = 19 where the annual rain fall is >120 cm.)

Catchment Area at Site'M' = 25 Sq. Km. Refer catchment sheet Enclosed

Q = C x M3/4

Q = (19X (25)^3/4)

Q = 212.43 m^3/sec

b) Discharge By Area -Velocity Method

Cross section considered as per SP-13-2004 Clause 3.3(Table -3.1)

Section	Q(m3/sec)	Velocity (m/sec)	HFL (in Meter)	Avg flow depth
At 300 m d/s	250.407573	2.32	969.64	2.073
At Proposed site	195.45	2.10	970.54	1.779
At 300 m u/s	168.6186768	1.98	971.43	1.63

Max discharge from area velocity method 195.45 m3/sec

Max discharge from Dickens formula 212.43 m3/sec

max discharge - 212.43 m^3/sec

Discharge =	Q =AV	
	A = Q/V	
Linear water way required =	Lx D =Q/V	
	L = Q/(VxD)	
	212/(2.1x1.78)	

2 **Linear water way required = 56.790094 M**

Provide 3 Span of 16 m

Calculation for design velocity -

The length of bridge proposed =	48	M
The average flow depth below H.F.L. =	1.78	M
No of piers proposed =	2	Nos
Thickness of proposed pier =	1.2	M
Width of Abutment in flow area	0.4	M
Thus Clear water way avilable =	(48-2X1.2- 2 x0.4)	
	44.8	M

Thus the design velocity = Q/ A

V= (212.43)/(44.8X1.78)

V= 2.66 M/Sec

The Design velocity 2.66 m/sec

3 **Afflux**

The theoritical Afflux at proposed site shall be calculated using Moles worth formula

a =	((V^2 / 17.88) - 0.015) X ((A/a)^2 - 1)
Where as	
A=	Area of cross section at H.F.L. site as compared to the u/s & d/s areas)
a =	Area of clear water way under the proposed bridge in sqm.
V =	Velocity in m/sec
A =	92.98192479 Sqm
a =	1.77946153846144X44.8
	79.72 Sqm
V =	2.66 m/sec
Afflux =	((2.66^2 / 17.88) - 0.015) X ((92.98/79.72)^2 -1)
	0.1372091 m
I.e.	137.2090995 mm

Consider afflux is 200 mm.

4 Scour Depth

For the design of foundation in accordance with the provisions of IRC-78,2000 clause 703.1.1.
above discharge has been further increased by 30% for Calculation of scour depth.

Considering the available linear water way at bridge as = 44.8 M

Thus the discharge per unit width 'Db' = 1.30 X Q design /44.8

1.3x212.43/44.8

Db' = 6.16 m^3/sec

Thus the theoretical mean scour depth

MSD = 1.34x(Db^2/Ksf)^(1/3)

Where 'Ksf' = 2.4 (as per IRC-78,2000 clause 703.2.2.1)

There fore NSD = 1.34x(6.16^2 /2.4)^(1/3)

3.36 M from HFL.

The scour level for abutment = H.F.L. - 1.27 X N.S.D.(as per IRC-78,2000 clause 703.3.2.)

= 970.535 -1.27X3.365

The scour level for abutment = 966.262 M

(Foundation level is 2m below scour depth in soil OR Rock level which ever is higher)

Foundation level for abutment = 960.458 M

Foundation level for Pier = 957.337 M

Formation level calculations -

a)	HFL at Proposed site=	970.535	m
b)	Vertical clearance as per IRC -5	0.9	m
c)	Afflux	0.2	m
d)	Depth of deck	1.666	m
e)	Depth of wearing coat	0.075	m

5 **Formation level by HFL Consideration (a+b+c+d+e) =** 973.376 **m**

6 **Formation level by Profile Improvements = 973.376 m**

Location - Des Ch- 157+500

Calculation of Discharge By Area Velocity Method at **Proposed Site.**

H.F.L 970.535 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff(m)	Perimeter (m)	Area(Sqm)
24.00	970.458		0.077		0.000	
20.00	970.138	4	0.397	0.320	4.013	0.950
16.00	969.397	4	1.138	0.741	4.068	3.096
12.00	968.777	4	1.758	0.620	4.048	5.827
8.00	967.337	4	3.198	1.440	4.251	10.223
4.00	967.214	4	3.321	0.123	4.002	13.041
0.00	967.093	4	3.442	0.121	4.002	13.529
4.00	967.205	4	3.330	0.112	4.002	13.547
8.00	967.325	4	3.210	0.120	4.002	13.083
12.00	968.837	4	1.698	1.512	4.276	10.155
16.00	969.467	4	1.068	0.630	4.049	5.566
20.00	970.127	4	0.408	0.660	4.054	2.972
24.00	970.447	4	0.088	0.320	4.013	0.994
		avg.Depth =	1.779		48.779	92.982

Discharge Calculation by Area Velocity method

Using Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)
A = 92.982 Sqm
P = 48.779 M
Avg. depth of flow = 1.779 m
R=A/P
R = 92.98/48.78
1.91
S = 0.00298333
n = 0.04
V = 6x0^0.5/0.04
V = 2.10207116 m/sec

Q=A*V
Q = 2.1x92.98
Q = 195.455 m^3/sec

Location - Des Ch- 157+500

Calculation of Discharge By Area Velocity Method at **300U/S**

H.F.L 971.425 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff	Perimeter	Area
24.00	971.333		0.092		0.000	
20.00	970.883	4	0.542	0.450	4.025	1.272
16.00	970.363	4	1.062	0.520	4.034	3.221
12.00	969.643	4	1.782	0.720	4.064	5.734
8.00	969.023	4	2.402	0.620	4.048	8.418
4.00	968.503	4	3.442	1.040	4.133	11.882
0.00	967.983	4	2.922	0.520	4.034	12.782
4.00	968.493	4	2.932	0.010	4.000	11.708
8.00	969.003	4	2.422	0.510	4.032	10.751
12.00	969.613	4	1.812	0.610	4.046	8.517
16.00	970.323	4	1.102	0.710	4.063	5.874
20.00	970.833	4	0.592	0.510	4.032	3.402
24.00	971.283	4	0.142	0.450	4.025	1.473
		avg.Depth =	1.634		48.536	85.033

Discharge Calculation by Area Velocity method

Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 85.033 Sqm

P = 48.536 M

depth of 1.634 m

R=A/P

R = 85.03/48.54

1.75

S = 0.0029833

n = 0.04

V = 1.75^0.66x0^0.5/0.04

V = 1.9829743 m/sec

Q=A*V

Q = 1.98x85.03

Q = 168.619 m^3/sec

Location - Des Ch- 157+500

Calculation of Discharge By Area Velocity Method at **300D/S**

H.F.L 969.635 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff	Perimeter	Area
24.00	969.543		0.092		0.000	
20.00	968.693	4	0.942	0.850	4.089	2.091
16.00	967.873	4	1.762	0.820	4.083	5.464
12.00	967.153	4	2.482	0.720	4.064	8.556
8.00	966.633	4	3.002	0.520	4.034	11.014
4.00	966.313	4	3.322	0.320	4.013	12.668
0.00	966.193	4	3.442	0.120	4.002	13.531
4.00	966.303	4	3.332	0.110	4.002	13.551
8.00	966.513	4	3.122	0.210	4.006	12.917
12.00	967.123	4	2.512	0.610	4.046	11.333
16.00	967.833	4	1.802	0.710	4.063	8.695
20.00	968.643	4	0.992	0.810	4.081	5.645
24.00	969.493	4	0.142	0.850	4.089	2.293
		avg.Depth =	2.073		48.571	107.759

Discharge Calculation by Area Velocity method

Using Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 107.759 Sqm

P = 48.571 M

depth of 2.073 m

R=A/P

R = 7.76/48.57

2.22

S = 0.002983

n = 0.04

V = 2.22^0.66x0^0.5/0.04

V = 2.323775 m/sec

Q=A*V

Q = 32x107.76

Q = 250.408 m^3/sec

Location - Des Ch- 157+500

L - Section of River/nalla

Chainage (M)	G .L (M)
-300.000	967.983
-280.000	967.913
-260.000	967.843
-240.000	967.773
-220.000	967.703
-200.000	967.653
-180.000	967.603
-160.000	967.553
-140.000	967.503
-120.000	967.453
-100.000	967.383
-80.000	967.333
-60.000	967.283
-40.000	967.233
-20.000	967.183
0.000	967.093
20.000	967.033
40.000	966.973
60.000	966.913
80.000	966.853
100.000	966.793
120.000	966.733
140.000	966.673
160.000	966.613
180.000	966.553
200.000	966.493
220.000	966.433
240.000	966.373
260.000	966.313
280.000	966.253
300.000	966.193

Slope = (967.983-966.19)/(300--300)
0.002983

DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

INDEX

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

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INTRODUCTION

This design note present the detailed calculations for abutment having POT/PTFE bearings. Design note contains the typical design of abutment cap, abutment, pile cap and pile. In the analysis, the forces have been worked out at the pile cap bottom level for pile cap design and at the top of pile cap for abutment shaft design.

This design is applicable for abutment

Abutment Nos.	Road Top Level	GROUND LEVEL	Pile cap bottom	DIFF
	(M)	(M)	(M)	(M)
A1 & A2	973.376	970.458	968.158	5.218

DESIGN DATA

Span Arrangement C/C of exp. Joint	=	**16**	m
Deck Width	=	**18**	m
Carriageway Width	=	**11**	m
Structural system	=	simply supported	
construction type	=	RCC	
Effective Span	=	**15.20**	m
Expansion gap in abutment	=	**40**	mm
No of Lane considered for design	=	**4**	
Bearing type	=	**Elastome ric**	**Bearing**
Skew Angle	=	**0**	Degree

SALIENT REDUCED LEVELS

Deck Top Level	=	**973.376**
Soffit Level	=	**972.076**
Abutment Cap Top Level	=	**972.026**
Abutment Cap Bottom Level	=	**971.526**
HFL	=	**970.535**
Pile cap bottom Level	=	**968.158**
Scour Level	=	**966.262**

DETAILS OF STRUCTURE & OTHER PARAMETERS

Type of structure		**RCC**	
Depth of Superstructure	=	**1.200**	m
Thickness of wearing coat	=	**0.075**	m
Camber in both direction	=	2.50%	
Expansion joint Type	=	**Strip seal**	
Impact (including Congestion Factor)	=	1.394	
Thickness of Return	=	**0.5**	m

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MATERIAL PARAMETERS

Concrete — **Refer Table 6.5, IRC:112-2019**

Grade of concrete for sub structure and foundation		=	**M30**
Cube strength of concrete at 28 days	f_{ck}	=	**30** MPa
Design value of concrete compressive strength	f_{cd}	=	$\alpha f_{ck}/\gamma_m$
		α =	0.67
For Basic Combination	f_{cd}	=	13.40 MPa
For Accidental Combination	f_{cd}	=	16.75 MPa
For Seismic Combination	f_{cd}	=	13.40 MPa
Modulus of Elasticity	E_c	=	31000 MPa
Mean value of axial tensile strength of concrete	f_{ctm}	=	2.5 MPa
Wet Density **2.00** t/m3	Dry Density	=	**2.50** t/m^3

Reinforcing Steel

Grade		=	**Fe500**
Characteristics yield strength	f_{yk}	=	500 MPa
Design yield strength	f_{yd}	=	f_{yk}/γ_m
For Basic Combination	f_{yd}	=	434.8 MPa
For Accidental Combination	f_{yd}	=	500.0 MPa
For Seismic Combination	f_{yd}	=	434.8 MPa
Modulus of Elasticity	E_s	=	**2.00E+05** Mpa
	Ecm	=	**3.10E+04** Mpa
Density		=	**7.85** t/m3
Soil Wet density **1.00** t/m3	Soil Dry Density	=	**2.00** t/m3

'(As per STAAD Output)

21 m span Reactions (KN)			
Bearing No.	**DL**	**SIDL1 (WC)**	**SIDL2 (CB)**
1	437	51	156
2	483	43	-19
3	469	50	5
4	479	43	-28
5	448	53	159
	2316	**240**	**273**

Partial Safety Factor for Materials

Material	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
Concrete	1.50	1.20	1.50
Steel	1.15	1.00	1.15

Cl 6.4 2.8, IRC:112-2011
Cl 6 2.2, IRC:112-2011

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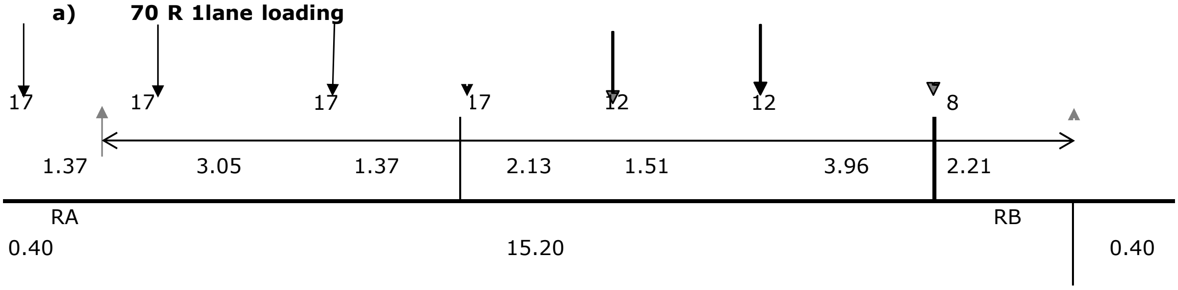
LIVE LOAD CALCULATIONS

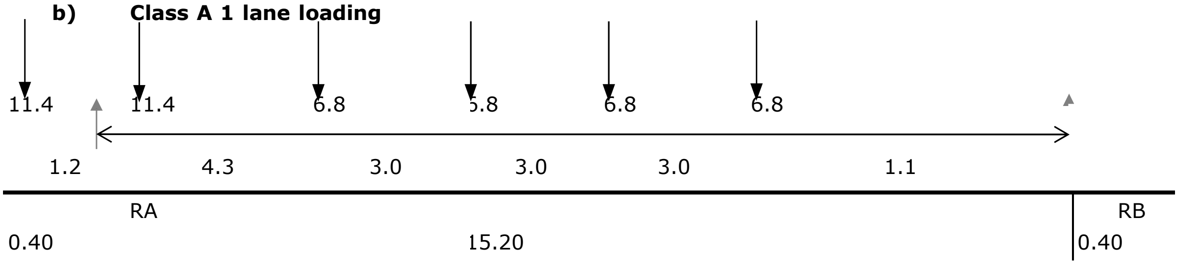
1. MAX. MOMENT CASE

a) 70 R 1lane loading



Ra	=	1047.82	/	15.20	=	68.9	t
		Impact	1.394		=	96.1	t
RB	=					31.06	t

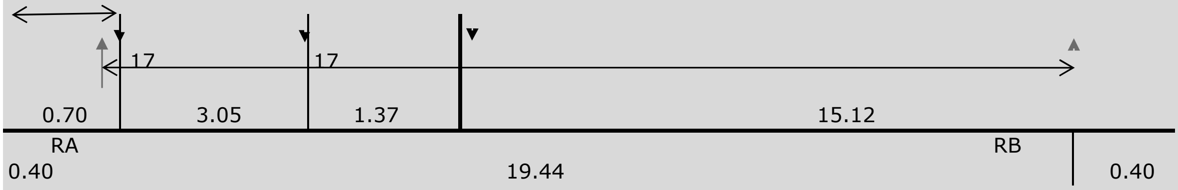
b) Class A 1 lane loading



Ra =	494.32	/	15.20	=	32.5	t
		Impact	1.394	=	45.3	t
RB =				=	17.5	t

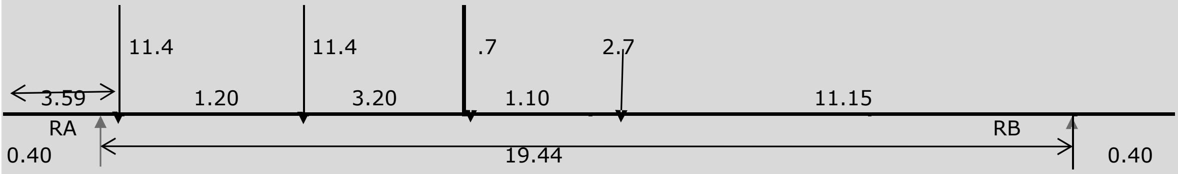
2. MAX. REACTION/ TRANSVERSE MOMENT CASE

a) 70 R 1lane loading



Ra =	848.96	/	19.44	=	43.67	t
		Impact	1.394	=	60.88	t
RB =				=	7.3	t

b) **Class A 1 lane loading**



Ra =	417.81	/	19.44	=	21.49	t
		Impact	1.394	=	29.96	t
RB =				=	6.7	t

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Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

PARTIAL SAFETY FACTORS

Ultimate Limit State

Partial Safety for Verification of Structural Strength **Table B.1, Annex B, IRC:6-2017**

Also refer IRC Amendment dated August, 2019

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturnin g or Sliding or Uplift Effect	Restoring or Resisting Effect
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 Permanent Loads:						
1.1 Dead Load, SIDL except surfacing, Backfill Weight,Settlement, Creep and shrinkage effect	1.1	0.9	1	1	1.1	0.9
1.2 Surfacing	1.35	1.0	1.0	1.0	1.35	1.0
1.3 Prestressing and secondary effect of prestress	Refer Note No. 5					
1.4 Earth Pressure due to Backfill	1.50	1	1.0	1	1.0	1
2 Variable Loads:						
2.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:						
a) Leading Load	1.5	0	0.75	0	-	-
b) Accompanying Load	1.15	0	0.2	0	0.2	0
c) Construction Live Load	1.35	0	1.0	0	1.0	0
2.2 Thermal Loads						
a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	0.5	0	0.5	0
2.3 Wind Load						
a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	-	-	-	-
2.4 Live Load Surcharge (as accompanying	1.2	0	-	-	-	-
3 Accidental Effects:						
3.1 Vehicle Collision	-	-	1.0	-	-	-
3.2 Barge Impact	-	-	1.0	-	-	-
3.3 Impact due to floating bodies	-	-	1.0	-	-	-
4 Seismic Effect						
a) During Service	-	-	-	-	1.5	-
b) During Construction	-	-	-	-	0.75	-
5 Construction Condition:						
5.1 Counter Weights:						
a) When density or self weight is well defined	-	0.9	-	1.0	-	1.0
b) When density or self weight is not wel defined	-	0.8	-	1.0	-	1.0
5.2 Construction dead loads(such as wt. of launching girder, truss or cantilever construction equipments	1.10	0.90	1.1	0.9	1.1	0.9
5.3 Wind						
a) As Leading Load	1.50	0	-	-	-	-
b) As Accompanying Load	1.20	0	-	-	-	-
6 Hydraulic Loads (Accompanying Load):						
6.1 Water Current Forces	1.0	0	1.0	0	1.0	-
6.2 Wave Pressure	1.0	0	1.0	0	1.0	-
6.3 Hydrodynamic Effect	-	-	-	-	1.0	-
6.4 Buoyancy	1.0	-	1.0	-	1.0	-

Partial Safety for Verification of Structural Strength **Table B.2, Annex B, IRC:6-2017**

Also refer IRC Amendment dated August, 2019

Loads	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
(1)	(2)	(3)	(4)
1 Permanent Loads:			
1.1 Dead Load, snow load (if present) SIDL except surfacing			
a) Adding to the effect of variable loads	1.35	1.00	1.35
b) Relieving the effect of variable loads	1.00	1.00	1.00
1.2 Surfacing:			
a) Adding to the effect of variable loads	1.75	1.00	1.75
b) Relieving the effect of variable loads	1.00	1.00	1.00
1.3 Prestressing and secondary effect of prestress	Refer Note No. 2		
1.4 Backfill Weight			
(a) When Causing Adverse Effect	1.35	1.00	1.00
(b) When Causing Relieving Effect	1.00	1.00	1.00
1.5 Earth Pressure			
a) Adding to the effect of loads	1.50	0.00	1.00
b) Relieving the effect of loads	1.00	1.00	1.00
2 Variable Loads:			
2.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.50	0.75	-
b) Accompanying Load	1.15	0.20	0.20
c) Construction Live Load	1.35	1.00	1.00
2.2 Wind during service and construction			
a) Leading Load	1.50	-	-
b) Accompanying Load	0.90	-	-
2.3 Live Load Surcharge (as accompanying load)	1.20	0.20	0.20
2.4 Construction dead loads(such as wt. of launching girder, truss or cantilever construction equipments	1.35	1.00	1.35
2.5 Thermal Load			
a) Leading Load	1.50	-	-
b) Accompanying Load	0.90	0.50	0.50
3 Accidental Effects:			
i) Vehicle Collision	-	1.00	-
ii) Barge Impact	-	1.00	-
iii) Impact due to floating bodies	-	1.00	-
4 Seismic Effect			
a) During Service	-	-	1.50
b) During Construction	-	-	0.75
5 Hydraulic Loads (Accompanying Load):			
5.1 Water Current Forces	1.00	1.00	1.00
5.2 Wave Pressure	1.00	1.00	1.00
5.3 Hydrodynamic Effect	-	-	1.00
5.4 Buoyancy	0.15	0.15	1.00

Serviceability Limit State
Partial Safety for Verification of Serviceability Limit State

Table B.3, Annex B, IRC:6-2017

Also refer IRC Amendment dated August, 2019

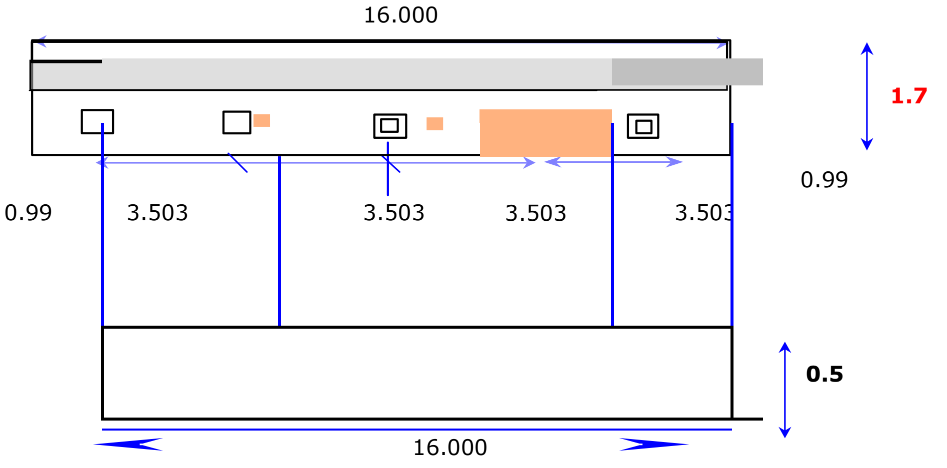
Loads	**Partial Safety Factor**		
	Rare Combination	**Frequent Combination**	**Quasi-permanent Combination**
(1)	**(2)**	**(3)**	**(4)**
1 Permanent Loads:			
1.1 Dead Load, Snow Load(if any), Backfill, SIDL except surfacing	1.00	1.00	1.00
1.2 Surfacing	1.00	1.00	1.00
a) Adding the effect of variable Loads	1.20	1.20	1.20
b) Relieving the effect of variable Loads	1.00	1.00	1.00
1.3 Earth Pressure	1.00	1.00	1.00
1.4 Prestress and secondary effect of prestressing	Refer Note no. 4		
1.5 Shrinkage and Creep Effects	1.00	1.00	1.00
2 Settlement Effects			
a) Adding to the permanent loads	1.00	1.00	1.00
b) Opposing the permanent loads	0.00	0.00	0.00
3 Variable Loads:			
3.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.00	0.75	-
b) Accompanying Load	0.75	0.20	0.00
3.2 Thermal Loads:			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load	0.60	0.50	0.50
3.3 Wind			
a) Leading Load	1.00	0.60	-
b) Accompanying Load	0.60	0.50	0.00
3.4 Live Load Surcharge as Accompanying load	0.80	0.00	0.00
4 Hydraulic Loads (Accompanying Load):			
4.1 Water Current	1.00	1.00	-
4.2 Wave Pressure	1.00	1.00	-
4.3 Buoyancy	0.15	0.15	0.15

Partial Safety for Checking the Base Pressure and Design of Foundation

Also refer IRC Amendment dated August, 2019 **Table B.4, Annex B, IRC:6-2017**

Load	Partial Safety Factor			
	Combination-1	Combination-2	Combination-3	Combination-4
(1)	(2)	(3)	(4)	(5)
1. Permanent Loads:				
1.1 Dead Load, Snow Load (if any), SIDL except surfacing and Back fill				
a) When causing adverse effects	1.35	1.00	1.35	1.00
b) When causing Relieving effects	1.00	1.00	1.00	1.00
1.2 SIDL surfacing				
a) When causing adverse effects	1.75	1.00	1.75	1.00
b) When causing Relieving effects	1.00	1.00	1.00	1.00
1.3 Prestress Effect	Refer Note 4			
1.4 Settlement Effect	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
1.5 Earth Pressure				
a) Adding to the effect of loads	1.50	1.30	1.00	1.00
b) Relieving to the effect of loads	1.00	0.85	1.00	1.00
2. Variable Loads:				
2.1 All carriageway loads and associated loads (braking, tractive and centrifugal) and footway live load				
a) Leading Load	1.50	1.30	0.75 or 0	0.75 or 0
b) Accompanying Load	1.15	1.00	0.20	0.20
c) Construction Dead Load	1.35	1.00	1.35	1.00
2.2 Thermal load as accompanying load	0.90	0.80	0.50	0.50
2.3 Wind Load				
a) Leading Load	1.50	1.30	-	-
b) Accompanying Load	0.90	0.80	0.00	0.00
2.4 Live load surcharge as Accompanying Load (if applicable)				
3. Accidental Effect or Seismic Effect				
a) During Service	-	-	1.50	1.00
b) During Construction	-	-	0.75	0.50
4. Construction Dead Load (Such as Wt. of launching girder, truss or cantilever construction equipments)	1.35	1.00	1.35	1.00
5. Hydraulic Loads:				
5.1 Water Current	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
5.2 Wave Pressure	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
5.3 Hydodynamic effect	-	-	1.0 or 0	-
6. Buoyancy:				
a) For Base Pressure	1.00	1.00	1.00	1.00
b) For Structural Design	0.15	0.15	0.15	0.15

ABUTMENT CAP LOAD CALCULATION



Abutment cap is fully resting on abutment wall, so provide min. reinforcement.

cl. 16.5.1.1 (1) of IRC :112-2011

$A_{S.min}$ = 0.26 f_{ctm} b_t d / f_{yk} >= 0.0013 b_t d

f_{ctm}	2.5	
b_t	1700	
d	500	
f_{yk}	500	
0.26 f_{ctm} b_t d / f_{yk}	1105	mm^2
0.0013 b_t d	1105	mm^2
Provide	1105	mm^2

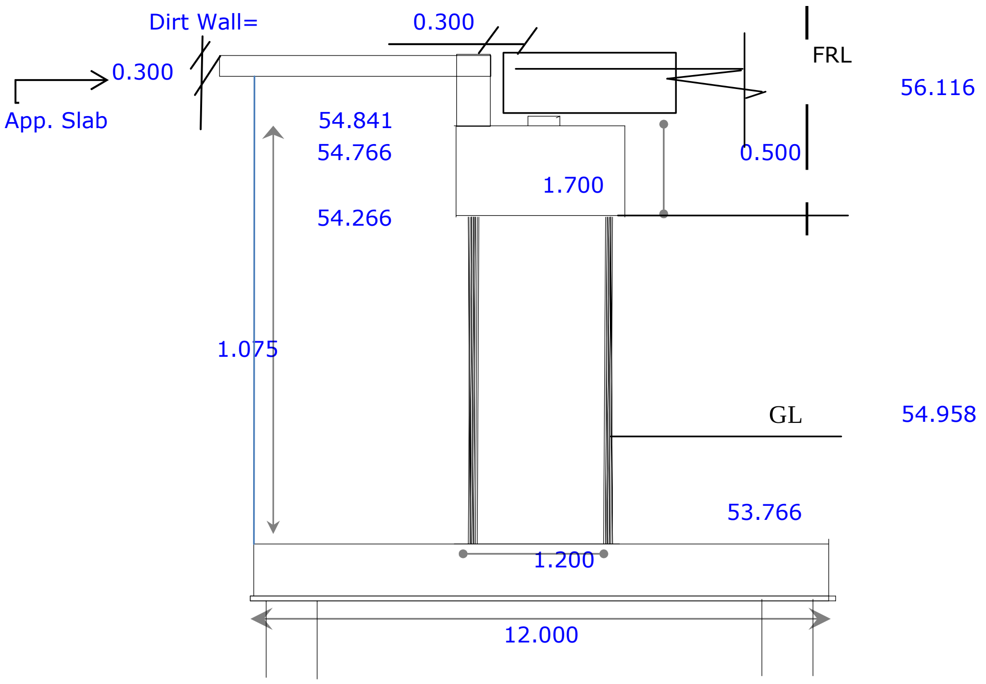
16 ϕ @	**150 mm c/c**	**1340** OK	**mm^2**	**at top and bottom**
12 ϕ @	**150 mm c/c**	**754** OK	**mm^2**	**as distribution in the form of stirrup**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

LOAD CALCULATION FOR ABUTMENT & PILE CAP

SALIENT REDUCED LEVELS

Deck Top Level	=	973.376	m
Bearing Top Level	=	972.076	m
Abutment Cap Top Level	=	972.026	m
Abutment Cap Bottom Level	=	971.526	m
Abutment Bottom Level	=	969.958	m
Depth of Pile cap	=	1.8	m
GL	=	970.458	m
Pile cap bottom Level	=	968.158	m
HFL	=	970.535	m
LBL	=	967.093	m
Expansion Gap	=	0.040	m
Width of abutment	=	**1.000**	m
Length of the abut	=	**18.000**	m
Length of Pile cap	=	**18.000**	m
Width of Pile cap	=	**4.300**	m
Thickness of Wearing coat (W/c)	=	0.075	m
Height of Deck+Girder	=	1.200	m
Thickness of bearing	=	**0.100**	m
Height of Pedestal	=	**0.250**	m
Total Height from w/c to Abut Cap top	=	1.350	m
Span EJ to EJ	=	16.000	m



2.350
0.086

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designe dby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date &Rev.	

LOAD CALCULATIONS

Taking Moments about founding level

		RIGHT SPAN	LEFT SPAN	L (Long)	L (Trans)	ML	Mt	
				m	m	t-m	t-m	
Dead Load		236.33		0.00	0.00	0.00	0.00	
SIDL1 w/c		24.49		0.00	0.00	0.00	0.00	
SIDL 2 exl w/c		27.86		0.00	0.00	0.00	0.00	
LL1 (Max Reaction)								
70 R + 2Class A		120.81		0.00	1.875	0.00	226.51	2.103
2 70 R		121.76		0.00	3.080	0.00	375.03	2.910
70 R		60.88		0.00	4.905	0.00	298.62	4.905
Class 4 A		119.85		0.00	1.075	0.00	128.84	0.950
70 R + Class A		90.84		0.00	4.201	0.00	381.63	3.958
LL2 (Max Moment)								
70 R + 2Class A		186.78		0.00	1.875	0.00	350.21	2.103
2 70 R		192.21		0.00	3.080	0.00	592.00	2.910
70 R		96.10		0.00	4.905	0.00	471.39	4.905
Class 4 A		181.35		0.00	1.075	0.00	194.95	0.950
70 R + Class A		141.44		0.00	4.201	0.00	594.19	3.958

Horizontal Force Due to braking at				POT PTFE Bearing		Fixed abut		
	μ =	0.05	(as per IRC 6:2017)	Fh/2 + μ(Rg+Rq) OR Fh - μ(Rg+Rq)	**@foundation**		**abut Bottom**	
	Fh	Rg	Rq	**H**	**Lev**	**ML**	**Lev**	**ML**
	t	**t**	**t**	**t**	**m**	**t-m**	**m**	**t-m**
70 R + 2Class A		288.67	186.78	23.77	2.18	51.90	1.07	25.56
Class 2 70R	20.43	288.67	192.21	34.26	2.18	74.79	1.07	36.83
Class 70 R	20.00	288.67	96.10	29.24	2.18	63.83	1.07	31.43
Class 4 A	15.51	288.67	181.35	31.26	2.18	68.23	1.07	33.60
70 R + Class A	20.49	288.67	141.44	31.75	2.18	69.31	1.07	34.13

Horizontal braking force	=	34.26	t
ML @ foundation	=	74.79	tm
ML @ abut bottom	=	36.83	tm

@foundation	P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)	Fh(t)
LL1B	3	75	0	34.26	0.00	20.43
LL2B	0	0	0			
LL3B	3	69	0	31.75	0.00	20.49
@abutment bottom	P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)	Fh(t)
LL1B	3	37	0	34.26	0.00	20.43
LL2B	0	0	0			
LL3B	3	34	0	31.75	0.00	20.49

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

WIND FORCES ON SUPER STRUCTURE

REF: IRC 6-2017 CL NO:209.2

Basic wind speed	=	47 m/s	Plain terrain				
Design wind speed	=	39.59 m/s	at height	10.00 m			27.80 m/s
Design wind pressure P_Z	=	940.60 N/m^2	at height	10.00 m			463.70 N/m^2
$F_T = P_Z A_1 G C_D$	=	374 Kg/m^2		G =	2.00	C_D =	1.95
F_L =	=	93.48 Kg/m^2					
$F_V = P_Z A_3 G C_L$	=	144 Kg/m^2		G =	2.00	C_L =	0.75

Up ward or downward vertical wind Load

F_V = 8.00 x **16.000** x 143.82 = 18.41 t

WIND FORCES ON LIVE LOAD

Basic wind speed	=	0 m/s	Plain terrain				
Design wind speed	=	0.00 m/s	at height	10.00	m		27.80 m/s
Design wind pressure P_Z	=	0.00 N/m^2	at height	10.00	m		463.70 N/m^2
$F_T = P_Z A_1 G C_D$	=	0 Kg/m^2		G =	2.00	C_D =	1.20
F_L =	=	0.00 Kg/m^2					
$F_V = P_Z A_3 G C_L$	=	0 Kg/m^2		G =	2.00	C_L =	0.75

WIND FORCES ON SUB STRUCTURE

Basic wind speed	=	47 m/s	Plain terrain				
Design wind speed	=	39.59 m/s	at height	10.00 m			27.80 m/s
Design wind pressure P_Z	=	940.60 N/m^2	at height	10.00 m			463.70 N/m^2

REF: IRC 6-2017 CL NO:209.4

$F_T = P_Z A_1 G C_D$	=	96 Kg/m^2		G =	2.00	C_D =	0.50
F_L =	=	23.97 Kg/m^2					
$F_V = P_Z A_3 G C_L$	=	144 Kg/m^2		G =	2.00	C_L =	0.75

TRANSVERSE DIRECTION		Moments about FL			Abutment Bottom	
DESCRITPTION		H	Lev	Mt	Lev	Mt
		t	M	t-m	M	t-m
WIND ON SUPER STR ACT @	55.48	11.29	2.82	31.84	1.71	19.33
WIND ON MOVING LOAD @	57.62	0.00	4.96	0.00	3.85	0.00
WIND ON abutment CAP @	54.52	0.08	1.86	0.15	0.75	0.06
WIND ON abutment @	54.61	-0.07	1.95	-0.13	0.85	-0.06
	TOTAL	11.30		31.86		19.34

LONGITUDINAL DIRECTION		Moments about FL			Abutment Bottom	
DESCRITPTION		H	Lev	Mt	Lev	Mt
		t	M	t-m	M	t-m
WIND ON SUPER STR ACT @	55.48	4.71	2.82	43.05	1.71	34.57
WIND ON MOVING LOAD @	57.62	0.00	4.96	0.00	3.85	0.00
WIND ON abutment CAP @	54.52	0.71	1.86	5.25	0.75	3.97
WIND ON abutment @	54.61	-0.02	1.95	-0.03	0.85	-0.01
	TOTAL	5.53		48.85		38.89

DEAD WEIGHT OF ABUTMENT CAP WITH DIRT WALL

	Nos	L	B	H	Qty	wt	L. A.	ML (tm)
		m	m	m	m3	t		
Abut. Cap	1	16.000	1.70	0.500	13.60	34.00	0.00	0.00
Dirt wall	1	16.000	0.30	1.350	6.48	16.20	-0.70	-11.34
Pedestals (5 nos)	5	**0.800**	**0.800**	**0.400**	1.28	3.20	0.00	0.00
DL+SIDL (approach span) load	1	16.000		5.2	**0.92** t/m2	37.70	-0.70	-26.39
LL (approach span) LL surcharge(1.2m)	1	16.000		5.150	**2.40** t/m2	98.88	-0.70	-69.22
Total						**189.98**		**-59.49**

DEAD WEIGHT OF ABUTMENT & FOUNDATION

				LWL	HFL	LA C/L of abut / found(m)	LWL	HFL
	L	B	H	wt	wt		ML	ML
	m	m	m	t	t		(t.m)	(t.m)
Abut. Stem	16.000	1.00	-0.69	-27.68	-22.14	0.00	0.00	0.00
	16.000	1.00	1.19	47.68	38.14	0.00	0.00	0.00
Foundation	16.000	4.30	1.80	309.60	247.68	0.00	0.00	0.00
Return wall	1.00	1.650	1.85	7.63	6.10	-1.33	-10.11	-8.09
	1.00	1.650	0.09	0.35	0.28	-1.33	-0.47	-0.38
	1.00	1.650	0.41	1.71	1.37	-1.33	-2.26	-1.81
Soil Above the Foundation	15.000	1.650	1.47	73.01	36.51	-1.33	-96.74	-48.37
	15.000	1.650	0.09	4.26	2.13	-1.33	-5.64	-2.82
	15.000	1.650	0.41	20.49	10.25	-1.33	-27.15	-13.58
Total				**437.06**	**320.32**		**-142.38**	**-75.04**
					116.74			**-67.34**

Earth pressure		At foundation		At abut. Bottom	
		LWL	HFL	LWL	HFL
Height	m	3.458	3.458	2.35	2.35
Dry unit wt. of soil	t/m3	2.00		2.00	
Wet unit wt. of soil	t/m3		1.00		1.00
Coulomb's theory Ka (Normal case)					
Angle of friction	ϕ	**30.00**			
Angle of deflection	δ	**20.00**			
wall inclination to horizontal	α	**90.00**			
soil surcharge inclination to horizontal	β	**0.00**			
Ka (Normal case)		0.279			
Coulomb's theory Ka (Seismic case)					
Seismic Zone		III			
α_h		0.0800			
α_v		0.0533			
$\theta = \tan^{-1}(\alpha_h/(1+\alpha_v))$		0.0758			
		0.0843			
Coefficient of active earth pressure (Seismic case)		0.344			
Coefficient of active earth pressure		0.279	0.279	0.279	0.279
Live load surcharge	m	**1.20**	**1.20**	**1.20**	**1.20**
Active earth pressure		1.93	0.97	1.31	0.66
Pressure due to live load surcharge		0.67	0.34	0.67	0.34
Force due to live load surcharge	t/m	37	19	25	13
Force due to active earth pressure	t/m	53	27	25	12
Moment due to live load surcharge	t.m/m	64	32	30	15
Moment due to active earth pressure	t.m/m	78	39	24	12

Dynamic increment due to earth pressure		At foundation		At abut. Bottom	
As per Cl. 219.5.4 & 214.1.2 of IRC 6-2017		LWL	HFL	LWL	HFL
Coefficient of active earth pressure		0.000	0.000	0.000	0.000
Live load surcharge	m	**1.20**	**1.20**	**1.20**	**1.20**
Active earth pressure		0.00	0.00	0.00	0.00
Pressure due to live load surcharge		0.00	0.00	0.00	0.00
Force due to live load surcharge	t/m	0	0	0	0
Force due to active earth pressure	t/m	0	0	0	0
Moment due to live load surcharge	t.m/m	0	0	0	0

Moment due to active earth pressure	t.m/m	0	0	0	0

Fundamental Time Period of Vibration due to Seismic Waves :

According to **Annexure D (Clause 219.5)** IRC 6 :2017 -

T	=	2.0 x sqrt(D/(1000*F))

Where,

T	=	Fundamental Time Period Of Vibration
D	=	Appropriate dead Load of the superstructure and Live load in KN
F	=	Horizontal Force in KN required to be applied at the centre of mass of superstructure for 1 mm horizontal deflection at the top of the 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 Longitudinal direction

			Longitudinal Direction		Transverse Direction		
	F	=	$d*(3EI)/L^3$	Unit	$d*(3EI)/L^3$	Unit	
	d	=	0.001	m	0.001	m	
	L	=	1.608	m	2.158	m	
	E	=	3.10E+07	KN/m2	3.10E+07	KN/m2	
	I	=	1.000	m4	256.000	m4	
	F	=	22367.880	KN	#######	KN	
	D	=	2829.000	KN	3206.109	KN	(DL+0.2*LL)
	T	**=**	***0.02***	***sec***	***0.00***	***sec***	
Seismic Zone		=	III		III		
Zone Factor Z		=	0.16		0.16		
Importance Factor I		=	1.2		1.2		
Response Reduction Factor		=	3		3		
Soil Strata		=	Type II	Medium soil			
Sa/g			2.5		2.5		
Horizontal Acceleration Coefficient (Ah) Z/2*Sa/g*I/R		=	0.08		0.08		

For design of foundation seismic loads are increased by 35% As per Cl. 219.8 of IRC 6-2017

Seismic Force Calculations		**For Foundation**		
		Horizontal	**Vertical (2/3 of Horizontal)**	
Long Seismic Coefficient		0.108	0.072	(including over strength factor)
Trans Seismic Coefficient		0.108	0.072	(including over strength factor)

Seismic For design of foundation seismic loads are increased by 35%

						@ Foundation		
	V (t)	**H Comp**	**V Comp**	**Acting At**	**Ecc (For H)**	**ML Due to H**	**Moment Due to V**	
							ML	**MT**
DL	472.2	51.0	34.0	54.8	2.2	111.3	0.0	0.0
SIDL1	48.9	5.3	3.5	54.8	2.2	11.5	0.0	0.0
SIDL2	55.7	6.0	4.0	54.8	2.2	13.1	0.0	0.0
Abt. but Cap+dirt wall	190.0	20.5	13.7	55.2	2.50	51.2	0.0	0.0
abut	20.0	2.2	1.4	54.0	1.4	2.9	0.0	0.0
return wall	9.7	1.0	0.7	54.9	2.3	2.4	0.0	0.0
Soil above found	97.8	10.6	7.0	54.9	2.3	24.1	0.0	0.0
LL1	38.4	4.2	2.8	54.8	2.2	9.1	0.0	8.5
LL2	38.4	4.2	2.8	54.8	2.2	9.1	0.0	8.5
LL3	28.3	3.1	2.0	54.8	2.2	6.7	0.0	8.6

Longitudinal seismic

	V (t)	ML (t.m)	MT (t.m)
DL	56.85	191.94	0.00
SIDL1	3.52	11.54	0.00
SIDL2	4.01	13.12	0.00
LL1	2.77	9.06	8.52
LL2	2.77	9.06	8.52
LL3	2.04	6.67	8.56

Tranverse seismic

	V (t)	ML (t.m)	MT (t.m)
DL	56.85	0.00	191.94
SIDL1	3.52	0.00	11.54
SIDL2	4.01	0.00	13.12
LL1	2.77	0.00	17.59
LL2	2.77	0.00	17.59
LL3	2.04	0.00	15.23

Combination of Orthogonal Seismic Force

		V (t)	**ML (t.m)**	**MT (t.m)**	**PSF**	**V (t)**	**ML (t.m)**	**MT (t.m)**
DL		56.85	249.53	0.00	1.00	**56.9**	**249.5**	**0.0**
SIDL1		3.52	15.00	0.00	1.00	**3.5**	**15.0**	**0.0**
SIDL2		4.01	17.06	0.00	1.00	**4.0**	**17.1**	**0.0**
LL1		2.77	14.34	8.52	1.00	**2.8**	**14.3**	**8.5**
LL2		2.77	14.34	8.52	1.00	**2.8**	**14.3**	**8.5**
LL3		2.04	11.24	8.56	1.00	**2.0**	**11.2**	**8.6**
DL		56.85	0.00	249.53	1.00	**56.9**	**0.0**	**249.5**
SIDL1		3.52	0.00	15.00	1.00	**3.5**	**0.0**	**15.0**
SIDL2		4.01	0.00	17.06	1.00	**4.0**	**0.0**	**17.1**
LL1		2.77	2.56	20.31	1.00	**2.8**	**2.6**	**20.3**
LL2		2.77	2.56	20.31	1.00	**2.8**	**2.6**	**20.3**
LL3		2.04	2.57	17.23	1.00	**2.0**	**2.6**	**17.2**

	V (t)	ML (t.m)	MT (t.m)
DL+SIDL1+SIDL2+LL1	67.15	295.92	8.52
DL+SIDL1+SIDL2+LL2	67.15	295.92	8.52
DL+SIDL1+SIDL2+LL3	66.42	292.82	8.56
DL+SIDL1+SIDL2+LL1	67.15	2.56	301.89
DL+SIDL1+SIDL2+LL2	67.15	2.56	301.89
DL+SIDL1+SIDL2+LL3	66.42	2.57	298.81
DL+SIDL1+SIDL2+LL1	67	296	9
DL+SIDL1+SIDL2+LL2	67	296	9
DL+SIDL1+SIDL2+LL3	67	3	302

Seismic Force Calculations					For abutment			
	Horizontal		Vertical (2/3 of Horizontal)					
Long Seismic Coefficient		0.080	0.053	***Refer Seismic Calculations Appendex 1***				
Trans Seismic Coefficient		0.080	0.053					
Seismic								
						@ Stem Bottom		
	V (t)	**H Comp**	**V Comp**	**Acting At**	**Ecc (For H)**	**ML Due to H**	**Moment Due to V**	
							ML	**MT**
DL	472.2	37.8	25.2	54.8	1.1	40.6	0.0	0.0
SIDL1	48.9	3.9	2.6	54.8	1.1	4.2	0.0	0.0
SIDL2	55.7	4.5	3.0	54.8	1.1	4.8	0.0	0.0
abut Cap	190.0	15.2	10.1	55.2	1.4	21.1	0.0	0.0
abut Stem	20.0	1.6	1.1	54.0	0.3	0.4	0.0	0.0
LL1	38.4	3.1	2.1	54.8	1.1	3.3	0.0	6.3
LL2	38.4	3.1	2.1	54.8	1.1	3.3	0.0	6.3
LL3	28.3	2.3	1.5	54.8	1.1	2.4	0.0	6.3

Longitudinal seismic

	V (t)	ML (t.m)	MT (t.m)
DL	36.38	62	0.00
SIDL1	2.61	4.21	0.00
SIDL2	2.97	4.79	0.00
LL1	2.05	3.31	6.31
LL2	2.05	3.31	6.31
LL3	1.51	2.43	6.34

Tranverse seismic

	V (t)	ML (t.m)	MT (t.m)
DL	36.38	0.00	62.09
SIDL1	2.61	0.00	4.21
SIDL2	2.97	0.00	4.79
LL1	2.05	0.00	9.62
LL2	2.05	0.00	9.62
LL3	1.51	0.00	8.77

Combination of Orthogonal Seismic Force

		V (t)	**ML (t.m)**	**MT (t.m)**	**PSF**	**V (t)**	**ML (t.m)**	**MT (t.m)**
DL		36.38	80.72	0.00	1.00	**36.4**	**80.7**	**0.0**
SIDL1		2.61	5.47	0.00	1.00	**2.6**	**5.5**	**0.0**
SIDL2		2.97	6.22	0.00	1.00	**3.0**	**6.2**	**0.0**
LL1		2.05	6.19	6.31	1.00	**2.1**	**6.2**	**6.3**
LL2		2.05	6.19	6.31	1.00	**2.1**	**6.2**	**6.3**
LL3		1.51	5.06	6.34	1.00	**1.5**	**5.1**	**6.3**
DL		36.38	0.00	80.72	1.00	**36.4**	**0.0**	**80.7**
SIDL1		2.61	0.00	5.47	1.00	**2.6**	**0.0**	**5.5**
SIDL2		2.97	0.00	6.22	1.00	**3.0**	**0.0**	**6.2**
LL1		2.05	1.89	10.61	1.00	**2.1**	**1.9**	**10.6**
LL2		2.05	1.89	10.61	1.00	**2.1**	**1.9**	**10.6**
LL3		1.51	1.90	9.50	1.00	**1.5**	**1.9**	**9.5**

	V (t)	ML (t.m)	MT (t.m)
DL+SIDL1+SIDL2+LL1	44.01	98.60	6.31
DL+SIDL1+SIDL2+LL2	44.01	98.60	6.31
DL+SIDL1+SIDL2+LL3	43.47	97.47	6.34
DL+SIDL1+SIDL2+LL1	44.01	1.89	103.02
DL+SIDL1+SIDL2+LL2	44.01	1.89	103.02
DL+SIDL1+SIDL2+LL3	43.47	1.90	101.91
DL+SIDL1+SIDL2+LL1	44	99	6
DL+SIDL1+SIDL2+LL2	44	99	6
DL+SIDL1+SIDL2+LL3	44	2	103

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

COMBINATION FOR DESIGN OF FOUNDATION & BASE PRESSURE (ULS)

Following load combinations are con As per Annex B of IRC:112-2011

1 Combination 1

2 Combination 2

3 Seismic Combination

4 Combination for base pressure check

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	Dead Load (due to superstructure+substructure+foundtion		863	-202	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		190	-59	0	0	0
4	ABUT + RETURN WALL		30	-13	0	0	0
5	FOUNDATION		310	0	0	0	0
6	SOIL ABOVE FDN		98	-130	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	192	0	592	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	141	0	594	0	0
12	LL1B	Live Load Moment due to braking	3	75	0	34.26	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.08	0
14	LL3B	Live Load Moment due to braking	3	69	0	31.75	0
15	W1	Wind vertically down without LL	18	5	32	5.40	11.30
16	W2	Wind vertically up without LL	-18	5	32	5.40	11.30
17	W3	Wind vertically down with LL	18	49	32	5.53	11.30
18	W4	Wind vertically up with LL	-18	49	32	5.53	11.30
19	S1	Seimic	67	296	9	100.7	0
20	S2	Seimic	67	3	302	0.0	100.7
21	S3	Seimic	-67	296	9	100.7	0
22	S4	Seimic	-67	3	302	0.0	100.7
23	HFL		-117	67	0	0.0	0.0
24	Active earth pressure LWL		0	78	0	53.5	0.0
25	LL surcharge LWL		0	64	0	37.1	0.0
26	Active earth pressure HFL		0	39	0	26.7	0.0
27	LL surcharge HFL		0	32	0	18.5	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0.0
29	LL surcharge LWL		0	0	0	0	0.0
30	Active earth pressure HFL		0	0	0	0	0.0
31	LL surcharge HFL		0	0	0	0	0.0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

	Combination 1				**Combination 2**				**Seismic Combination**				**Combination for base pressure check**		
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)	P(t)	ML (tm)	MT (tm)
DL	1.35	1166	-249	-111	1.00	863	-184	-82	1.25	1079	-231	-103	863	-184	-82
SIDL1	1.75	43	0	0	1.00	24	0	0	1.75	43	0	0	24	0	0
SIDL2	1.35	38	0	0	1.00	28	0	0	1.25	35	0	0	28	0	0
LL1	1.50	288	361	811	1.30	250	313	703	0.20	38	48	108	192	241	541
LL2	1.50	252	431	969	1.30	219	374	840	0.20	34	58	129	168	288	646
LL3	1.50	212	363	814	1.30	184	314	706	0.20	28	48	109	141	242	543
LL1B	1.50	5	102	46	1.30	4	89	40	0.20	1	14	6	3	68	30
LL2B	1.50	0	0	0	1.30	0	0	0	0.20	0	0	0	0	0	0
LL3B	1.50	5	95	42	1.30	4	82	37	0.20	1	13	6	3	63	28
W1	0.90	17	16	28	0.80	15	14	25	0.00	0	0	0	18	18	31
W2	0.90	-17	16	28	0.80	-15	14	25	0.00	0	0	0	-18	18	31
W3	0.90	17	52	44	0.80	15	46	39	0.00	0	0	0	18	58	49
W4	0.90	-17	52	44	0.80	-15	46	39	0.00	0	0	0	-18	58	49
S1	0.00	0	0	0	0.00	0	0	0	1.50	101	411	192	67	274	128
S2	0.00	0	0	0	0.00	0	0	0	1.50	101	188	415	67	125	277
S3	0.00	0	0	0	0.00	0	0	0	1.50	-101	411	192	-67	274	128
S4	0.00	0	0	0	0.00	0	0	0	1.50	-101	188	415	-67	125	277
HFL	1.00	-117	62	27	1.00	-117	62	27	1.00	-117	62	27	-117	62	27
EP	1.00	0	71	32	0.85	0	60	27	1.00	0	71	32	0	71	32
LL S.	1.20	0	70	31	1.00	0	59	26	0.20	0	12	5	0	59	26
EP.HFL	1.00	0	35	16	0.85	0	30	13	1.00	0	35	16	0	35	16
LL.S.HFL	1.20	0	35	16	1.00	0	29	13	0.20	0	6	3	0	29	13
Active earth pressure LWL					Dynamic increment in earth pressure due to seismic				1.00	0	0	0	0	0	0
LL surcharge LWL									0.20	0	0	0	0	0	0
Active earth pressure HFL									1.00	0	0	0	0	0	0
LL surcharge HFL									0.20	0	0	0	0	0	0

Case 1 Combination 1

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1246	-178	-79
Case 2 DL+SIDL1+SIDL2+LL1	1539	356	809
Case 3 DL+SIDL1+SIDL2+LL2	1498	324	921
Case 4 DL+SIDL1+SIDL2+LL3	1463	350	809
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1262	-162	-51
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1556	408	853
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1515	376	965
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1480	402	853
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1229	-162	-51
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1523	408	853
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1482	376	965
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1447	402	853

HFL			
Case 1 DL+SIDL1+SIDL2+HFL	1129	-152	-68
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1422	347	805
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1382	315	917
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1346	341	805
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1146	-136	-40
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1439	399	849
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1398	366	961
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1363	392	849
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	1113	-136	-40
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1406	399	849
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1365	366	961
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1330	392	849

MAXIMUM REACTION CASE	1556	408	853
MAXIMUM LONGITUDINAL MOMENT CASE	1556	408	853
MAXIMUM TRANSVERSE MOMENT CASE	1515	376	965

Case 2 Combination 2

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	916	-124	-55
Case 2 DL+SIDL1+SIDL2+LL1	1170	336	713
Case 3 DL+SIDL1+SIDL2+LL2	1134	308	811
Case 4 DL+SIDL1+SIDL2+LL3	1104	331	713
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	930	-110	-30
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1185	382	753
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1149	354	850
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1119	377	752
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	901	-110	-30
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1155	382	753
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1120	354	850
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1089	377	752

HFL			
Case 1 DL+SIDL1+SIDL2+HFL	799	-93	-41
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1053	338	714
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1018	310	812
Case 4 DL+SIDL1+SIDL2+LL3+HFL	987	333	714
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	814	-79	-16
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1068	384	754
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1032	357	851
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1002	379	753
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	784	-79	-16
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1038	384	754
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1003	357	851
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	972	379	753

MAXIMUM REACTION CASE	1185	382	753
MAXIMUM LONGITUDINAL MOMENT CASE	1068	384	754
MAXIMUM TRANSVERSE MOMENT CASE	1032	357	851

Case 3 Seismic Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
Normal	t	t-m	t-m
Downward seismic in longitudinal direction			
Case 1 DL+SIDL1+SIDL2+ seismic	1258	251	121
Case 2 DL+SIDL1+SIDL2+LL1+ seismic	1297	325	241
Case 3 DL+SIDL1+SIDL2+LL2+ seismic	1291	320	256
Case 4 DL+SIDL1+SIDL2+LL3+ seismic	1286	324	241
Downward seismic in transverse direction			
Case 5 DL+SIDL1+SIDL2+ seismic	1258	28	344
Case 6 DL+SIDL1+SIDL2+LL1+ seismic	1297	102	464
Case 7 DL+SIDL1+SIDL2+LL2+ seismic	1291	97	479
Case 8 DL+SIDL1+SIDL2+LL3+ seismic	1286	101	464
Upward seismic in longitudinal direction			
Case 9 DL+SIDL1+SIDL2+ seismic	1056	251	121
Case 10 DL+SIDL1+SIDL2+LL1+ seismic	1095	325	241
Case 11 DL+SIDL1+SIDL2+LL2+ seismic	1090	320	256
Case 12 DL+SIDL1+SIDL2+LL3+ seismic	1085	324	241
Upward seismic in transverse direction			
Case 13 DL+SIDL1+SIDL2+ seismic	1056	28	344
Case 14 DL+SIDL1+SIDL2+LL1+ seismic	1095	102	464
Case 15 DL+SIDL1+SIDL2+LL2+ seismic	1090	97	479
Case 16 DL+SIDL1+SIDL2+LL3+ seismic	1085	101	464
HFL CASE			
Downward seismic in longitudinal direction			
Case 1 DL+SIDL1+SIDL2+ seismic+HFL	1141	277	133
Case 2 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1180	345	250
Case 3 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1174	341	265
Case 4 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1170	344	250
Downward seismic in transverse direction			
Case 5 DL+SIDL1+SIDL2+ seismic+HFL	1141	54	356
Case 6 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1180	122	473
Case 7 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1174	67	488
Case 8 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1170	121	473
Upward seismic in longitudinal direction			
Case 9 DL+SIDL1+SIDL2+ seismic+HFL	939	277	133
Case 10 DL+SIDL1+SIDL2+LL1+ seismic+HFL	978	345	250
Case 11 DL+SIDL1+SIDL2+LL2+ seismic+HFL	973	341	265
Case 12 DL+SIDL1+SIDL2+LL3+ seismic+HFL	968	344	250
Upward seismic in transverse direction			
Case 13 DL+SIDL1+SIDL2+ seismic+HFL	939	54	356
Case 14 DL+SIDL1+SIDL2+LL1+ seismic+HFL	978	122	473
Case 15 DL+SIDL1+SIDL2+LL2+ seismic+HFL	973	118	488
Case 16 DL+SIDL1+SIDL2+LL3+ seismic+HFL	968	121	473

MAXIMUM REACTION CASE	1297	325	241
MAXIMUM LONGITUDINAL MOMENT CASE	1180	345	250
MAXIMUM TRANSVERSE MOMENT CASE	1174	67	488

Case 4 Combination for base pressure check

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	916	-113	-51
Case 2	DL+SIDL1+SIDL2+LL1	1111	254	547
Case 3	DL+SIDL1+SIDL2+LL2	1084	233	622
Case 4	DL+SIDL1+SIDL2+LL3	1060	250	547
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	934	-96	-19
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	1130	312	596
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	1102	290	671
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	1079	308	596
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	897	-96	-19
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	1093	312	596
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	1066	290	671
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	1042	308	596
Downward seismic in longitudinal direction				
Case 13	DL+SIDL1+SIDL2+ seismic	983	160	78
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	1178	528	675
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	1151	507	750
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	1128	524	675
Downward seismic in transverse direction				
Case 17	DL+SIDL1+SIDL2+ seismic	983	12	226
Case 18	DL+SIDL1+SIDL2+LL1+ seismic	1178	379	824
Case 19	DL+SIDL1+SIDL2+LL2+ seismic	1151	358	898
Case 20	DL+SIDL1+SIDL2+LL3+ seismic	1128	375	823
Upward seismic in longitudinal direction				
Case 21	DL+SIDL1+SIDL2+ seismic	849	160	78
Case 22	DL+SIDL1+SIDL2+LL1+ seismic	1044	528	675
Case 23	DL+SIDL1+SIDL2+LL2+ seismic	1017	507	750
Case 24	DL+SIDL1+SIDL2+LL3+ seismic	993	524	675
Upward seismic in transverse direction				
Case 25	DL+SIDL1+SIDL2+ seismic	849	12	226
Case 26	DL+SIDL1+SIDL2+LL1+ seismic	1044	379	824
Case 27	DL+SIDL1+SIDL2+LL2+ seismic	1017	358	898
Case 28	DL+SIDL1+SIDL2+LL3+ seismic	993	375	823

HFL				
Case 1	DL+SIDL1+SIDL2+HFL	799	-87	-39
Case 2	DL+SIDL1+SIDL2+LL1+HFL	994	251	545
Case 3	DL+SIDL1+SIDL2+LL2+HFL	967	229	620
Case 4	DL+SIDL1+SIDL2+LL3+HFL	944	247	545
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	817	-70	-8
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1013	309	594
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	986	287	669
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	962	304	594
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	781	-70	-8
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	976	309	594
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	949	226	669
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	925	304	594
Downward seismic in longitudinal direction				
Case 13	DL+SIDL1+SIDL2+ seismic+HFL	866	186	89
Case 14	DL+SIDL1+SIDL2+LL1+ seismic+HFL	1062	525	673
Case 15	DL+SIDL1+SIDL2+LL2+ seismic+HFL	1034	503	748
Case 16	DL+SIDL1+SIDL2+LL3+ seismic+HFL	1011	521	673
Downward seismic in transverse direction				
Case 17	DL+SIDL1+SIDL2+ seismic+HFL	866	38	238
Case 18	DL+SIDL1+SIDL2+LL1+ seismic+HFL	1062	376	822

Case 19 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1034	355	897
Case 20 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1011	372	822
Upward seismic in longitudinal direction			
Case 21 DL+SIDL1+SIDL2+ seismic+HFL	732	186	89
Case 22 DL+SIDL1+SIDL2+LL1+ seismic+HFL	927	525	673
Case 23 DL+SIDL1+SIDL2+LL2+ seismic+HFL	900	503	748
Case 24 DL+SIDL1+SIDL2+LL3+ seismic+HFL	877	521	673
Upward seismic in transverse direction			
Case 25 DL+SIDL1+SIDL2+ seismic+HFL	732	38	238
Case 26 DL+SIDL1+SIDL2+LL1+ seismic+HFL	927	376	822
Case 27 DL+SIDL1+SIDL2+LL2+ seismic+HFL	900	355	897
Case 28 DL+SIDL1+SIDL2+LL3+ seismic+HFL	877	372	822

MAXIMUM REACTION CASE	1178	528	675
MAXIMUM LONGITUDINAL MOMENT CASE	1178	528	675
MAXIMUM TRANSVERSE MOMENT CASE	1151	358	898

1 Normal			
Load Case	**Factored Forces/Moments**		
	V	**ML**	**MT**
	t	**t-m**	**t-m**
Case 1 Normal max. Vertical load	**1111**	**254**	**547**
Case 2 Normal max. longitudinal moment	**1111**	**254**	**547**
Case 3 Normal max. transverse moment	**1084**	**233**	**622**
2 Seismic / wind			
Load Case	**Factored Forces/Moments**		
	V	**ML**	**MT**
	t	**t-m**	**t-m**
Case 1 Seismic/wind max. Vertical load	**1178**	**528**	**675**
Case 2 Seismic/wind max. longitudinal moment	**1178**	**528**	**675**
Case 3 Seismic/wind max. transverse moment	**1151**	**358**	**898**

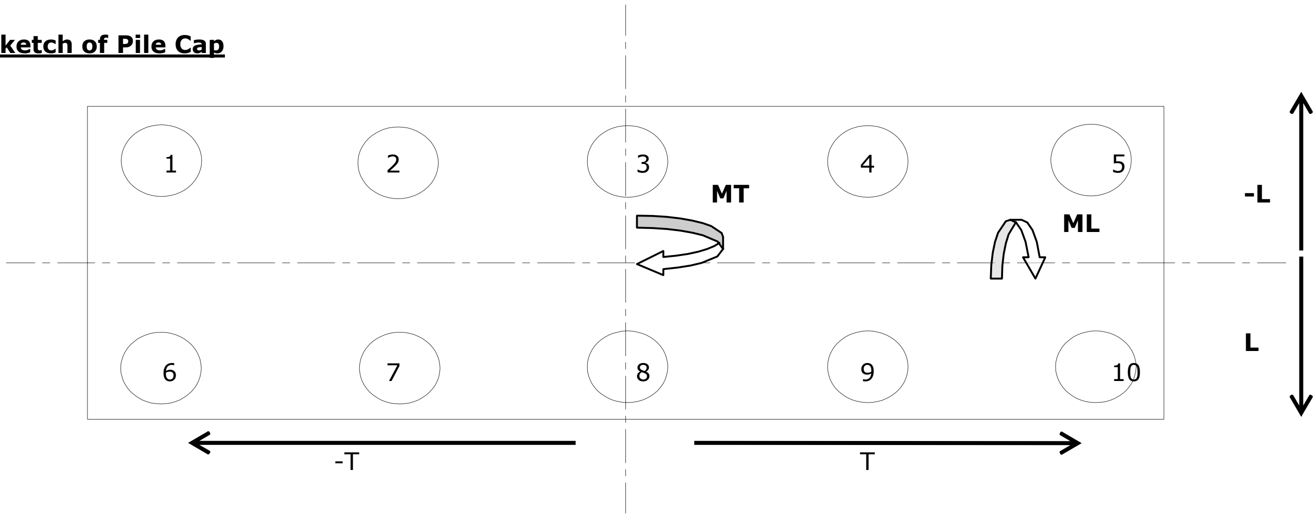
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Load on Pile for Base Pressure Check

Load combination		V	ML	MT
		t	t-m	t-m
DL+SIDL1+SIDL2	Case 1	1111	254	547
DL+SIDL1+SIDL2+LL1	Case 2	1111	254	547
DL+SIDL1+SIDL2+LL2	Case 3	1084	233	622
DL+SIDL1+SIDL2+Seismic	Case 4	1178	528	675
DL+SIDL1+SIDL2+LL1+Seismic	Case 5	1178	528	675
DL+SIDL1+SIDL2+LL2+Seismic	Case 6	1151	358	898

Diameter of Pile	=	1.200	m	
Shift	=	0.000	m	
Vertical Capacity of Pile	=	3600.000	T	As per Geotechnical Report
	=	9.000	m	Length below cutoff for A1
		10.000	m	Length below cutoff for A2

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_L2$	$_T2$	Z_L	Z_T
1	-1.800	-7.200	3.240	51.840	-18.000	-36.000
2	-1.800	-3.600	3.240	12.960	-18.000	-72.000
3	-1.800	0.000	3.240	0.000	-18.000	0.000
4	-1.800	3.600	3.240	12.960	-18.000	72.000
5	-1.800	7.200	3.240	51.840	-18.000	36.000
6	1.800	-7.200	3.240	51.840	18.000	-36.000
7	1.800	-3.600	3.240	12.960	18.000	-72.000
8	1.800	0.000	3.240	0.000	18.000	0.000
9	1.800	3.600	3.240	12.960	18.000	72.000
10	1.800	7.200	3.240	51.840	18.000	36.000

I_{LL} = **32.40** Sq.m

I_{TT} = **259.20** Sq.m

Normal case :- Lateral force

Case 1 **Horizontal force =** **650.933** t **Force per Pile =** **65.1** t **OK**

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	M_T/Z_T (T)	Total Load (T)	Inference
1	111.12	-14.12	-15.19	0.00	0.00	81.81	OK
2	111.12	-14.12	-7.59	0.00	0.00	89.40	OK
3	111.12	-14.12	0.00	0.00	0.00	97.00	OK
4	111.12	-14.12	7.59	0.00	0.00	104.59	OK
5	111.12	-14.12	15.19	0.00	0.00	112.18	OK
6	111.12	14.12	-15.19	0.00	0.00	110.05	OK
7	111.12	14.12	-7.59	0.00	0.00	117.65	OK
8	111.12	14.12	0.00	0.00	0.00	125.24	OK
9	111.12	14.12	7.59	0.00	0.00	132.84	OK
10	111.12	14.12	15.19	0.00	0.00	140.43	OK

Case 2

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	M_T/Z_T (T)	Total Load (T)	Inference
1	111.12	-14.12	-15.19	0.00	0.00	81.81	OK
2	111.12	-14.12	-7.59	0.00	0.00	89.40	OK
3	111.12	-14.12	0.00	0.00	0.00	97.00	OK
4	111.12	-14.12	7.59	0.00	0.00	104.59	OK
5	111.12	-14.12	15.19	0.00	0.00	112.18	OK
6	111.12	14.12	-15.19	0.00	0.00	110.05	OK
7	111.12	14.12	-7.59	0.00	0.00	117.65	OK
8	111.12	14.12	0.00	0.00	0.00	125.24	OK
9	111.12	14.12	7.59	0.00	0.00	132.84	OK
10	111.12	14.12	15.19	0.00	0.00	140.43	OK

Case 3

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	M_T/Z_T (T)	Total Load (T)	Inference
1	108.40	-12.93	-17.27	0.00	0.00	78.20	OK
2	108.40	-12.93	-8.63	0.00	0.00	86.84	OK
3	108.40	-12.93	0.00	0.00	0.00	95.47	OK
4	108.40	-12.93	8.63	0.00	0.00	104.10	OK
5	108.40	-12.93	17.27	0.00	0.00	112.73	OK
6	108.40	12.93	-17.27	0.00	0.00	104.06	OK
7	108.40	12.93	-8.63	0.00	0.00	112.69	OK
8	108.40	12.93	0.00	0.00	0.00	121.33	OK
9	108.40	12.93	8.63	0.00	0.00	129.96	OK
10	108.40	12.93	17.27	0.00	0.00	138.59	OK

Seismic Case :- Lateral force

Case 4 **Horizontal force =** **696.150** t **Force per Pile =** **55.7** t **OK**

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	Due to Shift M_T/Z_T (T)	Total Load (T)	Inference
1	117.83	-29.33	-18.75	0.00	0.00	69.75	OK
2	117.83	-29.33	-9.37	0.00	0.00	79.13	OK
3	117.83	-29.33	0.00	0.00	0.00	88.50	OK
4	117.83	-29.33	9.37	0.00	0.00	97.87	OK
5	117.83	-29.33	18.75	0.00	0.00	107.25	OK
6	117.83	29.33	-18.75	0.00	0.00	128.42	OK
7	117.83	29.33	-9.37	0.00	0.00	137.79	OK
8	117.83	29.33	0.00	0.00	0.00	147.17	OK
9	117.83	29.33	9.37	0.00	0.00	156.54	OK
10	117.83	29.33	18.75	0.00	0.00	165.92	OK

Case 5

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	Due to Shift M_T/Z_T (T)	Total Load (T)	Inference
1	117.83	-29.33	-18.75	0.00	0.00	69.75	OK
2	117.83	-29.33	-9.37	0.00	0.00	79.13	OK
3	117.83	-29.33	0.00	0.00	0.00	88.50	OK
4	117.83	-29.33	9.37	0.00	0.00	97.87	OK
5	117.83	-29.33	18.75	0.00	0.00	107.25	OK
6	117.83	29.33	-18.75	0.00	0.00	128.42	OK
7	117.83	29.33	-9.37	0.00	0.00	137.79	OK
8	117.83	29.33	0.00	0.00	0.00	147.17	OK
9	117.83	29.33	9.37	0.00	0.00	156.54	OK
10	117.83	29.33	18.75	0.00	0.00	165.92	OK

Case 6

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	Due to Shift M_T/Z_T (T)	Total Load (T)	Inference
1	115.11	-19.88	-24.96	0.00	0.00	70.28	OK
2	115.11	-19.88	-12.48	0.00	0.00	82.76	OK
3	115.11	-19.88	0.00	0.00	0.00	95.23	OK
4	115.11	-19.88	12.48	0.00	0.00	107.71	OK
5	115.11	-19.88	24.96	0.00	0.00	120.19	OK
6	115.11	19.88	-24.96	0.00	0.00	110.04	OK
7	115.11	19.88	-12.48	0.00	0.00	122.52	OK
8	115.11	19.88	0.00	0.00	0.00	134.99	OK
9	115.11	19.88	12.48	0.00	0.00	147.47	OK
10	115.11	19.88	24.96	0.00	0.00	159.95	OK

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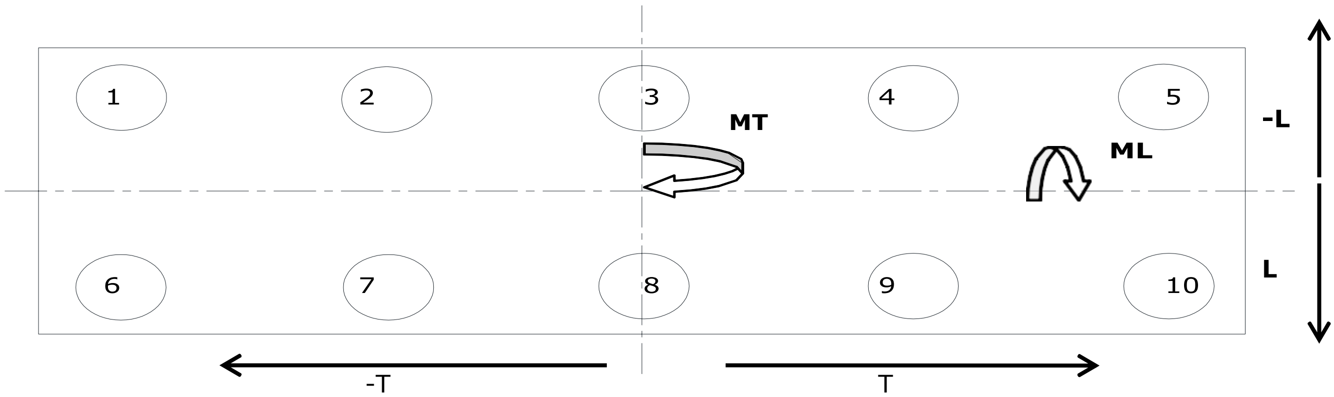
Load Calculations for Design of Pile (ULS)

		V	ML	MT
		t	**t-m**	**t-m**
Max. vertical load Combination 1	Case 1	1556	408	853
Max. longitudinal moment Combination 1	Case 2	1556	408	853
Max. transverse moment Combination 1	Case 3	1515	376	965
Max. vertical load Combination 2	Case 4	1185	382	753
Max. longitudinal moment Combination 2	Case 5	1068	384	754
Max. transverse moment Combination 2	Case 6	1032	357	851
Max. vertical load seismic/accidental combination	Case 7	1297	325	241
Max. longitudinal moment seismic/accidental combination	Case 8	1180	345	250
Max. transverse moment seismic/accidental combination	Case 9	1174	67	488

Diameter of Pile = 1.200 m
Shift = 0.000 m

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_{L}2$	$_{T}2$	Z_L	Z_T
1	1.235	-7.881	1.526	62.116	73.021	-39.407
2	-0.368	-3.941	0.135	15.529	-245.437	-78.814
3	-1.970	0.000	3.882	0.000	-45.781	0.000
4	-3.573	3.941	12.768	15.529	-25.245	78.814
5	-5.176	7.881	26.791	62.116	-17.427	39.407
6	5.176	-7.881	26.791	62.116	17.427	-39.407
7	3.573	-3.941	12.768	15.529	25.245	-78.814
8	1.970	0.000	3.882	0.000	45.781	0.000
9	0.368	3.941	0.135	15.529	245.437	78.814
10	-1.235	7.881	1.526	62.116	-73.021	39.407

I_{LL} = **90.20** Sq.m
I_{TT} = **310.58** Sq.m

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Case 1

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	155.6	5.6	-21.6	0.0	0.0	139.5
2	155.6	-1.7	-10.8	0.0	0.0	143.1
3	155.6	-8.9	0.0	0.0	0.0	146.7
4	155.6	-16.2	10.8	0.0	0.0	150.2
5	155.6	-23.4	21.6	0.0	0.0	153.8
6	155.6	23.4	-21.6	0.0	0.0	157.3
7	155.6	16.2	-10.8	0.0	0.0	160.9
8	155.6	8.9	0.0	0.0	0.0	164.5
9	155.6	1.7	10.8	0.0	0.0	168.1
10	155.6	-5.6	21.6	0.0	0.0	171.6

Case 2

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	155.6	5.6	-21.6	0.0	0.0	139.5
2	155.6	-1.7	-10.8	0.0	0.0	143.1
3	155.6	-8.9	0.0	0.0	0.0	146.7
4	155.6	-16.2	10.8	0.0	0.0	150.2
5	155.6	-23.4	21.6	0.0	0.0	153.8
6	155.6	23.4	-21.6	0.0	0.0	157.3
7	155.6	16.2	-10.8	0.0	0.0	160.9
8	155.6	8.9	0.0	0.0	0.0	164.5
9	155.6	1.7	10.8	0.0	0.0	168.1
10	155.6	-5.6	21.6	0.0	0.0	171.6

Case 3

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	151.5	5.1	-24.5	0.0	0.0	132.1
2	151.5	-1.5	-12.2	0.0	0.0	137.7
3	151.5	-8.2	0.0	0.0	0.0	143.3
4	151.5	-14.9	12.2	0.0	0.0	148.9
5	151.5	-21.5	24.5	0.0	0.0	154.4
6	151.5	21.5	-24.5	0.0	0.0	148.6
7	151.5	14.9	-12.2	0.0	0.0	154.1
8	151.5	8.2	0.0	0.0	0.0	159.7
9	151.5	1.5	12.2	0.0	0.0	165.3
10	151.5	-5.1	24.5	0.0	0.0	170.8

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Case 4

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	118.5	5.2	-19.1	0.0	0.0	104.6
2	118.5	-1.6	-9.5	0.0	0.0	107.4
3	118.5	-8.4	0.0	0.0	0.0	110.1
4	118.5	-15.1	9.5	0.0	0.0	112.9
5	118.5	-21.9	19.1	0.0	0.0	115.6
6	118.5	21.9	-19.1	0.0	0.0	121.3
7	118.5	15.1	-9.5	0.0	0.0	124.1
8	118.5	8.4	0.0	0.0	0.0	126.8
9	118.5	1.6	9.5	0.0	0.0	129.6
10	118.5	-5.2	19.1	0.0	0.0	132.3

Case 5

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	106.8	5.3	-19.1	0.0	0.0	92.9
2	106.8	-1.6	-9.6	0.0	0.0	95.7
3	106.8	-8.4	0.0	0.0	0.0	98.4
4	106.8	-15.2	9.6	0.0	0.0	101.1
5	106.8	-22.1	19.1	0.0	0.0	103.8
6	106.8	22.1	-19.1	0.0	0.0	109.7
7	106.8	15.2	-9.6	0.0	0.0	112.5
8	106.8	8.4	0.0	0.0	0.0	115.2
9	106.8	1.6	9.6	0.0	0.0	117.9
10	106.8	-5.3	19.1	0.0	0.0	120.6

Case 6

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	103.2	4.9	-21.6	0.0	0.0	86.5
2	103.2	-1.5	-10.8	0.0	0.0	91.0
3	103.2	-7.8	0.0	0.0	0.0	95.5
4	103.2	-14.1	10.8	0.0	0.0	99.9
5	103.2	-20.5	21.6	0.0	0.0	104.4
6	103.2	20.5	-21.6	0.0	0.0	102.1
7	103.2	14.1	-10.8	0.0	0.0	106.6
8	103.2	7.8	0.0	0.0	0.0	111.0
9	103.2	1.5	10.8	0.0	0.0	115.5
10	103.2	-4.9	21.6	0.0	0.0	120.0

Case 7

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	129.7	4.4	-6.1	0.0	0.0	128.0
2	129.7	-1.3	-3.1	0.0	0.0	125.3
3	129.7	-7.1	0.0	0.0	0.0	122.6
4	129.7	-12.9	3.1	0.0	0.0	119.9
5	129.7	-18.6	6.1	0.0	0.0	117.1
6	129.7	18.6	-6.1	0.0	0.0	142.2
7	129.7	12.9	-3.1	0.0	0.0	139.5
8	129.7	7.1	0.0	0.0	0.0	136.8
9	129.7	1.3	3.1	0.0	0.0	134.0
10	129.7	-4.4	6.1	0.0	0.0	131.3

Case 8

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	118.0	4.7	-6.3	0.0	0.0	116.4
2	118.0	-1.4	-3.2	0.0	0.0	113.4
3	118.0	-7.5	0.0	0.0	0.0	110.5
4	118.0	-13.7	3.2	0.0	0.0	107.5
5	118.0	-19.8	6.3	0.0	0.0	104.5
6	118.0	19.8	-6.3	0.0	0.0	131.4
7	118.0	13.7	-3.2	0.0	0.0	128.5
8	118.0	7.5	0.0	0.0	0.0	125.5
9	118.0	1.4	3.2	0.0	0.0	122.6
10	118.0	-4.7	6.3	0.0	0.0	119.6

Case 9

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	117.4	0.9	-12.4	0.0	0.0	106.0
2	117.4	-0.3	-6.2	0.0	0.0	111.0
3	117.4	-1.5	0.0	0.0	0.0	116.0
4	117.4	-2.7	6.2	0.0	0.0	121.0
5	117.4	-3.9	12.4	0.0	0.0	126.0
6	117.4	3.9	-12.4	0.0	0.0	108.9
7	117.4	2.7	-6.2	0.0	0.0	113.9
8	117.4	1.5	0.0	0.0	0.0	118.9
9	117.4	0.3	6.2	0.0	0.0	123.9
10	117.4	-0.9	12.4	0.0	0.0	128.9

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Calculation of Depth of Fixity — As per IS 2911, Annexure C

Stiffness factor	T	=	5√(EI/K1)	m	For pile in sand and normally loaded Clays
Stiffness factor	R	=	4√(EI/BK2)	m	For pile in preloaded clays
	E	=	31000	MN/m2	
	I	=	0.1018	m4	
	ŋh	=	3.3008	MN/m3	
	K	=	4.86	MN/m3	
	T	=	3.945		OK
	R	=	4.823		
Pile length over sand layer, L1		=	0	m	
Case I	L1/R	=	0		
Case II	L1/T	=	0		
Case I	Lf/R	=	0		(for fixed head pile)
Case II	Lf/T	=	2.2		
Case I	Depth of Fixity, Lf	=	0.000	m	
Case II	Depth of Fixity, Lf	=	8.68	m	
	L1+Lf	=	8.680	m	
Reduction Factor	m	=	0.85		
	MT	=	Q (L1 + Lf)/2*m		(for fixed head pile)
		=	3.689	Q	

	Moment on pile =		3.689	Q					
	Combination 1			Combination 2			Seismic/Accidental Combination		
	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)
MAX	**171.64**	16	60	**132.32**	14	51	**142.19**	22	81
MIN	**132.15**	16	59	**86.54**	10	37	**104.54**	18	67

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<u>Moments & shear force for pile cap</u>

Width of abut.	=	1.00	m
Length of abut.		16.00	
Dia. Of pile	=	1.20	m
Length of Pile cap	=	16.00	m
Width of Pile cap	=	4.30	m
Thickness of pile cap	=	1.80	m
Unit wt. of concrete	=	2.50	t/m^3
Unit wt. of Soil	=	2.00	t/m^3
Thickness of soil above pile cap	=	1.19	m
Downward force & moment due to pile cap		1.20	0.00

Transverse direction	L	B	H	Unit Weight	Load (t)	Moment (t.m)
Self wt. of pile cap	0.00	4.30	1.80	2.50	0.00	0.00
Wt. due to soil	0.00	4.30	1.19	2.00	0.00	0.00
Longitudinal direction	L	B	H	Unit Weight	Load (t)	Moment (t.m)
Self wt. of pile cap	1.65	16.00	1.80	2.50	118.80	98.01
Wt. due to soil	1.65	16.00	1.19	2.00	62.94	51.92

	Combination 1			**Combination 2**			**Seismic/Accidental Combination**		
	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)
LL	790	38 /m	50 /m	606	27 /m	36 /m	680	31 /m	42 /m
TT	644	150 /m	/m	490	114 /m	/m	535	124 /m	/m
Max	790	644	798	606	490	578	680	535	667

ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	13.40	N/mm^2	Basic Combination
	f_{cd}	=	16.75	N/mm^2	Accidental Combination
	f_{cd}	=	13.40	N/mm^2	Seismic Combination
	E_c	=	31000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	434.78	N/mm^2	Basic Combination
	f_{Yd}	=	500.00	N/mm^2	Accidental Combination
	f_{Yd}	=	434.78	N/mm^2	Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb	
xu,$_{lim}$/d	0.62	0.58	0.62	
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97	Here R_{lim} is in MPa

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	4300	mm
Depth of section D	=	1800	mm
Clear cover	=	75	mm

Moment on the section	Moment at face of support		
	Combination (1)	Seismic Combi.	Combination (2)
Actual moment (KNm)	7833	5232	5667
Grade of Concrete	30	30	30
Grade of steel fy	500	500	500
b	4300	4300	4300
D	1800	1800	1800
c	75	75	75
d	1696.5	1696.5	1696.5
f_{cd}	13.40	13.40	13.40
f_{Yd}	435	435	435
$xu_{,lim}/d$	0.62	0.62	0.62
$R_{sls} = M_{u,sls}/bd^2$	4.97	4.97	4.97
$M_{u,Lim}$ (KNm)	61560	61560	61560
	OK	**OK**	**OK**
Ast Req.	5445	3606	3911
Dia of bar (main tension) (mm)	25	25	25
Spacing (mm)	120	120	120
+ dia of bar (main tension) (mm)	25	25	25
Spacing (mm)	120	120	120
Ast provided (sq mm)	35179	35179	35179
Dia of bar(main compresion at top mm)	12	12	12
Spacing (mm)	120	120	120
Area of main compresion (mm^2)	4053	4053	4053
f_{ctm}	2.5	2.5	2.5
f_{yk}	435	435	435
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	10906	10906	10906
	OK	**OK**	**OK**
As.max = 0.025 Ac (main tension)	193500	193500	193500
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**	**OK**	**OK**
As.max = 0.04 Ac (tension + compresion)	309600	309600	309600
x (mm)	328	328	328
x/d	0.193	0.193	0.193
	OK	**OK**	**OK**
z (mm)	1560	1560	1560
MR (KNm)	47724	47724	47724
	OK	**OK**	**OK**
Shear on the section			
Actual shear V_{Ed} (KN)	5107	4670	3811
Actual shear stress (N/mm2)	0.700	0.640	0.522
Max shear capacity, 0.135 fck(1-fck/310)	3.66	3.66	3.66
	OK	**OK**	**OK**
Min shear capacity, 0.0924 fck(1-fck/310)	2.50	2.50	2.50
ϴ = 0.5 x $\sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	5.52	5.04	4.11
Min angle of inclination, ϴ (deg)	21.8	21.8	21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.343	1.343	1.343
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			

V(min) = 0.031 K^(3/2) fck^(1/2)	0.264	0.286	0.286
cl. 10.3.1 of IRC :112-2011			
r1 = $A_{sl}/(b_w\ d)$ <= 0.02	0.005	0.005	0.005
	OK	**OK**	**OK**
0.12 K (80 r1 $f_{ck})^{0.33}$	0.362	0.362	0.362
Axial compressive force N_{Ed} (KN)	0.0	0	0.0
$_{Scp}$ = N_{Ed} / A_c <= 0.2 f_{cd}	0.0	0.0	0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d >= (V_{min} + 0.15\ S_{cp})\ b_w\ d$ (KN)	2638	2638	2638
	PROVIDE SHEAR R/F	**PROVIDE SHEAR R/F**	**PROVIDE SHEAR R/F**
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010			
n = 0.6 (1 - fck / 310)	0.542	0.542	0.542
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011			
0.5 b_w d n f_{cd}	26488	26488	26488
	OK	**OK**	**OK**
No. of Links for shear R/f (Distribution)	2	2	2
Dia. of bar for shear reinf.	16	16	16
S(mm)	200	200	200
^{A}SW1	402	402	402
	OK	**OK**	**OK**
No. of link for shear reinf.	8	8	8
Dia. of bar for shear reinf.	10	10	10
S = Asw x 0.9 x d x cot θ x fy / V_E	150	150	150
^{A}SW2	628	628	628
^{A}SW	1030	1030	1030
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011			
$S_{l.max}$ = 0.75 d	600	600	600
	OK	**OK**	**OK**
z (mm)	1560	1560	1560
^{f}ywd	435	435	435
cl. 10.3.3.2 Eq. 10.7 of IRC :112-2011			
$V_{Rd.s}$ = A_{SW} z f_{ywd} cot θ / S (KN)	11650	9427	9427
	OK	**OK**	**OK**
acw = (s_{cp} = N_{Ed} / A_c = 0)	1.0	1.0	1.0
ν_1	0.6	0.6	0.6
cl. 10.3.3.2 Eq. 10.8 of IRC :112-2011			
VRd.max = acw bw z n1 fcd (KN)	53935	53935	53935
	OK	**OK**	**OK**
cl. 10.3.3.2 Eq. 10.10 of IRC :112-2011			
ASW.max <= 0.5 acw n1 fcd bw S / fywd	5964	5964	5964
	OK	**OK**	**OK**
cl. 10.3.1 of IRC :112-2011			
rw = ASW/(S bw sina)	0.0016	0.0016	0.0016
cl. 10.3.3.5 of IRC :112-2011			
rw,min = (0.072 fck^0.5) / fyk	0.0009	0.0009	0.0009
	OK	**OK**	**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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COMBINATION FOR DESIGN OF FOUNDATION & BASE PRESSURE (SLS)

Following load combinations are co As per Annex B of IRC:112-2011

1 Rare Combination

2 Quasi Permanent Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	DL	Dead Load (due to superstructure+substructure+found.	863	-202	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		190	-59	0	0	0
4	ABUT + RETURN WALL		30	-13	0	0	0
5	FDN		310	0	0	0	0
6	SOIL ABOVE FDN		98	-130	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	192	0	592	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	141	0	594	0	0
12	LL1B	Live Load Moment due to braking	3	75	0	34.26	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.08	0
14	LL3B	Live Load Moment due to braking	3	69	0	31.75	0
15	W1	Wind vertically down without LL	18	5	32	5.40	11.30
16	W2	Wind vertically up without LL	-18	5	32	5.40	11.30
17	W3	Wind vertically down with LL	18	49	32	5.53	11.30
18	W4	Wind vertically up with LL	-18	49	32	5.53	11.30
19	S1	Seimic	0	0	0	0	0
20	S2		0	0	0	0	0
21	S3		0	0	0	0	0
22	S4		0	0	0	0	0
23	HFL		-117	67	0	0.0	0.0
24	Active earth pressure LWL		0	78	0	53.5	0.0
25	LL surcharge LWL		0	64	0	37.1	0.0
26	Active earth pressure HFL		0	39	0	26.7	0.0
27	LL surcharge HFL		0	32	0	18.5	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0
29	LL surcharge LWL		0	0	0	0	0
30	Active earth pressure HFL		0	0	0	0	0
31	LL surcharge HFL		0	0	0	0	0

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	Rare Combination				**Quasi Permanent Combination**			
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)
DL	1.00	863	-184	-82	1.00	863	-184	-82
SIDL1	1.00	24	0	0	1.00	24	0	0
SIDL2	1.00	28	0	0	1.00	28	0	0
LL1	1.00	192	241	541	0.00	0	0	0
LL2	1.00	168	288	646	0.00	0	0	0
LL3	1.00	141	242	543	0.00	0	0	0
LL1B	1.00	3	68	30	0.00	0	0	0
LL2B	1.00	0	0	0	0.00	0	0	0
LL3B	1.00	3	63	28	0.00	0	0	0
W1	0.60	11	11	19	0.00	0	0	0
W2	0.60	-11	11	19	0.00	0	0	0
W3	0.60	11	35	29	0.00	0	0	0
W4	0.60	-11	35	29	0.00	0	0	0
S1	0.00	0	0	0	0.00	0	0	0
S2	0.00	0	0	0	0.00	0	0	0
S3	0.00	0	0	0	0.00	0	0	0
S4	0.00	0	0	0	0.00	0	0	0
HFL	1.00	-117	62	27	1.00	-117	62	27
EP	1.00	0	71	32	1.00	0	71	32
LL S.	0.80	0	47	21	0.00	0	0	0
EP HFL	1.00	0	35	16	1.00	0	35	16
LL.S.HFL	0.80	0	23	10	0.00	0	0	0

Case 1 Rare Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	916	-113	-51
Case 2 DL+SIDL1+SIDL2+LL1	1111	242	542
Case 3 DL+SIDL1+SIDL2+LL2	1084	221	616
Case 4 DL+SIDL1+SIDL2+LL3	1060	238	541
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	927	-103	-32
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1122	277	571
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1095	256	646
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1071	273	571
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	905	-103	-32
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1100	277	571
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1073	256	646
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1049	273	571
HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	799	-87	-39
Case 2 DL+SIDL1+SIDL2+LL1+HFL	994	245	543
Case 3 DL+SIDL1+SIDL2+LL2+HFL	967	224	618
Case 4 DL+SIDL1+SIDL2+LL3+HFL	944	241	543
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	810	-77	-20
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1005	280	572
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	978	258	647
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	955	276	572
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	788	-77	-20
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	983	280	572
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	956	258	647
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	933	276	572

MAXIMUM REACTION CASE	1122	277	571
MAXIMUM LONGITUDINAL MOMENT CASE	1005	280	572
MAXIMUM TRANSVERSE MOMENT CASE	978	258	647

Case 2 Quasi Permanent Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	916	-113	-51
Case 2 DL+SIDL1+SIDL2+LL1	916	-113	-51
Case 3 DL+SIDL1+SIDL2+LL2	916	-113	-51
Case 4 DL+SIDL1+SIDL2+LL3	916	-113	-51
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	916	-113	-51
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	916	-113	-51
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	916	-113	-51
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	916	-113	-51
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	916	-113	-51
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	916	-113	-51
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	916	-113	-51
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	916	-113	-51

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	799	-87	-39
Case 2 DL+SIDL1+SIDL2+LL1+HFL	799	-87	-39
Case 3 DL+SIDL1+SIDL2+LL2+HFL	799	-87	-39
Case 4 DL+SIDL1+SIDL2+LL3+HFL	799	-87	-39
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	799	-87	-39
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	799	-87	-39
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	799	-87	-39
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	799	-87	-39
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	799	-87	-39
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	799	-87	-39
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	799	-87	-39
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	799	-87	-39

MAXIMUM REACTION CASE	916	-113	-51
MAXIMUM LONGITUDINAL MOMENT CASE	799	-87	-39
MAXIMUM TRANSVERSE MOMENT CASE	799	-87	-39

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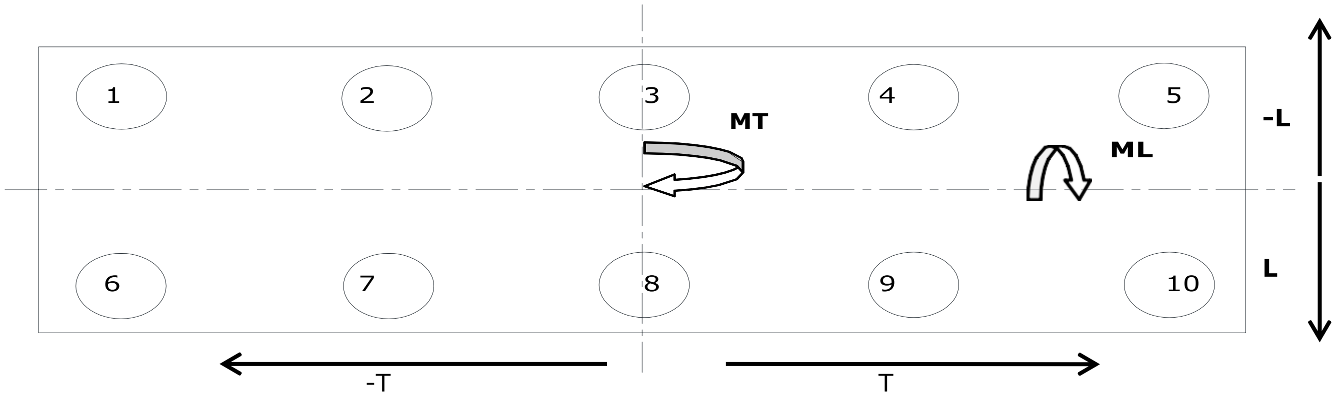
Load Calculations for Design of Pile (SLS)

	V	ML	MT
	t	t-m	t-m
Case 1	1122	277	571
Case 2	1005	280	572
Case 3	978	258	647
Case 4	916	-113	-51
Case 5	799	-87	-39
Case 6	799	-87	-39

Diameter of Pile = 1.200 m
Shift = 0.000 m

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_L2$	$_T2$	Z_L	Z_T
1	1.235	-7.881	1.526	62.116	73.021	-39.407
2	-0.368	-3.941	0.135	15.529	-245.437	-78.814
3	-1.970	0.000	3.882	0.000	-45.781	0.000
4	-3.573	3.941	12.768	15.529	-25.245	78.814
5	-5.176	7.881	26.791	62.116	-17.427	39.407
6	5.176	-7.881	26.791	62.116	17.427	-39.407
7	3.573	-3.941	12.768	15.529	25.245	-78.814
8	1.970	0.000	3.882	0.000	45.781	0.000
9	0.368	3.941	0.135	15.529	245.437	78.814
10	-1.235	7.881	1.526	62.116	-73.021	39.407

I_{LL} = **90.20** Sq.m
I_{TT} = **310.58** Sq.m

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Case 1

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift**		**Total**
				M_L/Z_L	**M_T/Z_T**	**Load**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**
1	112.2	3.8	-14.5	0.0	0.0	101.5
2	112.2	-1.1	-7.2	0.0	0.0	103.9
3	112.2	-6.1	0.0	0.0	0.0	106.2
4	112.2	-11.0	7.2	0.0	0.0	108.5
5	112.2	-15.9	14.5	0.0	0.0	110.8
6	112.2	15.9	-14.5	0.0	0.0	113.6
7	112.2	11.0	-7.2	0.0	0.0	116.0
8	112.2	6.1	0.0	0.0	0.0	118.3
9	112.2	1.1	7.2	0.0	0.0	120.6
10	112.2	-3.8	14.5	0.0	0.0	122.9

Case 2

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift**		**Total**
				M_L/Z_L	**M_T/Z_T**	**Load**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**
1	100.5	3.8	-14.5	0.0	0.0	89.9
2	100.5	-1.1	-7.3	0.0	0.0	92.2
3	100.5	-6.1	0.0	0.0	0.0	94.4
4	100.5	-11.1	7.3	0.0	0.0	96.7
5	100.5	-16.0	14.5	0.0	0.0	99.0
6	100.5	16.0	-14.5	0.0	0.0	102.1
7	100.5	11.1	-7.3	0.0	0.0	104.4
8	100.5	6.1	0.0	0.0	0.0	106.7
9	100.5	1.1	7.3	0.0	0.0	108.9
10	100.5	-3.8	14.5	0.0	0.0	111.2

Case 3

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift**		**Total**
				M_L/Z_L	**M_T/Z_T**	**Load**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**
1	97.8	3.5	-16.4	0.0	0.0	84.9
2	97.8	-1.1	-8.2	0.0	0.0	88.6
3	97.8	-5.6	0.0	0.0	0.0	92.2
4	97.8	-10.2	8.2	0.0	0.0	95.8
5	97.8	-14.8	16.4	0.0	0.0	99.4
6	97.8	14.8	-16.4	0.0	0.0	96.2
7	97.8	10.2	-8.2	0.0	0.0	99.8
8	97.8	5.6	0.0	0.0	0.0	103.5
9	97.8	1.1	8.2	0.0	0.0	107.1
10	97.8	-3.5	16.4	0.0	0.0	110.7

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Case 4

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	91.6	-1.6	1.3	0.0	0.0	91.3
2	91.6	0.5	0.6	0.0	0.0	92.7
3	91.6	2.5	0.0	0.0	0.0	94.0
4	91.6	4.5	-0.6	0.0	0.0	95.4
5	91.6	6.5	-1.3	0.0	0.0	96.8
6	91.6	-6.5	1.3	0.0	0.0	86.3
7	91.6	-4.5	0.6	0.0	0.0	87.7
8	91.6	-2.5	0.0	0.0	0.0	89.1
9	91.6	-0.5	-0.6	0.0	0.0	90.5
10	91.6	1.6	-1.3	0.0	0.0	91.8

Case 5

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	79.9	-1.2	1.0	0.0	0.0	79.7
2	79.9	0.4	0.5	0.0	0.0	80.7
3	79.9	1.9	0.0	0.0	0.0	81.8
4	79.9	3.5	-0.5	0.0	0.0	82.9
5	79.9	5.0	-1.0	0.0	0.0	83.9
6	79.9	-5.0	1.0	0.0	0.0	75.9
7	79.9	-3.5	0.5	0.0	0.0	76.9
8	79.9	-1.9	0.0	0.0	0.0	78.0
9	79.9	-0.4	-0.5	0.0	0.0	79.0
10	79.9	1.2	-1.0	0.0	0.0	80.1

Case 6

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	79.9	-1.2	1.0	0.0	0.0	79.7
2	79.9	0.4	0.5	0.0	0.0	80.7
3	79.9	1.9	0.0	0.0	0.0	81.8
4	79.9	3.5	-0.5	0.0	0.0	82.9
5	79.9	5.0	-1.0	0.0	0.0	83.9
6	79.9	-5.0	1.0	0.0	0.0	75.9
7	79.9	-3.5	0.5	0.0	0.0	76.9
8	79.9	-1.9	0.0	0.0	0.0	78.0
9	79.9	-0.4	-0.5	0.0	0.0	79.0
10	79.9	1.2	-1.0	0.0	0.0	80.1

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Moment on pile =		3.689	Q			
	Rare Combination			Quasi Permanent Combination		
	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)
MAX	**122.92**	13	46	**96.80**	5	20
MIN	**84.95**	8	31	**75.86**	3	10

Moments & shear force for pile cap

Width of abut.	=	1.00	m
Length of Abutment	=	16.00	m
Dia. Of pile	=	1.20	m
Length of Pile cap	=	16.00	m
Width of Pile cap	=	4.30	m
Thickness of pile cap	=	1.80	m
Unit wt. of concrete	=	2.50	t/m^3
Unit wt. of Soil	=	2.00	t/m^3
Thickness of soil above pile cap	=	1.19	m
Downward force & moment due to pile cap		1.20	0.00

Transverse direction	**L**	**B**	**H**	**Unit Weight**	**Load (t)**	**Moment (t.m)**
Self wt. of pile cap	0.00	4.30	1.80	2.50	0.00	0.00
Wt. due to soil	0.00	4.30	1.19	2.00	0.00	0.00
Longitudinal direction	**L**	**B**	**H**	**Unit Weight**	**Load (t)**	**Moment (t.m)**
Self wt. of pile cap	1.65	16.00	1.80	2.50	118.80	98.01
Wt. due to soil	1.65	16.00	1.19	2.00	62.94	51.92

DIRECTION	**Rare Combination**			**Quasi Permanent Combination**		
	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)
LL	570	24 /m	33 /m	471	18 /m	26 /m
TT	463	108 /m	/m	375	87 /m	/m
Max	570	463	534	471	375	415

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SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	Rare Combination
	f_{cd}	=	14.40	N/mm^2	Frequent Combination
	f_{cd}	=	10.80	N/mm^2	Quasi Permanent Comb.
	E_c	=	31000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	300.00	N/mm^2	Rare Combination
	f_{Yd}	=	300.00	N/mm^2	Frequent Combination
	f_{Yd}	=	300.00	N/mm^2	Quasi Permanent Comb.

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.5*fcd*(xu $_{lim}$/d)*(1-0.33*xu $_{lim}$/d)

	Rare Combination	Frequent Combination	Quasi Perm.
$xu_{,lim}/d$	0.70	0.70	0.70
$R_{lim} = M_{u,Lim}/bd^2$	3.86	3.86	2.90

Here R_{lim} is in MPa

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	16000	mm
Depth of section D	=	4300	mm
Clear cover	=	75	mm

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Moment on the section	**Moment at face of support**		
	Rare Combination		**Quasi Permanent Combination**
Actual moment (KNm)	5239		4071
Grade of Concrete	30		30
Grade of steel fy	500		500
b	16000		16000
D	4300		4300
c	75		75
d	4212.5		4212.5
f_{cd}	14.40		10.80
f_{Yd}	300		300
$x_{u,lim}/d$	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.86		2.90
$M_{u,Lim}$ (KNm)	1097077		822807
	OK		**OK**
Ast Req.	4149		3224
Dia of bar (main tension) (mm)	25		25
Spacing (mm)	120		120
+ dia of bar (main tension) (mm)	25		25
Spacing (mm)	120		120
Ast provided (sq mm)	8181		8181
Dia of bar(main compresion at top mm)	12		12
Spacing (mm)	120		120
Area of main compresion (mm^2)	15080		15080
f_{ctm}	2.5		2.5
x (mm)	21		28
x/d	0.005		0.007
	OK		**OK**
z (mm)	4205		4203
MR (KNm)	10322		10316
	OK		**OK**
$\sigma_{sc} = M/(A_s z)$	152		118
	OK		**OK**
$\sigma_{ca} = M/(0.5 z b x_u)$	7.31		4.26
	OK		**OK**

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Calculation of crack width	**Moment at face of support**		
n_1	8		8
n_2	8		8
$\phi_{eq} = (n_1 \phi_1^2 + n_2 \phi_2^2) / (n_1 \phi_1 + n_2 \phi_2)$	25		25
cl. 12.3.4 (3) of IRC :112-2011			
c	50		50
k1	0.2		0.2
k2	0.5		0.5
For skew slab refer eq. 12.10 of IRC :112-2011			
$\rho_{p.eff} = A_s / A_{c,eff}$	0.002		0.002
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 \phi) / \rho_{p.eff} \}$	625		625
cl. 12.3.4 (3) of IRC :112-2011			
k_t	0.5		0.5
$f_{ct,eff}$	2.90		2.90
E_s	200000		200000
E_{cm}	31000		31000
$\alpha_e = E_s / E_{cm}$	6.45		6.45
$(\varepsilon_{sm} - \varepsilon_{cm}) = (\sigma_{sc} - k_t f_{ct,eff} (1 + \alpha_e \rho_{p,eff}) / \rho_{p,eff}) / E_s$	0.0005		0.0004
cl. 12.3.4 (2) of IRC :112-2011			
$w_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$	0.20		0.22
cl. 12.3.4 (1) of IRC :112-2011			
	OK		**OK**

CHECK FOR SAFETY OF SECTION OF PILE

		Unit	Rare Combination		Quasi Permanent	
			Max.	Min.	Max.	Min.
Loads	P	KN	1229	849	968	759
Moments	M	KNm	464	307	197	99
Dia of Section	D	mm	1200	1200	1200	1200
Radius of Section	R	mm	600	600	600	600
Effective Cover	C	mm	100	100	100	100
Effective Radius	R-C	mm	500	500	500	500
Modular Ratio	m		9.3333333	9.3333333	9.3333333	9.3333333
No. of Bars		Nos.	28	28	28	28
Dia of Bar		mm	25	25	25	25
+No of Bars		Nos.	28	28	28	28
+No of Bars		mm	25	25	25	25
Area of Steel	Ast	mm2	2.33E+04	2.33E+04	2.33E+04	2.33E+04
Area of Section	Ac	mm2	1.13E+06	1.13E+06	1.13E+06	1.13E+06
% of Steel	p	%	2.06	2.06	2.06	2.06
Net Area of Concrete	Anet	mm2	1.11E+06	1.11E+06	1.11E+06	1.11E+06
Transformed Area		mm2	1.32E+06	1.32E+06	1.32E+06	1.32E+06
Transformed MI		mm4	1.50E+11	1.50E+11	1.50E+11	1.50E+11
Section Modulus		mm3	2.50E+08	2.50E+08	2.50E+08	2.50E+08
Actual Stress						
P/A	σcc,cal	Mpa	0.93	0.64	0.73	0.57
M/Z	σcbc,cal	Mpa	1.85	1.22	0.79	0.39
Permissible Stress						
	σcc	Mpa	7.5	7.5	7.5	7.5
	σcbc	Mpa	10.00	10.00	10.00	10.00
Check for safety of Section						
	$\frac{\sigma cc,cal}{\sigma cc} + \frac{\sigma cbc,cal}{\sigma cbc}$	Mpa	0.31	0.21	0.18	0.12
			ok	ok	ok	ok
Check for Cracked/Uncracked Section						
	σcc,cal - σcbc,cal	Mpa	-0.93	-0.58	-0.06	0.18
Permissible Tensile Stress in concrete		Mpa	-3.83	-3.83	-3.83	-3.83
Section is to be designed as			**UNCRACKED**	**CRACKED**	**CRACKED**	**CRACKED**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode..	Designed by:	
Client	NHIDCL	Checked by:	RJ
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COMBINATION FOR DESIGN OF ABUTMENT (ULS)

Following load combinations are con As per Annex B of IRC:112-2011

1 Basic Combination

2 Seismic Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	Dead Load (due to superstructure+substructure+foundation		446	-59	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		190	-59	0	0	0
4	ABUT + RETURN WALL		20	0	0	0	0
5	FDN		0	0	0	0	0
6	SOIL ABOVE FDN		0	0	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	192	0	592	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	141	0	594	0	0
12	LL1B	Live Load Moment due to braking	3	37	0	34.26	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.09	0
14	LL3B	Live Load Moment due to braking	3	34	0	31.75	0
15	W1	Wind vertically down without LL	18	4	19	5.40	11.30
16	W2	Wind vertically up without LL	-18	4	19	5.40	11.30
17	W3	Wind vertically down with LL	18	39	19	5.53	11.30
18	W4	Wind vertically up with LL	-18	39	19	5.53	11.30
19	S1	Seimic	44	99	6	66.0	0
20	S2		44	2	103	0.0	66.0
21	S3		-44	99	6	66.0	0
22	S4		-44	2	103	0.0	66.0
23	HFL		-4	0	0	0.0	0.0
24	Active earth pressure LWL		0	24	0	24.7	0.0
25	LL surcharge LWL		0	30	0	25.2	0.0
26	Active earth pressure HFL		0	12	0	12.3	0.0
27	LL surcharge HFL		0	15	0	12.6	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0.0
29	LL surcharge LWL		0	0	0	0	0.0
30	Active earth pressure HFL		0	0	0	0	0.0
31	LL surcharge HFL		0	0	0	0	0.0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode..	Designed by:	
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	Basic Combination				Seismic Combination			
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)
DL	1.35	603	-73	-33	1.35	603	-73	-33
SIDL1	1.75	43	0	0	1.75	43	0	0
SIDL2	1.35	38	0	0	1.35	38	0	0
LL1	1.50	288	361	811	0.20	38	48	108
LL2	1.50	252	431	969	0.20	34	58	129
LL3	1.50	212	363	814	0.20	28	48	109
LL1B	1.50	5	50	22	0.20	1	7	3
LL2B	1.50	0	0	0	0.20	0	0	0
LL3B	1.50	5	47	21	0.20	1	6	3
W1	0.90	17	10	17	0.00	0	0	0
W2	0.90	-17	10	17	0.00	0	0	0
W3	0.90	17	39	30	0.00	0	0	0
W4	0.90	-17	39	30	0.00	0	0	0
S1	0.00	0	0	0	1.50	66	139	69
S2	0.00	0	0	0	1.50	66	65	142
S3	0.00	0	0	0	1.50	-66	139	69
S4	0.00	0	0	0	1.50	-66	65	142
HFL	1.00	-4	0	0	1.00	-4	0	0
EP	1.00	0	22	10	1.00	0	22	10
LL S.	1.20	0	32	14	0.20	0	5	2
EP HFL	1.00	0	11	5	1.00	0	11	5
LL.S.HFL	1.20	0	16	7	0.20	0	3	1
Active earth pressure LWL	Dynamic incr. in earth press.(Seismic)				1.00	0	0	0
LL surcharge LWL					0.20	0	0	0
Active earth pressure HFL					1.00	0	0	0
LL surcharge HFL					0.20	0	0	0

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Case 1 **Basic Combination**

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	683	-51	-23
Case 2	DL+SIDL1+SIDL2+LL1	976	393	825
Case 3	DL+SIDL1+SIDL2+LL2	935	413	961
Case 4	DL+SIDL1+SIDL2+LL3	900	391	827
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	699	-41	-5
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	993	432	856
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	952	452	991
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	917	430	857
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	666	-41	-5
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	960	432	856
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	919	452	991
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	883	430	857
HFL CASE				
Case 1	DL+SIDL1+SIDL2+HFL	679	-62	-28
Case 2	DL+SIDL1+SIDL2+LL1+HFL	972	366	813
Case 3	DL+SIDL1+SIDL2+LL2+HFL	931	385	949
Case 4	DL+SIDL1+SIDL2+LL3+HFL	896	363	815
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	695	-52	-10
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	989	405	843
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	948	424	979
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	913	402	845
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	662	-52	-10
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	956	405	843
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	915	424	979
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	879	402	845

MAXIMUM REACTION CASE	993	432	856
MAXIMUM LONGITUDINAL MOMENT CASE	952	452	991
MAXIMUM TRANSVERSE MOMENT CASE	952	452	991

Case 2 **Seismic Combination**

Load Case		Factored Forces/Moments		
		V	ML	MT
Normal		t	t-m	t-m
Downward seismic in longitudinal direction				
Case 1	DL+SIDL1+SIDL2+ seismic	749	88	46
Case 2	DL+SIDL1+SIDL2+LL1+ seismic	788	148	160
Case 3	DL+SIDL1+SIDL2+LL2+ seismic	783	151	178
Case 4	DL+SIDL1+SIDL2+LL3+ seismic	778	148	160
Downward seismic in transverse direction				
Case 5	DL+SIDL1+SIDL2+ seismic	749	14	120
Case 6	DL+SIDL1+SIDL2+LL1+ seismic	788	75	233
Case 7	DL+SIDL1+SIDL2+LL2+ seismic	783	77	251
Case 8	DL+SIDL1+SIDL2+LL3+ seismic	778	74	233
Upward seismic in longitudinal direction				
Case 9	DL+SIDL1+SIDL2+ seismic	617	88	46
Case 10	DL+SIDL1+SIDL2+LL1+ seismic	656	148	160
Case 11	DL+SIDL1+SIDL2+LL2+ seismic	651	151	178
Case 12	DL+SIDL1+SIDL2+LL3+ seismic	646	148	160
Upward seismic in transverse direction				
Case 13	DL+SIDL1+SIDL2+ seismic	617	14	120
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	656	75	233
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	651	77	251
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	646	74	233

HFL CASE

Downward seismic in longitudinal direction				
Case 1	DL+SIDL1+SIDL2+ seismic	745	77	41
Case 2	DL+SIDL1+SIDL2+LL1+ seismic	784	134	153
Case 3	DL+SIDL1+SIDL2+LL2+ seismic	779	137	172
Case 4	DL+SIDL1+SIDL2+LL3+ seismic	774	134	154
Downward seismic in transverse direction				
Case 5	DL+SIDL1+SIDL2+ seismic	745	3	115
Case 6	DL+SIDL1+SIDL2+LL1+ seismic	784	61	227
Case 7	DL+SIDL1+SIDL2+LL2+ seismic	779	63	245
Case 8	DL+SIDL1+SIDL2+LL3+ seismic	774	60	227
Upward seismic in longitudinal direction				
Case 9	DL+SIDL1+SIDL2+ seismic	613	77	41
Case 10	DL+SIDL1+SIDL2+LL1+ seismic	652	134	153
Case 11	DL+SIDL1+SIDL2+LL2+ seismic	647	137	172
Case 12	DL+SIDL1+SIDL2+LL3+ seismic	642	134	154
Upward seismic in transverse direction				
Case 13	DL+SIDL1+SIDL2+ seismic	613	3	115
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	652	61	227
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	647	63	245
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	642	60	227

MAXIMUM REACTION CASE	788	148	160
MAXIMUM LONGITUDINAL MOMENT CASE	783	151	178
MAXIMUM TRANSVERSE MOMENT CASE	783	77	251

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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COMBINATION FOR DESIGN OF ABUTMENT (SLS)

Following load combinations are conAs per Annex B of IRC:112-2011

1 Rare Combination

2 Quasi Permanent Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	DL	Dead Load (due to superstructure+substructure+found.	446	-59	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		190	-59	0	0	0
4	ABUT + RETURN WALL		20	0	0	0	0
5	FDN		0	0	0	0	0
6	SOIL ABOVE FDN		0	0	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	192	0	592	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	141	0	594	0	0
12	LL1B	Live Load Moment due to braking	3	37	0	34.26	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.09	0
14	LL3B	Live Load Moment due to braking	3	34	0	31.75	0
15	W1	Wind vertically down without LL	18	4	19	5.40	11.30
16	W2	Wind vertically up without LL	-18	4	19	5.40	11.30
17	W3	Wind vertically down with LL	18	39	19	5.53	11.30
18	W4	Wind vertically up with LL	-18	39	19	5.53	11.30
19	S1	Seimic	0	0	0	0	0
20	S2		0	0	0	0	0
21	S3		0	0	0	0	0
22	S4		0	0	0	0	0
23	HFL		-4	0	0	0	0
24	Active earth pressure LWL		0	24	0	24.7	0.0
25	LL surcharge LWL		0	30	0	25.2	0.0
26	Active earth pressure HFL		0	12	0	12.3	0.0
27	LL surcharge HFL		0	15	0	12.6	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0
29	LL surcharge LWL		0	0	0	0	0
30	Active earth pressure HFL		0	0	0	0	0
31	LL surcharge HFL		0	0	0	0	0

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Client	NHIDCL	Checked by:	RJ
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	Rare Combination					**Quasi Permanent Combination**			
	PSF	P (t)	ML (tm)	MT (tm)		PSF	P (t)	ML (tm)	MT (tm)
DL	1.00	446	-54	-24		1.00	446	-54	-24
SIDL1	1.00	24	0	0		1.00	24	0	0
SIDL2	1.00	28	0	0		1.00	28	0	0
LL1	1.00	192	241	541		0.00	0	0	0
LL2	1.00	168	288	646		0.00	0	0	0
LL3	1.00	141	242	543		0.00	0	0	0
LL1B	1.00	3	34	15		0.00	0	0	0
LL2B	1.00	0	0	0		0.00	0	0	0
LL3B	1.00	3	31	14		0.00	0	0	0
W1	0.60	11	7	12		0.00	0	0	0
W2	0.60	-11	7	12		0.00	0	0	0
W3	0.60	11	26	20		0.00	0	0	0
W4	0.60	-11	26	20		0.00	0	0	0
S1	0.00	0	0	0		0.00	0	0	0
S2	0.00	0	0	0		0.00	0	0	0
S3	0.00	0	0	0		0.00	0	0	0
S4	0.00	0	0	0		0.00	0	0	0
HFL	1.00	-4	0	0		1.00	-4	0	0
EP	1.00	0	22	10		1.00	0	22	10
LL S.	0.80	0	22	10		0.00	0	0	0
EP HFL	1.00	0	11	5		1.00	0	11	5
LL.S.HFL	0.80	0	11	5		0.00	0	0	0
Active earth pressure LWL					Dynamic incr. in earth press.(Seismic)	1.00	0	0	0
LL surcharge LWL						0.20	0	0	0
Active earth pressure HFL						1.00	0	0	0
LL surcharge HFL						0.20	0	0	0

Case 1 Rare Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	499	-32	-14
Case 2 DL+SIDL1+SIDL2+LL1	694	264	551
Case 3 DL+SIDL1+SIDL2+LL2	667	277	641
Case 4 DL+SIDL1+SIDL2+LL3	643	262	552
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	510	-25	-3
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	705	290	571
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	678	303	661
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	654	288	572
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	488	-25	-3
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	683	290	571
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	656	303	661
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	632	288	572

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	495	-43	-19
Case 2 DL+SIDL1+SIDL2+LL1+HFL	690	242	541
Case 3 DL+SIDL1+SIDL2+LL2+HFL	663	255	632
Case 4 DL+SIDL1+SIDL2+LL3+HFL	639	240	542
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	506	-36	-8
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	701	268	561
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	674	281	652
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	650	267	562
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	484	-36	-8
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	679	268	561
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	652	281	652
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	628	267	562

MAXIMUM REACTION CASE	705	290	571
MAXIMUM LONGITUDINAL MOMENT CASE	678	303	661
MAXIMUM TRANSVERSE MOMENT CASE	678	303	661

Case 2 Quasi Permanent Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	499	-32	-14
Case 2 DL+SIDL1+SIDL2+LL1	499	-32	-14
Case 3 DL+SIDL1+SIDL2+LL2	499	-32	-14
Case 4 DL+SIDL1+SIDL2+LL3	499	-32	-14
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	499	-32	-14
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	499	-32	-14
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	499	-32	-14
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	499	-32	-14
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	499	-32	-14
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	499	-32	-14
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	499	-32	-14
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	499	-32	-14

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	495	-43	-19
Case 2 DL+SIDL1+SIDL2+LL1+HFL	495	-43	-19
Case 3 DL+SIDL1+SIDL2+LL2+HFL	495	-43	-19
Case 4 DL+SIDL1+SIDL2+LL3+HFL	495	-43	-19
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	495	-43	-19
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	495	-43	-19
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	495	-43	-19
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	495	-43	-19
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	495	-43	-19
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	495	-43	-19
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	495	-43	-19
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	495	-43	-19

MAXIMUM REACTION CASE	499	-32	-14
MAXIMUM LONGITUDINAL MOMENT CASE	499	-32	-14
MAXIMUM TRANSVERSE MOMENT CASE	499	-32	-14

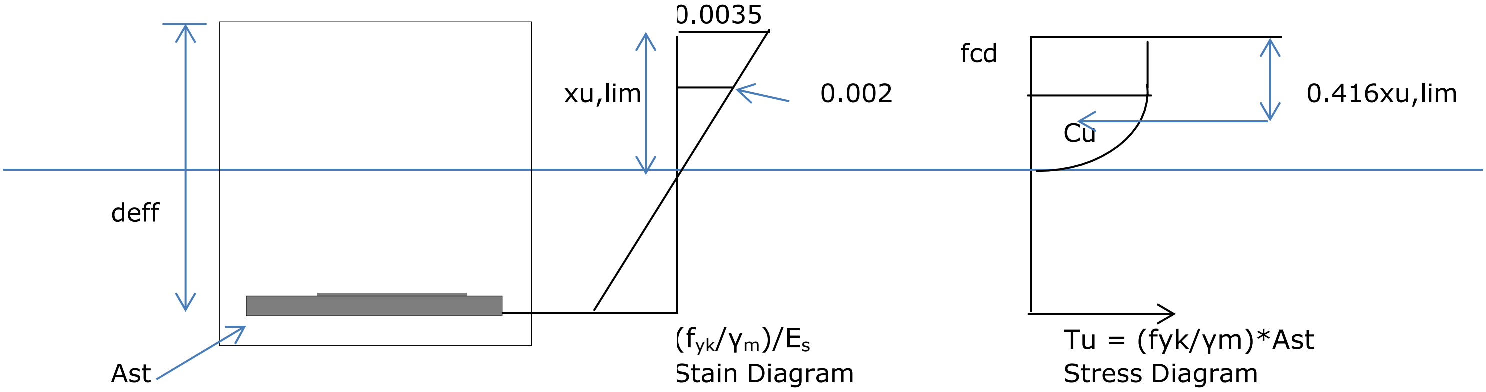
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

CALCULATION OF DIRT WALL FORCES

Height of dirt wall	1.35	m
Thickness of dirt wall	0.3	m
Thickness of approach slab	0.3	m
Thickness of wearing coat on approach slab	0.075	m
Unit wt. of soil	2.00	t/m3
Unit wt. of concrete	2.50	t/m3
Unit wt. of wearing coat	2.20	t/m3
Earth Pressure considered	Y	
Coefficient of active earth pressure	0.279	
Live load surcharge	1.2	m
Active earth pressure	0.75	t/m^2 per meter
Pressure due to live load surcharge	0.67	t/m^2 per meter
Force due to live load surcharge	0.91	t per meter
Force due to active earth pressure	0.51	t per meter
Moment due to live load surcharge	0.61	t.m
Moment due to active earth pressure Ignoring vertical load	0.29	t.m

	unit	actual value	ULS basic PSF	ULS basic Comb.	SLS Rare PSF	SLS Rare comb.	SLS Quasi permanent	SLS Quasi permanent
Moment due to live load surcharge	t.m per meter	0.61	1.20	0.73	0.80	0.49	0.00	0.00
Moment due to active earth pressure	t.m per meter	0.29	1.50	0.43	1.00	0.29	1.00	0.29
	t.m per meter			**1.17**		**0.78**		**0.29**
Force due to live load surcharge	t per meter	0.91	1.20	1.09	0.80	0.72	0.00	0.00
Force due to active earth pressure	t per meter	0.51	1.50	0.76	1.00	0.51	1.00	0.51
	t per meter			**1.85**		**1.23**		**0.51**

VERIFICATION OF STRUCTURAL STRENGTH FOR DIRT WALL



ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	13.40	N/mm^2	Basic Combination
	f_{cd}	=	16.75	N/mm^2	Accidental Combination
	f_{cd}	=	13.40	N/mm^2	Seismic Combination
	E_c	=	31000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	435	N/mm^2	Basic Combination
	f_{Yd}	=	500.00	N/mm^2	Accidental Combination
	f_{Yd}	=	435	N/mm^2	Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = $fcd*b*(3/7xu_{,lim} + 2/3*4/7xu_{,lim})$

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.8095fcd*(xu_{\ lim}/d)*(1-0.416*xu_{\ lim}/d)$

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	mm

Moment on the section	**Moment at face of support**		
	Basic Combination		
Actual moment (KNm)	11		
Grade of Concrete	30		
Grade of steel fy	500		
b	1000		
D	300		
c	50		
d	234.0		
f_{cd}	13.40		
f_{Yd}	435		
$xu_{,lim}/d$	0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97		
$M_{u,Lim}$ (KNm)	272		
	OK		
Ast Req.	113		
Dia of bar (main tension) (mm)	16		
Spacing (mm)	150		
+ dia of bar (main tension) (mm)	0		
Spacing (mm)	150		
Ast provided (sq mm)	1340		
Dia of bar(main compresion at top mm)	12		
Spacing (mm)	150		
Area of main compresion (mm^2)	754		
f_{ctm}	2.5		
f_{yk}	435		
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	350		
	OK		
As.max = 0.025 Ac (main tension)	7500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**		
As.max = 0.04 Ac (tension + compresion)	12000		
x (mm)	54		
x/d	0.230		
	OK		
z (mm)	212		
MR (KNm)	123		
	OK		

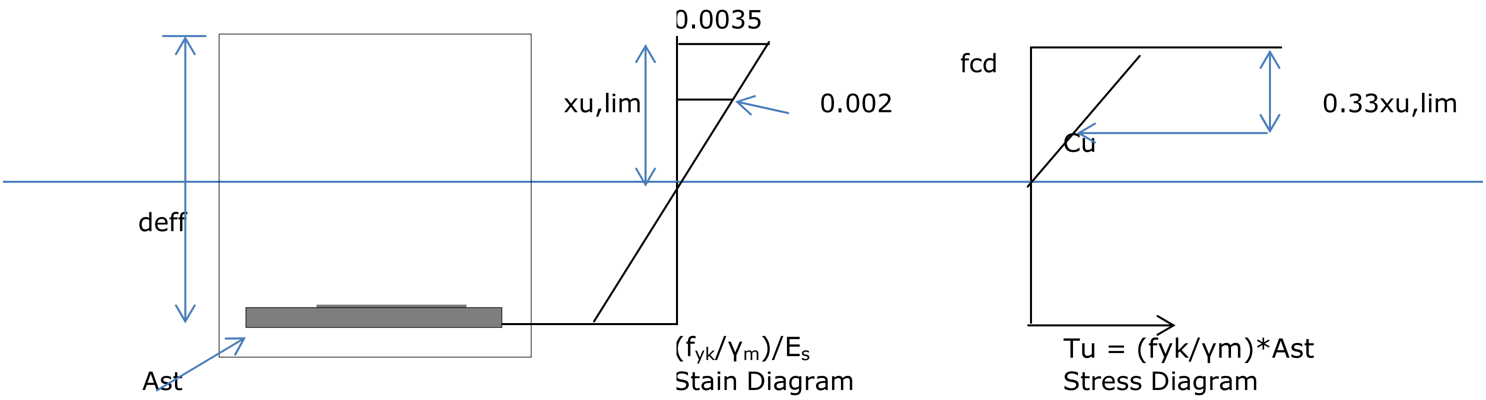
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Shear on the section

Actual shear V_{Ed} (KN)	18		
Actual shear stress (N/mm2)	0.078		
Max shear capacity, 0.135 fck(1-fck/310)	3.66		
	OK		
Min shear capacity, 0.0924 fck(1-fck/310)	2.50		
$\theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	0.61		
Min angle of inclination, θ (deg)	21.8		
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.925		
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
V(min) = 0.031 K^(3/2) fck^(1/2)	0.453		
cl. 10.3.1 of IRC :112-2011			
$r1 = A_{sl}/(b_w\ d) <= 0.02$	0.006		
	OK		
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.548		
Axial compressive force N_{Ed} (KN)	0.0		
$S_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d >=(V_{min} + 0.15\ S_{cp})\ b_w\ d$ (KN)	128		
	NO SHEAR R/F REQ.		
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010			
n = 0.6 (1 - fck / 310)	0.542		
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011			
$0.5\ b_w\ d\ n\ f_{cd}$	850		
	OK		
No. of Links for shear R/f (Distribution)	0		
Dia. of bar for shear reinf.	10		
S(mm)	150		
$^{A}SW1$	0		
	OK		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF SERVICEABILITY LIMIT STATE FOR DIRT WALL



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	Rare Combination
	f_{cd}	=	14.40	N/mm^2	Frequent Combination
	f_{cd}	=	10.80	N/mm^2	Quasi Permanent Comb.
	E_c	=	31000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	300.00	N/mm^2	Rare Combination
	f_{Yd}	=	300.00	N/mm^2	Frequent Combination
	f_{Yd}	=	300.00	N/mm^2	Quasi Permanent Comb.

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.5*fcd*(xu_{lim}/d)*(1-0.33*xu_{lim}/d)$

	Rare Combination	Frequent Combination	Quasi Perm.
$xu_{,lim}/d$	0.70	0.70	0.70
$R_{lim} = M_{u,Lim}/bd^2$	3.86	3.86	2.90

Here R_{lim} is in MPa

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	mm

Moment on the section	**Moment at face of support**		
	Rare Combination		**Quasi Permanent Combination**
Actual moment (KNm)	8		3
Grade of Concrete	30		30
Grade of steel fy	500		500
b	1000		1000
D	300		300
c	50		50
d	234.0		234.0
f_{cd}	14.40		10.80
f_{Yd}	300		300
$xu_{,lim}/d$	0.70		0.70
$R_{sls} = M_{u,sls}/bd2$	3.86		2.90
$M_{u,Lim}$ (KNm)	212		159
	OK		**OK**
Ast Req.	109		40
Dia of bar (main tension) (mm)	16		16
Spacing (mm)	150		150
+ dia of bar (main tension) (mm)	0		0
Spacing (mm)	150		150
Ast provided (sq mm)	1340		1340
Dia of bar(main compresion at top mm)	12		12
Spacing (mm)	150		150
Area of main compresion (mm^2)	754		754
f_{ctm}	2.5		2.5
x (mm)	56		74
x/d	0.239		0.318
	OK		**OK**
z (mm)	215		209
MR (KNm)	87		84
	OK		**OK**
$\sigma_{sc} = M/(A_s z)$	26		10
	OK		**OK**
$\sigma_{ca} = M/(0.5 z b x_u)$	1.27		0.36
	OK		**OK**

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Calculation of crack width	Moment at face of support		
n_1	7		7
n_2	7		7
$\phi_{eq} = (n_1\phi_1^2 + n_2\phi_2^2) / (n_1\phi_1 + n_2\phi_2)$	16		16
cl. 12.3.4 (3) of IRC :112-2011			
c	50		50
k1	0.8		0.8
k2	0.5		0.5
For skew slab refer eq. 12.10 of IRC :112-2011			
$\rho_{p.eff} = A_s / A_{c,eff}$	0.009		0.009
$S_{r,max} = \{ 3.4\,c + (0.425\,k_1\,k_2\,\phi) / \rho_{p.eff} \}$	474		474
cl. 12.3.4 (3) of IRC :112-2011			
k_t	0.5		0.5
$f_{ct,eff}$	2.90		2.90
E_s	200000		200000
E_{cm}	31000		31000
$\alpha_e = E_s / E_{cm}$	6.45		6.45
$(\varepsilon_{sm} - \varepsilon_{cm}) = (\sigma_{sc} - k_t\, f_{ct,eff} (1 + \alpha_e\, \rho_{p,eff}) / \rho_{p,eff}) / E_s$	0.0001		0.0000
cl. 12.3.4 (2) of IRC :112-2011			
$W_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$	0.04		0.01
cl. 12.3.4 (1) of IRC :112-2011			
	OK		**OK**

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APPENDEX - I

Fundamental Time Period of Vibration due to Seismic Waves :

According to **Annexure D (Clause 219.5)** IRC 6 :2017 -

T = 2.0 x sqrt(D/(1000*F))

Where,

T = Fundamental Time Period Of Vibration

D = Appropriate dead Load of the superstructure and Live load in KN

F = Horizontal Force in KN required to be applied at the centre of mass of superstructure for 1 mm horizontal deflection at the top of the 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 Longitudinal direction

			Longitudinal Direction		Transverse Direction	
	F	=	$d*(3EI)/L^3$	Unit	$d*(3EI)/L^3$	Unit
	d	=	0.001	m	0.001	m
	L	=	1.608	m	2.158	m
	E	=	3.10E+07	KN/m2	3.10E+07	KN/m2
	I	=	1.000	m4	256.000	m4
	F	=	22367.880	KN	2369019.267	KN
	D	=	2829.000	KN	3206.109	KN
	T	**=**	***0.02***	***sec***	***0.00***	***sec***
Seismic Zone		=	III		III	
Zone Factor Z		=	0.16		0.16	
Importance Factor I		=	1.2		1.2	
Response Reduction Factor		=	3		3	
Soil Strata		=	Type II	Medium soil		
Sa/g			2.5		2.5	
Horizontal Acceleration Coefficient (Ah) Z/2*Sa/g*I/R		=	0.08		0.08	

APPENDEX - II DESIGN CURVE OF PILE SHAFT FOR MAXIMUM BENDING MOMENTS

SLENDERNESS CHECK AND CHECK FOR SECOND ORDER EFFECTS

Slenderness check as per IRC 112,Cl.8.3.2

lx/ly <=2.0 & ly/lx <=2.0 — as per eq. 8.1

$(e_x / h_{eq}) / (e_y / b_{eq}) <= 0.20$ OR — as per eq. 8.2

$(e_y / b_{eq}) / (e_x / h_{eq}) <= 0.20$ — From table 11.1:IRC 112

lex	=	13019.71 mm	ley	=	13019.71 mm	
Ixx	=	1.0E+11 mm4	Iyy	=	1.0E+11 mm4	
A	=	1130973 mm2	A	=	1130973 mm2	
$i_y=\sqrt{I/A}$	=	300.0 mm	$i_x=\sqrt{I/A}$	=	300.0 mm	Radius of gyration
b_{eq}	=	86.6 mm	h_{eq}	=	86.6 mm	
l_x	=	43.40	l_y	=	43.40	

Check for Slenderness

1.0 $\mathbf{l_x / l_y}$ **= 1.00 <=2** Condition Satisfied — from eq 8.1 IRC 112

$\mathbf{l_y / l_x}$ **= 1.00 <=2** Condition Satisfied

2.0 Design Cases — from eq 8.2 IRC 112

		Case-1	Case-2	Case-3	Case-4
e_x	=	348.26	447.4	385.7	423.4
e_y	=	348.26	447.4	385.7	423.4
$(e_x/h_{eq}) / (e_y/b_{eq})$	=	1.00	1.00	1.00	1.00
$(e_y/b_{eq}) / (e_x/h_{eq})$	=	1.00	1.00	1.00	1.00

Hence Check for Bending is required

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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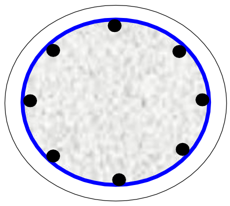
Design of Pile Shaft Subjected to Axial Load & Maximum Bending Moments-

Given Data

Pile Size

Diameter (D) = 1200 mm

Area of Pile (Ag) = 1.13E+06 mm2



Section R/f

	Equivalent Dia (mm)	Nos.	Area
Outer Peripheri	37	22	23259.869
	37	0	0.00

PROVIDE				
		28 X	25	Dia
	+	28 X	25	Dia
	+	0 X	25	Dia

Ast Provided	=	27488.936	mm2	**OK**
Total No. of Longitudinal Bar	=	22	Nos.	
Total Ast	=	23259.869	mm2	
% of Reinforcement (Pt)	=	2.06	%	
Effective Spacing of Bars	=	141.27	mm	**OK**
Clear Cover	=	75	mm	
Dia of Tie Bar	=	12	mm	
Effective Cover (d')	=	105	mm	
d'/D ratio	=	0.088		

Transverse Reinforcement

As per Clause 16.2.3 of IRC 112:2011

Minimum Diameter of Tie Bars = 0.25 x 25 = 6.25 mm

or 8 mm whichever is greater

Adopt 8 mm dia Helical Reinforcement

Pitch of Lateral Ties shall not exceed

= 12 x 25 = 300 mm

or 1200 mm

or 200 mm whichever is less

or 150 mm As per IRC 78-2014

Adopt 150 mm c/c spacing

Provide 8mm dia bar @ 150c/c as Spiral Helical Tie Bar beyond Point of Fixity

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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Ductile Detailing as per IRC:112-2019, Clause 17.2.1

Confinement Reinforcement

$nk = \frac{N_{ED}}{Acfck} = \frac{3372165}{3.39E+07} = 0.10 > 0.06$

IF nk > 0.064 , Confinement R/f shall be provided as per Clause 17.2.1.4 of IRC:112-2019

IF nk < 0.064 , Confinement R/f shall be provided as per Clause 17.2.2 of IRC:112-2019

Adopt Spacing of Hoops = 125 mm

As per Cl. 17.2.1.3 of IRC 112:2019

Spacing of Hoops

SL	<=	5	x	25	=	125	mm	OK
	<=	0.2	x	1042	=	208.4	mm	OK

Dsp = 1050 mm

Dia of Spiral Provided = 10 mm

$\omega_{wd} = \rho_w \, f_{yd}/f_{cd}$

where $\rho_w = \frac{4*Asp}{Dsp*SL}$

Asp	=	78.54	mm2
SL	=	125	mm c/c
Dsp	=	1050	mm
ρ_w	=	0.002	
$\omega_{wd,c}$	=	0.078	

Minimum Confining Reinforcement: as per Clause 17.2.1.2 of IRC:112-2019

$\omega_{wd,c} >= \max(1.4*\omega_{w.req}, 0.18)$

$\omega_{w,req} = \frac{0.37Ac*nk}{Acc} + \frac{0.13*fyd(\rho L-0.01)}{fcd}$

Ac	=	1.13E+06	
Acc	=	8.66E+05	mm^2
nk	=	0.10	
ρL	=	0.02431	
$\omega_{w,req}$	=	0.10837	
$\omega_{wd,c}$	=	0.18000	

105.00962

$\omega_{wd,c}$ = 6.990 OK

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

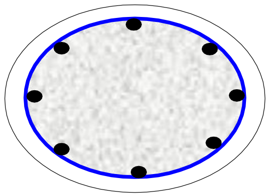
Material Property

Concrete Grade	=	**M30**	
Steel Grade	=	**Fe500**	
Characteristic Compressive Strength of Concrete at 28 days,fck	=	30.00	N/mm^2
Design strength of concrete, fcd=0.446fck	=	13.40	N/mm^2
Yield Strength of Reinforcement Steel ,fy	=	500	N/mm^2
Design Yield Strength of Reinforcement Steel ,fyd	=	434.78	N/mm^2
Modulus of Elasticity of Concrete (Ec)	=	27386.1	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2
Factor of Safety For Concrete	=	1.5	
Factor of Safety For Steel	=	1.15	
Maximum Strain in Concrete,εcu	=	0.0035	
Yield Strain in Concrete, ε_{cd}	=	0.002	
Yield Strain in Steel,$\varepsilon_{st}(\varepsilon_{yd})$	=	0.002174	
Max. Strain in steel, ε_{stu}	=	0.004174	

Summary of Design Forces at Pile Fixity:

Load Cases		Axial Load (KN)	Initial Resultant Moment (KN-m)	Final Design Moment (KN-m)
		Pu	M	Mu
Normal Dry Case	Max	1683.79	293.20	293.20
	Min	848.96	179.73	179.73
Seismic Case	Max	1394.84	316.74	316.74
	Min	1025.50	261.04	261.04

DESIGN OF RECTANGULAR SECTION FOR ABUTMENT SHAFT - ULTIMATE LIMIT STATE



Section dimensions of pier shaft

Length, B = 1200 mm (equivalent length of pier shaft)
Thickness,D = 0 mm

Material properties

fck = 30.00 Mpa
fyk = 500 Mpa
Es = 200000 Mpa

Design axial resistance of section

N_{Rd} = Ac * fcd + As * fyd

fcd = α_{cc} xf_{ck} /γ_m α_{cc} = 0.67
= 13.400 Mpa γ_m = 1.5

fyd = fyk/γ_s γ_s = 1.15
= 434.7826 Mpa

N_{Rd} = 11951.71 KN

Reinforcement Details

Reinf.	Dia.(mm)	Spacing (mm)	Cover (mm)	From (mm)	To (mm)	Y_{CG} (mm)	Nos.
As1	25	141	75	0	0	0.00	28.00
As2	25	75	75	0	0	0.00	28.00

Total reinforcement

As3 (Along length Tension face) = 0.00 mm^2
As4 (Along length Compression face) = 0.00 mm^2
As2 (Along width Tension face) = 13744.47 mm^2
As1 (Along width Compression face) = 13744.47 mm^2
Total As = **27488.9 mm^2**
Total As = **mm^2**
= **2.06 %**

Formula used for interaction diagram

Pu = Cc +Cs
Mu = Mc + Ms

Cc = 0.361*fck*Xu*b for Xu ≤ D
= 0.447*fck*(1-4*g/21)*b*D for Xu ≥ D

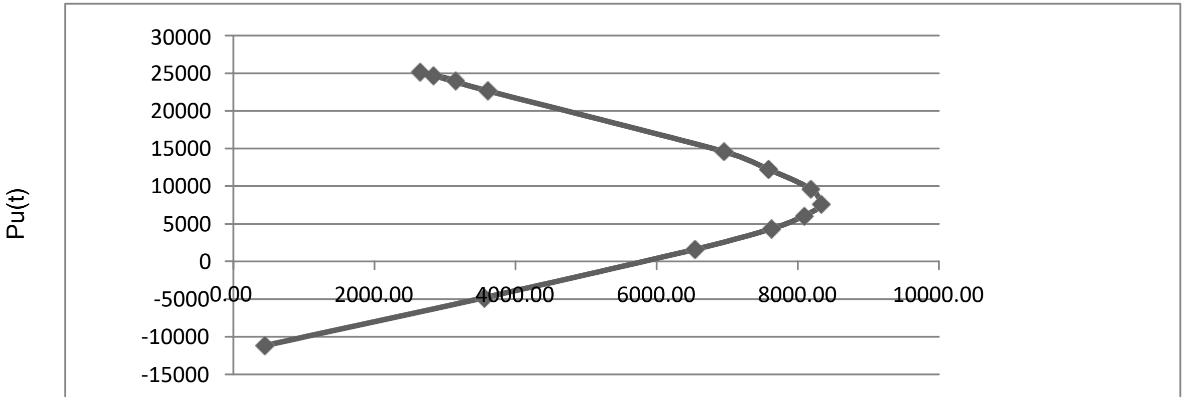
g = 16 / (7Xu / D-3)^2

Cs	=	$\sum$ (fsi - fci) Asi	
fci	=	0.00	for ε_{si} <_0
		0.447 fck	for ε_{si} >_0.002
		0.447fck 2* (ε_{si}/0.002)-(ε_{si}/0.002)^2	otherwise
fsi	=	-0.87 fy	for ε_{si} <_-0.00217
		ε_{si} * Es	for 0.00217 $\geq \varepsilon_{si}$ > -0.00217
		0.87fy	for ε_{si} > 0.00217
Mc	=	Cc * (0.5D -x)	
Ms	=	$\sum$ Csi * yi	
x	=	0.416 Xu	for Xu $\leq$ D
	=	(0.5 - 8*g /49)* D/(1-4*g/21)	for Xu $\geq$ D
Where x	=	Centroid of stress block area from most compressed edge.	
ε_{si}	=	$\dfrac{0.0035 * \ Xu- D/2 +y_i}{Xu}$	for Xu $\leq$ D
	=	$\dfrac{0.002* \ 1+ y_i - D/14}{Xu - 3D/7}$	for Xu > D
Where y_i	=	Distance of ith row of steel from the centroidal axis measured positive in the direction towards the highly compressed edge.	

Along traffic direction

Xu/D	=	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
D(mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Xu (mm)	=	60	120	240	360	480	600	720	840	960	1080	1200	1320	1440
	<	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
g (Mpa)	=	2.278391	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.366864	1.469238	1	0.72431	0.54869684
Cc (KN)	=	779.8	1559.5	3119.0	4678.6	6238.1	7797.6	9357.1	10916.6	12476.2	14035.7	15632.2	16646.3	17292.2
y1 (compr. face in mm)	=	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5
y1 (tension face in mm)	=	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5
y2 (compr. face in mm)	=	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5
y2 (tension face in mm)	=	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5
ε_{si}(compr. face in mm)	=	-0.0023	0.000598	0.002049	0.002533	0.002774	0.00292	0.003016	0.003085	0.003137	0.003178	0.00321	0.00303	0.00289614
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.0607	-0.0286	-0.01255	-0.0072	-0.00452	-0.00292	-0.00185	-0.001085	-0.000512	-6.64E-05	0.00029	0.000545	0.00073349
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{s2}(compr. face in mm)	=	-0.00522	-0.00086	0.00132	0.002047	0.00241	0.002628	0.002773	0.002877	0.002955	0.003016	0.003064	0.002905	0.00278812
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{s2} (tension face in mm)	=	-1.52158	-1.07676	-0.45388	-0.12235	-0.00499	-0.02464	-0.104108	-0.166229	-0.133827	0.070275	0.52325	0.000669	0.00084151
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	6.819529	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41
fsi(comp.face in Mpa)	=	-435	119.5833	409.7917	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	3.609343	6.31129	8.03241057
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-369.9306	-217.0833	-102.4479	-13.29	58.04167	108.9716	146.697531
fc2 (comp.face in Mpa)	=	0	0	11.85885	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41
fs2(comp.face in Mpa)	=	-435	-172.083	263.9583	409.3056	435	435	435	435	435	435	435	435	435
fc2 (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	13.41	13.41	7.470589	8.91063105
fs2 (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-435	-435	-435	435.00	435	133.7943	168.302469
Cs (KN)	=	-11957.7	-6386.5	-1522.3	-360.9	-184.3	-184.3	262.9	1313.3	2101.1	8600.5	9065.9	7368.2	7842.8
Mc (KN-m)	=	448.4	857.9	1560.0	2106.5	2497.2	2732.3	2811.6	2735.3	2503.2	2115.5	1576.4	1141.8	864.9
Ms (KN-m)	=	0.00	2698.04	4986.80	5518.69	5598.24	5598.24	5374.43	4848.70	4454.41	1495.78	1262.86	2011.10	1784.89
Pu (KN)	**=**	**-11177.9**	**-4827.0**	**1596.7**	**4317.7**	**6053.8**	**7613.3**	**9620.0**	**12229.9**	**14577.2**	**22636.2**	**24698.1**	**24014.4**	**25135.0**
Mu (KN-m)	**=**	**448.4**	**3555.9**	**6546.8**	**7625.2**	**8095.5**	**8330.5**	**8186.1**	**7584.0**	**6957.6**	**3611.2**	**2839.2**	**3152.9**	**2649.8**

Mu (KN-m)	**Pu (KN)**
448.4	-11177.9
3555.90	-4826.98
6546.82	1596.71
7625.17	4317.67
8095.47	6053.77
8330.52	7613.29
8186.06	9619.98
7583.98	12229.90
6957.63	14577.22
3611.24	22636.16
2839.22	24698.10



3152.87	24014.43	
2649.83	25135.05	

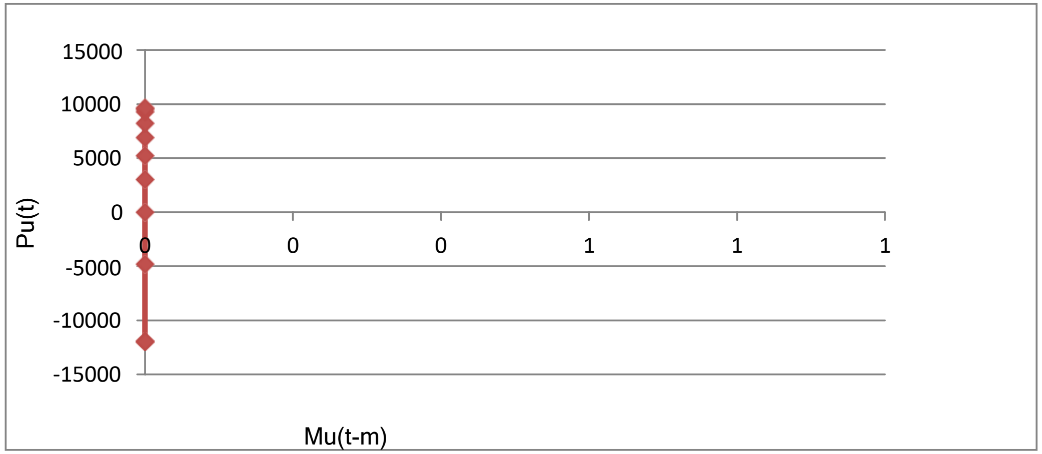
Series1

Interaction diagram Mu(t-m)

Along transverse direction

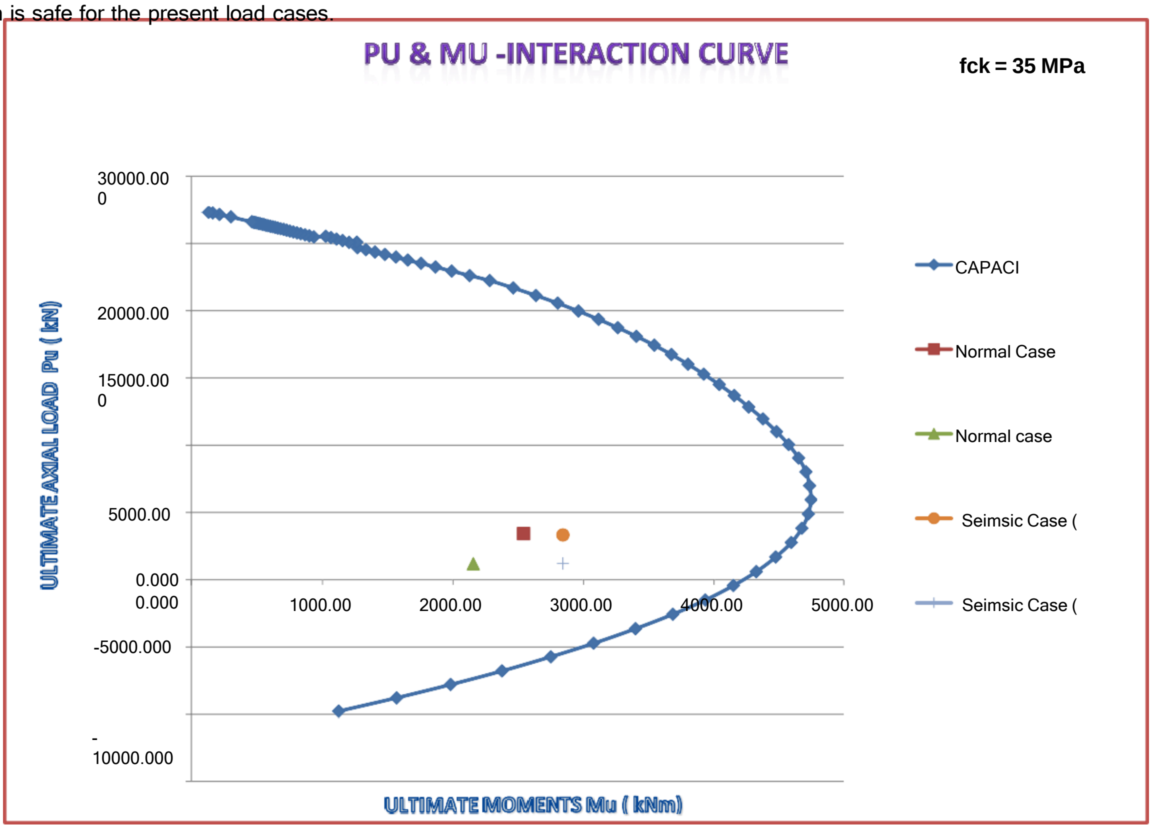
Xu/D	=	0.025	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
D(mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Xu (mm)	=	30	120	240	360	480	600	720	840	960	1080	1200	1320	1440
	<	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
g (Mpa)		2.004856	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.366864	1.469238	1	0.72431	0.54869684
Cc (KN)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yi (compr. face in mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
yi (tension face in mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
ε_{si}(compr. face in mm)	=	-0.0665	-0.014	-0.00525	-0.00233	-0.00088	0	0.000583	0.001	0.001313	0.001556	0.00175	0.001787	0.00181481
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.0665	-0.014	-0.00525	-0.00233	-0.00088	0	0.000583	0.001	0.001313	0.001556	0.001750	0.001787	0.00181481
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	0	0	0	0	0	6.681719	10.0575	11.82542	12.74778	13.20047	13.25823	13.2950309
fsi(comp.face in Mpa)	=	-435	-435	-435	-435	-175	0	116.6667	200	262.5	311.1111	350	357.4468	362.962963
fci (tension face in Mpa)	=	0	0	0	0	0	0	6.681719	10.0575	11.82542	12.74778	13.20047	13.25823	13.2950309
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-175	0	116.6667	200	262.5	311.1111	350	357.4468	362.962963
Cs (KN)	=	-11957.7	-11957.7	-11957.7	-11957.7	-4810.6	0.0	3023.4	5221.3	6890.8	8201.7	9258.3	9461.4	9612.0
Mc KN-m)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ms (KN-m)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu (KN)	**=**	**-11957.7**	**-11957.7**	**-11957.7**	**-11957.7**	**-4810.6**	**0.0**	**3023.4**	**5221.3**	**6890.8**	**8201.7**	**9258.3**	**9461.4**	**9612.0**
Mu (KN-m)	**=**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Mu (KN-M)	**Pu (KN)**
0.00	-11957.69
0.00	-11957.69
0.00	-11957.69
0.00	-11957.69
0.00	-4810.56
0.00	0.00
0.00	3023.37
0.00	5221.32
0.00	6890.78
0.00	8201.69
0.00	9258.26
0.00	9461.38
0.00	9612.00



Interaction diagram

ve figure presents a typical axial force - bending moment interaction curve for pile section at top for given amount of reinforcement. The a
s due to various load cases as presented in table are shown by filled circles. This provides a graphical representation of capacity of the s
s due to various load cases. Since demand points are within the interaction curve,
on is safe for the present load cases.



ANNEXURE IIA:- DESIGN CURVE OF PILE SHAFT FOR MAXIMUM BENDING MOMENTS (CURTAILMENT)

APPENDEX - III DESIGN CURVE OF ABUTMENT SHAFT FOR MAXIMUM BENDING MOMENTS

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

SLENDERNESS CHECK AND CHECK FOR SECOND ORDER EFFECTS

Slenderness check as per IRC 112,Cl.8.3.2- page 74

lx/ly <=2.0 & ly/lx <=2.0 — as per eq. 8.1

$(e_x / h_{eq}) / (e_y / b_{eq}) <= 0.20$ OR $(e_y / b_{eq}) / (e_x / h_{eq}) <= 0.20$ — as per eq. 8.2

Type of Bearings = POT PTFE Bearing

Effective Length = 1.4

l	=	0.50 m Clear Height of Pier			
b_{eq}	=	16000 mm			
h_{eq}	=	1000 mm			
lex	=	700 mm	ley	=	700 mm
Ixx	=	3.4E+14 mm4	Iyy	=	1.3E+12
A	=	1.60E+07 mm2	A	=	1.60E+07 mm2
$i_y=\sqrt{I/A}$	=	4618.8 mm	$i_x=\sqrt{I/A}$	=	288.7 mm
b_{eq}	=	16000 mm	h_{eq}	=	1000 mm
l_x	=	0.2	l_y	=	2.4

Check for Biaxial Bending

1.0	l_x / l_y	=	**0.06**	**<=2**	Condition Satisfied	from eq 8.1 IRC 112
	l_y / l_x	=	**16.00**	**>2**	Condition not Satisfied	

2.0	Design Cases		Case-1	Case-2	Case-3	from eq 8.2 IRC 112
	e_x	=	435.22	474.65	474.65	
	e_y	=	861.77	1040.85	1040.85	
	$(e_x/h_{eq}) / (e_y/b_{eq})$	=	8.08	7.30	7.30	
	$(e_y/b_{eq}) / (e_x/h_{eq})$	=	0.12	0.14	0.14	

Hence Check for Biaxial Bending is required

3.0 **Check for Second Order Effect**

Second order effect may be ignored og the slenderness ratio is less than

l_{lim}	=	20ABC / √n	Concrete Grade		M30
A	=	$1/(1+0.2\Phi_{eff})$	0.7		
Φ_{eff}	=	$\Phi(\infty,t_0)$	1.57	M_{0Eqp} =	First Order BM in Quasi Permanent Combinations
				M_{0Ed} =	First Order BM in Design Load Combinations
B	=	$\sqrt{(1+2\omega)}$	1.1	ω =	A_sf_{yd} / A_cf_{cd} Reinforcement Ratio
C	=	$1.7-r_m$	0.7	r_m =	M_{01}/M_{02} Moment Ratio
n	=	$N_{Ed} / (A_cf_{cd})$		M_{01}, M_{02} =	First Order End Moments at two ends of Member

As per Cl. 11.2.1 IRC-112-2011 initial dimensioning A, B C can be taken as 0.7, 1.1 and 0.7 respectively

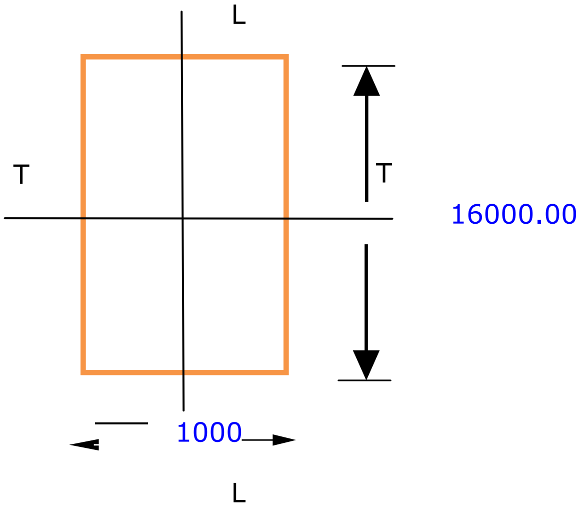
	N_{Ed}	=	992.76	951.95	951.95
	A_c	=	1.60E+07	1.60E+07	1.60E+07
	f_{cd}	=	13.40	13.40	13.40
	n	=	0.0463	0.0444	0.0444
Long	M_{0Eqp}	=	-32.09	-32.09	-32.09
Long	M_{0Ed}	=	432.07	451.85	451.85
	Φ_{eff}	=	-0.12	-0.11	-0.11
	A	=	1.02	1.02	1.02
	l_{lim}	=	73.28	74.83	74.83
	l_x	=	0.2	0.2	0.2
	Check	=	**Second Order Effects shall be Ignored in x Direction**		
Trans	M_{0Eqp}	=	-14.29	-14.29	-14.29
Trans	M_{0Ed}	=	855.53	990.84	990.84
	Φ_{eff}	=	-0.03	-0.02	-0.02
	A	=	1.01	1.00	1.00
	l_{lim}	=	71.94	73.47	73.47
	l_y	=	2.4	2.4	2.4
	Check	=	**Second Order Effects shall be Ignored in y Direction**		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

CHECKING OF STRESS IN WALL TYPE ABUTMENT SHAFTY

Given Data :

Abutment Size:



Width (B)	=	1000	mm
Depth (D)	=	16000.00	mm
Area (Ac)	=	1.60E+07	mm2
Length (Lo)	=	**0.500**	m

Section Reinforcement:

Dia. Of Bars	=	25	mm
Nos. of Bars Along Width (B)	=	6	Nos.
Nos. of Bars Along Depth (D)	=	130	Nos.
Total Nos. of Bars	=	272	Nos.
Total Ast	=	133518	mm^2
% of Reinforcement (Pt)	=	0.83	%
Clear Cover	=	50	mm
Dia of Tie bar	=	12	mm
D/B	=	16.00	Wall Type Abutment

Vertical Reinforcement For Wall Type Abutment as per IRC: 112-2019 , Clause 16.3.1

Minimum Vertical Reinforcement	=	0.0012 Ac	on each Face	
	=	19200 mm^2		
Provided Vertical Reinforcement	=	66759 mm^2		**OK**
Maximum Vertical Reinforcement	=	0.02 Ac	on each face	
	=	320000 mm^2		**OK**
Spacing between Vertical Reinf.	=	123 mm		**<200 mm OK**

Horizontal Reinforcement for Wall Type Abutment as per IRC: 112-2019 , Clause 16.3.2

Horizontal r/f should be	=	0.2500 x	133517.7	=	33379.42	
maximum of following	=	0.001 x	1.60E+07	=	16000.00	
Minimum Horizontal Reinf.	=	33379 mm^2				
Dia of bar	=	20 mm			**OK**	
Min dia of bar	=	0.25Ø mm		=	6.25 mm	
	or	8 mm				
Maximum Spacing between bars	<=	300 mm c/c				
Provide 2 L	32 dia@	80	c/c	=	301593	mm^2
					OK	
					35582	

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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Ductile Detailing as per IRC:112-2019, Clause 17.2.1

Confinement Reinforcement

nk = $\frac{N_{ED}}{A_c f_{ck}}$ = $\frac{9738990}{4.80E+08}$ = 0.02 < 0.064

IF nk > 0.064 , Confinement R/f shall be provided as per Clause 17.2.1.4 of IRC:112-2019

IF nk < 0.064 , Confinement R/f shall be provided as per Clause 17.2.2 of IRC:112-2019

Specing of Transverse Ties

	SL	<=	5	x	25	=	125	mm
		<=	0.2	x	876	=	175.2	mm
Provide	SL	=	125	mm	OK			

	ω_{wd}	=	ρw fyd/fcd					
where	ρw	=	$\frac{Asw}{SL*b}$					
	Asw	=	25	dia	2L	=	981.748	mm^2
	SL	=	150	mm c/c				
	b	=	1000	mm				
	ρw	=	0.00654					
	ω_{wd}	=	0.2124	OK				

Minimum Confining Reinforcement: as per Clause 17.2.1.2 of IRC:112-2019

ω_{wd} = max (ωw.req, 0.12)

$\omega_{w,req}$ = $\frac{0.37Ac*nk}{Acc}$ + $\frac{0.13*fyd(\rho L-0.01)}{fcd}$

Ac	=	1.60E+07
Acc	=	13907376 mm^2
nk	=	0.02
ρL	=	0.00834
$\omega_{w,req}$	=	0.00166
ω_{wd}	=	0.12000

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

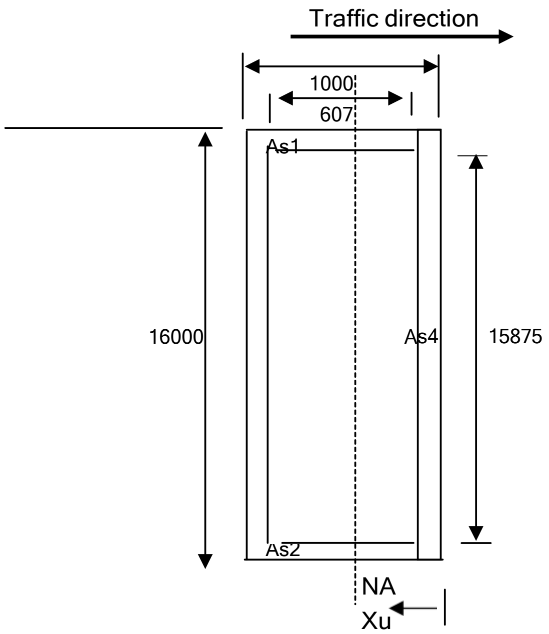
Material Property

Concrete Grade	=	**M30**	
Steel Grade	=	**Fe500**	
Characteristic Compressive Strength of Concrete at 28 days,fck	=	30.00	N/mm^2
Design strength of concrete, fcd=0.446fck	=	13.40	N/mm^2
Yield Strength of Reinforcement Steel ,fy	=	500	N/mm^2
Design Yield Strength of Reinforcement Steel ,fyd	=	434.78	N/mm^2
Modulus of Elasticity of Concrete (Ec)	=	27386.1	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2
Factor of Safety For Concrete	=	1.5	
Factor of Safety For Steel	=	1.15	
Maximum Strain in Concrete,εcu	=	0.0035	
Yield Strain in Concrete, ε_{cd}	=	0.002	
Yield Strain in Steel,$\varepsilon_{st}(\varepsilon_{yd})$	=	0.002174	
Max. Strain in steel, ε_{stu}	=	0.004174	

Summary of Design Forces at Abutment Shaft Bottom :

Load Cases	Axial Load (kN)	Initial Moment (kNm)		Final Design Moment (kNm)	
	Pu or N_{Ed}	Mx(MT)	My(ML)	Mux	Muy
Normal Case 1	9739.0	8392.7	4238.6	8392.75	4238.56
Normal Case 2	9338.6	9720.1	4432.6	9720.11	4432.60
Normal Case 3	9338.6	9720.1	4432.6	9720.11	4432.60
Seismic Case 4	7730.4	1565.9	1453.4	1565.90	1453.41
Seismic Case 5	7677.0	1742.9	1479.3	1742.89	1479.29
Seismic Case 6	7677.0	2464.1	758.1	2464.09	758.08

DESIGN OF RECTANGULAR SECTION FOR ABUTMENT SHAFT - ULTIMATE LIMIT STATE



Section dimensions of pier shaft

Length, B = 16000 mm (equivalent length of pier shaft)

Thickness,D = 1000 mm

Material properties

fck = 30.00 Mpa

fyk = 500 Mpa

Es = 200000 Mpa

Design axial resistance of section

N_{Rd} = Ac * fcd + As * fyd

fcd = α_{cc} xf_{ck} /γ_m α_{cc} = 0.67

= 13.400 Mpa γ_m = 1.5

fyd = fyk/γ_s γ_s = 1.15

= 434.7826 Mpa

N_{Rd} = 272451.2 KN

Reinforcement Details

Reinf.	Dia.(mm)	Spacing (mm)	Cover (mm)	From (mm)	To (mm)	Y_{CG} (mm)	Nos.
As1	25	134	50	196.5	803.5	401.75	6.00
As2	25	134	50	197	804	401.75	6.00
As3	25	134	50	62.5	15938	7968.75	130.00
As4	25	134	50	62.5	15938	7968.75	130.00

Total reinforcement

As3 (Along length Tension face) = 63813.60 mm^2

As4 (Along length Compression face) = 63813.60 mm^2

As2 (Along width Tension face) = 2945.24 mm^2

As1 (Along width Compression face) = 2945.24 mm^2

Total As = **133517.7 mm^2**

= **0.83 %**

Formula used for interaction diagram

Pu = Cc +Cs

Mu = Mc + Ms

Cc = 0.361*fck*Xu*b   for Xu ≤ D

= 0.447*fck*(1-4*g/21)*b*D   for Xu ≥ D

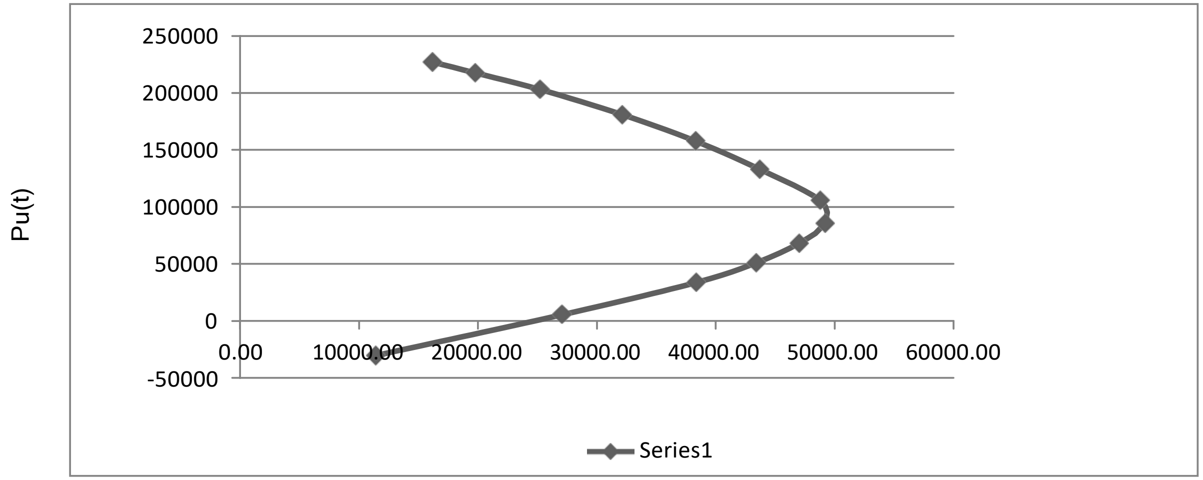
g = 16 / (7Xu / D-3)^2

Cs	=	$\sum$ (fsi - fci) Asi	
fci	=	0.00	for $\varepsilon_{si} \leq 0$
		0.447 fck	for $\varepsilon_{si} \geq 0.002$
		$0.447fck\ \ 2^* (\varepsilon_{si}/0.002)-(\varepsilon_{si}/0.002)^2$	otherwise
fsi	=	-0.87 fy	for $\varepsilon_{si} \leq -0.00217$
		ε_{si} * Es	for $0.00217 \geq \varepsilon_{si} > -0.00217$
		0.87fy	for $\varepsilon_{si} > 0.00217$
Mc	=	Cc * (0.5D -x)	
Ms	=	$\sum$ Csi * yi	
x	=	0.416 Xu	for Xu $\leq$ D
	=	(0.5 - 8*g /49)* D/(1-4*g/21)	for Xu $\geq$ D
Where x	=	Centroid of stress block area from most compressed edge.	
ε_{si}	=	$\dfrac{0.0035 *\ \ Xu- D/2 +y_i}{Xu}$	for Xu $\leq$ D
	=	$0.002^*\ \ 1+ \dfrac{y_i - D/14}{Xu - 3D/7}$	for Xu > D
Where y_i	=	Distance of ith row of steel from the centroidal axis measured positive in the direction towards the highly compressed edge.	

Along traffic direction

Xu/D	=	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
D(mm)	=	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Xu (mm)	=	50	100	200	300	400	500	600	700	800	900	1000	1100	1200
	<	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
g (Mpa)	=	2.278391	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.3668639	1.469238	1	0.72431	0.548697
Cc (KN)	=	8664.0	17328.0	34656.0	51984.0	69312.0	86640.0	103968.0	121296.0	138624.0	155952.0	173691.4	184958.5	192135.5
yi (compr. face in mm)	=	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5
yi (tension face in mm)	=	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5
ε_{si}(compr. face in mm)	=	-0.00088	0.001313	0.002406	0.002771	0.002953	0.003063	0.003135	0.003188	0.0032266	0.003257	0.003281	0.00309	0.002949
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.06213	-0.02931	-0.01291	-0.00744	-0.0047	-0.00306	-0.001969	-0.001188	-0.000602	-0.000146	0.000219	0.000484	0.000681
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	11.82542	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41
fsi(comp.face in Mpa)	=	-175	262.5	435	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	2.773015	5.705529	7.57352
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-393.75	-237.5	-120.3125	-29.17	43.75	96.80851	136.1111
Cs (KN)	=	-38926.3	-11762.5	-855.7	-855.7	-855.7	-855.7	1776.6	11747.4	19225.6	25041.9	29518.1	32716.8	35105.6
Mc (KN-m)	=	4151.8	7943.2	14444.6	19504.4	23122.5	25298.9	26033.6	25326.6	23177.9	19587.6	14595.9	10572.0	8008.7
Ms (KN-m)	=	7258.8	19143.0	23914.7	23914.7	23914.7	23914.7	22763.0	18400.8	15129.1	12584.4	10626.1	9226.7	8181.6
Pu (KN)	**=**	**-30262.3**	**5565.5**	**33800.3**	**51128.3**	**68456.3**	**85784.3**	**105744.6**	**133043.4**	**157849.6**	**180993.9**	**203209.5**	**217675.3**	**227241.2**
Mu (KN-m)	**=**	**11410.6**	**27086.1**	**38359.3**	**43419.1**	**47037.1**	**49213.5**	**48796.6**	**43727.4**	**38307.0**	**32172.0**	**25222.0**	**19798.6**	**16190.3**

Mu (KN-m)	**Pu (KN)**
11410.6	-30262.3
27086.13	5565.53
38359.29	33800.26
43419.06	51128.26
47037.15	68456.26
49213.55	85784.26
48796.62	105744.57
43727.38	133043.45
38307.01	157849.60
32172.00	180993.95
25222.04	203209.49
19798.65	217675.28
16190.30	227241.17

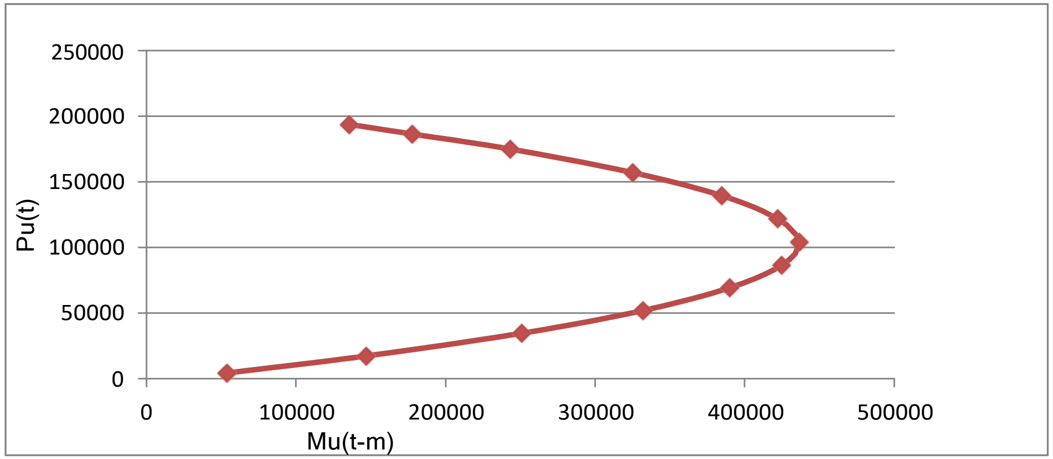


Interaction diagram Mu(t-m)

Along transverse direction

Xu/D	=	0.025	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
D(mm)	=	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Xu (mm)	=	400	1600	3200	4800	6400	8000	9600	11200	12800	14400	16000	17600	19200
	<	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
g (Mpa)		2.004856	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.3668639	1.469238	1	0.72431	0.548697
Cc (KN)	=	4332.0	17328.0	34656.0	51984.0	69312.0	86640.0	103968.0	121296.0	138624.0	155952.0	173691.4	184958.5	192135.5
yi (compr. face in mm)	=	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5
yi (tension face in mm)	=	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5
ε_{si}(compr. face in mm)	=	0.002953	0.003363	0.003432	0.003454	0.003466	0.003473	0.003477	0.00348	0.0034829	0.003485	0.003486	0.003265	0.003101
	>	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.13595	-0.03136	-0.01393	-0.00812	-0.00522	-0.00347	-0.002311	-0.00148	-0.000858	-0.000374	0.000014	0.00031	0.000529
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41
fsi(comp.face in Mpa)	=	435	435	435	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	0.182713	3.829349	6.152229
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-435	-296.0938	-171.582	-74.73958	2.734375	61.9016	105.7292
Cs (KN)	=	-39.5	-39.5	-39.5	-39.5	-39.5	-39.5	-39.5	369.6	736.3	1021.6	1249.2	1412.7	1535.0
Mc KN-m)	=	33935.2	127090.5	231113.9	312070.3	369959.7	404782.1	416537.4	405225.7	370846.9	313401.1	233534.7	169151.4	128139.7
Ms (KN-m)	=	20025.2	20025.2	20025.2	20025.2	20025.2	20025.2	20025.2	16777.9	13867.1	11603.1	9796.2	8498.3	7528.0
Pu (KN)	**=**	**4292.5**	**17288.5**	**34616.5**	**51944.5**	**69272.5**	**86600.5**	**103928.5**	**121665.6**	**139360.3**	**156973.6**	**174940.6**	**186371.2**	**193670.5**
Mu (KN-m)	**=**	**53960.4**	**147115.7**	**251139.2**	**332095.6**	**389985.0**	**424807.3**	**436562.6**	**422003.6**	**384714.0**	**325004.3**	**243330.9**	**177649.7**	**135667.7**

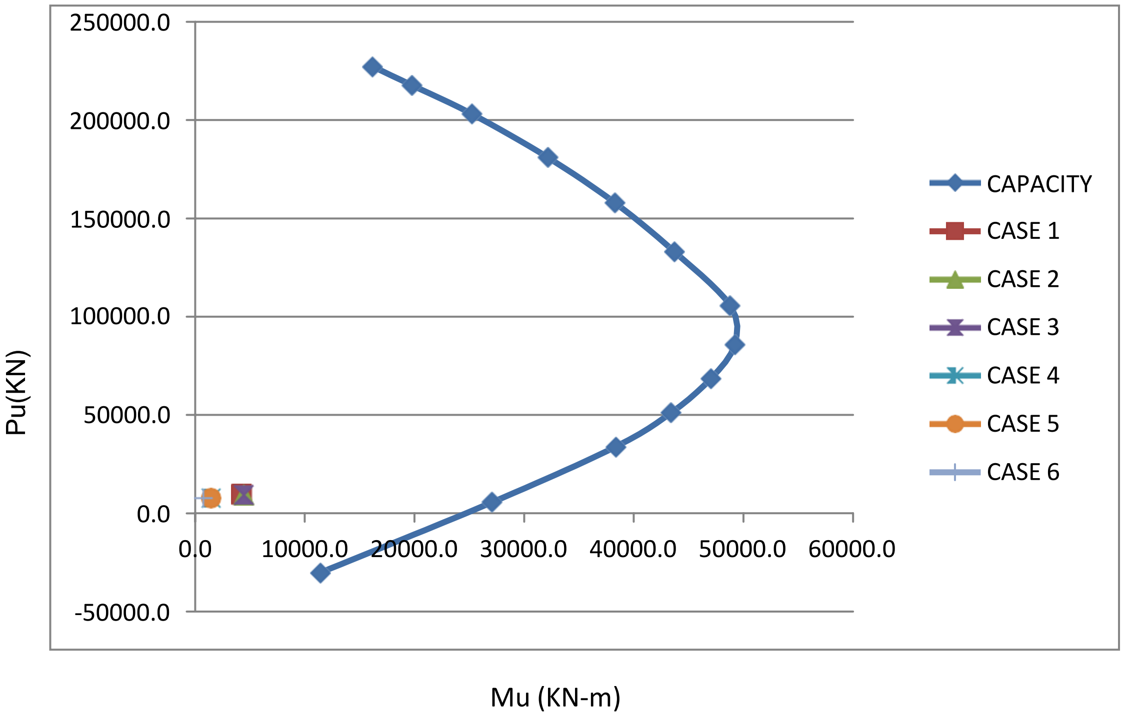
Mu (KN-M)	**Pu (KN)**
53960.40	4292.50
147115.73	17288.50
251139.18	34616.50
332095.60	51944.50
389984.98	69272.50
424807.33	86600.50
436562.64	103928.50
422003.59	121665.62
384714.02	139360.33
325004.27	156973.56
243330.92	174940.63
177649.70	186371.22
135667.73	193670.51



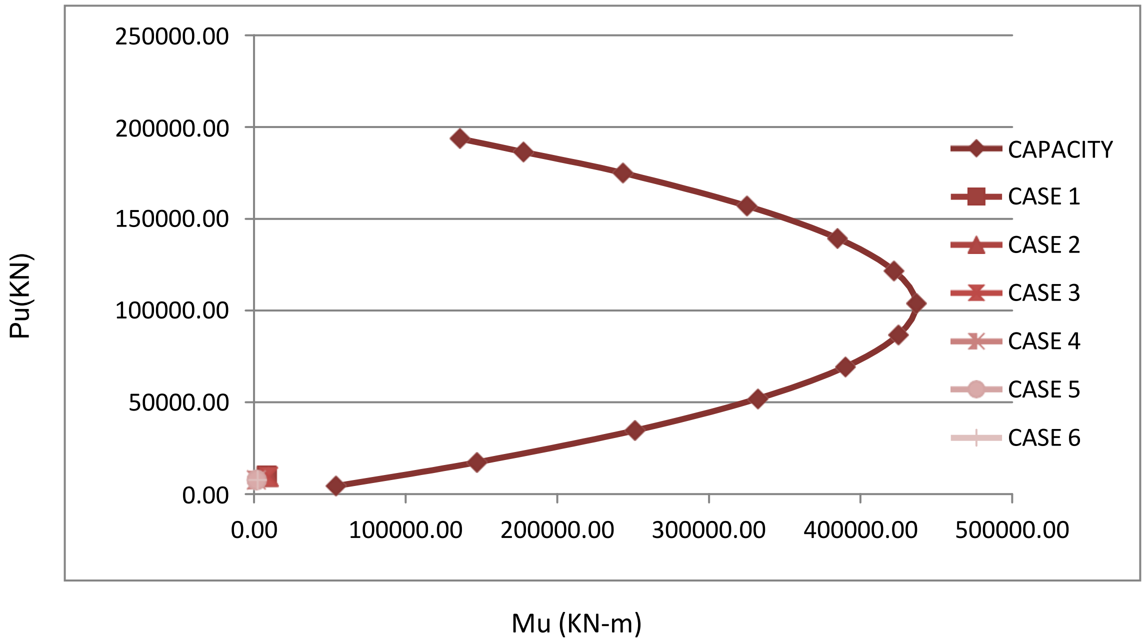
Interaction diagram

Load Cases	Axial Load (kN)	Final Design Moment (kNm)		Permissible Moment (kNm)		Max. Tensile Stress in Steel (N/mm^2)		N_{ED}/N_{RD}	a	$\left(\frac{Mux}{Mux1}\right)^{a} + \left(Muy1\right)^{a}$	**Section Status**
	Pu or N_{Ed}	Mux	Muy	Mux1	Muy1	Fsx	Fsy				
Normal Case 1	9739.0	8392.7	4238.6	93000.81	28752.45	434.8	434.8	0.04	1.00	0.24	**SAFE**
Normal Case 2	9338.6	9720.1	4432.6	90131.01	28592.59	434.8	434.8	0.03	1.00	0.26	**SAFE**
Normal Case 3	9338.6	9720.1	4432.6	90131.01	28592.59	434.8	434.8	0.03	1.00	0.26	**SAFE**
Seismic Case 4	7730.4	1565.9	1453.4	78603.38	27950.49	434.8	434.8	0.03	1.00	0.07	**SAFE**
Seismic Case 5	7677.0	1742.9	1479.3	78220.74	27929.18	434.8	434.8	0.03	1.00	0.08	**SAFE**
Seismic Case 6	7677.0	2464.1	758.1	78220.74	27929.18	434.8	434.8	0.03	1.00	0.06	**SAFE**

Pu-Mu Interaction Curve
Along the Traffic Direction



Pu-Mu Interaction Curve
Across the Traffic Direction



Calculation of Creep Coeffiecient *(As per Annexure A2, A2.5, IRC:112-2011)*

$\Phi(t,t_0)$	=	$\beta_c(t,t_0).\Phi_0$	=	**1.57**	
Where,					
Φ_0	=	$\Phi_{RH}\ \beta(f_{cm})\ \beta(t_0).$	=	1.60	
t	=	Age of concrete in days at time the time considered =	=	25550	days
t_0	=	is the age of Concrete in days at time of loading	=	90	days
Φ_{RH}	=	$1+(1-RH/100)/(0.1*h_0^{1/3})$ for fcm <= 45	=	1.38	
RH	=	Relative Humidity	=	63	%
fck	=	Characteristic Compressive Strength	=	30	MPa
fcm	=	Mean Compressive Strength	=	40	MPa
$\beta(f_{cm})$	=	$18.78/\sqrt{f_{cm}}$	=	2.97	
$\beta(t_0).$	=	$1/(0.1+t_0^{0.2})$	=	0.39	
h_0	=	Notional side of Member 2Ac/u	=	941.2	mm
w	=	Width of Section	=	16000	mm
h	=	Depth of Section	=	1000	mm
Ac	=	Cross Sectional Area, mm2	=	1.6E+07	mm2
u	=	Perimeter in Contact with atmosphere	=	34000	mm
$\beta_c(t,t_0)$	=	$[(t-t_0)/(\beta H + t - t_0)]^{0.3}$	=	0.983	
$(t-t_0)$	=	Actual duration of loading	=	25460	days
βH	=	$1.5(1+(1.2\ RH/RH_0)^{18})h_0 + 250$ <= 1500 fcm = 45	=	1500.0	
RH_0	=		=	100	%

AT Des Ch-170+210

Hydraulic calculation

Tamenglong- Mahur Road

Location - Des Ch- 170+210

1 Discharge:-

a) Discharge from catchment area

Dicken's Discharge 'Q' = C x $M^{3/4}$ as per SP-13-2004 Clause 4.2.

Where 'C' = 19 (Clause 4.2 of SP-13 ,C = 19 where the annual rain fall is >120 cm.)

Catchment Area at Site'M' = 40 Sq. Km. Refer catchment sheet Enclosed

Q = C x M3/4

Q = (19X (40)^3/4)

Q = 302.20 m^3/sec

b) Discharge By Area -Velocity Method

Cross section considered as per SP-13-2004 Clause 3.3(Table -3.1)

Section	Q(m3/sec)	Velocity (m/sec)	HFL (in Meter)	Avg flow depth
At 300 m d/s	968.7267207	3.99	572.12	4.866
At Proposed site	300.55	2.46	573.02	2.280
At 300 m u/s	821.8847958	3.74	573.91	4.43

Max discharge from area velocity method 300.55 m3/sec

Max discharge from Dickens formula 302.20 m3/sec

max discharge - 302.20 m^3/sec

Discharge =	Q =AV	
	A = Q/V	
Linear water way required =	Lx D =Q/V	
	L = Q/(VxD)	
	302/(2.46x2.28)	

2 **Linear water way required =** **53.847476 M**

Provide 3 Span of 16 m

Calculation for design velocity -

The length of bridge proposed =	48	M
The average flow depth below H.F.L. =	2.28	M
No of piers proposed =	2	Nos
Thickness of proposed pier =	1.2	M
Width of Abutment in flow area	0.4	M
Thus Clear water way avilable =	(48-2X1.2- 2 x0.4)	
	44.8	M

Thus the design velocity = Q/ A

V= (302.2)/(44.8X2.28)

V= 2.96 M/Sec

The Design velocity **2.96 m/sec**

3 **Afflux**

The theoritical Afflux at proposed site shall be calculated using Moles worth formula

a =	((V^2 / 17.88) - 0.015) X ((A/a)^2 - 1)
Where as	
A=	Area of cross section at H.F.L.
	site as compared to the u/s & d/s areas)
a =	Area of clear water way under the proposed bridge in sqm.
V =	Velocity in m/sec
A =	122.1074241 Sqm
a =	2.2801538461537X44.8
	102.15 Sqm
V =	2.96 m/sec
Afflux =	((2.96^2 / 17.88) - 0.015) X ((122.11/102.15)^2 -1)
	0.203745787 m
I.e.	203.745787 mm

Consider afflux is 200 mm.

4 Scour Depth

For the design of foundation in accordance with the provisions of IRC-78,2000 clause 703.1.1. above discharge has been further increased by 30% for Calculation of scour depth.

Considering the available linear water way at bridge as = 44.8 M

Thus the discharge per unit width 'Db' = 1.30 X Q design /44.8

1.3x302.2/44.8

Db' = 8.77 m^3/sec

Thus the theoretical mean scour depth

MSD = 1.34x(Db^2/Ksf)^(1/3)

Where 'Ksf' = 2.4 (as per IRC-78,2000 clause 703.2.2.1)

There fore NSD = 1.34x(8.77^2 /2.4)^(1/3)

4.26 M from HFL.

The scour level for abutment = H.F.L. - 1.27 X N.S.D.(as per IRC-78,2000 clause 703.3.2.)

= 573.015 -1.27X4.256

The scour level for abutment = 567.61 M

(Foundation level is 2m below scour depth in soil OR Rock level which ever is higher)

Foundation level for abutment = 562.945 M

Foundation level for Pier = 558.824 M

Formation level calculations -

a)	HFL at Proposed site=	573.015	m
b)	Vertical clearance as per IRC -5	0.9	m
c)	Afflux	0.2	m
d)	Depth of deck	1.666	m
e)	Depth of wearing coat	0.075	m

5 **Formation level by HFL Consideration (a+b+c+d+e) =** 575.856 **m**

6 **Formation level by Profile Improvements = 577.856 m**

Location - Des Ch- 170+210

Calculation of Discharge By Area Velocity Method at **Proposed Site.**

H.F.L 573.015 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff(m)	Perimeter (m)	Area(Sqm)
24.00	572.945		0.070		0.000	
20.00	572.825	4	0.190	0.120	4.002	0.520
16.00	572.584	4	0.431	0.241	4.007	1.243
12.00	571.564	4	1.451	1.020	4.128	3.824
8.00	568.824	4	4.191	2.740	4.848	12.481
4.00	567.701	4	5.314	1.123	4.155	19.377
0.00	566.780	4	6.235	0.921	4.105	23.400
4.00	567.692	4	5.323	0.912	4.103	23.413
8.00	568.812	4	4.203	1.120	4.154	19.418
12.00	571.524	4	1.491	2.712	4.833	12.573
16.00	572.554	4	0.461	1.030	4.130	3.968
20.00	572.814	4	0.201	0.260	4.008	1.325
24.00	572.934	4	0.081	0.120	4.002	0.564
		avg.Depth =	2.280		50.475	122.107

Discharge Calculation by Area Velocity method

Using Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)
A = 122.107 Sqm
P = 50.475 M
Avg. depth of flow = 2.280 m
R=A/P
R = 122.11/50.47
2.42
S = 0.00298333
n = 0.04
V = 6x0^0.5/0.04
V = 2.46132571 m/sec

Q=A*V
Q = 2.46x122.11
Q = 300.546 m^3/sec

Location - Des Ch- 170+210

Calculation of Discharge By Area Velocity Method at **300U/S**

H.F.L 573.905 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff	Perimeter	Area
24.00	571.020		2.885		0.000	
20.00	570.570	4	3.335	0.450	4.025	12.479
16.00	570.050	4	3.855	0.520	4.034	14.441
12.00	569.330	4	4.575	0.720	4.064	16.995
8.00	568.710	4	5.195	0.620	4.048	19.657
4.00	568.190	4	6.235	1.040	4.133	23.240
0.00	567.670	4	5.715	0.520	4.034	24.001
4.00	568.180	4	5.725	0.010	4.000	22.880
8.00	568.690	4	5.215	0.510	4.032	21.969
12.00	569.300	4	4.605	0.610	4.046	19.754
16.00	570.010	4	3.895	0.710	4.063	17.133
20.00	570.520	4	3.385	0.510	4.032	14.619
24.00	570.970	4	2.935	0.450	4.025	12.680
		avg.Depth =	4.427		48.536	219.846

Discharge Calculation by Area Velocity method

Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 219.846 Sqm

P = 48.536 M

depth of 4.427 m

R=A/P

R = 19.85/48.54

4.53

S = 0.0029833

n = 0.04

V = 4.53^0.66x0^0.5/0.04

V = 3.7384527 m/sec

Q=A*V

Q = 3.74x219.85

Q = 821.885 m^3/sec

Location - Des Ch- 170+210

Calculation of Discharge By Area Velocity Method at **300D/S**

H.F.L 572.115 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff	Perimeter	Area
24.00	569.230		2.885		0.000	
20.00	568.380	4	3.735	0.850	4.089	13.388
16.00	567.560	4	4.555	0.820	4.083	16.752
12.00	566.840	4	5.275	0.720	4.064	19.818
8.00	566.320	4	5.795	0.520	4.034	22.233
4.00	566.000	4	6.115	0.320	4.013	23.858
0.00	565.880	4	6.235	0.120	4.002	24.706
4.00	565.990	4	6.125	0.110	4.002	24.725
8.00	566.200	4	5.915	0.210	4.006	24.097
12.00	566.810	4	5.305	0.610	4.046	22.570
16.00	567.520	4	4.595	0.710	4.063	19.955
20.00	568.330	4	3.785	0.810	4.081	16.930
24.00	569.180	4	2.935	0.850	4.089	13.590
	avg.Depth =		4.866		48.571	242.621

Discharge Calculation by Area Velocity method

Using Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 242.621 Sqm

P = 48.571 M

depth of 4.866 m

R=A/P

R = 2.62/48.57

5

S = 0.002983

n = 0.04

V = 5^0.66x0^0.5/0.04

V = 3.99276 m/sec

Q=A*V

Q = 99x242.62

Q = 968.727 m^3/sec

Location - Des Ch- 170+210

L - Section of River/nalla

Chainage (M)	G .L (M)
-300.000	567.670
-280.000	567.600
-260.000	567.530
-240.000	567.460
-220.000	567.390
-200.000	567.340
-180.000	567.290
-160.000	567.240
-140.000	567.190
-120.000	567.140
-100.000	567.070
-80.000	567.020
-60.000	566.970
-40.000	566.920
-20.000	566.870
0.000	566.780
20.000	566.720
40.000	566.660
60.000	566.600
80.000	566.540
100.000	566.480
120.000	566.420
140.000	566.360
160.000	566.300
180.000	566.240
200.000	566.180
220.000	566.120
240.000	566.060
260.000	566.000
280.000	565.940
300.000	565.880

Slope = (567.67-565.88)/(300--300)
0.002983

DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2

AT DES CH- 170+210

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

INDEX

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

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INTRODUCTION

This design note present the detailed calculations for abutment having POT/PTFE bearings. Design note contains the typical design of abutment cap, abutment, pile cap and pile. In the analysis, the forces have been worked out at the pile cap bottom level for pile cap design and at the top of pile cap for abutment shaft design.

This design is applicable for abutment

Abutment Nos.	Road Top Level	GROUND LEVEL	Pile cap bottom	DIFF
	(M)	(M)	(M)	(M)
A1 & A2	577.856	572.945	570.645	7.211

DESIGN DATA

Span Arrangement C/C of exp. Joint	=	16	m
Deck Width	=	18	m
Carriageway Width	=	11	m
Structural system	=	simply supported	
construction type	=	RCC	
Effective Span	=	15.20	m
Expansion gap in abutment	=	40	mm
No of Lane considered for design	=	4	
Bearing type	=	Elastome ric	Bearing
Skew Angle	=	0	Degree

SALIENT REDUCED LEVELS

Deck Top Level	=	577.856
Soffit Level	=	576.556
Abutment Cap Top Level	=	576.506
Abutment Cap Bottom Level	=	576.006
HFL	=	573.015
Pile cap bottom Level	=	570.645
Scour Level	=	567.61

DETAILS OF STRUCTURE & OTHER PARAMETERS

Type of structure		RCC	
Depth of Superstructure	=	1.200	m
Thickness of wearing coat	=	0.075	m
Camber in both direction	=	2.50%	
Expansion joint Type	=	Strip seal	
Impact (including Congestion Factor)	=	1.394	
Thickness of Return	=	0.5	m

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MATERIAL PARAMETERS

Concrete **Refer Table 6.5, IRC:112-2019**

Grade of concrete for sub structure and foundation		=	**M30**	
Cube strength of concrete at 28 days	f_{ck}	=	**30**	MPa
Design value of concrete compressive strength	f_{cd}	=	$\alpha f_{ck}/\gamma_m$	
		α =	0.67	
For Basic Combination	f_{cd}	=	13.40	MPa
For Accidental Combination	f_{cd}	=	16.75	MPa
For Seismic Combination	f_{cd}	=	13.40	MPa
Modulus of Elasticity	E_c	=	31000	MPa
Mean value of axial tensile strength of concrete	f_{ctm}	=	2.5	MPa
Wet Density **2.00** t/m3	Dry Density	=	**2.50**	t/m^3

Reinforcing Steel

Grade		=	**Fe500**	
Characteristics yield strength	f_{yk}	=	500	MPa
Design yield strength	f_{yd}	=	f_{yk}/γ_m	
For Basic Combination	f_{yd}	=	434.8	MPa
For Accidental Combination	f_{yd}	=	500.0	MPa
For Seismic Combination	f_{yd}	=	434.8	MPa
Modulus of Elasticity	E_s	=	**2.00E+05**	Mpa
	Ecm	=	**3.10E+04**	Mpa
Density		=	**7.85**	t/m3
Soil Wet density **1.00** t/m3	Soil Dry Density	=	**2.00**	t/m3

'(As per STAAD Output)

21 m span Reactions (KN)			
Bearing No.	**DL**	**SIDL1 (WC)**	**SIDL2 (CB)**
1	437	51	156
2	483	43	-19
3	469	50	5
4	479	43	-28
5	448	53	159
	2316	**240**	**273**

Partial Safety Factor for Materials

Material	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
Concrete	1.50	1.20	1.50
Steel	1.15	1.00	1.15

Cl 6.4 2.8, IRC:112-2011
Cl 6 2.2, IRC:112-2011

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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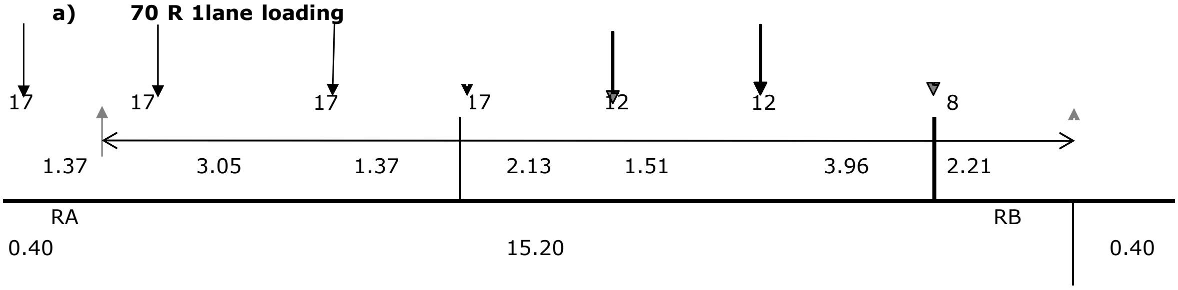
LIVE LOAD CALCULATIONS

1. MAX. MOMENT CASE

a) 70 R 1lane loading

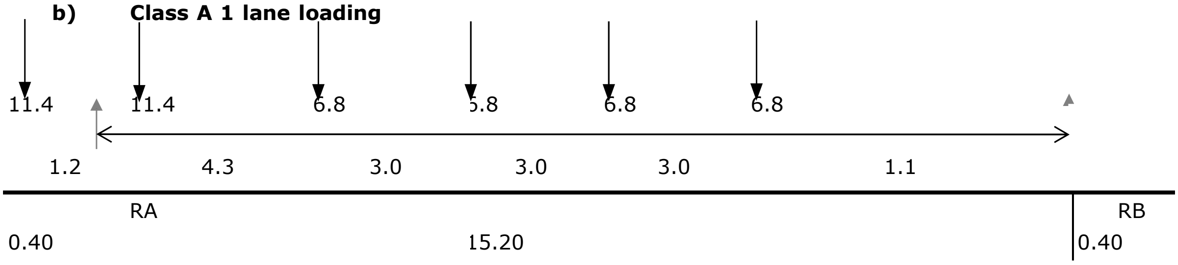


Ra = 1047.82 / 15.20 = 68.9 t

Impact 1.394 = 96.1 t

RB = 31.06 t

b) Class A 1 lane loading



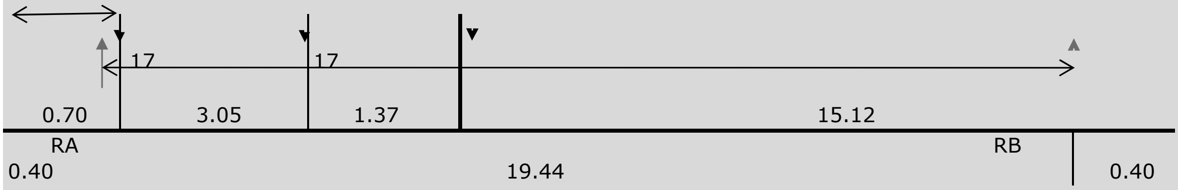
Ra = 494.32 / 15.20 = 32.5 t

Impact 1.394 = 45.3 t

RB = = 17.5 t

2. MAX. REACTION/ TRANSVERSE MOMENT CASE

a) 70 R 1lane loading

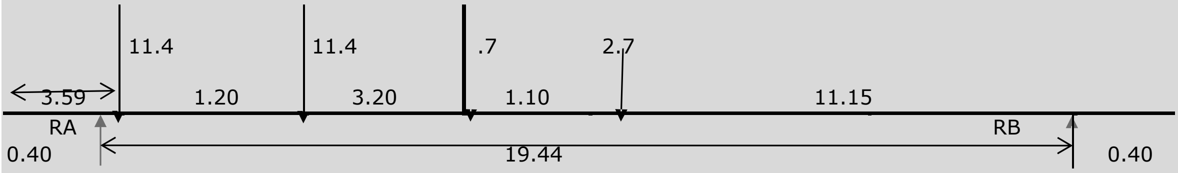


Ra = 848.96 / 19.44 = 43.67 t

Impact 1.394 = 60.88 t

RB = = 7.3 t

b) Class A 1 lane loading



Ra =	417.81	/	19.44	=	21.49	t
		Impact	1.394	=	29.96	t
RB =				=	6.7	t

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

PARTIAL SAFETY FACTORS

Ultimate Limit State

Partial Safety for Verification of Structural Strength **Table B.1, Annex B, IRC:6-2017**

Also refer IRC Amendment dated August, 2019

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
	Overturnin g or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturnin g or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturnin g or Sliding or Uplift Effect	Restoring or Resisting Effect
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 Permanent Loads:						
1.1 Dead Load, SIDL except surfacing, Backfill Weight,Settlement, Creep and shrinkage effect	1.1	0.9	1	1	1.1	0.9
1.2 Surfacing	1.35	1.0	1.0	1.0	1.35	1.0
1.3 Prestressing and secondary effect of prestress	Refer Note No. 5					
1.4 Earth Pressure due to Backfill	1.50	1	1.0	1	1.0	1
2 Variable Loads:						
2.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:						
a) Leading Load	1.5	0	0.75	0	-	-
b) Accompanying Load	1.15	0	0.2	0	0.2	0
c) Construction Live Load	1.35	0	1.0	0	1.0	0
2.2 Thermal Loads						
a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	0.5	0	0.5	0
2.3 Wind Load						
a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	-	-	-	-
2.4 Live Load Surcharge (as accompanying	1.2	0	-	-	-	-
3 Accidental Effects:						
3.1 Vehicle Collision	-	-	1.0	-	-	-
3.2 Barge Impact	-	-	1.0	-	-	-
3.3 Impact due to floating bodies	-	-	1.0	-	-	-
4 Seismic Effect						
a) During Service	-	-	-	-	1.5	-
b) During Construction	-	-	-	-	0.75	-
5 Construction Condition:						
5.1 Counter Weights:						
a) When density or self weight is well defined	-	0.9	-	1.0	-	1.0
b) When density or self weight is not wel defined	-	0.8	-	1.0	-	1.0
5.2 Construction dead loads(such as wt. of launching girder, truss or cantilever construction equipments	1.10	0.90	1.1	0.9	1.1	0.9
5.3 Wind						
a) As Leading Load	1.50	0	-	-	-	-
b) As Accompanying Load	1.20	0	-	-	-	-
6 Hydraulic Loads (Accompanying Load):						
6.1 Water Current Forces	1.0	0	1.0	0	1.0	-
6.2 Wave Pressure	1.0	0	1.0	0	1.0	-
6.3 Hydrodynamic Effect	-	-	-	-	1.0	-
6.4 Buoyancy	1.0	-	1.0	-	1.0	-

Partial Safety for Verification of Structural Strength **Table B.2, Annex B, IRC:6-2017**

Also refer IRC Amendment dated August, 2019

Loads	Partial Safety Factor		
	Basic Combination	**Accidental Combination**	**Seismic Combination**
(1)	**(2)**	**(3)**	**(4)**
1 Permanent Loads:			
1.1 Dead Load, snow load (if present) SIDL except surfacing			
a) Adding to the effect of variable loads	1.35	1.00	1.35
b) Relieving the effect of variable loads	1.00	1.00	1.00
1.2 Surfacing:			
a) Adding to the effect of variable loads	1.75	1.00	1.75
b) Relieving the effect of variable loads	1.00	1.00	1.00
1.3 Prestressing and secondary effect of prestress	Refer Note No. 2		
1.4 Backfill Weight			
(a) When Causing Adverse Effect	1.35	1.00	1.00
(b) When Causing Relieving Effect	1.00	1.00	1.00
1.5 Earth Pressure			
a) Adding to the effect of loads	1.50	0.00	1.00
b) Relieving the effect of loads	1.00	1.00	1.00
2 Variable Loads:			
2.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.50	0.75	-
b) Accompanying Load	1.15	0.20	0.20
c) Construction Live Load	1.35	1.00	1.00
2.2 Wind during service and construction			
a) Leading Load	1.50	-	-
b) Accompanying Load	0.90	-	-
2.3 Live Load Surcharge (as accompanying load)	1.20	0.20	0.20
2.4 Construction dead loads(such as wt. of launching girder, truss or cantilever construction equipments	1.35	1.00	1.35
2.5 Thermal Load			
a) Leading Load	1.50	-	-
b) Accompanying Load	0.90	0.50	0.50
3 Accidental Effects:			
i) Vehicle Collision	-	1.00	-
ii) Barge Impact	-	1.00	-
iii) Impact due to floating bodies	-	1.00	-
4 Seismic Effect			
a) During Service	-	-	1.50
b) During Construction	-	-	0.75
5 Hydraulic Loads (Accompanying Load):			
5.1 Water Current Forces	1.00	1.00	1.00
5.2 Wave Pressure	1.00	1.00	1.00
5.3 Hydrodynamic Effect	-	-	1.00
5.4 Buoyancy	0.15	0.15	1.00

Serviceability Limit State
Partial Safety for Verification of Serviceability Limit State

Table B.3, Annex B, IRC:6-2017

Also refer IRC Amendment dated August, 2019

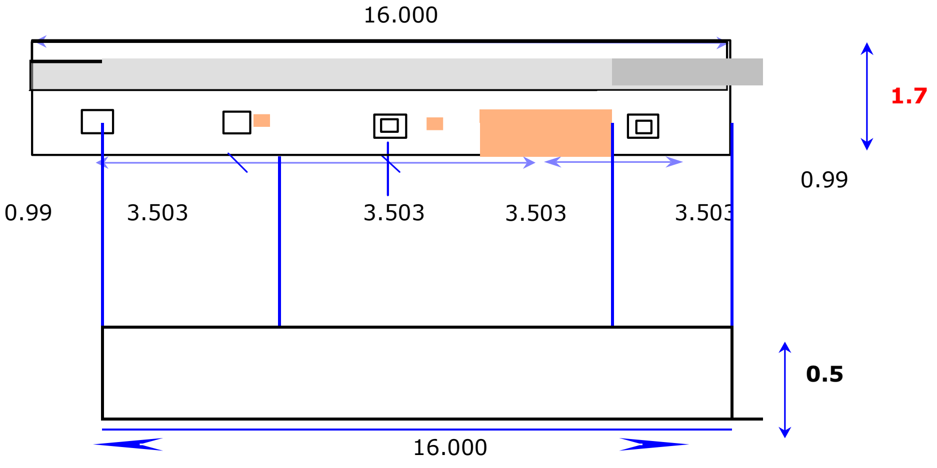
Loads	**Partial Safety Factor**		
	Rare Combination	**Frequent Combination**	**Quasi-permanent Combination**
(1)	**(2)**	**(3)**	**(4)**
1 Permanent Loads:			
1.1 Dead Load, Snow Load(if any), Backfill, SIDL except surfacing	1.00	1.00	1.00
1.2 Surfacing	1.00	1.00	1.00
a) Adding the effect of variable Loads	1.20	1.20	1.20
b) Relieving the effect of variable Loads	1.00	1.00	1.00
1.3 Earth Pressure	1.00	1.00	1.00
1.4 Prestress and secondary effect of prestressing	Refer Note no. 4		
1.5 Shrinkage and Creep Effects	1.00	1.00	1.00
2 Settlement Effects			
a) Adding to the permanent loads	1.00	1.00	1.00
b) Opposing the permanent loads	0.00	0.00	0.00
3 Variable Loads:			
3.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.00	0.75	-
b) Accompanying Load	0.75	0.20	0.00
3.2 Thermal Loads:			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load	0.60	0.50	0.50
3.3 Wind			
a) Leading Load	1.00	0.60	-
b) Accompanying Load	0.60	0.50	0.00
3.4 Live Load Surcharge as Accompanying load	0.80	0.00	0.00
4 Hydraulic Loads (Accompanying Load):			
4.1 Water Current	1.00	1.00	-
4.2 Wave Pressure	1.00	1.00	-
4.3 Buoyancy	0.15	0.15	0.15

Partial Safety for Checking the Base Pressure and Design of Foundation

Also refer IRC Amendment dated August, 2019 **Table B.4, Annex B, IRC:6-2017**

Load	Partial Safety Factor			
	Combination-1	Combination-2	Combination-3	Combination-4
(1)	(2)	(3)	(4)	(5)
1. Permanent Loads:				
1.1 Dead Load, Snow Load (if any), SIDL except surfacing and Back fill				
a) When causing adverse effects	1.35	1.00	1.35	1.00
b) When causing Relieving effects	1.00	1.00	1.00	1.00
1.2 SIDL surfacing				
a) When causing adverse effects	1.75	1.00	1.75	1.00
b) When causing Relieving effects	1.00	1.00	1.00	1.00
1.3 Prestress Effect	Refer Note 4			
1.4 Settlement Effect	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
1.5 Earth Pressure				
a) Adding to the effect of loads	1.50	1.30	1.00	1.00
b) Relieving to the effect of loads	1.00	0.85	1.00	1.00
2. Variable Loads:				
2.1 All carriageway loads and associated loads (braking, tractive and centrifugal) and footway live load				
a) Leading Load	1.50	1.30	0.75 or 0	0.75 or 0
b) Accompanying Load	1.15	1.00	0.20	0.20
c) Construction Dead Load	1.35	1.00	1.35	1.00
2.2 Thermal load as accompanying load	0.90	0.80	0.50	0.50
2.3 Wind Load				
a) Leading Load	1.50	1.30	-	-
b) Accompanying Load	0.90	0.80	0.00	0.00
2.4 Live load surcharge as Accompanying Load (if applicable)				
3. Accidental Effect or Seismic Effect				
a) During Service	-	-	1.50	1.00
b) During Construction	-	-	0.75	0.50
4. Construction Dead Load (Such as Wt. of launching girder, truss or cantilever construction equipments)	1.35	1.00	1.35	1.00
5. Hydraulic Loads:				
5.1 Water Current	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
5.2 Wave Pressure	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
5.3 Hydodynamic effect	-	-	1.0 or 0	-
6. Buoyancy:				
a) For Base Pressure	1.00	1.00	1.00	1.00
b) For Structural Design	0.15	0.15	0.15	0.15

ABUTMENT CAP LOAD CALCULATION



Abutment cap is fully resting on abutment wall, so provide min. reinforcement.

cl. 16.5.1.1 (1) of IRC :112-2011

$A_{S.min} = 0.26 f_{ctm} b_t d / f_{yk} >= 0.0013 b_t d$

f_{ctm}	2.5	
b_t	1700	
d	500	
f_{yk}	500	
$0.26 f_{ctm} b_t d / f_{yk}$	1105	mm^2
$0.0013 b_t d$	1105	mm^2
Provide	1105	mm^2

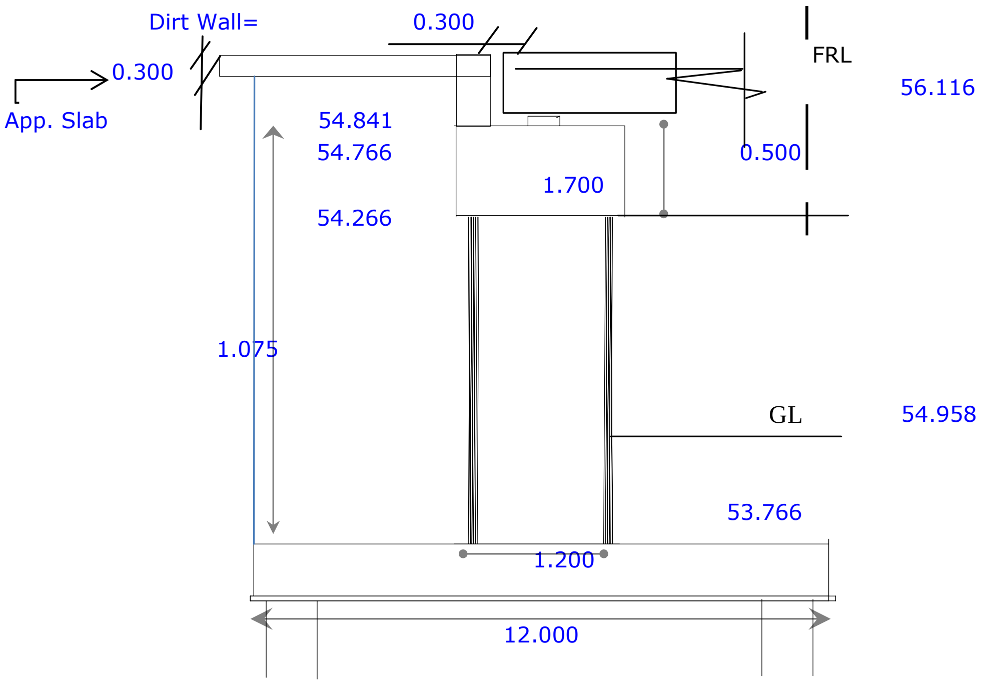
16 ϕ	@	**150 mm c/c**	**1340**	**mm^2**	**at top and bottom**
			OK		
12 ϕ	@	**150 mm c/c**	**754**	**mm^2**	**as distribution in the form of stirrup**
			OK		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

LOAD CALCULATION FOR ABUTMENT & PILE CAP

SALIENT REDUCED LEVELS

Deck Top Level	=	577.856	m
Bearing Top Level	=	576.556	m
Abutment Cap Top Level	=	576.506	m
Abutment Cap Bottom Level	=	576.006	m
Abutment Bottom Level	=	572.445	m
Depth of Pile cap	=	1.8	m
GL	=	572.945	m
Pile cap bottom Level	=	570.645	m
HFL	=	573.015	m
LBL	=	566.78	m
Expansion Gap	=	0.040	m
Width of abutment	=	**1.000**	m
Length of the abut	=	**18.000**	m
Length of Pile cap	=	**18.000**	m
Width of Pile cap	=	**4.300**	m
Thickness of Wearing coat (W/c)	=	0.075	m
Height of Deck+Girder	=	1.200	m
Thickness of bearing	=	**0.100**	m
Height of Pedestal	=	**0.250**	m
Total Height from w/c to Abut Cap top	=	1.350	m
Span EJ to EJ	=	16.000	m



2.350
0.086

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designe dby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date &Rev.	

LOAD CALCULATIONS

Taking Moments about founding level

		RIGHT SPAN	LEFT SPAN	L (Long)	L (Trans)	ML	Mt	
				m	m	t-m	t-m	
Dead Load		236.33		0.00	0.00	0.00	0.00	
SIDL1 w/c		24.49		0.00	0.00	0.00	0.00	
SIDL 2 exl w/c		27.86		0.00	0.00	0.00	0.00	
LL1 (Max Reaction)								
70 R + 2Class A		120.81		0.00	1.875	0.00	226.51	2.103
2 70 R		121.76		0.00	3.080	0.00	375.03	2.910
70 R		60.88		0.00	4.905	0.00	298.62	4.905
Class 4 A		119.85		0.00	1.075	0.00	128.84	0.950
70 R + Class A		90.84		0.00	4.201	0.00	381.63	3.958
LL2 (Max Moment)								
70 R + 2Class A		186.78		0.00	1.875	0.00	350.21	2.103
2 70 R		192.21		0.00	3.080	0.00	592.00	2.910
70 R		96.10		0.00	4.905	0.00	471.39	4.905
Class 4 A		181.35		0.00	1.075	0.00	194.95	0.950
70 R + Class A		141.44		0.00	4.201	0.00	594.19	3.958
Horizontal Force Due to braking at				POT PTFE Bearing		Fixed abut		
	μ =	0.05	(as per IRC 6:2017)	Fh/2 + μ(Rg+Rq) OR Fh - μ(Rg+Rq)	**@foundation**		**abut Bottom**	
	Fh	Rg	Rq	**H**	**Lev**	**ML**	**Lev**	**ML**
	t	**t**	**t**	**t**	**m**	**t-m**	**m**	**t-m**
70 R + 2Class A		288.67	186.78	23.77	2.18	51.90	1.07	25.56
Class 2 70R	20.43	288.67	192.21	34.26	2.18	74.79	1.07	36.83
Class 70 R	20.00	288.67	96.10	29.24	2.18	63.83	1.07	31.43
Class 4 A	15.51	288.67	181.35	31.26	2.18	68.23	1.07	33.60
70 R + Class A	20.49	288.67	141.44	31.75	2.18	69.31	1.07	34.13

Horizontal braking force	=	34.26	t
ML @ foundation	=	74.79	tm
ML @ abut bottom	=	36.83	tm

@foundation	P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)	Fh(t)
LL1B	3	75	0	34.26	0.00	20.43
LL2B	0	0	0			
LL3B	3	69	0	31.75	0.00	20.49
@abutment bottom	P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)	Fh(t)
LL1B	3	37	0	34.26	0.00	20.43
LL2B	0	0	0			
LL3B	3	34	0	31.75	0.00	20.49

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

WIND FORCES ON SUPER STRUCTURE

REF: IRC 6-2017 CL NO:209.2

Basic wind speed	=	47 m/s	Plain terrain				
Design wind speed	=	39.59 m/s	at height	10.00 m			**27.80 m/s**
Design wind pressure P_Z	=	940.60 N/m^2	at height	10.00 m			**463.70 N/m^2**
$F_T = P_Z A_1 G C_D$	=	374 Kg/m^2		G =	**2.00**	**C_D =**	**1.95**
F_L =	=	93.48 Kg/m^2					
$F_V = P_Z A_3 G C_L$	=	144 Kg/m^2		G =	**2.00**	**C_L =**	**0.75**

Up ward or downward vertical wind Load

F_V = 8.00 x **16.000** x 143.82 = 18.41 t

WIND FORCES ON LIVE LOAD

Basic wind speed	=	0 m/s	Plain terrain				
Design wind speed	=	0.00 m/s	at height	10.00	m		**27.80 m/s**
Design wind pressure P_Z	=	0.00 N/m^2	at height	10.00	m		**463.70 N/m^2**
$F_T = P_Z A_1 G C_D$	=	0 Kg/m^2		G =	**2.00**	**C_D =**	**1.20**
F_L =	=	0.00 Kg/m^2					
$F_V = P_Z A_3 G C_L$	=	0 Kg/m^2		G =	**2.00**	**C_L =**	**0.75**

WIND FORCES ON SUB STRUCTURE

Basic wind speed	=	47 m/s	Plain terrain				
Design wind speed	=	39.59 m/s	at height	10.00 m			**27.80 m/s**
Design wind pressure P_Z	=	940.60 N/m^2	at height	10.00 m			**463.70 N/m^2**

REF: IRC 6-2017 CL NO:209.4

$F_T = P_Z A_1 G C_D$	=	96 Kg/m^2	G =	**2.00**	**C_D =**	**0.50**
F_L =	=	23.97 Kg/m^2				
$F_V = P_Z A_3 G C_L$	=	144 Kg/m^2	G =	**2.00**	**C_L =**	**0.75**

TRANSVERSE DIRECTION		**Moments about FL**			**Abutment Bottom**	
DESCRITPTION		**H**	**Lev**	**Mt**	**Lev**	**Mt**
		t	**M**	**t-m**	**M**	**t-m**
WIND ON SUPER STR ACT @	55.48	11.29	2.82	31.84	1.71	19.33
WIND ON MOVING LOAD @	57.62	0.00	4.96	0.00	3.85	0.00
WIND ON abutment CAP @	54.52	0.08	1.86	0.15	0.75	0.06
WIND ON abutment @	54.61	-0.07	1.95	-0.13	0.85	-0.06
	TOTAL	**11.30**		**31.86**		**19.34**

LONGITUDINAL DIRECTION		**Moments about FL**			**Abutment Bottom**	
DESCRITPTION		**H**	**Lev**	**Mt**	**Lev**	**Mt**
		t	**M**	**t-m**	**M**	**t-m**
WIND ON SUPER STR ACT @	55.48	4.71	2.82	43.05	1.71	34.57
WIND ON MOVING LOAD @	57.62	0.00	4.96	0.00	3.85	0.00
WIND ON abutment CAP @	54.52	0.71	1.86	5.25	0.75	3.97
WIND ON abutment @	54.61	-0.02	1.95	-0.03	0.85	-0.01
	TOTAL	**5.53**		**48.85**		**38.89**

DEAD WEIGHT OF ABUTMENT CAP WITH DIRT WALL

	Nos	L	B	H	Qty	wt	L. A.	ML (tm)
		m	m	m	m3	t		
Abut. Cap	1	16.000	1.70	0.500	13.60	34.00	0.00	0.00
Dirt wall	1	16.000	0.30	1.350	6.48	16.20	-0.70	-11.34
Pedestals (5 nos)	5	**0.800**	**0.800**	**0.400**	1.28	3.20	0.00	0.00
DL+SIDL (approach span) load	1	16.000		5.2	**0.92** t/m2	37.70	-0.70	-26.39
LL (approach span) LL surcharge(1.2m)	1	16.000		5.150	**2.40** t/m2	98.88	-0.70	-69.22
Total						**189.98**		**-59.49**

DEAD WEIGHT OF ABUTMENT & FOUNDATION

	L	B	H	LWL wt	HFL wt	LA C/L of abut / found(m)	LWL ML	HFL ML
	m	m	m	t	t		(t.m)	(t.m)
Abut. Stem	16.000	1.00	-0.69	-27.68	-22.14	0.00	0.00	0.00
	16.000	1.00	1.19	47.68	38.14	0.00	0.00	0.00
Foundation	16.000	4.30	1.80	309.60	247.68	0.00	0.00	0.00
Return wall	1.00	1.650	1.85	7.63	6.10	-1.33	-10.11	-8.09
	1.00	1.650	0.09	0.35	0.28	-1.33	-0.47	-0.38
	1.00	1.650	0.41	1.71	1.37	-1.33	-2.26	-1.81
Soil Above the Foundation	15.000	1.650	1.47	73.01	36.51	-1.33	-96.74	-48.37
	15.000	1.650	0.09	4.26	2.13	-1.33	-5.64	-2.82
	15.000	1.650	0.41	20.49	10.25	-1.33	-27.15	-13.58
Total				**437.06**	**320.32**		**-142.38**	**-75.04**
					116.74			**-67.34**

Earth pressure		At foundation		At abut. Bottom	
		LWL	HFL	LWL	HFL
Height	m	3.458	3.458	2.35	2.35
Dry unit wt. of soil	t/m3	2.00		2.00	
Wet unit wt. of soil	t/m3		1.00		1.00
Coulomb's theory Ka (Normal case)					
Angle of friction	φ	**30.00**			
Angle of deflection	δ	**20.00**			
wall inclination to horizontal	α	**90.00**			
soil surcharge inclination to horizontal	β	**0.00**			
Ka (Normal case)		0.279			
Coulomb's theory Ka (Seismic case)					
Seismic Zone		III			
α_h		0.0800			
α_v		0.0533			
$\theta = \tan^{-1}(\alpha_h/(1+\_\alpha_v)$		0.0758			
		0.0843			
Coefficient of active earth pressure (Seismic case)		0.344			
Coefficient of active earth pressure		0.279	0.279	0.279	0.279
Live load surcharge	m	**1.20**	**1.20**	**1.20**	**1.20**
Active earth pressure		1.93	0.97	1.31	0.66
Pressure due to live load surcharge		0.67	0.34	0.67	0.34
Force due to live load surcharge	t/m	37	19	25	13
Force due to active earth pressure	t/m	53	27	25	12
Moment due to live load surcharge	t.m/m	64	32	30	15
Moment due to active earth pressure	t.m/m	78	39	24	12

Dynamic increment due to earth pressure		**At foundation**		**At abut. Bottom**	
As per Cl. 219.5.4 & 214.1.2 of IRC 6-2017		**LWL**	**HFL**	**LWL**	**HFL**
Coefficient of active earth pressure		0.000	0.000	0.000	0.000
Live load surcharge	m	**1.20**	**1.20**	**1.20**	**1.20**
Active earth pressure		0.00	0.00	0.00	0.00
Pressure due to live load surcharge		0.00	0.00	0.00	0.00
Force due to live load surcharge	t/m	0	0	0	0
Force due to active earth pressure	t/m	0	0	0	0
Moment due to live load surcharge	t.m/m	0	0	0	0

Moment due to active earth pressure	t.m/m	0	0	0	0

Fundamental Time Period of Vibration due to Seismic Waves :

According to **Annexure D (Clause 219.5)** IRC 6 :2017 -

T = 2.0 x sqrt(D/(1000*F))

Where,

T	=	Fundamental Time Period Of Vibration
D	=	Appropriate dead Load of the superstructure and Live load in KN
F	=	Horizontal Force in KN required to be applied at the centre of mass of superstructure for 1 mm horizontal deflection at the top of the 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 Longitudinal direction

			Longitudinal Direction		Transverse Direction		
	F	=	$d*(3EI)/L^3$	Unit	$d*(3EI)/L^3$	Unit	
	d	=	0.001	m	0.001	m	
	L	=	1.608	m	2.158	m	
	E	=	3.10E+07	KN/m2	3.10E+07	KN/m2	
	I	=	1.000	m4	256.000	m4	
	F	=	22367.880	KN	#######	KN	
	D	=	2829.000	KN	3206.109	KN	(DL+0.2*LL)
	T	**=**	***0.02***	***sec***	***0.00***	***sec***	
Seismic Zone		=	III		III		
Zone Factor Z		=	0.16		0.16		
Importance Factor I		=	1.2		1.2		
Response Reduction Factor		=	3		3		
Soil Strata		=	Type II	Medium soil			
Sa/g			2.5		2.5		
Horizontal Acceleration Coefficient (Ah) Z/2*Sa/g*I/R		=	0.08		0.08		

For design of foundation seismic loads are increased by 35% As per Cl. 219.8 of IRC 6-2017

Seismic Force Calculations		**For Foundation**			
		Horizontal	**Vertical (2/3 of Horizontal)**		
Long Seismic Coefficient		0.108	0.072	(including over strength factor)	
Trans Seismic Coefficient		0.108	0.072	(including over strength factor)	

Seismic For design of foundation seismic loads are increased by 35%

						@ Foundation		
	V (t)	**H Comp**	**V Comp**	**Acting At**	**Ecc (For H)**	**ML Due to H**	**Moment Due to V**	
							ML	**MT**
DL	472.2	51.0	34.0	54.8	2.2	111.3	0.0	0.0
SIDL1	48.9	5.3	3.5	54.8	2.2	11.5	0.0	0.0
SIDL2	55.7	6.0	4.0	54.8	2.2	13.1	0.0	0.0
Abt. but Cap+dirt wall	190.0	20.5	13.7	55.2	2.50	51.2	0.0	0.0
abut	20.0	2.2	1.4	54.0	1.4	2.9	0.0	0.0
return wall	9.7	1.0	0.7	54.9	2.3	2.4	0.0	0.0
Soil above found	97.8	10.6	7.0	54.9	2.3	24.1	0.0	0.0
LL1	38.4	4.2	2.8	54.8	2.2	9.1	0.0	8.5
LL2	38.4	4.2	2.8	54.8	2.2	9.1	0.0	8.5
LL3	28.3	3.1	2.0	54.8	2.2	6.7	0.0	8.6

Longitudinal seismic

	V (t)	ML (t.m)	MT (t.m)
DL	56.85	191.94	0.00
SIDL1	3.52	11.54	0.00
SIDL2	4.01	13.12	0.00
LL1	2.77	9.06	8.52
LL2	2.77	9.06	8.52
LL3	2.04	6.67	8.56

Tranverse seismic

	V (t)	ML (t.m)	MT (t.m)
DL	56.85	0.00	191.94
SIDL1	3.52	0.00	11.54
SIDL2	4.01	0.00	13.12
LL1	2.77	0.00	17.59
LL2	2.77	0.00	17.59
LL3	2.04	0.00	15.23

Combination of Orthogonal Seismic Force

		V (t)	**ML (t.m)**	**MT (t.m)**	**PSF**	**V (t)**	**ML (t.m)**	**MT (t.m)**
DL		56.85	249.53	0.00	1.00	**56.9**	**249.5**	**0.0**
SIDL1		3.52	15.00	0.00	1.00	**3.5**	**15.0**	**0.0**
SIDL2		4.01	17.06	0.00	1.00	**4.0**	**17.1**	**0.0**
LL1		2.77	14.34	8.52	1.00	**2.8**	**14.3**	**8.5**
LL2		2.77	14.34	8.52	1.00	**2.8**	**14.3**	**8.5**
LL3		2.04	11.24	8.56	1.00	**2.0**	**11.2**	**8.6**
DL		56.85	0.00	249.53	1.00	**56.9**	**0.0**	**249.5**
SIDL1		3.52	0.00	15.00	1.00	**3.5**	**0.0**	**15.0**
SIDL2		4.01	0.00	17.06	1.00	**4.0**	**0.0**	**17.1**
LL1		2.77	2.56	20.31	1.00	**2.8**	**2.6**	**20.3**
LL2		2.77	2.56	20.31	1.00	**2.8**	**2.6**	**20.3**
LL3		2.04	2.57	17.23	1.00	**2.0**	**2.6**	**17.2**

	V (t)	ML (t.m)	MT (t.m)
DL+SIDL1+SIDL2+LL1	67.15	295.92	8.52
DL+SIDL1+SIDL2+LL2	67.15	295.92	8.52
DL+SIDL1+SIDL2+LL3	66.42	292.82	8.56
DL+SIDL1+SIDL2+LL1	67.15	2.56	301.89
DL+SIDL1+SIDL2+LL2	67.15	2.56	301.89
DL+SIDL1+SIDL2+LL3	66.42	2.57	298.81
DL+SIDL1+SIDL2+LL1	67	296	9
DL+SIDL1+SIDL2+LL2	67	296	9
DL+SIDL1+SIDL2+LL3	67	3	302

Seismic Force Calculations					For abutment			
		Horizontal	Vertical (2/3 of Horizontal)					
Long Seismic Coefficient		0.080	0.053	***Refer Seismic Calculations Appendex 1***				
Trans Seismic Coefficient		0.080	0.053					
Seismic								
						@ Stem Bottom		
	V (t)	**H Comp**	**V Comp**	**Acting At**	**Ecc (For H)**	**ML Due to H**	**Moment Due to V**	
							ML	**MT**
DL	472.2	37.8	25.2	54.8	1.1	40.6	0.0	0.0
SIDL1	48.9	3.9	2.6	54.8	1.1	4.2	0.0	0.0
SIDL2	55.7	4.5	3.0	54.8	1.1	4.8	0.0	0.0
abut Cap	190.0	15.2	10.1	55.2	1.4	21.1	0.0	0.0
abut Stem	20.0	1.6	1.1	54.0	0.3	0.4	0.0	0.0
LL1	38.4	3.1	2.1	54.8	1.1	3.3	0.0	6.3
LL2	38.4	3.1	2.1	54.8	1.1	3.3	0.0	6.3
LL3	28.3	2.3	1.5	54.8	1.1	2.4	0.0	6.3

Longitudinal seismic				**Tranverse seismic**			
	V (t)	ML (t.m)	MT (t.m)		V (t)	ML (t.m)	MT (t.m)
DL	36.38	62	0.00	DL	36.38	0.00	62.09
SIDL1	2.61	4.21	0.00	SIDL1	2.61	0.00	4.21
SIDL2	2.97	4.79	0.00	SIDL2	2.97	0.00	4.79
LL1	2.05	3.31	6.31	LL1	2.05	0.00	9.62
LL2	2.05	3.31	6.31	LL2	2.05	0.00	9.62
LL3	1.51	2.43	6.34	LL3	1.51	0.00	8.77

Combination of Orthogonal Seismic Force								
		V (t)	**ML (t.m)**	**MT (t.m)**	**PSF**	**V (t)**	**ML (t.m)**	**MT (t.m)**
DL		36.38	80.72	0.00	1.00	**36.4**	**80.7**	**0.0**
SIDL1		2.61	5.47	0.00	1.00	**2.6**	**5.5**	**0.0**
SIDL2		2.97	6.22	0.00	1.00	**3.0**	**6.2**	**0.0**
LL1		2.05	6.19	6.31	1.00	**2.1**	**6.2**	**6.3**
LL2		2.05	6.19	6.31	1.00	**2.1**	**6.2**	**6.3**
LL3		1.51	5.06	6.34	1.00	**1.5**	**5.1**	**6.3**
DL		36.38	0.00	80.72	1.00	**36.4**	**0.0**	**80.7**
SIDL1		2.61	0.00	5.47	1.00	**2.6**	**0.0**	**5.5**
SIDL2		2.97	0.00	6.22	1.00	**3.0**	**0.0**	**6.2**
LL1		2.05	1.89	10.61	1.00	**2.1**	**1.9**	**10.6**
LL2		2.05	1.89	10.61	1.00	**2.1**	**1.9**	**10.6**
LL3		1.51	1.90	9.50	1.00	**1.5**	**1.9**	**9.5**

	V (t)	ML (t.m)	MT (t.m)
DL+SIDL1+SIDL2+LL1	44.01	98.60	6.31
DL+SIDL1+SIDL2+LL2	44.01	98.60	6.31
DL+SIDL1+SIDL2+LL3	43.47	97.47	6.34
DL+SIDL1+SIDL2+LL1	44.01	1.89	103.02
DL+SIDL1+SIDL2+LL2	44.01	1.89	103.02
DL+SIDL1+SIDL2+LL3	43.47	1.90	101.91
DL+SIDL1+SIDL2+LL1	44	99	6
DL+SIDL1+SIDL2+LL2	44	99	6
DL+SIDL1+SIDL2+LL3	44	2	103

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

COMBINATION FOR DESIGN OF FOUNDATION & BASE PRESSURE (ULS)

Following load combinations are con As per Annex B of IRC:112-2011

1 Combination 1

2 Combination 2

3 Seismic Combination

4 Combination for base pressure check

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	Dead Load (due to superstructure+substructure+foundtion		863	-202	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		190	-59	0	0	0
4	ABUT + RETURN WALL		30	-13	0	0	0
5	FOUNDATION		310	0	0	0	0
6	SOIL ABOVE FDN		98	-130	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	192	0	592	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	141	0	594	0	0
12	LL1B	Live Load Moment due to braking	3	75	0	34.26	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.08	0
14	LL3B	Live Load Moment due to braking	3	69	0	31.75	0
15	W1	Wind vertically down without LL	18	5	32	5.40	11.30
16	W2	Wind vertically up without LL	-18	5	32	5.40	11.30
17	W3	Wind vertically down with LL	18	49	32	5.53	11.30
18	W4	Wind vertically up with LL	-18	49	32	5.53	11.30
19	S1	Seimic	67	296	9	100.7	0
20	S2	Seimic	67	3	302	0.0	100.7
21	S3	Seimic	-67	296	9	100.7	0
22	S4	Seimic	-67	3	302	0.0	100.7
23	HFL		-117	67	0	0.0	0.0
24	Active earth pressure LWL		0	78	0	53.5	0.0
25	LL surcharge LWL		0	64	0	37.1	0.0
26	Active earth pressure HFL		0	39	0	26.7	0.0
27	LL surcharge HFL		0	32	0	18.5	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0.0
29	LL surcharge LWL		0	0	0	0	0.0
30	Active earth pressure HFL		0	0	0	0	0.0
31	LL surcharge HFL		0	0	0	0	0.0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

	Combination 1				**Combination 2**				**Seismic Combination**				**Combination for base pressure check**		
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)	P(t)	ML (tm)	MT (tm)
DL	1.35	1166	-249	-111	1.00	863	-184	-82	1.25	1079	-231	-103	863	-184	-82
SIDL1	1.75	43	0	0	1.00	24	0	0	1.75	43	0	0	24	0	0
SIDL2	1.35	38	0	0	1.00	28	0	0	1.25	35	0	0	28	0	0
LL1	1.50	288	361	811	1.30	250	313	703	0.20	38	48	108	192	241	541
LL2	1.50	252	431	969	1.30	219	374	840	0.20	34	58	129	168	288	646
LL3	1.50	212	363	814	1.30	184	314	706	0.20	28	48	109	141	242	543
LL1B	1.50	5	102	46	1.30	4	89	40	0.20	1	14	6	3	68	30
LL2B	1.50	0	0	0	1.30	0	0	0	0.20	0	0	0	0	0	0
LL3B	1.50	5	95	42	1.30	4	82	37	0.20	1	13	6	3	63	28
W1	0.90	17	16	28	0.80	15	14	25	0.00	0	0	0	18	18	31
W2	0.90	-17	16	28	0.80	-15	14	25	0.00	0	0	0	-18	18	31
W3	0.90	17	52	44	0.80	15	46	39	0.00	0	0	0	18	58	49
W4	0.90	-17	52	44	0.80	-15	46	39	0.00	0	0	0	-18	58	49
S1	0.00	0	0	0	0.00	0	0	0	1.50	101	411	192	67	274	128
S2	0.00	0	0	0	0.00	0	0	0	1.50	101	188	415	67	125	277
S3	0.00	0	0	0	0.00	0	0	0	1.50	-101	411	192	-67	274	128
S4	0.00	0	0	0	0.00	0	0	0	1.50	-101	188	415	-67	125	277
HFL	1.00	-117	62	27	1.00	-117	62	27	1.00	-117	62	27	-117	62	27
EP	1.00	0	71	32	0.85	0	60	27	1.00	0	71	32	0	71	32
LL S.	1.20	0	70	31	1.00	0	59	26	0.20	0	12	5	0	59	26
EP.HFL	1.00	0	35	16	0.85	0	30	13	1.00	0	35	16	0	35	16
LL.S.HFL	1.20	0	35	16	1.00	0	29	13	0.20	0	6	3	0	29	13
Active earth pressure LWL					Dynamic increment in earth pressure due to seismic				1.00	0	0	0	0	0	0
LL surcharge LWL									0.20	0	0	0	0	0	0
Active earth pressure HFL									1.00	0	0	0	0	0	0
LL surcharge HFL									0.20	0	0	0	0	0	0

Case 1 Combination 1

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1246	-178	-79
Case 2 DL+SIDL1+SIDL2+LL1	1539	356	809
Case 3 DL+SIDL1+SIDL2+LL2	1498	324	921
Case 4 DL+SIDL1+SIDL2+LL3	1463	350	809
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1262	-162	-51
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1556	408	853
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1515	376	965
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1480	402	853
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1229	-162	-51
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1523	408	853
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1482	376	965
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1447	402	853

HFL			
Case 1 DL+SIDL1+SIDL2+HFL	1129	-152	-68
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1422	347	805
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1382	315	917
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1346	341	805
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1146	-136	-40
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1439	399	849
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1398	366	961
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1363	392	849
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	1113	-136	-40
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1406	399	849
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1365	366	961
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1330	392	849

MAXIMUM REACTION CASE	1556	408	853
MAXIMUM LONGITUDINAL MOMENT CASE	1556	408	853
MAXIMUM TRANSVERSE MOMENT CASE	1515	376	965

Case 2 Combination 2

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	916	-124	-55
Case 2 DL+SIDL1+SIDL2+LL1	1170	336	713
Case 3 DL+SIDL1+SIDL2+LL2	1134	308	811
Case 4 DL+SIDL1+SIDL2+LL3	1104	331	713
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	930	-110	-30
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1185	382	753
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1149	354	850
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1119	377	752
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	901	-110	-30
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1155	382	753
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1120	354	850
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1089	377	752

HFL			
Case 1 DL+SIDL1+SIDL2+HFL	799	-93	-41
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1053	338	714
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1018	310	812
Case 4 DL+SIDL1+SIDL2+LL3+HFL	987	333	714
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	814	-79	-16
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1068	384	754
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1032	357	851
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1002	379	753
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	784	-79	-16
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1038	384	754
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1003	357	851
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	972	379	753

MAXIMUM REACTION CASE	1185	382	753
MAXIMUM LONGITUDINAL MOMENT CASE	1068	384	754
MAXIMUM TRANSVERSE MOMENT CASE	1032	357	851

Case 3 Seismic Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
Normal	t	t-m	t-m
Downward seismic in longitudinal direction			
Case 1 DL+SIDL1+SIDL2+ seismic	1258	251	121
Case 2 DL+SIDL1+SIDL2+LL1+ seismic	1297	325	241
Case 3 DL+SIDL1+SIDL2+LL2+ seismic	1291	320	256
Case 4 DL+SIDL1+SIDL2+LL3+ seismic	1286	324	241
Downward seismic in transverse direction			
Case 5 DL+SIDL1+SIDL2+ seismic	1258	28	344
Case 6 DL+SIDL1+SIDL2+LL1+ seismic	1297	102	464
Case 7 DL+SIDL1+SIDL2+LL2+ seismic	1291	97	479
Case 8 DL+SIDL1+SIDL2+LL3+ seismic	1286	101	464
Upward seismic in longitudinal direction			
Case 9 DL+SIDL1+SIDL2+ seismic	1056	251	121
Case 10 DL+SIDL1+SIDL2+LL1+ seismic	1095	325	241
Case 11 DL+SIDL1+SIDL2+LL2+ seismic	1090	320	256
Case 12 DL+SIDL1+SIDL2+LL3+ seismic	1085	324	241
Upward seismic in transverse direction			
Case 13 DL+SIDL1+SIDL2+ seismic	1056	28	344
Case 14 DL+SIDL1+SIDL2+LL1+ seismic	1095	102	464
Case 15 DL+SIDL1+SIDL2+LL2+ seismic	1090	97	479
Case 16 DL+SIDL1+SIDL2+LL3+ seismic	1085	101	464
HFL CASE			
Downward seismic in longitudinal direction			
Case 1 DL+SIDL1+SIDL2+ seismic+HFL	1141	277	133
Case 2 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1180	345	250
Case 3 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1174	341	265
Case 4 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1170	344	250
Downward seismic in transverse direction			
Case 5 DL+SIDL1+SIDL2+ seismic+HFL	1141	54	356
Case 6 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1180	122	473
Case 7 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1174	67	488
Case 8 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1170	121	473
Upward seismic in longitudinal direction			
Case 9 DL+SIDL1+SIDL2+ seismic+HFL	939	277	133
Case 10 DL+SIDL1+SIDL2+LL1+ seismic+HFL	978	345	250
Case 11 DL+SIDL1+SIDL2+LL2+ seismic+HFL	973	341	265
Case 12 DL+SIDL1+SIDL2+LL3+ seismic+HFL	968	344	250
Upward seismic in transverse direction			
Case 13 DL+SIDL1+SIDL2+ seismic+HFL	939	54	356
Case 14 DL+SIDL1+SIDL2+LL1+ seismic+HFL	978	122	473
Case 15 DL+SIDL1+SIDL2+LL2+ seismic+HFL	973	118	488
Case 16 DL+SIDL1+SIDL2+LL3+ seismic+HFL	968	121	473

MAXIMUM REACTION CASE	1297	325	241
MAXIMUM LONGITUDINAL MOMENT CASE	1180	345	250
MAXIMUM TRANSVERSE MOMENT CASE	1174	67	488

Case 4 Combination for base pressure check

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	916	-113	-51
Case 2	DL+SIDL1+SIDL2+LL1	1111	254	547
Case 3	DL+SIDL1+SIDL2+LL2	1084	233	622
Case 4	DL+SIDL1+SIDL2+LL3	1060	250	547
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	934	-96	-19
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	1130	312	596
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	1102	290	671
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	1079	308	596
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	897	-96	-19
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	1093	312	596
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	1066	290	671
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	1042	308	596
Downward seismic in longitudinal direction				
Case 13	DL+SIDL1+SIDL2+ seismic	983	160	78
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	1178	528	675
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	1151	507	750
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	1128	524	675
Downward seismic in transverse direction				
Case 17	DL+SIDL1+SIDL2+ seismic	983	12	226
Case 18	DL+SIDL1+SIDL2+LL1+ seismic	1178	379	824
Case 19	DL+SIDL1+SIDL2+LL2+ seismic	1151	358	898
Case 20	DL+SIDL1+SIDL2+LL3+ seismic	1128	375	823
Upward seismic in longitudinal direction				
Case 21	DL+SIDL1+SIDL2+ seismic	849	160	78
Case 22	DL+SIDL1+SIDL2+LL1+ seismic	1044	528	675
Case 23	DL+SIDL1+SIDL2+LL2+ seismic	1017	507	750
Case 24	DL+SIDL1+SIDL2+LL3+ seismic	993	524	675
Upward seismic in transverse direction				
Case 25	DL+SIDL1+SIDL2+ seismic	849	12	226
Case 26	DL+SIDL1+SIDL2+LL1+ seismic	1044	379	824
Case 27	DL+SIDL1+SIDL2+LL2+ seismic	1017	358	898
Case 28	DL+SIDL1+SIDL2+LL3+ seismic	993	375	823

HFL				
Case 1	DL+SIDL1+SIDL2+HFL	799	-87	-39
Case 2	DL+SIDL1+SIDL2+LL1+HFL	994	251	545
Case 3	DL+SIDL1+SIDL2+LL2+HFL	967	229	620
Case 4	DL+SIDL1+SIDL2+LL3+HFL	944	247	545
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	817	-70	-8
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1013	309	594
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	986	287	669
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	962	304	594
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	781	-70	-8
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	976	309	594
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	949	226	669
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	925	304	594
Downward seismic in longitudinal direction				
Case 13	DL+SIDL1+SIDL2+ seismic+HFL	866	186	89
Case 14	DL+SIDL1+SIDL2+LL1+ seismic+HFL	1062	525	673
Case 15	DL+SIDL1+SIDL2+LL2+ seismic+HFL	1034	503	748
Case 16	DL+SIDL1+SIDL2+LL3+ seismic+HFL	1011	521	673
Downward seismic in transverse direction				
Case 17	DL+SIDL1+SIDL2+ seismic+HFL	866	38	238
Case 18	DL+SIDL1+SIDL2+LL1+ seismic+HFL	1062	376	822

Case 19 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1034	355	897
Case 20 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1011	372	822
Upward seismic in longitudinal direction			
Case 21 DL+SIDL1+SIDL2+ seismic+HFL	732	186	89
Case 22 DL+SIDL1+SIDL2+LL1+ seismic+HFL	927	525	673
Case 23 DL+SIDL1+SIDL2+LL2+ seismic+HFL	900	503	748
Case 24 DL+SIDL1+SIDL2+LL3+ seismic+HFL	877	521	673
Upward seismic in transverse direction			
Case 25 DL+SIDL1+SIDL2+ seismic+HFL	732	38	238
Case 26 DL+SIDL1+SIDL2+LL1+ seismic+HFL	927	376	822
Case 27 DL+SIDL1+SIDL2+LL2+ seismic+HFL	900	355	897
Case 28 DL+SIDL1+SIDL2+LL3+ seismic+HFL	877	372	822

MAXIMUM REACTION CASE	1178	528	675
MAXIMUM LONGITUDINAL MOMENT CASE	1178	528	675
MAXIMUM TRANSVERSE MOMENT CASE	1151	358	898

1 Normal			
Load Case	**Factored Forces/Moments**		
	V	**ML**	**MT**
	t	**t-m**	**t-m**
Case 1 Normal max. Vertical load	**1111**	**254**	**547**
Case 2 Normal max. longitudinal moment	**1111**	**254**	**547**
Case 3 Normal max. transverse moment	**1084**	**233**	**622**
2 Seismic / wind			
Load Case	**Factored Forces/Moments**		
	V	**ML**	**MT**
	t	**t-m**	**t-m**
Case 1 Seismic/wind max. Vertical load	**1178**	**528**	**675**
Case 2 Seismic/wind max. longitudinal moment	**1178**	**528**	**675**
Case 3 Seismic/wind max. transverse moment	**1151**	**358**	**898**

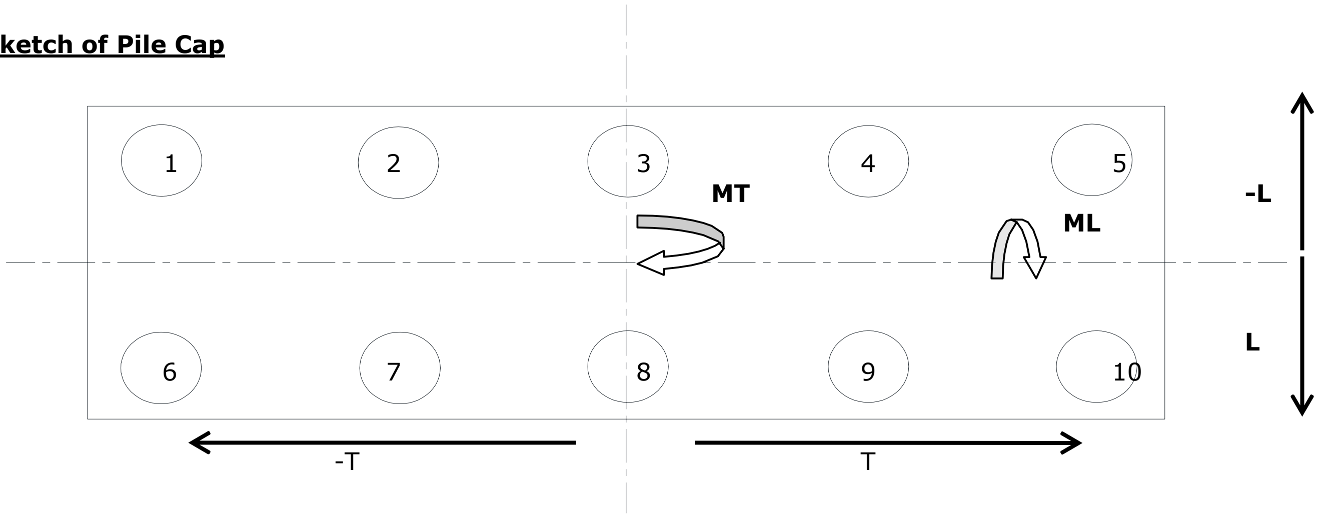
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Load on Pile for Base Pressure Check

		V	ML	MT
		t	t-m	t-m
DL+SIDL1+SIDL2	Case 1	1111	254	547
DL+SIDL1+SIDL2+LL1	Case 2	1111	254	547
DL+SIDL1+SIDL2+LL2	Case 3	1084	233	622
DL+SIDL1+SIDL2+Seismic	Case 4	1178	528	675
DL+SIDL1+SIDL2+LL1+Seismic	Case 5	1178	528	675
DL+SIDL1+SIDL2+LL2+Seismic	Case 6	1151	358	898

Diameter of Pile	=	1.200	m	
Shift	=	0.000	m	
Vertical Capacity of Pile	=	3600.000	T	As per Geotechnical Report
	=	9.000	m	Length below cutoff for A1
		10.000	m	Length below cutoff for A2

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_{L}2$	$_{T}2$	Z_L	Z_T
1	-1.800	-7.200	3.240	51.840	-18.000	-36.000
2	-1.800	-3.600	3.240	12.960	-18.000	-72.000
3	-1.800	0.000	3.240	0.000	-18.000	0.000
4	-1.800	3.600	3.240	12.960	-18.000	72.000
5	-1.800	7.200	3.240	51.840	-18.000	36.000
6	1.800	-7.200	3.240	51.840	18.000	-36.000
7	1.800	-3.600	3.240	12.960	18.000	-72.000
8	1.800	0.000	3.240	0.000	18.000	0.000
9	1.800	3.600	3.240	12.960	18.000	72.000
10	1.800	7.200	3.240	51.840	18.000	36.000

I_{LL} = **32.40** Sq.m

I_{TT} = **259.20** Sq.m

Normal case :- Lateral force

Case 1	**Horizontal force =**	**650.933**	t	**Force per Pile =**	**65.1**	**t**	**OK**

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift M_L/Z_L**	**Due to Shift M_T/Z_T**	**Total Load**	**Inference**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**	
1	111.12	-14.12	-15.19	0.00	0.00	81.81	OK
2	111.12	-14.12	-7.59	0.00	0.00	89.40	OK
3	111.12	-14.12	0.00	0.00	0.00	97.00	OK
4	111.12	-14.12	7.59	0.00	0.00	104.59	OK
5	111.12	-14.12	15.19	0.00	0.00	112.18	OK
6	111.12	14.12	-15.19	0.00	0.00	110.05	OK
7	111.12	14.12	-7.59	0.00	0.00	117.65	OK
8	111.12	14.12	0.00	0.00	0.00	125.24	OK
9	111.12	14.12	7.59	0.00	0.00	132.84	OK
10	111.12	14.12	15.19	0.00	0.00	140.43	OK

Case 2

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift M_L/Z_L**	**Due to Shift M_T/Z_T**	**Total Load**	**Inference**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**	
1	111.12	-14.12	-15.19	0.00	0.00	81.81	OK
2	111.12	-14.12	-7.59	0.00	0.00	89.40	OK
3	111.12	-14.12	0.00	0.00	0.00	97.00	OK
4	111.12	-14.12	7.59	0.00	0.00	104.59	OK
5	111.12	-14.12	15.19	0.00	0.00	112.18	OK
6	111.12	14.12	-15.19	0.00	0.00	110.05	OK
7	111.12	14.12	-7.59	0.00	0.00	117.65	OK
8	111.12	14.12	0.00	0.00	0.00	125.24	OK
9	111.12	14.12	7.59	0.00	0.00	132.84	OK
10	111.12	14.12	15.19	0.00	0.00	140.43	OK

Case 3

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift M_L/Z_L**	**Due to Shift M_T/Z_T**	**Total Load**	**Inference**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**	
1	108.40	-12.93	-17.27	0.00	0.00	78.20	OK
2	108.40	-12.93	-8.63	0.00	0.00	86.84	OK
3	108.40	-12.93	0.00	0.00	0.00	95.47	OK
4	108.40	-12.93	8.63	0.00	0.00	104.10	OK
5	108.40	-12.93	17.27	0.00	0.00	112.73	OK
6	108.40	12.93	-17.27	0.00	0.00	104.06	OK
7	108.40	12.93	-8.63	0.00	0.00	112.69	OK
8	108.40	12.93	0.00	0.00	0.00	121.33	OK
9	108.40	12.93	8.63	0.00	0.00	129.96	OK
10	108.40	12.93	17.27	0.00	0.00	138.59	OK

Seismic Case :- Lateral force

Case 4 **Horizontal force =** **696.150** t **Force per Pile =** **55.7** t **OK**

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	117.83	-29.33	-18.75	0.00	0.00	69.75	OK
2	117.83	-29.33	-9.37	0.00	0.00	79.13	OK
3	117.83	-29.33	0.00	0.00	0.00	88.50	OK
4	117.83	-29.33	9.37	0.00	0.00	97.87	OK
5	117.83	-29.33	18.75	0.00	0.00	107.25	OK
6	117.83	29.33	-18.75	0.00	0.00	128.42	OK
7	117.83	29.33	-9.37	0.00	0.00	137.79	OK
8	117.83	29.33	0.00	0.00	0.00	147.17	OK
9	117.83	29.33	9.37	0.00	0.00	156.54	OK
10	117.83	29.33	18.75	0.00	0.00	165.92	OK

Case 5

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	117.83	-29.33	-18.75	0.00	0.00	69.75	OK
2	117.83	-29.33	-9.37	0.00	0.00	79.13	OK
3	117.83	-29.33	0.00	0.00	0.00	88.50	OK
4	117.83	-29.33	9.37	0.00	0.00	97.87	OK
5	117.83	-29.33	18.75	0.00	0.00	107.25	OK
6	117.83	29.33	-18.75	0.00	0.00	128.42	OK
7	117.83	29.33	-9.37	0.00	0.00	137.79	OK
8	117.83	29.33	0.00	0.00	0.00	147.17	OK
9	117.83	29.33	9.37	0.00	0.00	156.54	OK
10	117.83	29.33	18.75	0.00	0.00	165.92	OK

Case 6

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	115.11	-19.88	-24.96	0.00	0.00	70.28	OK
2	115.11	-19.88	-12.48	0.00	0.00	82.76	OK
3	115.11	-19.88	0.00	0.00	0.00	95.23	OK
4	115.11	-19.88	12.48	0.00	0.00	107.71	OK
5	115.11	-19.88	24.96	0.00	0.00	120.19	OK
6	115.11	19.88	-24.96	0.00	0.00	110.04	OK
7	115.11	19.88	-12.48	0.00	0.00	122.52	OK
8	115.11	19.88	0.00	0.00	0.00	134.99	OK
9	115.11	19.88	12.48	0.00	0.00	147.47	OK
10	115.11	19.88	24.96	0.00	0.00	159.95	OK

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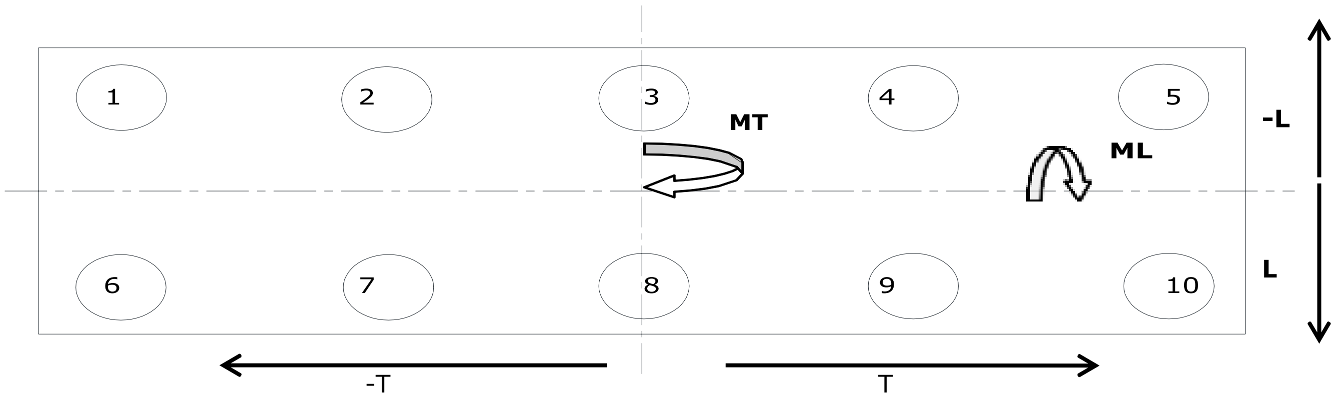
Load Calculations for Design of Pile (ULS)

		V	ML	MT
		t	**t-m**	**t-m**
Max. vertical load Combination 1	Case 1	1556	408	853
Max. longitudinal moment Combination 1	Case 2	1556	408	853
Max. transverse moment Combination 1	Case 3	1515	376	965
Max. vertical load Combination 2	Case 4	1185	382	753
Max. longitudinal moment Combination 2	Case 5	1068	384	754
Max. transverse moment Combination 2	Case 6	1032	357	851
Max. vertical load seismic/accidental combination	Case 7	1297	325	241
Max. longitudinal moment seismic/accidental combination	Case 8	1180	345	250
Max. transverse moment seismic/accidental combination	Case 9	1174	67	488

Diameter of Pile = 1.200 m
Shift = 0.000 m

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_L2$	$_T2$	Z_L	Z_T
1	1.235	-7.881	1.526	62.116	73.021	-39.407
2	-0.368	-3.941	0.135	15.529	-245.437	-78.814
3	-1.970	0.000	3.882	0.000	-45.781	0.000
4	-3.573	3.941	12.768	15.529	-25.245	78.814
5	-5.176	7.881	26.791	62.116	-17.427	39.407
6	5.176	-7.881	26.791	62.116	17.427	-39.407
7	3.573	-3.941	12.768	15.529	25.245	-78.814
8	1.970	0.000	3.882	0.000	45.781	0.000
9	0.368	3.941	0.135	15.529	245.437	78.814
10	-1.235	7.881	1.526	62.116	-73.021	39.407

I_{LL} = **90.20** Sq.m
I_{TT} = **310.58** Sq.m

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Case 1

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	155.6	5.6	-21.6	0.0	0.0	139.5
2	155.6	-1.7	-10.8	0.0	0.0	143.1
3	155.6	-8.9	0.0	0.0	0.0	146.7
4	155.6	-16.2	10.8	0.0	0.0	150.2
5	155.6	-23.4	21.6	0.0	0.0	153.8
6	155.6	23.4	-21.6	0.0	0.0	157.3
7	155.6	16.2	-10.8	0.0	0.0	160.9
8	155.6	8.9	0.0	0.0	0.0	164.5
9	155.6	1.7	10.8	0.0	0.0	168.1
10	155.6	-5.6	21.6	0.0	0.0	171.6

Case 2

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	155.6	5.6	-21.6	0.0	0.0	139.5
2	155.6	-1.7	-10.8	0.0	0.0	143.1
3	155.6	-8.9	0.0	0.0	0.0	146.7
4	155.6	-16.2	10.8	0.0	0.0	150.2
5	155.6	-23.4	21.6	0.0	0.0	153.8
6	155.6	23.4	-21.6	0.0	0.0	157.3
7	155.6	16.2	-10.8	0.0	0.0	160.9
8	155.6	8.9	0.0	0.0	0.0	164.5
9	155.6	1.7	10.8	0.0	0.0	168.1
10	155.6	-5.6	21.6	0.0	0.0	171.6

Case 3

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	151.5	5.1	-24.5	0.0	0.0	132.1
2	151.5	-1.5	-12.2	0.0	0.0	137.7
3	151.5	-8.2	0.0	0.0	0.0	143.3
4	151.5	-14.9	12.2	0.0	0.0	148.9
5	151.5	-21.5	24.5	0.0	0.0	154.4
6	151.5	21.5	-24.5	0.0	0.0	148.6
7	151.5	14.9	-12.2	0.0	0.0	154.1
8	151.5	8.2	0.0	0.0	0.0	159.7
9	151.5	1.5	12.2	0.0	0.0	165.3
10	151.5	-5.1	24.5	0.0	0.0	170.8

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Case 4

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	118.5	5.2	-19.1	0.0	0.0	104.6
2	118.5	-1.6	-9.5	0.0	0.0	107.4
3	118.5	-8.4	0.0	0.0	0.0	110.1
4	118.5	-15.1	9.5	0.0	0.0	112.9
5	118.5	-21.9	19.1	0.0	0.0	115.6
6	118.5	21.9	-19.1	0.0	0.0	121.3
7	118.5	15.1	-9.5	0.0	0.0	124.1
8	118.5	8.4	0.0	0.0	0.0	126.8
9	118.5	1.6	9.5	0.0	0.0	129.6
10	118.5	-5.2	19.1	0.0	0.0	132.3

Case 5

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	106.8	5.3	-19.1	0.0	0.0	92.9
2	106.8	-1.6	-9.6	0.0	0.0	95.7
3	106.8	-8.4	0.0	0.0	0.0	98.4
4	106.8	-15.2	9.6	0.0	0.0	101.1
5	106.8	-22.1	19.1	0.0	0.0	103.8
6	106.8	22.1	-19.1	0.0	0.0	109.7
7	106.8	15.2	-9.6	0.0	0.0	112.5
8	106.8	8.4	0.0	0.0	0.0	115.2
9	106.8	1.6	9.6	0.0	0.0	117.9
10	106.8	-5.3	19.1	0.0	0.0	120.6

Case 6

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	103.2	4.9	-21.6	0.0	0.0	86.5
2	103.2	-1.5	-10.8	0.0	0.0	91.0
3	103.2	-7.8	0.0	0.0	0.0	95.5
4	103.2	-14.1	10.8	0.0	0.0	99.9
5	103.2	-20.5	21.6	0.0	0.0	104.4
6	103.2	20.5	-21.6	0.0	0.0	102.1
7	103.2	14.1	-10.8	0.0	0.0	106.6
8	103.2	7.8	0.0	0.0	0.0	111.0
9	103.2	1.5	10.8	0.0	0.0	115.5
10	103.2	-4.9	21.6	0.0	0.0	120.0

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Case 7

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	129.7	4.4	-6.1	0.0	0.0	128.0
2	129.7	-1.3	-3.1	0.0	0.0	125.3
3	129.7	-7.1	0.0	0.0	0.0	122.6
4	129.7	-12.9	3.1	0.0	0.0	119.9
5	129.7	-18.6	6.1	0.0	0.0	117.1
6	129.7	18.6	-6.1	0.0	0.0	142.2
7	129.7	12.9	-3.1	0.0	0.0	139.5
8	129.7	7.1	0.0	0.0	0.0	136.8
9	129.7	1.3	3.1	0.0	0.0	134.0
10	129.7	-4.4	6.1	0.0	0.0	131.3

Case 8

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	118.0	4.7	-6.3	0.0	0.0	116.4
2	118.0	-1.4	-3.2	0.0	0.0	113.4
3	118.0	-7.5	0.0	0.0	0.0	110.5
4	118.0	-13.7	3.2	0.0	0.0	107.5
5	118.0	-19.8	6.3	0.0	0.0	104.5
6	118.0	19.8	-6.3	0.0	0.0	131.4
7	118.0	13.7	-3.2	0.0	0.0	128.5
8	118.0	7.5	0.0	0.0	0.0	125.5
9	118.0	1.4	3.2	0.0	0.0	122.6
10	118.0	-4.7	6.3	0.0	0.0	119.6

Case 9

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	117.4	0.9	-12.4	0.0	0.0	106.0
2	117.4	-0.3	-6.2	0.0	0.0	111.0
3	117.4	-1.5	0.0	0.0	0.0	116.0
4	117.4	-2.7	6.2	0.0	0.0	121.0
5	117.4	-3.9	12.4	0.0	0.0	126.0
6	117.4	3.9	-12.4	0.0	0.0	108.9
7	117.4	2.7	-6.2	0.0	0.0	113.9
8	117.4	1.5	0.0	0.0	0.0	118.9
9	117.4	0.3	6.2	0.0	0.0	123.9
10	117.4	-0.9	12.4	0.0	0.0	128.9

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Calculation of Depth of Fixity

As per IS 2911, Annexure C

Stiffness factor	T	=	5√(EI/K1)	m	For pile in sand and normally loaded Clays
Stiffness factor	R	=	4√(EI/BK2)	m	For pile in preloaded clays
	E	=	31000	MN/m2	
	I	=	0.1018	m4	
	ŋh	=	3.3008	MN/m3	
	K	=	4.86	MN/m3	
	T	=	3.945		OK
	R	=	4.823		
Pile length over sand layer, L1		=	0	m	
Case I	L1/R	=	0		
Case II	L1/T	=	0		
Case I	Lf/R	=	0		(for fixed head pile)
Case II	Lf/T	=	2.2		
Case I	Depth of Fixity, Lf	=	0.000	m	
Case II	Depth of Fixity, Lf	=	8.68	m	
	L1+Lf	=	8.680	m	
Reduction Factor	m	=	0.85		
	MT	=	Q (L1 + Lf)/2*m		(for fixed head pile)
		=	3.689	Q	

	Moment on pile =		3.689	Q					
	Combination 1			Combination 2			Seismic/Accidental Combination		
	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)
MAX	**171.64**	16	60	**132.32**	14	51	**142.19**	22	81
MIN	**132.15**	16	59	**86.54**	10	37	**104.54**	18	67

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Moments & shear force for pile cap

Width of abut.	=	1.00	m
Length of abut.		16.00	
Dia. Of pile	=	1.20	m
Length of Pile cap	=	16.00	m
Width of Pile cap	=	4.30	m
Thickness of pile cap	=	1.80	m
Unit wt. of concrete	=	2.50	t/m^3
Unit wt. of Soil	=	2.00	t/m^3
Thickness of soil above pile cap	=	1.19	m
Downward force & moment due to pile cap		1.20	0.00

Transverse direction	L	B	H	Unit Weight	Load (t)	Moment (t.m)
Self wt. of pile cap	0.00	4.30	1.80	2.50	0.00	0.00
Wt. due to soil	0.00	4.30	1.19	2.00	0.00	0.00
Longitudinal direction	L	B	H	Unit Weight	Load (t)	Moment (t.m)
Self wt. of pile cap	1.65	16.00	1.80	2.50	118.80	98.01
Wt. due to soil	1.65	16.00	1.19	2.00	62.94	51.92

	Combination 1			Combination 2			Seismic/Accidental Combination		
	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)
LL	790	38 /m	50 /m	606	27 /m	36 /m	680	31 /m	42 /m
TT	644	150 /m	/m	490	114 /m	/m	535	124 /m	/m
Max	790	644	798	606	490	578	680	535	667

ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	13.40	N/mm^2	Basic Combination
	f_{cd}	=	16.75	N/mm^2	Accidental Combination
	f_{cd}	=	13.40	N/mm^2	Seismic Combination
	E_c	=	31000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	434.78	N/mm^2	Basic Combination
	f_{Yd}	=	500.00	N/mm^2	Accidental Combination
	f_{Yd}	=	434.78	N/mm^2	Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = $fcd*b*(3/7xu_{,lim} + 2/3*4/7xu_{,lim})$

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.8095fcd*(xu_{lim}/d)*(1-0.416*xu_{lim}/d)$

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	4300	mm
Depth of section D	=	1800	mm
Clear cover	=	75	mm

Moment on the section	Moment at face of support		
	Combination (1)	Seismic Combi.	Combination (2)
Actual moment (KNm)	7833	5232	5667
Grade of Concrete	30	30	30
Grade of steel fy	500	500	500
b	4300	4300	4300
D	1800	1800	1800
c	75	75	75
d	1696.5	1696.5	1696.5
f_{cd}	13.40	13.40	13.40
f_{Yd}	435	435	435
$xu_{,lim}/d$	0.62	0.62	0.62
$R_{sls} = M_{u,sls}/bd2$	4.97	4.97	4.97
$M_{u,Lim}$ (KNm)	61560	61560	61560
	OK	**OK**	**OK**
Ast Req.	5445	3606	3911
Dia of bar (main tension) (mm)	25	25	25
Spacing (mm)	120	120	120
+ dia of bar (main tension) (mm)	25	25	25
Spacing (mm)	120	120	120
Ast provided (sq mm)	35179	35179	35179
Dia of bar(main compresion at top mm)	12	12	12
Spacing (mm)	120	120	120
Area of main compresion (mm^2)	4053	4053	4053
f_{ctm}	2.5	2.5	2.5
f_{yk}	435	435	435
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	10906	10906	10906
	OK	**OK**	**OK**
As.max = 0.025 Ac (main tension)	193500	193500	193500
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**	**OK**	**OK**
As.max = 0.04 Ac (tension + compresion)	309600	309600	309600
x (mm)	328	328	328
x/d	0.193	0.193	0.193
	OK	**OK**	**OK**
z (mm)	1560	1560	1560
MR (KNm)	47724	47724	47724
	OK	**OK**	**OK**
Shear on the section			
Actual shear V_{Ed} (KN)	5107	4670	3811
Actual shear stress (N/mm2)	0.700	0.640	0.522
Max shear capacity, 0.135 fck(1-fck/310)	3.66	3.66	3.66
	OK	**OK**	**OK**
Min shear capacity, 0.0924 fck(1-fck/310)	2.50	2.50	2.50
$\theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	5.52	5.04	4.11
Min angle of inclination, θ (deg)	21.8	21.8	21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.343	1.343	1.343
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			

V(min) = 0.031 K^(3/2) fck^(1/2)	0.264	0.286	0.286
cl. 10.3.1 of IRC :112-2011			
r1 = $A_{sl}/(b_w\ d)$ <= 0.02	0.005	0.005	0.005
	OK	**OK**	**OK**
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.362	0.362	0.362
Axial compressive force N_{Ed} (KN)	0.0	0	0.0
$_{Scp}$ = N_{Ed} / A_c <= 0.2 f_{cd}	0.0	0.0	0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d$ >=(V_{min} + 0.15 S_{cp}) b_w d (KN)	2638	2638	2638
	PROVIDE SHEAR R/F	**PROVIDE SHEAR R/F**	**PROVIDE SHEAR R/F**
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010			
n = 0.6 (1 - fck / 310)	0.542	0.542	0.542
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011			
0.5 b_w d n f_{cd}	26488	26488	26488
	OK	**OK**	**OK**
No. of Links for shear R/f (Distribution)	2	2	2
Dia. of bar for shear reinf.	16	16	16
S(mm)	200	200	200
^{A}SW1	402	402	402
	OK	**OK**	**OK**
No. of link for shear reinf.	8	8	8
Dia. of bar for shear reinf.	10	10	10
S = Asw x 0.9 x d x cot θ x fy / V_E	150	150	150
^{A}SW2	628	628	628
^{A}SW	1030	1030	1030
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011			
$S_{l.max}$ = 0.75 d	600	600	600
	OK	**OK**	**OK**
z (mm)	1560	1560	1560
^{f}ywd	435	435	435
cl. 10.3.3.2 Eq. 10.7 of IRC :112-2011			
$V_{Rd.s}$ = A_{SW} z f_{ywd} cot θ / S (KN)	11650	9427	9427
	OK	**OK**	**OK**
acw = (s_{cp} = N_{Ed} / A_c = 0)	1.0	1.0	1.0
ν_1	0.6	0.6	0.6
cl. 10.3.3.2 Eq. 10.8 of IRC :112-2011			
VRd.max = acw bw z n1 fcd (KN)	53935	53935	53935
	OK	**OK**	**OK**
cl. 10.3.3.2 Eq. 10.10 of IRC :112-2011			
ASW.max <= 0.5 acw n1 fcd bw S / fywd	5964	5964	5964
	OK	**OK**	**OK**
cl. 10.3.1 of IRC :112-2011			
rw = ASW/(S bw sina)	0.0016	0.0016	0.0016
cl. 10.3.3.5 of IRC :112-2011			
rw,min = (0.072 fck^0.5) / fyk	0.0009	0.0009	0.0009
	OK	**OK**	**OK**

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COMBINATION FOR DESIGN OF FOUNDATION & BASE PRESSURE (SLS)

Following load combinations are co As per Annex B of IRC:112-2011

1 Rare Combination

2 Quasi Permanent Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	DL	Dead Load (due to superstructure+substructure+found.	863	-202	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		190	-59	0	0	0
4	ABUT + RETURN WALL		30	-13	0	0	0
5	FDN		310	0	0	0	0
6	SOIL ABOVE FDN		98	-130	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	192	0	592	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	141	0	594	0	0
12	LL1B	Live Load Moment due to braking	3	75	0	34.26	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.08	0
14	LL3B	Live Load Moment due to braking	3	69	0	31.75	0
15	W1	Wind vertically down without LL	18	5	32	5.40	11.30
16	W2	Wind vertically up without LL	-18	5	32	5.40	11.30
17	W3	Wind vertically down with LL	18	49	32	5.53	11.30
18	W4	Wind vertically up with LL	-18	49	32	5.53	11.30
19	S1	Seimic	0	0	0	0	0
20	S2		0	0	0	0	0
21	S3		0	0	0	0	0
22	S4		0	0	0	0	0
23	HFL		-117	67	0	0.0	0.0
24	Active earth pressure LWL		0	78	0	53.5	0.0
25	LL surcharge LWL		0	64	0	37.1	0.0
26	Active earth pressure HFL		0	39	0	26.7	0.0
27	LL surcharge HFL		0	32	0	18.5	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0
29	LL surcharge LWL		0	0	0	0	0
30	Active earth pressure HFL		0	0	0	0	0
31	LL surcharge HFL		0	0	0	0	0

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	Rare Combination				**Quasi Permanent Combination**			
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)
DL	1.00	863	-184	-82	1.00	863	-184	-82
SIDL1	1.00	24	0	0	1.00	24	0	0
SIDL2	1.00	28	0	0	1.00	28	0	0
LL1	1.00	192	241	541	0.00	0	0	0
LL2	1.00	168	288	646	0.00	0	0	0
LL3	1.00	141	242	543	0.00	0	0	0
LL1B	1.00	3	68	30	0.00	0	0	0
LL2B	1.00	0	0	0	0.00	0	0	0
LL3B	1.00	3	63	28	0.00	0	0	0
W1	0.60	11	11	19	0.00	0	0	0
W2	0.60	-11	11	19	0.00	0	0	0
W3	0.60	11	35	29	0.00	0	0	0
W4	0.60	-11	35	29	0.00	0	0	0
S1	0.00	0	0	0	0.00	0	0	0
S2	0.00	0	0	0	0.00	0	0	0
S3	0.00	0	0	0	0.00	0	0	0
S4	0.00	0	0	0	0.00	0	0	0
HFL	1.00	-117	62	27	1.00	-117	62	27
EP	1.00	0	71	32	1.00	0	71	32
LL S.	0.80	0	47	21	0.00	0	0	0
EP HFL	1.00	0	35	16	1.00	0	35	16
LL.S.HFL	0.80	0	23	10	0.00	0	0	0

Case 1 Rare Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	916	-113	-51
Case 2 DL+SIDL1+SIDL2+LL1	1111	242	542
Case 3 DL+SIDL1+SIDL2+LL2	1084	221	616
Case 4 DL+SIDL1+SIDL2+LL3	1060	238	541
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	927	-103	-32
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1122	277	571
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1095	256	646
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1071	273	571
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	905	-103	-32
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1100	277	571
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1073	256	646
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1049	273	571
HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	799	-87	-39
Case 2 DL+SIDL1+SIDL2+LL1+HFL	994	245	543
Case 3 DL+SIDL1+SIDL2+LL2+HFL	967	224	618
Case 4 DL+SIDL1+SIDL2+LL3+HFL	944	241	543
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	810	-77	-20
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1005	280	572
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	978	258	647
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	955	276	572
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	788	-77	-20
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	983	280	572
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	956	258	647
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	933	276	572

MAXIMUM REACTION CASE	1122	277	571
MAXIMUM LONGITUDINAL MOMENT CASE	1005	280	572
MAXIMUM TRANSVERSE MOMENT CASE	978	258	647

Case 2 Quasi Permanent Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	916	-113	-51
Case 2 DL+SIDL1+SIDL2+LL1	916	-113	-51
Case 3 DL+SIDL1+SIDL2+LL2	916	-113	-51
Case 4 DL+SIDL1+SIDL2+LL3	916	-113	-51
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	916	-113	-51
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	916	-113	-51
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	916	-113	-51
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	916	-113	-51
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	916	-113	-51
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	916	-113	-51
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	916	-113	-51
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	916	-113	-51

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	799	-87	-39
Case 2 DL+SIDL1+SIDL2+LL1+HFL	799	-87	-39
Case 3 DL+SIDL1+SIDL2+LL2+HFL	799	-87	-39
Case 4 DL+SIDL1+SIDL2+LL3+HFL	799	-87	-39
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	799	-87	-39
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	799	-87	-39
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	799	-87	-39
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	799	-87	-39
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	799	-87	-39
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	799	-87	-39
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	799	-87	-39
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	799	-87	-39

MAXIMUM REACTION CASE	916	-113	-51
MAXIMUM LONGITUDINAL MOMENT CASE	799	-87	-39
MAXIMUM TRANSVERSE MOMENT CASE	799	-87	-39

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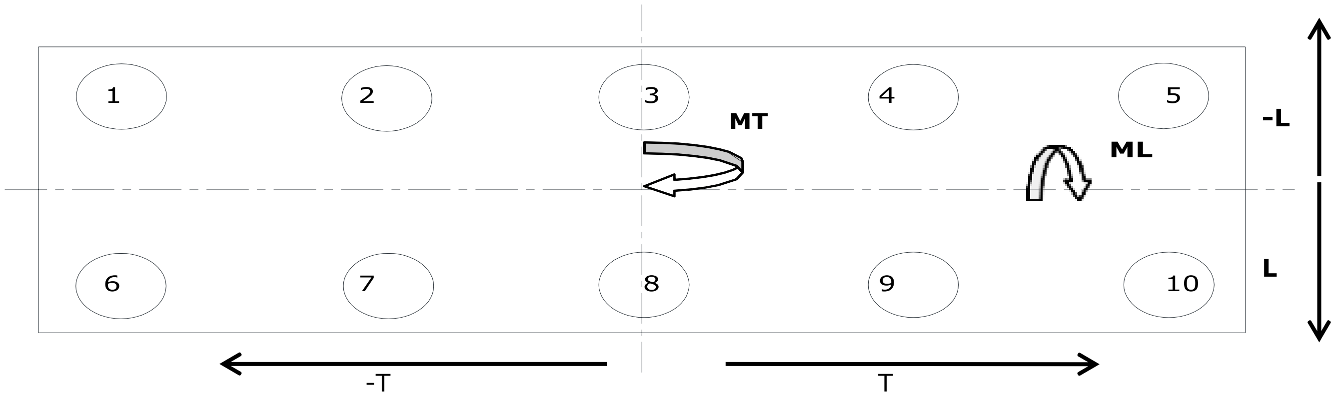
Load Calculations for Design of Pile (SLS)

	V	ML	MT
	t	t-m	t-m
Case 1	1122	277	571
Case 2	1005	280	572
Case 3	978	258	647
Case 4	916	-113	-51
Case 5	799	-87	-39
Case 6	799	-87	-39

Diameter of Pile = 1.200 m
Shift = 0.000 m

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_L2$	$_T2$	Z_L	Z_T
1	1.235	-7.881	1.526	62.116	73.021	-39.407
2	-0.368	-3.941	0.135	15.529	-245.437	-78.814
3	-1.970	0.000	3.882	0.000	-45.781	0.000
4	-3.573	3.941	12.768	15.529	-25.245	78.814
5	-5.176	7.881	26.791	62.116	-17.427	39.407
6	5.176	-7.881	26.791	62.116	17.427	-39.407
7	3.573	-3.941	12.768	15.529	25.245	-78.814
8	1.970	0.000	3.882	0.000	45.781	0.000
9	0.368	3.941	0.135	15.529	245.437	78.814
10	-1.235	7.881	1.526	62.116	-73.021	39.407

I_{LL} = **90.20** Sq.m
I_{TT} = **310.58** Sq.m

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Case 1

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift**		**Total**
				M_L/Z_L	**M_T/Z_T**	**Load**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**
1	112.2	3.8	-14.5	0.0	0.0	101.5
2	112.2	-1.1	-7.2	0.0	0.0	103.9
3	112.2	-6.1	0.0	0.0	0.0	106.2
4	112.2	-11.0	7.2	0.0	0.0	108.5
5	112.2	-15.9	14.5	0.0	0.0	110.8
6	112.2	15.9	-14.5	0.0	0.0	113.6
7	112.2	11.0	-7.2	0.0	0.0	116.0
8	112.2	6.1	0.0	0.0	0.0	118.3
9	112.2	1.1	7.2	0.0	0.0	120.6
10	112.2	-3.8	14.5	0.0	0.0	122.9

Case 2

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift**		**Total**
				M_L/Z_L	**M_T/Z_T**	**Load**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**
1	100.5	3.8	-14.5	0.0	0.0	89.9
2	100.5	-1.1	-7.3	0.0	0.0	92.2
3	100.5	-6.1	0.0	0.0	0.0	94.4
4	100.5	-11.1	7.3	0.0	0.0	96.7
5	100.5	-16.0	14.5	0.0	0.0	99.0
6	100.5	16.0	-14.5	0.0	0.0	102.1
7	100.5	11.1	-7.3	0.0	0.0	104.4
8	100.5	6.1	0.0	0.0	0.0	106.7
9	100.5	1.1	7.3	0.0	0.0	108.9
10	100.5	-3.8	14.5	0.0	0.0	111.2

Case 3

Pile No.	**P_T / N**	**M_L / Z_L**	**M_T / Z_T**	**Due to Shift**		**Total**
				M_L/Z_L	**M_T/Z_T**	**Load**
	(T)	**(T)**	**(T)**	**(T)**	**(T)**	**(T)**
1	97.8	3.5	-16.4	0.0	0.0	84.9
2	97.8	-1.1	-8.2	0.0	0.0	88.6
3	97.8	-5.6	0.0	0.0	0.0	92.2
4	97.8	-10.2	8.2	0.0	0.0	95.8
5	97.8	-14.8	16.4	0.0	0.0	99.4
6	97.8	14.8	-16.4	0.0	0.0	96.2
7	97.8	10.2	-8.2	0.0	0.0	99.8
8	97.8	5.6	0.0	0.0	0.0	103.5
9	97.8	1.1	8.2	0.0	0.0	107.1
10	97.8	-3.5	16.4	0.0	0.0	110.7

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Case 4

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	91.6	-1.6	1.3	0.0	0.0	91.3
2	91.6	0.5	0.6	0.0	0.0	92.7
3	91.6	2.5	0.0	0.0	0.0	94.0
4	91.6	4.5	-0.6	0.0	0.0	95.4
5	91.6	6.5	-1.3	0.0	0.0	96.8
6	91.6	-6.5	1.3	0.0	0.0	86.3
7	91.6	-4.5	0.6	0.0	0.0	87.7
8	91.6	-2.5	0.0	0.0	0.0	89.1
9	91.6	-0.5	-0.6	0.0	0.0	90.5
10	91.6	1.6	-1.3	0.0	0.0	91.8

Case 5

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	79.9	-1.2	1.0	0.0	0.0	79.7
2	79.9	0.4	0.5	0.0	0.0	80.7
3	79.9	1.9	0.0	0.0	0.0	81.8
4	79.9	3.5	-0.5	0.0	0.0	82.9
5	79.9	5.0	-1.0	0.0	0.0	83.9
6	79.9	-5.0	1.0	0.0	0.0	75.9
7	79.9	-3.5	0.5	0.0	0.0	76.9
8	79.9	-1.9	0.0	0.0	0.0	78.0
9	79.9	-0.4	-0.5	0.0	0.0	79.0
10	79.9	1.2	-1.0	0.0	0.0	80.1

Case 6

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	79.9	-1.2	1.0	0.0	0.0	79.7
2	79.9	0.4	0.5	0.0	0.0	80.7
3	79.9	1.9	0.0	0.0	0.0	81.8
4	79.9	3.5	-0.5	0.0	0.0	82.9
5	79.9	5.0	-1.0	0.0	0.0	83.9
6	79.9	-5.0	1.0	0.0	0.0	75.9
7	79.9	-3.5	0.5	0.0	0.0	76.9
8	79.9	-1.9	0.0	0.0	0.0	78.0
9	79.9	-0.4	-0.5	0.0	0.0	79.0
10	79.9	1.2	-1.0	0.0	0.0	80.1

Moment on pile =	3.689 Q					
	Rare Combination			Quasi Permanent Combination		
	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)
MAX	**122.92**	13	46	**96.80**	5	20
MIN	**84.95**	8	31	**75.86**	3	10

Moments & shear force for pile cap

Width of abut.	=	1.00	m
Length of Abutment	=	16.00	m
Dia. Of pile	=	1.20	m
Length of Pile cap	=	16.00	m
Width of Pile cap	=	4.30	m
Thickness of pile cap	=	1.80	m
Unit wt. of concrete	=	2.50	t/m^3
Unit wt. of Soil	=	2.00	t/m^3
Thickness of soil above pile cap	=	1.19	m
Downward force & moment due to pile cap		1.20	0.00

Transverse direction	**L**	**B**	**H**	**Unit Weight**	**Load (t)**	**Moment (t.m)**
Self wt. of pile cap	0.00	4.30	1.80	2.50	0.00	0.00
Wt. due to soil	0.00	4.30	1.19	2.00	0.00	0.00
Longitudinal direction	**L**	**B**	**H**	**Unit Weight**	**Load (t)**	**Moment (t.m)**
Self wt. of pile cap	1.65	16.00	1.80	2.50	118.80	98.01
Wt. due to soil	1.65	16.00	1.19	2.00	62.94	51.92

DIRECTION	**Rare Combination**			**Quasi Permanent Combination**		
	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)
LL	570	24 /m	33 /m	471	18 /m	26 /m
TT	463	108 /m	/m	375	87 /m	/m
Max	570	463	534	471	375	415

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SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	Rare Combination
	f_{cd}	=	14.40	N/mm^2	Frequent Combination
	f_{cd}	=	10.80	N/mm^2	Quasi Permanent Comb.
	E_c	=	31000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	300.00	N/mm^2	Rare Combination
	f_{Yd}	=	300.00	N/mm^2	Frequent Combination
	f_{Yd}	=	300.00	N/mm^2	Quasi Permanent Comb.

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.5*fcd*(xu_{lim}/d)*(1-0.33*xu_{lim}/d)$

	Rare Combination	Frequent Combination	Quasi Perm.
$xu_{,lim}/d$	0.70	0.70	0.70
$R_{lim} = M_{u,Lim}/bd^2$	3.86	3.86	2.90

Here R_{lim} is in MPa

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b = 16000 mm

Depth of section D = 4300 mm

Clear cover = 75 mm

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
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Moment on the section	**Moment at face of support**		
	Rare Combination		**Quasi Permanent Combination**
Actual moment (KNm)	5239		4071
Grade of Concrete	30		30
Grade of steel fy	500		500
b	16000		16000
D	4300		4300
c	75		75
d	4212.5		4212.5
f_{cd}	14.40		10.80
f_{Yd}	300		300
$x_{u,lim}/d$	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.86		2.90
$M_{u,Lim}$ (KNm)	1097077		822807
	OK		**OK**
Ast Req.	4149		3224
Dia of bar (main tension) (mm)	25		25
Spacing (mm)	120		120
+ dia of bar (main tension) (mm)	25		25
Spacing (mm)	120		120
Ast provided (sq mm)	8181		8181
Dia of bar(main compresion at top mm)	12		12
Spacing (mm)	120		120
Area of main compresion (mm^2)	15080		15080
f_{ctm}	2.5		2.5
x (mm)	21		28
x/d	0.005		0.007
	OK		**OK**
z (mm)	4205		4203
MR (KNm)	10322		10316
	OK		**OK**
$\sigma_{sc} = M/(A_s z)$	152		118
	OK		**OK**
$\sigma_{ca} = M/(0.5 z b x_u)$	7.31		4.26
	OK		**OK**

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Calculation of crack width	**Moment at face of support**		
n_1	8		8
n_2	8		8
$\phi_{eq} = (n_1 \phi_1^2 + n_2 \phi_2^2) / (n_1 \phi_1 + n_2 \phi_2)$	25		25
cl. 12.3.4 (3) of IRC :112-2011			
c	50		50
k1	0.2		0.2
k2	0.5		0.5
For skew slab refer eq. 12.10 of IRC :112-2011			
$\rho_{p.eff} = A_s / A_{c,eff}$	0.002		0.002
$S_{r,max} = \{ 3.4\, c + (0.425\, k_1 k_2 \phi) / \rho_{p.eff} \}$	625		625
cl. 12.3.4 (3) of IRC :112-2011			
k_t	0.5		0.5
$f_{ct,eff}$	2.90		2.90
E_s	200000		200000
E_{cm}	31000		31000
$\alpha_e = E_s / E_{cm}$	6.45		6.45
$(\varepsilon_{sm} - \varepsilon_{cm}) = (\sigma_{sc} - k_t f_{ct,eff} (1 + \alpha_e \rho_{p,eff}) / \rho_{p,eff}) / E_s$	0.0005		0.0004
cl. 12.3.4 (2) of IRC :112-2011			
$W_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$	0.20		0.22
cl. 12.3.4 (1) of IRC :112-2011			
	OK		**OK**

CHECK FOR SAFETY OF SECTION OF PILE

		Unit	Rare Combination		Quasi Permanent	
			Max.	**Min.**	**Max.**	**Min.**
Loads	P	KN	1229	849	968	759
Moments	M	KNm	464	307	197	99
Dia of Section	D	mm	1200	1200	1200	1200
Radius of Section	R	mm	600	600	600	600
Effective Cover	C	mm	100	100	100	100
Effective Radius	R-C	mm	500	500	500	500
Modular Ratio	m		9.3333333	9.3333333	9.3333333	9.3333333
No. of Bars		Nos.	28	28	28	28
Dia of Bar		mm	25	25	25	25
+No of Bars		Nos.	28	28	28	28
+No of Bars		mm	25	25	25	25
Area of Steel	Ast	mm2	2.33E+04	2.33E+04	2.33E+04	2.33E+04
Area of Section	Ac	mm2	1.13E+06	1.13E+06	1.13E+06	1.13E+06
% of Steel	p	%	2.06	2.06	2.06	2.06
Net Area of Concrete	Anet	mm2	1.11E+06	1.11E+06	1.11E+06	1.11E+06
Transformed Area		mm2	1.32E+06	1.32E+06	1.32E+06	1.32E+06
Transformed MI		mm4	1.50E+11	1.50E+11	1.50E+11	1.50E+11
Section Modulus		mm3	2.50E+08	2.50E+08	2.50E+08	2.50E+08
Actual Stress						
P/A	$\sigma_{cc,cal}$	Mpa	0.93	0.64	0.73	0.57
M/Z	$\sigma_{cbc,cal}$	Mpa	1.85	1.22	0.79	0.39
Permissible Stress						
	σ_{cc}	Mpa	7.5	7.5	7.5	7.5
	σ_{cbc}	Mpa	10.00	10.00	10.00	10.00
Check for safety of Section						
	$\frac{\sigma_{cc,cal}}{\sigma_{cc}} + \frac{\sigma_{cbc,cal}}{\sigma_{cbc}}$	Mpa	0.31	0.21	0.18	0.12
			ok	ok	ok	ok
Check for Cracked/Uncracked Section						
	$\sigma_{cc,cal}$ - $\sigma_{cbc,cal}$	Mpa	-0.93	-0.58	-0.06	0.18
Permissible Tensile Stress in concrete		Mpa	-3.83	-3.83	-3.83	-3.83
Section is to be designed as			**UNCRACKED**	**CRACKED**	**CRACKED**	**CRACKED**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode..	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

COMBINATION FOR DESIGN OF ABUTMENT (ULS)

Following load combinations are con As per Annex B of IRC:112-2011

1 Basic Combination

2 Seismic Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	Dead Load (due to superstructure+substructure+foundation		446	-59	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		190	-59	0	0	0
4	ABUT + RETURN WALL		20	0	0	0	0
5	FDN		0	0	0	0	0
6	SOIL ABOVE FDN		0	0	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	192	0	592	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	141	0	594	0	0
12	LL1B	Live Load Moment due to braking	3	37	0	34.26	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.09	0
14	LL3B	Live Load Moment due to braking	3	34	0	31.75	0
15	W1	Wind vertically down without LL	18	4	19	5.40	11.30
16	W2	Wind vertically up without LL	-18	4	19	5.40	11.30
17	W3	Wind vertically down with LL	18	39	19	5.53	11.30
18	W4	Wind vertically up with LL	-18	39	19	5.53	11.30
19	S1	Seimic	44	99	6	66.0	0
20	S2		44	2	103	0.0	66.0
21	S3		-44	99	6	66.0	0
22	S4		-44	2	103	0.0	66.0
23	HFL		-4	0	0	0.0	0.0
24	Active earth pressure LWL		0	24	0	24.7	0.0
25	LL surcharge LWL		0	30	0	25.2	0.0
26	Active earth pressure HFL		0	12	0	12.3	0.0
27	LL surcharge HFL		0	15	0	12.6	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0.0
29	LL surcharge LWL		0	0	0	0	0.0
30	Active earth pressure HFL		0	0	0	0	0.0
31	LL surcharge HFL		0	0	0	0	0.0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode..	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

	Basic Combination					**Seismic Combination**			
	PSF	P (t)	ML (tm)	MT (tm)		PSF	P (t)	ML (tm)	MT (tm)
DL	1.35	603	-73	-33		1.35	603	-73	-33
SIDL1	1.75	43	0	0		1.75	43	0	0
SIDL2	1.35	38	0	0		1.35	38	0	0
LL1	1.50	288	361	811		0.20	38	48	108
LL2	1.50	252	431	969		0.20	34	58	129
LL3	1.50	212	363	814		0.20	28	48	109
LL1B	1.50	5	50	22		0.20	1	7	3
LL2B	1.50	0	0	0		0.20	0	0	0
LL3B	1.50	5	47	21		0.20	1	6	3
W1	0.90	17	10	17		0.00	0	0	0
W2	0.90	-17	10	17		0.00	0	0	0
W3	0.90	17	39	30		0.00	0	0	0
W4	0.90	-17	39	30		0.00	0	0	0
S1	0.00	0	0	0		1.50	66	139	69
S2	0.00	0	0	0		1.50	66	65	142
S3	0.00	0	0	0		1.50	-66	139	69
S4	0.00	0	0	0		1.50	-66	65	142
HFL	1.00	-4	0	0		1.00	-4	0	0
EP	1.00	0	22	10		1.00	0	22	10
LL S.	1.20	0	32	14		0.20	0	5	2
EP HFL	1.00	0	11	5		1.00	0	11	5
LL.S.HFL	1.20	0	16	7		0.20	0	3	1
Active earth pressure LWL					Dynamic incr. in earth press.(Seismic)	1.00	0	0	0
LL surcharge LWL						0.20	0	0	0
Active earth pressure HFL						1.00	0	0	0
LL surcharge HFL						0.20	0	0	0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
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Case 1 **Basic Combination**

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	683	-51	-23
Case 2	DL+SIDL1+SIDL2+LL1	976	393	825
Case 3	DL+SIDL1+SIDL2+LL2	935	413	961
Case 4	DL+SIDL1+SIDL2+LL3	900	391	827
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	699	-41	-5
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	993	432	856
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	952	452	991
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	917	430	857
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	666	-41	-5
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	960	432	856
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	919	452	991
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	883	430	857
HFL CASE				
Case 1	DL+SIDL1+SIDL2+HFL	679	-62	-28
Case 2	DL+SIDL1+SIDL2+LL1+HFL	972	366	813
Case 3	DL+SIDL1+SIDL2+LL2+HFL	931	385	949
Case 4	DL+SIDL1+SIDL2+LL3+HFL	896	363	815
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	695	-52	-10
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	989	405	843
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	948	424	979
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	913	402	845
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	662	-52	-10
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	956	405	843
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	915	424	979
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	879	402	845

MAXIMUM REACTION CASE	993	432	856
MAXIMUM LONGITUDINAL MOMENT CASE	952	452	991
MAXIMUM TRANSVERSE MOMENT CASE	952	452	991

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
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Case 2 **Seismic Combination**

Load Case		Factored Forces/Moments		
		V	ML	MT
Normal		t	t-m	t-m
Downward seismic in longitudinal direction				
Case 1	DL+SIDL1+SIDL2+ seismic	749	88	46
Case 2	DL+SIDL1+SIDL2+LL1+ seismic	788	148	160
Case 3	DL+SIDL1+SIDL2+LL2+ seismic	783	151	178
Case 4	DL+SIDL1+SIDL2+LL3+ seismic	778	148	160
Downward seismic in transverse direction				
Case 5	DL+SIDL1+SIDL2+ seismic	749	14	120
Case 6	DL+SIDL1+SIDL2+LL1+ seismic	788	75	233
Case 7	DL+SIDL1+SIDL2+LL2+ seismic	783	77	251
Case 8	DL+SIDL1+SIDL2+LL3+ seismic	778	74	233
Upward seismic in longitudinal direction				
Case 9	DL+SIDL1+SIDL2+ seismic	617	88	46
Case 10	DL+SIDL1+SIDL2+LL1+ seismic	656	148	160
Case 11	DL+SIDL1+SIDL2+LL2+ seismic	651	151	178
Case 12	DL+SIDL1+SIDL2+LL3+ seismic	646	148	160
Upward seismic in transverse direction				
Case 13	DL+SIDL1+SIDL2+ seismic	617	14	120
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	656	75	233
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	651	77	251
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	646	74	233

HFL CASE

Downward seismic in longitudinal direction				
Case 1	DL+SIDL1+SIDL2+ seismic	745	77	41
Case 2	DL+SIDL1+SIDL2+LL1+ seismic	784	134	153
Case 3	DL+SIDL1+SIDL2+LL2+ seismic	779	137	172
Case 4	DL+SIDL1+SIDL2+LL3+ seismic	774	134	154
Downward seismic in transverse direction				
Case 5	DL+SIDL1+SIDL2+ seismic	745	3	115
Case 6	DL+SIDL1+SIDL2+LL1+ seismic	784	61	227
Case 7	DL+SIDL1+SIDL2+LL2+ seismic	779	63	245
Case 8	DL+SIDL1+SIDL2+LL3+ seismic	774	60	227
Upward seismic in longitudinal direction				
Case 9	DL+SIDL1+SIDL2+ seismic	613	77	41
Case 10	DL+SIDL1+SIDL2+LL1+ seismic	652	134	153
Case 11	DL+SIDL1+SIDL2+LL2+ seismic	647	137	172
Case 12	DL+SIDL1+SIDL2+LL3+ seismic	642	134	154
Upward seismic in transverse direction				
Case 13	DL+SIDL1+SIDL2+ seismic	613	3	115
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	652	61	227
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	647	63	245
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	642	60	227

MAXIMUM REACTION CASE	788	148	160
MAXIMUM LONGITUDINAL MOMENT CASE	783	151	178
MAXIMUM TRANSVERSE MOMENT CASE	783	77	251

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

COMBINATION FOR DESIGN OF ABUTMENT (SLS)

Following load combinations are conAs per Annex B of IRC:112-2011

1 Rare Combination

2 Quasi Permanent Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	DL	Dead Load (due to superstructure+substructure+found.	446	-59	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		190	-59	0	0	0
4	ABUT + RETURN WALL		20	0	0	0	0
5	FDN		0	0	0	0	0
6	SOIL ABOVE FDN		0	0	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	192	0	592	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	141	0	594	0	0
12	LL1B	Live Load Moment due to braking	3	37	0	34.26	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.09	0
14	LL3B	Live Load Moment due to braking	3	34	0	31.75	0
15	W1	Wind vertically down without LL	18	4	19	5.40	11.30
16	W2	Wind vertically up without LL	-18	4	19	5.40	11.30
17	W3	Wind vertically down with LL	18	39	19	5.53	11.30
18	W4	Wind vertically up with LL	-18	39	19	5.53	11.30
19	S1	Seimic	0	0	0	0	0
20	S2		0	0	0	0	0
21	S3		0	0	0	0	0
22	S4		0	0	0	0	0
23	HFL		-4	0	0	0	0
24	Active earth pressure LWL		0	24	0	24.7	0.0
25	LL surcharge LWL		0	30	0	25.2	0.0
26	Active earth pressure HFL		0	12	0	12.3	0.0
27	LL surcharge HFL		0	15	0	12.6	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0
29	LL surcharge LWL		0	0	0	0	0
30	Active earth pressure HFL		0	0	0	0	0
31	LL surcharge HFL		0	0	0	0	0

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Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

	Rare Combination				**Quasi Permanent Combination**			
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)
DL	1.00	446	-54	-24	1.00	446	-54	-24
SIDL1	1.00	24	0	0	1.00	24	0	0
SIDL2	1.00	28	0	0	1.00	28	0	0
LL1	1.00	192	241	541	0.00	0	0	0
LL2	1.00	168	288	646	0.00	0	0	0
LL3	1.00	141	242	543	0.00	0	0	0
LL1B	1.00	3	34	15	0.00	0	0	0
LL2B	1.00	0	0	0	0.00	0	0	0
LL3B	1.00	3	31	14	0.00	0	0	0
W1	0.60	11	7	12	0.00	0	0	0
W2	0.60	-11	7	12	0.00	0	0	0
W3	0.60	11	26	20	0.00	0	0	0
W4	0.60	-11	26	20	0.00	0	0	0
S1	0.00	0	0	0	0.00	0	0	0
S2	0.00	0	0	0	0.00	0	0	0
S3	0.00	0	0	0	0.00	0	0	0
S4	0.00	0	0	0	0.00	0	0	0
HFL	1.00	-4	0	0	1.00	-4	0	0
EP	1.00	0	22	10	1.00	0	22	10
LL S.	0.80	0	22	10	0.00	0	0	0
EP HFL	1.00	0	11	5	1.00	0	11	5
LL.S.HFL	0.80	0	11	5	0.00	0	0	0
Active earth pressure LWL	Dynamic incr. in earth press.(Seismic)				1.00	0	0	0
LL surcharge LWL					0.20	0	0	0
Active earth pressure HFL					1.00	0	0	0
LL surcharge HFL					0.20	0	0	0

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Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Case 1 Rare Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	499	-32	-14
Case 2 DL+SIDL1+SIDL2+LL1	694	264	551
Case 3 DL+SIDL1+SIDL2+LL2	667	277	641
Case 4 DL+SIDL1+SIDL2+LL3	643	262	552
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	510	-25	-3
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	705	290	571
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	678	303	661
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	654	288	572
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	488	-25	-3
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	683	290	571
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	656	303	661
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	632	288	572

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	495	-43	-19
Case 2 DL+SIDL1+SIDL2+LL1+HFL	690	242	541
Case 3 DL+SIDL1+SIDL2+LL2+HFL	663	255	632
Case 4 DL+SIDL1+SIDL2+LL3+HFL	639	240	542
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	506	-36	-8
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	701	268	561
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	674	281	652
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	650	267	562
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	484	-36	-8
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	679	268	561
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	652	281	652
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	628	267	562

MAXIMUM REACTION CASE	705	290	571
MAXIMUM LONGITUDINAL MOMENT CASE	678	303	661
MAXIMUM TRANSVERSE MOMENT CASE	678	303	661

Case 2 Quasi Permanent Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	499	-32	-14
Case 2 DL+SIDL1+SIDL2+LL1	499	-32	-14
Case 3 DL+SIDL1+SIDL2+LL2	499	-32	-14
Case 4 DL+SIDL1+SIDL2+LL3	499	-32	-14
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	499	-32	-14
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	499	-32	-14
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	499	-32	-14
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	499	-32	-14
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	499	-32	-14
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	499	-32	-14
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	499	-32	-14
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	499	-32	-14

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	495	-43	-19
Case 2 DL+SIDL1+SIDL2+LL1+HFL	495	-43	-19
Case 3 DL+SIDL1+SIDL2+LL2+HFL	495	-43	-19
Case 4 DL+SIDL1+SIDL2+LL3+HFL	495	-43	-19
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	495	-43	-19
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	495	-43	-19
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	495	-43	-19
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	495	-43	-19
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	495	-43	-19
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	495	-43	-19
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	495	-43	-19
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	495	-43	-19

MAXIMUM REACTION CASE	499	-32	-14
MAXIMUM LONGITUDINAL MOMENT CASE	499	-32	-14
MAXIMUM TRANSVERSE MOMENT CASE	499	-32	-14

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

CALCULATION OF DIRT WALL FORCES

Height of dirt wall	1.35	m
Thickness of dirt wall	0.3	m
Thickness of approach slab	0.3	m
Thickness of wearing coat on approach slab	0.075	m
Unit wt. of soil	2.00	t/m3
Unit wt. of concrete	2.50	t/m3
Unit wt. of wearing coat	2.20	t/m3
Earth Pressure considered	Y	
Coefficient of active earth pressure	0.279	
Live load surcharge	1.2	m
Active earth pressure	0.75	t/m^2 per meter
Pressure due to live load surcharge	0.67	t/m^2 per meter
Force due to live load surcharge	0.91	t per meter
Force due to active earth pressure	0.51	t per meter
Moment due to live load surcharge	0.61	t.m
Moment due to active earth pressure Ignoring vertical load	0.29	t.m

	unit	actual value	ULS basic PSF	ULS basic Comb.	SLS Rare PSF	SLS Rare comb.	SLS Quasi permanent	SLS Quasi permanent
Moment due to live load surcharge	t.m per meter	0.61	1.20	0.73	0.80	0.49	0.00	0.00
Moment due to active earth pressure	t.m per meter	0.29	1.50	0.43	1.00	0.29	1.00	0.29
	t.m per meter			**1.17**		**0.78**		**0.29**
Force due to live load surcharge	t per meter	0.91	1.20	1.09	0.80	0.72	0.00	0.00
Force due to active earth pressure	t per meter	0.51	1.50	0.76	1.00	0.51	1.00	0.51
	t per meter			**1.85**		**1.23**		**0.51**

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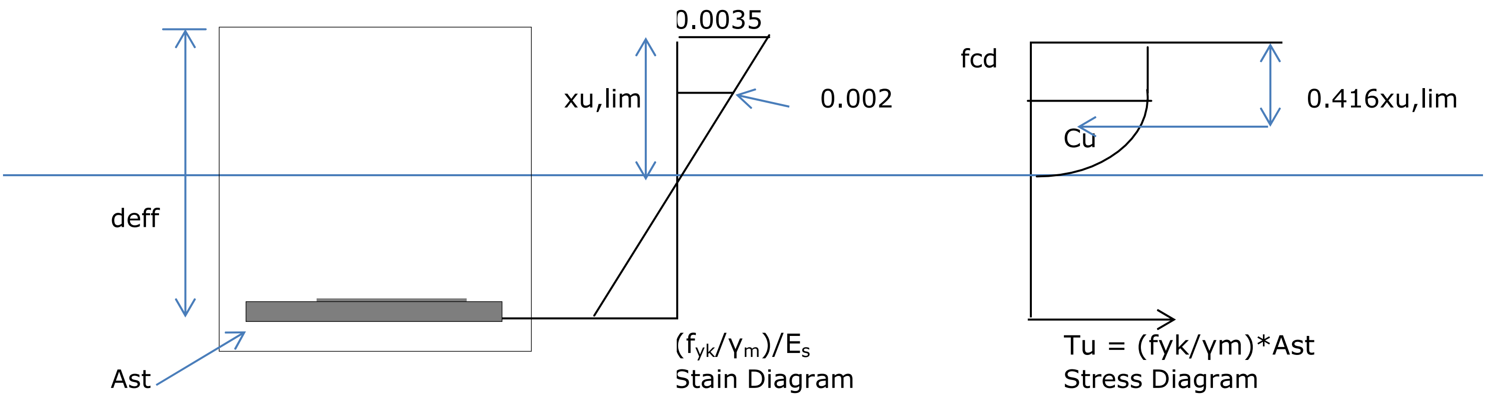
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR DIRT WALL



ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	13.40	N/mm^2	Basic Combination
	f_{cd}	=	16.75	N/mm^2	Accidental Combination
	f_{cd}	=	13.40	N/mm^2	Seismic Combination
	E_c	=	31000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	435	N/mm^2	Basic Combination
	f_{Yd}	=	500.00	N/mm^2	Accidental Combination
	f_{Yd}	=	435	N/mm^2	Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = $fcd*b*(3/7xu_{,lim} + 2/3*4/7xu_{,lim})$

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.8095fcd*(xu_{lim}/d)*(1-0.416*xu_{lim}/d)$

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	mm

Moment on the section	**Moment at face of support**		
	Basic Combination		
Actual moment (KNm)	11		
Grade of Concrete	30		
Grade of steel fy	500		
b	1000		
D	300		
c	50		
d	234.0		
f_{cd}	13.40		
f_{Yd}	435		
$x_{u,lim}/d$	0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97		
$M_{u,Lim}$ (KNm)	272		
	OK		
Ast Req.	113		
Dia of bar (main tension) (mm)	16		
Spacing (mm)	150		
+ dia of bar (main tension) (mm)	0		
Spacing (mm)	150		
Ast provided (sq mm)	1340		
Dia of bar(main compresion at top mm)	12		
Spacing (mm)	150		
Area of main compresion (mm^2)	754		
f_{ctm}	2.5		
f_{yk}	435		
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	350		
	OK		
As.max = 0.025 Ac (main tension)	7500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**		
As.max = 0.04 Ac (tension + compresion)	12000		
x (mm)	54		
x/d	0.230		
	OK		
z (mm)	212		
MR (KNm)	123		
	OK		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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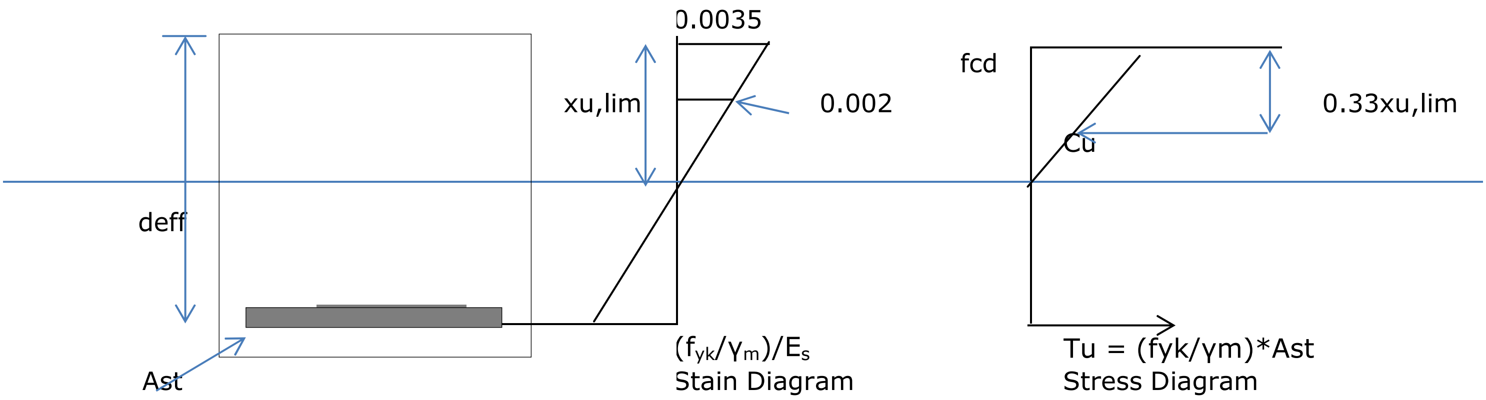
Shear on the section

Actual shear V_{Ed} (KN)	18		
Actual shear stress (N/mm2)	0.078		
Max shear capacity, 0.135 fck(1-fck/310)	3.66		
	OK		
Min shear capacity, 0.0924 fck(1-fck/310)	2.50		
$\theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	0.61		
Min angle of inclination, θ (deg)	21.8		
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.925		
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
V(min) = 0.031 K^(3/2) fck^(1/2)	0.453		
cl. 10.3.1 of IRC :112-2011			
$r1 = A_{sl}/(b_w\ d) <= 0.02$	0.006		
	OK		
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.548		
Axial compressive force N_{Ed} (KN)	0.0		
$_{Scp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d >= (V_{min} + 0.15\ S_{cp})\ b_w\ d$ (KN)	128		
	NO SHEAR R/F REQ.		
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010			
n = 0.6 (1 - fck / 310)	0.542		
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011			
$0.5\ b_w\ d\ n\ f_{cd}$	850		
	OK		
No. of Links for shear R/f (Distribution)	0		
Dia. of bar for shear reinf.	10		
S(mm)	150		
$^{A}SW1$	0		
	OK		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF SERVICEABILITY LIMIT STATE FOR DIRT WALL



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	14.40	N/mm^2	Rare Combination
	f_{cd}	=	14.40	N/mm^2	Frequent Combination
	f_{cd}	=	10.80	N/mm^2	Quasi Permanent Comb.
	E_c	=	31000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	300.00	N/mm^2	Rare Combination
	f_{Yd}	=	300.00	N/mm^2	Frequent Combination
	f_{Yd}	=	300.00	N/mm^2	Quasi Permanent Comb.

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.5*fcd*(xu_{lim}/d)*(1-0.33*xu_{lim}/d)$

	Rare Combination	Frequent Combination	Quasi Perm.
$xu_{,lim}/d$	0.70	0.70	0.70
$R_{lim} = M_{u,Lim}/bd^2$	3.86	3.86	2.90

Here R_{lim} is in MPa

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	mm

Moment on the section	**Moment at face of support**		
	Rare Combination		**Quasi Permanent Combination**
Actual moment (KNm)	8		3
Grade of Concrete	30		30
Grade of steel fy	500		500
b	1000		1000
D	300		300
c	50		50
d	234.0		234.0
f_{cd}	14.40		10.80
f_{Yd}	300		300
$xu_{,lim}/d$	0.70		0.70
$R_{sls} = M_{u,sls}/bd2$	3.86		2.90
$M_{u,Lim}$ (KNm)	212		159
	OK		**OK**
Ast Req.	109		40
Dia of bar (main tension) (mm)	16		16
Spacing (mm)	150		150
+ dia of bar (main tension) (mm)	0		0
Spacing (mm)	150		150
Ast provided (sq mm)	1340		1340
Dia of bar(main compresion at top mm)	12		12
Spacing (mm)	150		150
Area of main compresion (mm^2)	754		754
f_{ctm}	2.5		2.5
x (mm)	56		74
x/d	0.239		0.318
	OK		**OK**
z (mm)	215		209
MR (KNm)	87		84
	OK		**OK**
$\sigma_{sc} = M/(A_s z)$	26		10
	OK		**OK**
$\sigma_{ca} = M/(0.5 z b x_u)$	1.27		0.36
	OK		**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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Calculation of crack width	**Moment at face of support**		
n_1	7		7
n_2	7		7
$\phi_{eq} = (n_1 \phi_1^2 + n_2 \phi_2^2) / (n_1 \phi_1 + n_2 \phi_2)$	16		16
cl. 12.3.4 (3) of IRC :112-2011			
c	50		50
k1	0.8		0.8
k2	0.5		0.5
For skew slab refer eq. 12.10 of IRC :112-2011			
$\rho_{p.eff} = A_s / A_{c,eff}$	0.009		0.009
$S_{r,max} = \{ 3.4\ c + (0.425\ k_1\ k_2\ \phi) / \rho_{p.eff} \}$	474		474
cl. 12.3.4 (3) of IRC :112-2011			
k_t	0.5		0.5
$f_{ct,eff}$	2.90		2.90
E_s	200000		200000
E_{cm}	31000		31000
$\alpha_e = E_s / E_{cm}$	6.45		6.45
$(\varepsilon_{sm} - \varepsilon_{cm}) = (\sigma_{sc} - k_t\ f_{ct,eff} (1 + \alpha_e\ \rho_{p,eff}) / \rho_{p,eff}) / E_s$	0.0001		0.0000
cl. 12.3.4 (2) of IRC :112-2011			
$W_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$	0.04		0.01
cl. 12.3.4 (1) of IRC :112-2011			
	OK		**OK**

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APPENDEX - I

Fundamental Time Period of Vibration due to Seismic Waves :

According to **Annexure D (Clause 219.5)** IRC 6 :2017 -

T = 2.0 x sqrt(D/(1000*F))

Where,

T = Fundamental Time Period Of Vibration

D = Appropriate dead Load of the superstructure and Live load in KN

F = Horizontal Force in KN required to be applied at the centre of mass of superstructure for 1 mm horizontal deflection at the top of the 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 Longitudinal direction

			Longitudinal Direction		Transverse Direction	
	F	=	$d*(3EI)/L^3$	Unit	$d*(3EI)/L^3$	Unit
	d	=	0.001	m	0.001	m
	L	=	1.608	m	2.158	m
	E	=	3.10E+07	KN/m2	3.10E+07	KN/m2
	I	=	1.000	m4	256.000	m4
	F	=	22367.880	KN	2369019.267	KN
	D	=	2829.000	KN	3206.109	KN
	T	**=**	***0.02***	***sec***	***0.00***	***sec***
Seismic Zone		=	III		III	
Zone Factor Z		=	0.16		0.16	
Importance Factor I		=	1.2		1.2	
Response Reduction Factor		=	3		3	
Soil Strata		=	Type II	Medium soil		
Sa/g			2.5		2.5	
Horizontal Acceleration Coefficient (Ah) Z/2*Sa/g*I/R		=	0.08		0.08	

APPENDEX - II DESIGN CURVE OF PILE SHAFT FOR MAXIMUM BENDING MOMENTS

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Project	NHIDCL	Checked by:	RJ
Project	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

SLENDERNESS CHECK AND CHECK FOR SECOND ORDER EFFECTS

Slenderness check as per IRC 112,Cl.8.3.2

lx/ly <=2.0 & ly/lx <=2.0					as per eq. 8.1	
$(e_x / h_{eq}) / (e_y / b_{eq}) <= 0.20$			OR		as per eq. 8.2	
$(e_y / b_{eq}) / (e_x / h_{eq}) <= 0.20$				From table 11.1:IRC 112		
lex	=	13019.71 mm	ley	=	13019.71 mm	
Ixx	=	1.0E+11 mm4	Iyy	=	1.0E+11 mm4	
A	=	1130973 mm2	A	=	1130973 mm2	
$i_y=\sqrt{I/A}$	=	300.0 mm	$i_x=\sqrt{I/A}$	=	300.0 mm	Radius of gyration
b_{eq}	=	86.6 mm	h_{eq}	=	86.6 mm	
l_x	=	43.40	l_y	=	43.40	

Check for Slenderness

1.0	l_x / l_y	**=**	**1.00**	**<=2**	Condition Satisfied	from eq 8.1 IRC 112
	l_y / l_x	**=**	**1.00**	**<=2**	Condition Satisfied	

2.0	Design Cases		Case-1	Case-2	Case-3	Case-4	from eq 8.2 IRC 112
	e_x	=	348.26	447.4	385.7	423.4	
	e_y	=	348.26	447.4	385.7	423.4	
	$(e_x/h_{eq}) / (e_y/b_{eq})$	=	1.00	1.00	1.00	1.00	
	$(e_y/b_{eq}) / (e_x/h_{eq})$	=	1.00	1.00	1.00	1.00	

Hence Check for Bending is required

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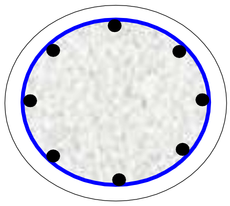
Design of Pile Shaft Subjected to Axial Load & Maximum Bending Moments-

Given Data

Pile Size

Diameter (D) = 1200 mm

Area of Pile (Ag) = 1.13E+06 mm2



Section R/f

	Equivalent Dia (mm)	Nos.	Area
Outer Peripheri	37	22	23259.869
	37	0	0.00

PROVIDE

	28	X	25	Dia
+	28	X	25	Dia
+	0	X	25	Dia

Ast Provided	=	27488.936	mm2	**OK**
Total No. of Longitudinal Bar	=	22	Nos.	
Total Ast	=	23259.869	mm2	
% of Reinforcement (Pt)	=	2.06	%	
Effective Spacing of Bars	=	141.27	mm	**OK**
Clear Cover	=	75	mm	
Dia of Tie Bar	=	12	mm	
Effective Cover (d')	=	105	mm	
d'/D ratio	=	0.088		

Transverse Reinforcement

As per Clause 16.2.3 of IRC 112:2011

Minimum Diameter of Tie Bars = 0.25 x 25 = 6.25 mm

or 8 mm whichever is greater

Adopt 8 mm dia Helical Reinforcement

Pitch of Lateral Ties shall not exceed

= 12 x 25 = 300 mm

or 1200 mm

or 200 mm whichever is less

or 150 mm As per IRC 78-2014

Adopt 150 mm c/c spacing

Provide 8mm dia bar @ 150c/c as Spiral Helical Tie Bar beyond Point of Fixity

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
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Ductile Detailing as per IRC:112-2019, Clause 17.2.1

Confinement Reinforcement

$nk = \frac{N_{ED}}{A_c f_{ck}} = \frac{3372165}{3.39E+07} =$ 0.10 > 0.06

IF nk > 0.064 , Confinement R/f shall be provided as per Clause 17.2.1.4 of IRC:112-2019

IF nk < 0.064 , Confinement R/f shall be provided as per Clause 17.2.2 of IRC:112-2019

Adopt Spacing of Hoops = 125 mm

As per Cl. 17.2.1.3 of IRC 112:2019

Spacing of Hoops

SL	<=	5 x	25	=	125	mm	OK
	<=	0.2 x	1042	=	208.4	mm	OK

Dsp = 1050 mm

Dia of Spiral Provided = 10 mm

ω_{wd} = ρw fyd/fcd

where ρw = $\frac{4*Asp}{Dsp*SL}$

Asp	=	78.54	mm2
SL	=	125	mm c/c
Dsp	=	1050	mm
ρw	=	0.002	
$\omega_{wd,c}$	=	0.078	

Minimum Confining Reinforcement: as per Clause 17.2.1.2 of IRC:112-2019

$\omega_{wd,c}$ >= max (1.4*ωw.req, 0.18)

$\omega_{w,req} = \frac{0.37Ac*nk}{Acc} + \frac{0.13*fyd(\rho L-0.01)}{fcd}$

Ac	=	1.13E+06	
Acc	=	8.66E+05	mm^2
nk	=	0.10	
ρL	=	0.02431	
$\omega_{w,req}$	=	0.10837	
$\omega_{wd,c}$	=	0.18000	

105.00962

$\omega_{wd,c}$ = 6.990 OK

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

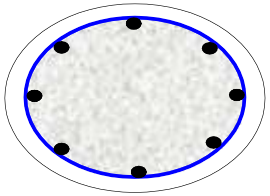
Material Property

Concrete Grade	=	**M30**
Steel Grade	=	**Fe500**
Characteristic Compressive Strength of Concrete at 28 days,fck	=	30.00 N/mm^2
Design strength of concrete, fcd=0.446fck	=	13.40 N/mm^2
Yield Strength of Reinforcement Steel ,fy	=	500 N/mm^2
Design Yield Strength of Reinforcement Steel ,fyd	=	434.78 N/mm^2
Modulus of Elasticity of Concrete (Ec)	=	27386.1 N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000 N/mm^2
Factor of Safety For Concrete	=	1.5
Factor of Safety For Steel	=	1.15
Maximum Strain in Concrete,εcu	=	0.0035
Yield Strain in Concrete, ε_{cd}	=	0.002
Yield Strain in Steel,$\varepsilon_{st}(\varepsilon_{yd})$	=	0.002174
Max. Strain in steel, ε_{stu}	=	0.004174

Summary of Design Forces at Pile Fixity:

Load Cases		Axial Load (KN)	Initial Resultant Moment (KN-m)	Final Design Moment (KN-m)
		Pu	**M**	**Mu**
Normal Dry Case	Max	1683.79	293.20	293.20
	Min	848.96	179.73	179.73
Seismic Case	Max	1394.84	316.74	316.74
	Min	1025.50	261.04	261.04

DESIGN OF RECTANGULAR SECTION FOR ABUTMENT SHAFT - ULTIMATE LIMIT STATE



Section dimensions of pier shaft

Length, B = 1200 mm (equivalent length of pier shaft)

Thickness,D = 0 mm

Material properties

fck = 30.00 Mpa

fyk = 500 Mpa

Es = 200000 Mpa

Design axial resistance of section

N_{Rd} = Ac * fcd + As * fyd

fcd = α_{cc} xf_{ck} /γ_m α_{cc} = 0.67

= 13.400 Mpa γ_m = 1.5

fyd = fyk/γ_s γ_s = 1.15

= 434.7826 Mpa

N_{Rd} = 11951.71 KN

Reinforcement Details

Reinf.	Dia.(mm)	Spacing (mm)	Cover (mm)	From (mm)	To (mm)	Y_{CG} (mm)	Nos.
As1	25	141	75	0	0	0.00	28.00
As2	25	75	75	0	0	0.00	28.00

Total reinforcement

As3 (Along length Tension face) = 0.00 mm^2

As4 (Along length Compression face) = 0.00 mm^2

As2 (Along width Tension face) = 13744.47 mm^2

As1 (Along width Compression face) = 13744.47 mm^2

Total As = **27488.9 mm^2**

Total As = **mm^2**

= **2.06 %**

Formula used for interaction diagram

Pu = Cc +Cs

Mu = Mc + Ms

Cc = 0.361*fck*Xu*b for Xu ≤ D

= 0.447*fck*(1-4*g/21)*b*D for Xu ≥ D

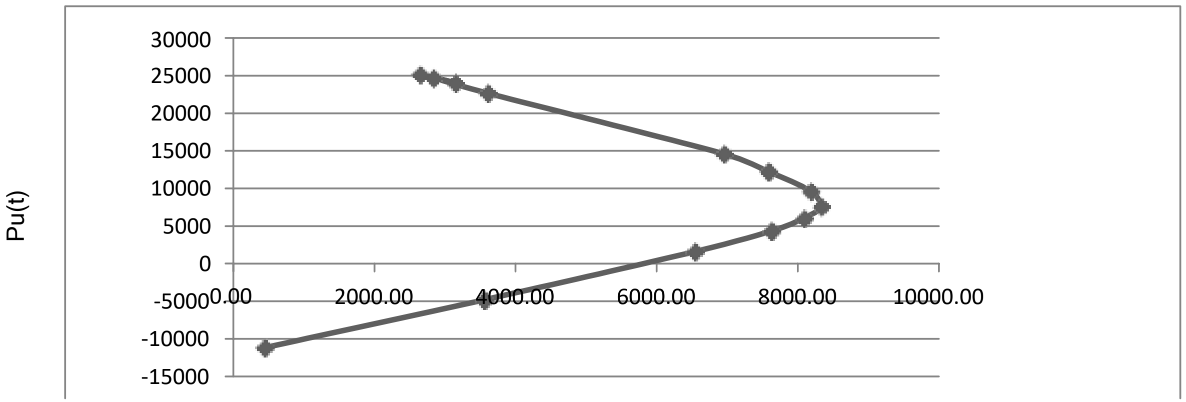
g = 16 / (7Xu / D-3)^2

Cs	=	$\sum$(fsi - fci) Asi	
fci	=	0.00	for $\varepsilon_{si} \leq 0$
		0.447 fck	for $\varepsilon_{si} \geq 0.002$
		$0.447fck\ \ 2^*\ (\varepsilon_{si}/0.002)-(\varepsilon_{si}/0.002)^2$	otherwise
fsi	=	-0.87 fy	for $\varepsilon_{si} \leq -0.00217$
		ε_{si} * Es	for $0.00217 \geq \varepsilon_{si} > -0.00217$
		0.87fy	for $\varepsilon_{si} > 0.00217$
Mc	=	Cc * (0.5D -x)	
Ms	=	$\sum$Csi * yi	
x	=	0.416 Xu	for Xu $\leq$ D
	=	(0.5 - 8*g /49)* D/(1-4*g/21)	for Xu $\geq$ D
Where x	=	Centroid of stress block area from most compressed edge.	
ε_{si}	=	$\dfrac{0.0035 *\ Xu- D/2 +y_i}{Xu}$	for Xu $\leq$ D
	=	$\dfrac{0.002*\ \ 1+ y_i - D/14}{Xu - 3D/7}$	for Xu > D
Where y_i	=	Distance of ith row of steel from the centroidal axis measured positive in the direction towards the highly compressed edge.	

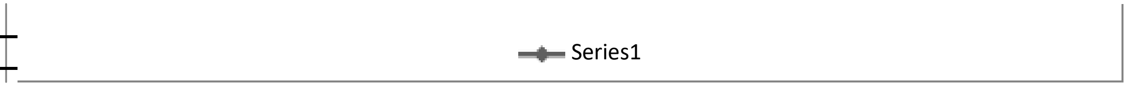
Along traffic direction

Xu/D	=	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
D(mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Xu (mm)	=	60	120	240	360	480	600	720	840	960	1080	1200	1320	1440
	<	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
g (Mpa)	=	2.278391	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.366864	1.469238	1	0.72431	0.54869684
Cc (KN)	=	779.8	1559.5	3119.0	4678.6	6238.1	7797.6	9357.1	10916.6	12476.2	14035.7	15632.2	16646.3	17292.2
y1 (compr. face in mm)	=	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5
y1 (tension face in mm)	=	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5
y2 (compr. face in mm)	=	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5
y2 (tension face in mm)	=	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5
ε_{si}(compr. face in mm)	=	-0.0023	0.000598	0.002049	0.002533	0.002774	0.00292	0.003016	0.003085	0.003137	0.003178	0.00321	0.00303	0.00289614
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.0607	-0.0286	-0.01255	-0.0072	-0.00452	-0.00292	-0.00185	-0.001085	-0.000512	-6.64E-05	0.00029	0.000545	0.00073349
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{s2}(compr. face in mm)	=	-0.00522	-0.00086	0.00132	0.002047	0.00241	0.002628	0.002773	0.002877	0.002955	0.003016	0.003064	0.002905	0.00278812
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{s2} (tension face in mm)	=	-1.52158	-1.07676	-0.45388	-0.12235	-0.00499	-0.02464	-0.104108	-0.166229	-0.133827	0.070275	0.52325	0.000669	0.00084151
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	6.819529	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41
fsi(comp.face in Mpa)	=	-435	119.5833	409.7917	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	3.609343	6.31129	8.03241057
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-369.9306	-217.0833	-102.4479	-13.29	58.04167	108.9716	146.697531
fc2 (comp.face in Mpa)	=	0	0	11.85885	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41
fs2(comp.face in Mpa)	=	-435	-172.083	263.9583	409.3056	435	435	435	435	435	435	435	435	435
fc2 (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	13.41	13.41	7.470589	8.91063105
fs2 (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-435	-435	-435	435.00	435	133.7943	168.302469
Cs (KN)	=	-11957.7	-6386.5	-1522.3	-360.9	-184.3	-184.3	262.9	1313.3	2101.1	8600.5	9065.9	7368.2	7842.8
Mc (KN-m)	=	448.4	857.9	1560.0	2106.5	2497.2	2732.3	2811.6	2735.3	2503.2	2115.5	1576.4	1141.8	864.9
Ms (KN-m)	=	0.00	2698.04	4986.80	5518.69	5598.24	5598.24	5374.43	4848.70	4454.41	1495.78	1262.86	2011.10	1784.89
Pu (KN)	**=**	**-11177.9**	**-4827.0**	**1596.7**	**4317.7**	**6053.8**	**7613.3**	**9620.0**	**12229.9**	**14577.2**	**22636.2**	**24698.1**	**24014.4**	**25135.0**
Mu (KN-m)	**=**	**448.4**	**3555.9**	**6546.8**	**7625.2**	**8095.5**	**8330.5**	**8186.1**	**7584.0**	**6957.6**	**3611.2**	**2839.2**	**3152.9**	**2649.8**

Mu (KN-m)	**Pu (KN)**
448.4	-11177.9
3555.90	-4826.98
6546.82	1596.71
7625.17	4317.67
8095.47	6053.77
8330.52	7613.29
8186.06	9619.98
7583.98	12229.90
6957.63	14577.22
3611.24	22636.16
2839.22	24698.10



3152.87	24014.43	
2649.83	25135.05	

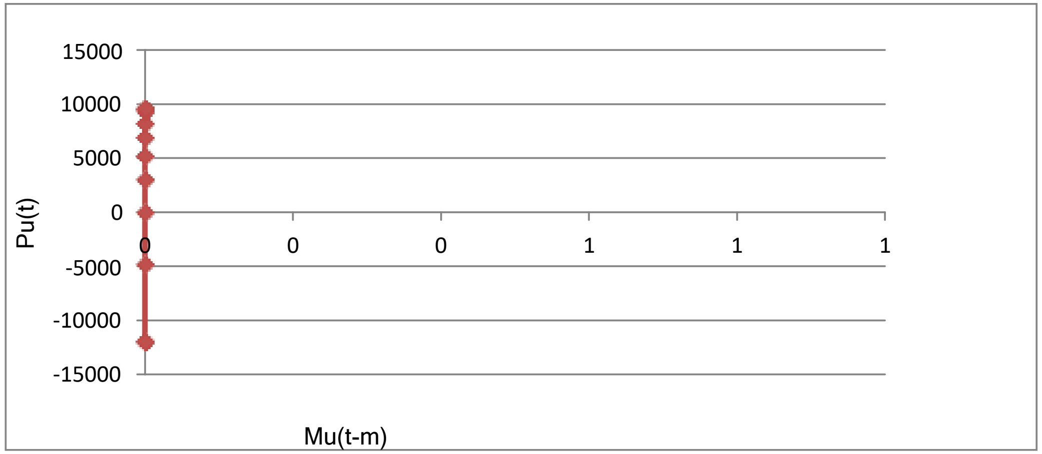


Interaction diagram Mu(t-m)

Along transverse direction

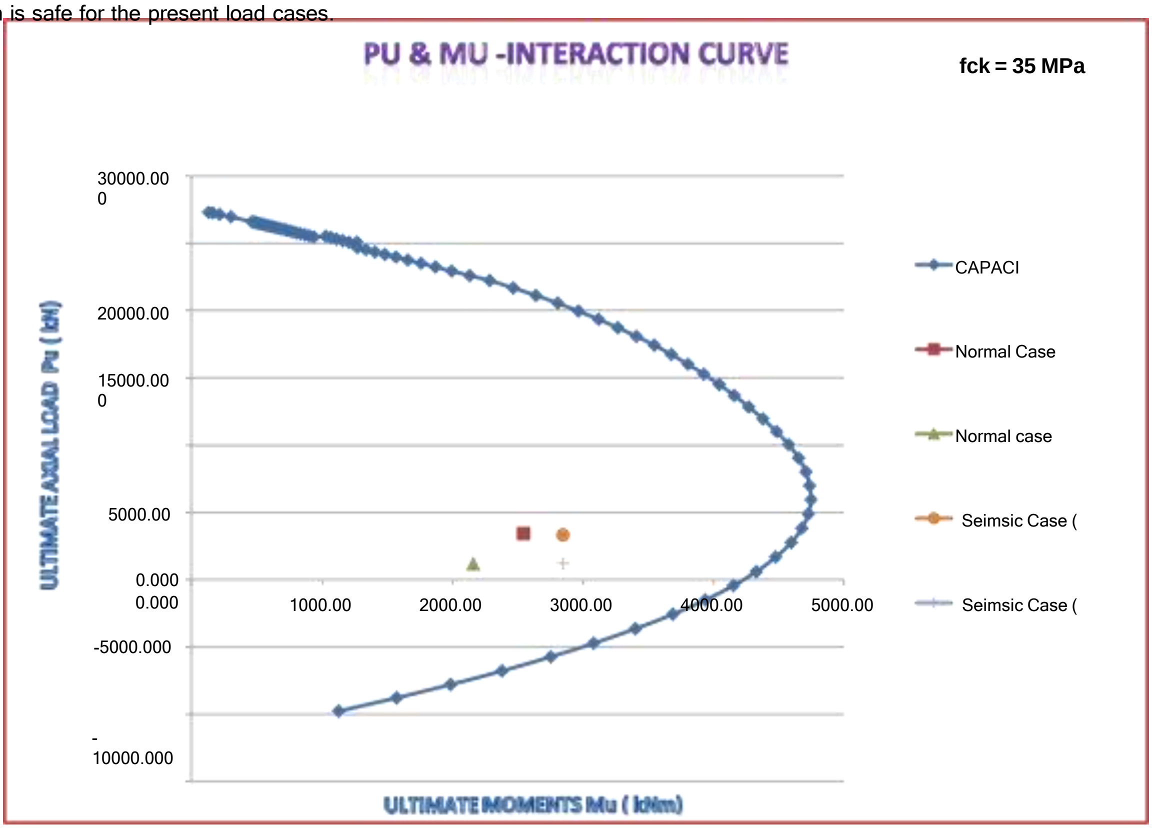
Xu/D	=	0.025	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
D(mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Xu (mm)	=	30	120	240	360	480	600	720	840	960	1080	1200	1320	1440
	<	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
g (Mpa)		2.004856	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.366864	1.469238	1	0.72431	0.54869684
Cc (KN)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yi (compr. face in mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
yi (tension face in mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
ε_{si}(compr. face in mm)	=	-0.0665	-0.014	-0.00525	-0.00233	-0.00088	0	0.000583	0.001	0.001313	0.001556	0.00175	0.001787	0.00181481
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.0665	-0.014	-0.00525	-0.00233	-0.00088	0	0.000583	0.001	0.001313	0.001556	0.001750	0.001787	0.00181481
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	0	0	0	0	0	6.681719	10.0575	11.82542	12.74778	13.20047	13.25823	13.2950309
fsi(comp.face in Mpa)	=	-435	-435	-435	-435	-175	0	116.6667	200	262.5	311.1111	350	357.4468	362.962963
fci (tension face in Mpa)	=	0	0	0	0	0	0	6.681719	10.0575	11.82542	12.74778	13.20047	13.25823	13.2950309
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-175	0	116.6667	200	262.5	311.1111	350	357.4468	362.962963
Cs (KN)	=	-11957.7	-11957.7	-11957.7	-11957.7	-4810.6	0.0	3023.4	5221.3	6890.8	8201.7	9258.3	9461.4	9612.0
Mc KN-m)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ms (KN-m)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu (KN)	**=**	**-11957.7**	**-11957.7**	**-11957.7**	**-11957.7**	**-4810.6**	**0.0**	**3023.4**	**5221.3**	**6890.8**	**8201.7**	**9258.3**	**9461.4**	**9612.0**
Mu (KN-m)	**=**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Mu (KN-M)	**Pu (KN)**
0.00	-11957.69
0.00	-11957.69
0.00	-11957.69
0.00	-11957.69
0.00	-4810.56
0.00	0.00
0.00	3023.37
0.00	5221.32
0.00	6890.78
0.00	8201.69
0.00	9258.26
0.00	9461.38
0.00	9612.00



Interaction diagram

ve figure presents a typical axial force - bending moment interaction curve for pile section at top for given amount of reinforcement. The a s due to various load cases as presented in table are shown by filled circles. This provides a graphical representation of capacity of the s s due to various load cases. Since demand points are within the interaction curve,
on is safe for the present load cases.



ANNEXURE IIA:- DESIGN CURVE OF PILE SHAFT FOR MAXIMUM BENDING MOMENTS (CURTAILMENT)

APPENDEX - III DESIGN CURVE OF ABUTMENT SHAFT FOR MAXIMUM BENDING MOMENTS

SLENDERNESS CHECK AND CHECK FOR SECOND ORDER EFFECTS

Slenderness check as per IRC 112,Cl.8.3.2- page 74

lx/ly <=2.0 & ly/lx <=2.0 — as per eq. 8.1

$(e_x / h_{eq}) / (e_y / b_{eq}) <= 0.20$ OR $(e_y / b_{eq}) / (e_x / h_{eq}) <= 0.20$ — as per eq. 8.2

Type of Bearings = POT PTFE Bearing

Effective Length = 1.4

l	=	0.50 m Clear Height of Pier			
b_{eq}	=	16000 mm			
h_{eq}	=	1000 mm			
lex	=	700 mm	ley	=	700 mm
Ixx	=	3.4E+14 mm4	Iyy	=	1.3E+12
A	=	1.60E+07 mm2	A	=	1.60E+07 mm2
$i_y=\sqrt{I/A}$	=	4618.8 mm	$i_x=\sqrt{I/A}$	=	288.7 mm
b_{eq}	=	16000 mm	h_{eq}	=	1000 mm
l_x	=	0.2	l_y	=	2.4

Check for Biaxial Bending

1.0	$\mathbf{l_x / l_y}$	**=**	**0.06**	**<=2**	Condition Satisfied	from eq 8.1 IRC 112
	$\mathbf{l_y / l_x}$	**=**	**16.00**	**>2**	Condition not Satisfied	

			Case-1	Case-2	Case-3	
2.0	Design Cases		Case-1	Case-2	Case-3	from eq 8.2 IRC 112
	e_x	=	435.22	474.65	474.65	
	e_y	=	861.77	1040.85	1040.85	
	$(e_x/h_{eq}) /(e_y/b_{eq})$	=	8.08	7.30	7.30	
	$(e_y/b_{eq}) /(e_x/h_{eq})$	=	0.12	0.14	0.14	

Hence Check for Biaxial Bending is required

3.0 **Check for Second Order Effect**

Second order effect may be ignored og the slenderness ratio is less than

l_{lim}	=	20ABC / √n	Concrete Grade		M30
A	=	$1/(1+0.2\Phi_{eff})$	0.7		
Φ_{eff}	=	$\Phi(\infty,t_0)$	1.57	M_{0Eqp} =	First Order BM in Quasi Permanent Combinations
				M_{0Ed} =	First Order BM in Design Load Combinations
B	=	$\sqrt{(1+2\omega)}$	1.1	ω =	A_sf_{yd} / A_cf_{cd} Reinforcement Ratio
C	=	$1.7-r_m$	0.7	r_m =	M_{01}/M_{02} Moment Ratio
n	=	$N_{Ed} / (A_cf_{cd})$		M_{01}, M_{02} =	First Order End Moments at two ends of Member

As per Cl. 11.2.1 IRC-112-2011 initial dimensioning A, B C can be taken as 0.7, 1.1 and 0.7 respectively

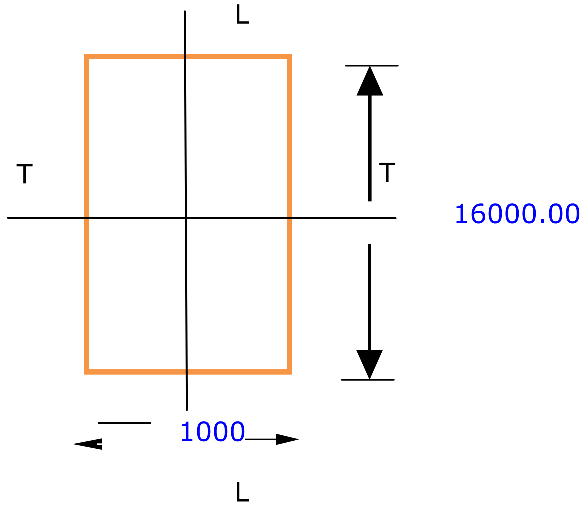
	N_{Ed}	=	992.76	951.95	951.95
	A_c	=	1.60E+07	1.60E+07	1.60E+07
	f_{cd}	=	13.40	13.40	13.40
	n	=	0.0463	0.0444	0.0444
Long	M_{0Eqp}	=	-32.09	-32.09	-32.09
Long	M_{0Ed}	=	432.07	451.85	451.85
	Φ_{eff}	=	-0.12	-0.11	-0.11
	A	=	1.02	1.02	1.02
	l_{lim}	=	73.28	74.83	74.83
	l_x	=	0.2	0.2	0.2
	Check	=	**Second Order Effects shall be Ignored in x Direction**		
Trans	M_{0Eqp}	=	-14.29	-14.29	-14.29
Trans	M_{0Ed}	=	855.53	990.84	990.84
	Φ_{eff}	=	-0.03	-0.02	-0.02
	A	=	1.01	1.00	1.00
	l_{lim}	=	71.94	73.47	73.47
	l_y	=	2.4	2.4	2.4
	Check	=	**Second Order Effects shall be Ignored in y Direction**		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

CHECKING OF STRESS IN WALL TYPE ABUTMENT SHAFTY

Given Data :

Abutment Size:



Width (B)	=	1000	mm
Depth (D)	=	16000.00	mm
Area (Ac)	=	1.60E+07	mm2
Length (Lo)	=	**0.500**	m

Section Reinforcement:

Dia. Of Bars	=	25	mm
Nos. of Bars Along Width (B)	=	6	Nos.
Nos. of Bars Along Depth (D)	=	130	Nos.
Total Nos. of Bars	=	272	Nos.
Total Ast	=	133518	mm^2
% of Reinforcement (Pt)	=	0.83	%
Clear Cover	=	50	mm
Dia of Tie bar	=	12	mm
D/B	=	16.00	Wall Type Abutment

Vertical Reinforcement For Wall Type Abutment as per IRC: 112-2019 , Clause 16.3.1

Minimum Vertical Reinforcement	=	0.0012 Ac	on each Face	
	=	19200 mm^2		
Provided Vertical Reinforcement	=	66759 mm^2		**OK**
Maximum Vertical Reinforcement	=	0.02 Ac	on each face	
	=	320000 mm^2		**OK**
Spacing between Vertical Reinf.	=	123 mm		**<200 mm OK**

Horizontal Reinforcement for Wall Type Abutment as per IRC: 112-2019 , Clause 16.3.2

Horizontal r/f should be	=	0.2500 x	133517.7 =	33379.42	
maximum of following	=	0.001 x	1.60E+07 =	16000.00	
Minimum Horizontal Reinf. =		33379 mm^2			
Dia of bar	=	20 mm		**OK**	
Min dia of bar	=	0.25Ø mm	=	6.25 mm	
	or	8 mm			
Maximum Spacing between bars	<=	300 mm c/c			
Provide 2 L	32 dia@	80	c/c	=	301593 mm^2
				OK	
				35582	

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Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Ductile Detailing as per IRC:112-2019, Clause 17.2.1

Confinement Reinforcement

$$nk = \frac{N_{ED}}{A_c f_{ck}} = \frac{9738990}{4.80E+08} = 0.02 < 0.064$$

IF nk > 0.064 , Confinement R/f shall be provided as per Clause 17.2.1.4 of IRC:112-2019

IF nk < 0.064 , Confinement R/f shall be provided as per Clause 17.2.2 of IRC:112-2019

Specing of Transverse Ties

	SL	<=	5	x	25	=	125	mm
		<=	0.2	x	876	=	175.2	mm
Provide	SL	=	125	mm	**OK**			

	ω_{wd}	=	$\rho_w\, f_{yd}/f_{cd}$					
where	ρ_w	=	$\frac{A_{sw}}{SL*b}$					
	Asw	=	25	dia	2L	=	981.748	mm^2
	SL	=	150	mm c/c				
	b	=	1000	mm				
	ρ_w	=	0.00654					
	ω_{wd}	=	0.2124	**OK**				

Minimum Confining Reinforcement: as per Clause 17.2.1.2 of IRC:112-2019

ω_{wd} = max ($\omega_{w.req}$, 0.12)

$$\omega_{w,req} = \frac{0.37 A_c * nk}{A_{cc}} + \frac{0.13 * f_{yd}(\rho_L - 0.01)}{f_{cd}}$$

Ac	=	1.60E+07	
Acc	=	13907376	mm^2
nk	=	0.02	
ρ_L	=	0.00834	
$\omega_{w,req}$	=	0.00166	
ω_{wd}	=	0.12000	

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

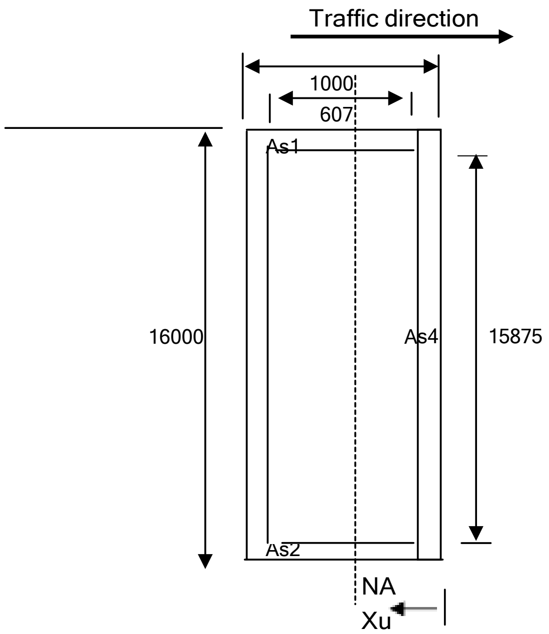
Material Property

Concrete Grade	=	**M30**	
Steel Grade	=	**Fe500**	
Characteristic Compressive Strength of Concrete at 28 days,fck	=	30.00	N/mm^2
Design strength of concrete, fcd=0.446fck	=	13.40	N/mm^2
Yield Strength of Reinforcement Steel ,fy	=	500	N/mm^2
Design Yield Strength of Reinforcement Steel ,fyd	=	434.78	N/mm^2
Modulus of Elasticity of Concrete (Ec)	=	27386.1	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2
Factor of Safety For Concrete	=	1.5	
Factor of Safety For Steel	=	1.15	
Maximum Strain in Concrete,εcu	=	0.0035	
Yield Strain in Concrete, ε_{cd}	=	0.002	
Yield Strain in Steel,ε_{st}(ε_{yd})	=	0.002174	
Max. Strain in steel, ε_{stu}	=	0.004174	

Summary of Design Forces at Abutment Shaft Bottom :

Load Cases	Axial Load (kN)	Initial Moment (kNm)		Final Design Moment (kNm)	
	Pu or N_{Ed}	Mx(MT)	My(ML)	Mux	Muy
Normal Case 1	9739.0	8392.7	4238.6	8392.75	4238.56
Normal Case 2	9338.6	9720.1	4432.6	9720.11	4432.60
Normal Case 3	9338.6	9720.1	4432.6	9720.11	4432.60
Seismic Case 4	7730.4	1565.9	1453.4	1565.90	1453.41
Seismic Case 5	7677.0	1742.9	1479.3	1742.89	1479.29
Seismic Case 6	7677.0	2464.1	758.1	2464.09	758.08

DESIGN OF RECTANGULAR SECTION FOR ABUTMENT SHAFT - ULTIMATE LIMIT STATE



Section dimensions of pier shaft

Length, B	=	16000 mm (equivalent length of pier shaft)
Thickness,D	=	1000 mm

Material properties

fck	=	30.00 Mpa
fyk	=	500 Mpa
Es	=	200000 Mpa

Design axial resistance of section

N_{Rd}	=	Ac * fcd + As * fyd			
fcd	=	α_{cc} xf_{ck} /γ_m	α_{cc}	=	0.67
	=	13.400 Mpa	γ_m	=	1.5
fyd	=	fyk/γ_s	γ_s	=	1.15
	=	434.7826 Mpa			
N_{Rd}	=	272451.2 KN			

Reinforcement Details

Reinf.	Dia.(mm)	Spacing (mm)	Cover (mm)	From (mm)	To (mm)	Y_{CG} (mm)	Nos.
As1	25	134	50	196.5	803.5	401.75	6.00
As2	25	134	50	197	804	401.75	6.00
As3	25	134	50	62.5	15938	7968.75	130.00
As4	25	134	50	62.5	15938	7968.75	130.00

Total reinforcement

As3 (Along length Tension face)	=	63813.60 mm^2
As4 (Along length Compression face)	=	63813.60 mm^2
As2 (Along width Tension face)	=	2945.24 mm^2
As1 (Along width Compression face)	=	2945.24 mm^2
Total As	**=**	**133517.7 mm^2**
	=	**0.83 %**

Formula used for interaction diagram

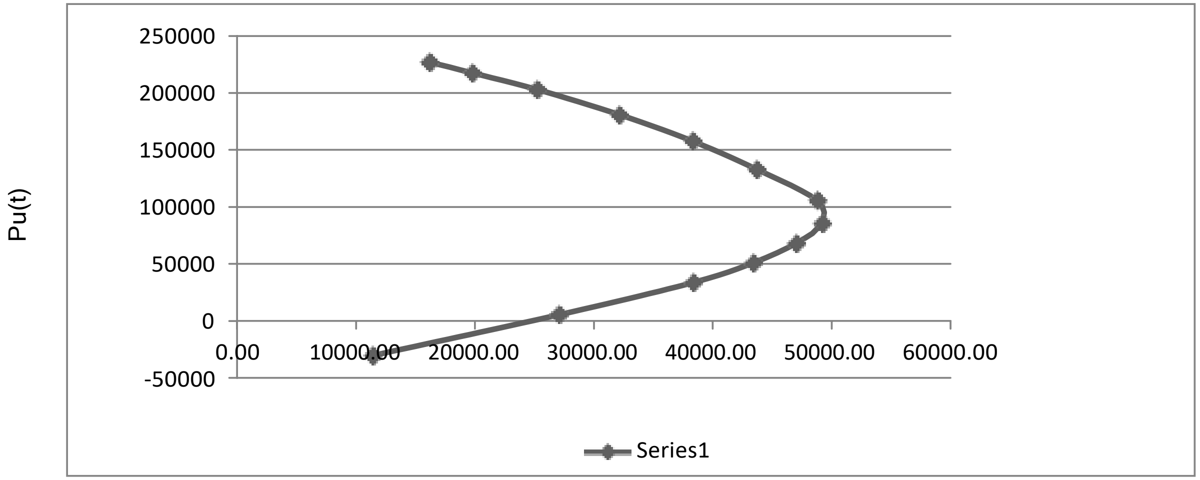
Pu	=	Cc +Cs	
Mu	=	Mc + Ms	
Cc	=	0.361*fck*Xu*b	for Xu ≤ D
	=	0.447*fck*(1-4*g/21)*b*D	for Xu ≥ D
g	=	16 / (7Xu / D-3)^2	

Cs	=	$\sum$ (fsi - fci) Asi	
fci	=	0.00	for $\varepsilon_{si} \leq 0$
		0.447 fck	for $\varepsilon_{si} \geq 0.002$
		0.447fck 2* (ε_{si}/0.002)-(ε_{si}/0.002)^2	otherwise
fsi	=	-0.87 fy	for $\varepsilon_{si} \leq -0.00217$
		ε_{si} * Es	for $0.00217 \geq \varepsilon_{si} > -0.00217$
		0.87fy	for $\varepsilon_{si} > 0.00217$
Mc	=	Cc * (0.5D -x)	
Ms	=	$\sum$ Csi * yi	
x	=	0.416 Xu	for Xu $\leq$ D
	=	(0.5 - 8*g /49)* D/(1-4*g/21)	for Xu $\geq$ D
Where x	=	Centroid of stress block area from most compressed edge.	
ε_{si}	=	$\dfrac{0.0035 * \text{ Xu- D/2 +}y_i}{\text{Xu}}$	for Xu $\leq$ D
	=	0.002* 1+ y_i - D/14 / Xu - 3D/7	for Xu > D
Where y_i	=	Distance of ith row of steel from the centroidal axis measured positive in the direction towards the highly compressed edge.	

Along traffic direction

Xu/D	=	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
D(mm)	=	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Xu (mm)	=	50	100	200	300	400	500	600	700	800	900	1000	1100	1200
	<	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
g (Mpa)	=	2.278391	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.3668639	1.469238	1	0.72431	0.548697
Cc (KN)	=	8664.0	17328.0	34656.0	51984.0	69312.0	86640.0	103968.0	121296.0	138624.0	155952.0	173691.4	184958.5	192135.5
yi (compr. face in mm)	=	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5
yi (tension face in mm)	=	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5
ε_{si}(compr. face in mm)	=	-0.00088	0.001313	0.002406	0.002771	0.002953	0.003063	0.003135	0.003188	0.0032266	0.003257	0.003281	0.00309	0.002949
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.06213	-0.02931	-0.01291	-0.00744	-0.0047	-0.00306	-0.001969	-0.001188	-0.000602	-0.000146	0.000219	0.000484	0.000681
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	11.82542	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41
fsi(comp.face in Mpa)	=	-175	262.5	435	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	2.773015	5.705529	7.57352
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-393.75	-237.5	-120.3125	-29.17	43.75	96.80851	136.1111
Cs (KN)	=	-38926.3	-11762.5	-855.7	-855.7	-855.7	-855.7	1776.6	11747.4	19225.6	25041.9	29518.1	32716.8	35105.6
Mc (KN-m)	=	4151.8	7943.2	14444.6	19504.4	23122.5	25298.9	26033.6	25326.6	23177.9	19587.6	14595.9	10572.0	8008.7
Ms (KN-m)	=	7258.8	19143.0	23914.7	23914.7	23914.7	23914.7	22763.0	18400.8	15129.1	12584.4	10626.1	9226.7	8181.6
Pu (KN)	**=**	**-30262.3**	**5565.5**	**33800.3**	**51128.3**	**68456.3**	**85784.3**	**105744.6**	**133043.4**	**157849.6**	**180993.9**	**203209.5**	**217675.3**	**227241.2**
Mu (KN-m)	**=**	**11410.6**	**27086.1**	**38359.3**	**43419.1**	**47037.1**	**49213.5**	**48796.6**	**43727.4**	**38307.0**	**32172.0**	**25222.0**	**19798.6**	**16190.3**

Mu (KN-m)	**Pu (KN)**
11410.6	-30262.3
27086.13	5565.53
38359.29	33800.26
43419.06	51128.26
47037.15	68456.26
49213.55	85784.26
48796.62	105744.57
43727.38	133043.45
38307.01	157849.60
32172.00	180993.95
25222.04	203209.49
19798.65	217675.28
16190.30	227241.17

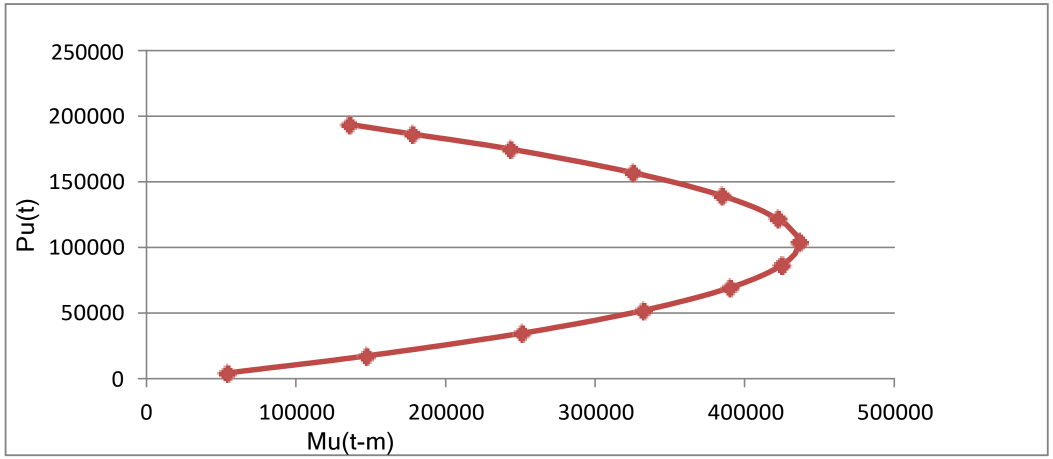


Interaction diagram Mu(t-m)

Along transverse direction

Xu/D	=	0.025	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
D(mm)	=	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Xu (mm)	=	400	1600	3200	4800	6400	8000	9600	11200	12800	14400	16000	17600	19200
	<	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
g (Mpa)		2.004856	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.3668639	1.469238	1	0.72431	0.548697
Cc (KN)	=	4332.0	17328.0	34656.0	51984.0	69312.0	86640.0	103968.0	121296.0	138624.0	155952.0	173691.4	184958.5	192135.5
yi (compr. face in mm)	=	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5
yi (tension face in mm)	=	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5
ε_{si}(compr. face in mm)	=	0.002953	0.003363	0.003432	0.003454	0.003466	0.003473	0.003477	0.00348	0.0034829	0.003485	0.003486	0.003265	0.003101
	>	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.13595	-0.03136	-0.01393	-0.00812	-0.00522	-0.00347	-0.002311	-0.00148	-0.000858	-0.000374	0.000014	0.00031	0.000529
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41	13.41
fsi(comp.face in Mpa)	=	435	435	435	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	0.182713	3.829349	6.152229
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-435	-296.0938	-171.582	-74.73958	2.734375	61.9016	105.7292
Cs (KN)	=	-39.5	-39.5	-39.5	-39.5	-39.5	-39.5	-39.5	369.6	736.3	1021.6	1249.2	1412.7	1535.0
Mc KN-m)	=	33935.2	127090.5	231113.9	312070.3	369959.7	404782.1	416537.4	405225.7	370846.9	313401.1	233534.7	169151.4	128139.7
Ms (KN-m)	=	20025.2	20025.2	20025.2	20025.2	20025.2	20025.2	20025.2	16777.9	13867.1	11603.1	9796.2	8498.3	7528.0
Pu (KN)	**=**	**4292.5**	**17288.5**	**34616.5**	**51944.5**	**69272.5**	**86600.5**	**103928.5**	**121665.6**	**139360.3**	**156973.6**	**174940.6**	**186371.2**	**193670.5**
Mu (KN-m)	**=**	**53960.4**	**147115.7**	**251139.2**	**332095.6**	**389985.0**	**424807.3**	**436562.6**	**422003.6**	**384714.0**	**325004.3**	**243330.9**	**177649.7**	**135667.7**

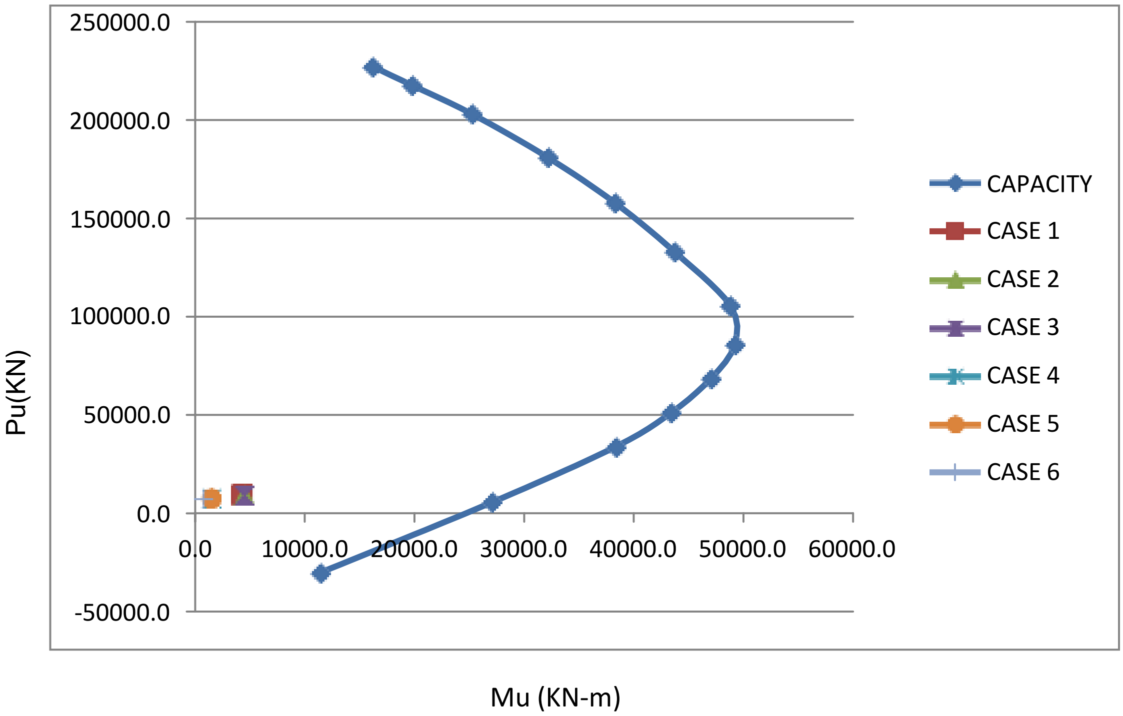
Mu (KN-M)	**Pu (KN)**
53960.40	4292.50
147115.73	17288.50
251139.18	34616.50
332095.60	51944.50
389984.98	69272.50
424807.33	86600.50
436562.64	103928.50
422003.59	121665.62
384714.02	139360.33
325004.27	156973.56
243330.92	174940.63
177649.70	186371.22
135667.73	193670.51



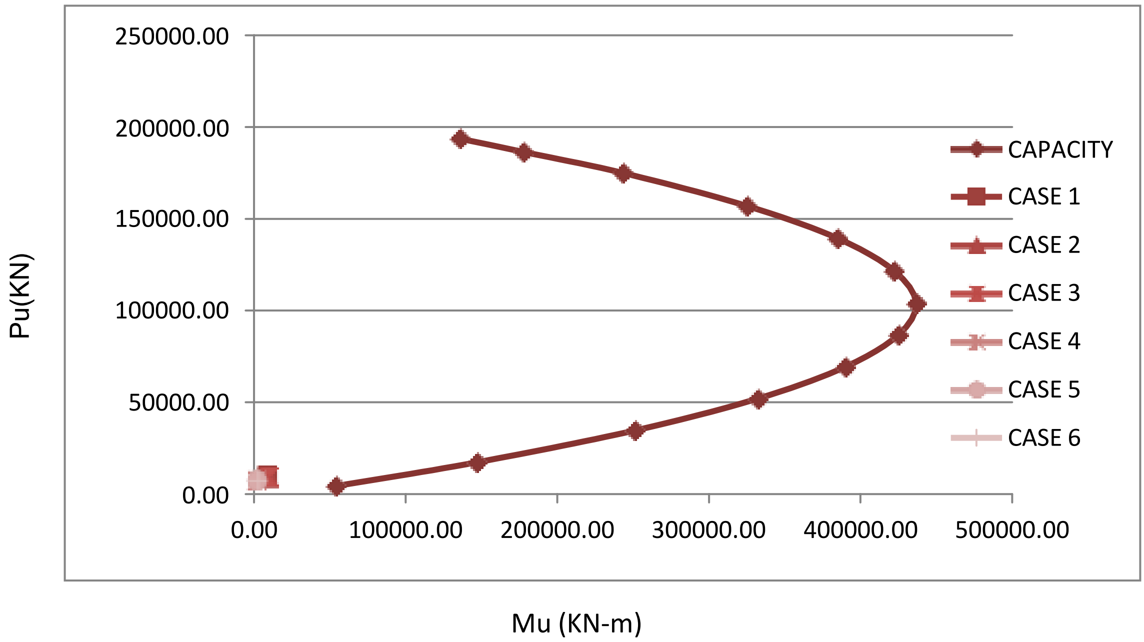
Interaction diagram

Load Cases	Axial Load (kN)	Final Design Moment (kNm)		Permissible Moment (kNm)		Max. Tensile Stress in Steel (N/mm^2)		N_{ED}/N_{RD}	a	$\left(\frac{Mux}{Mux1}\right)^{a} + \left(\frac{Muy}{Muy1}\right)^{a}$	**Section Status**
	Pu or N_{Ed}	Mux	Muy	Mux1	Muy1	Fsx	Fsy				
Normal Case 1	9739.0	8392.7	4238.6	93000.81	28752.45	434.8	434.8	0.04	1.00	0.24	**SAFE**
Normal Case 2	9338.6	9720.1	4432.6	90131.01	28592.59	434.8	434.8	0.03	1.00	0.26	**SAFE**
Normal Case 3	9338.6	9720.1	4432.6	90131.01	28592.59	434.8	434.8	0.03	1.00	0.26	**SAFE**
Seismic Case 4	7730.4	1565.9	1453.4	78603.38	27950.49	434.8	434.8	0.03	1.00	0.07	**SAFE**
Seismic Case 5	7677.0	1742.9	1479.3	78220.74	27929.18	434.8	434.8	0.03	1.00	0.08	**SAFE**
Seismic Case 6	7677.0	2464.1	758.1	78220.74	27929.18	434.8	434.8	0.03	1.00	0.06	**SAFE**

Pu-Mu Interaction Curve
Along the Traffic Direction



Pu-Mu Interaction Curve
Across the Traffic Direction



Calculation of Creep Coeffiecient *(As per Annexure A2, A2.5, IRC:112-2011)*

$\Phi(t,t_0)$	=	$\beta_c(t,t_0).\Phi_0$	=	**1.57**	
Where,					
Φ_0	=	$\Phi_{RH}\ \beta(f_{cm})\ \beta(t_0)$.	=	1.60	
t	=	Age of concrete in days at time the time considered =	=	25550	days
t_0	=	is the age of Concrete in days at time of loading	=	90	days
Φ_{RH}	=	$1+(1-RH/100)/(0.1*h_0^{1/3})$ for fcm <= 45	=	1.38	
RH	=	Relative Humidity	=	63	%
fck	=	Characteristic Compressive Strength	=	30	MPa
fcm	=	Mean Compressive Strength	=	40	MPa
$\beta(f_{cm})$	=	$18.78/\sqrt{f_{cm}}$	=	2.97	
$\beta(t_0)$.	=	$1/(0.1+t_0^{0.2})$	=	0.39	
h_0	=	Notional side of Member 2Ac/u	=	941.2	mm
w	=	Width of Section	=	16000	mm
h	=	Depth of Section	=	1000	mm
Ac	=	Cross Sectional Area, mm2	=	1.6E+07	mm2
u	=	Perimeter in Contact with atmosphere	=	34000	mm
$\beta_c(t,t_0)$	=	$[(t-t_0) / (\beta H + t - t_0)]^{0.3}$	=	0.983	
$(t-t_0)$	=	Actual duration of loading	=	25460	days
βH	=	$1.5(1+(1.2\ RH/RH_0)^{18})h_0 + 250$ <= 1500 fcm = 45	=	1500.0	
RH_0	=		=	100	%

AT Des Ch-170+435

Hydraulic calculation

Tamenglong- Mahur Road

Location - Des Ch- 170+435

1 Discharge:-

a) Discharge from catchment area

Dicken's Discharge 'Q' = C x $M^{3/4}$ as per SP-13-2004 Clause 4.2.

Where 'C' = 19 (Clause 4.2 of SP-13 ,C = 19 where the annual rain fall is >120 cm.)

Catchment Area at Site'M' = 4 Sq. Km. Refer catchment sheet Enclosed

Q = C x M3/4

Q = (19X (4)^3/4)

Q = 53.74 m^3/sec

b) Discharge By Area -Velocity Method

Cross section considered as per SP-13-2004 Clause 3.3(Table -3.1)

Section	Q(m3/sec)	Velocity (m/sec)	HFL (in Meter)	Avg flow depth
At 300 m d/s	51.01107305	1.62	559.82	1.209
At Proposed site	45.88	1.55	560.72	1.131
At 300 m u/s	35.0335228	1.39	561.61	0.96

Max discharge from area velocity method 45.88 m3/sec

Max discharge from Dickens formula 53.74 m3/sec

max discharge - 53.74 m^3/sec

Discharge =	Q =AV	
	A = Q/V	
Linear water way required =	Lx D =Q/V	
	L = Q/(VxD)	
	54/(1.55x1.13)	
2 **Linear water way required =**	**30.648812**	**M**

Provide 1 Span of 25 m

Calculation for design velocity -

The length of bridge proposed =	25	M
The average flow depth below H.F.L. =	1.13	M
No of piers proposed =	0	Nos
Thickness of proposed pier =	1.2	M
Width of Abutment in flow area	0.4	M
Thus Clear water way avilable =	(25-0X1.2- 2 x0.4)	
	24.2	M

Thus the design velocity =			Q/ A
	V=	(53.74)/(24.2X1.13)	
	V=	1.96	M/Sec
The Design velocity		**1.96**	**m/sec**

3 **Afflux**

The theoritical Afflux at proposed site shall be calculated using Moles worth formula

a =	((V^2 / 17.88) - 0.015) X ((A/a)^2 - 1)	
Where as		
A=	Area of cross section at H.F.L.	
	site as compared to the u/s & d/s areas)	
a =	Area of clear water way under the proposed bridge in sqm.	
V =	Velocity in m/sec	
A =	29.58935091	Sqm
a =	1.13084615384612X24.2	
	27.37	Sqm
V =	1.96	m/sec
Afflux =	((1.96^2 / 17.88) - 0.015) X ((29.59/27.37)^2 -1)	
	0.033725277	m
I.e.	33.7252774	mm

Consider afflux is 200 mm.

4 Scour Depth

For the design of foundation in accordance with the provisions of IRC-78,2000 clause 703.1.1. above discharge has been further increased by 30% for Calculation of scour depth.

Considering the available linear water way at bridge as = 24.2 M

Thus the discharge per unit width 'Db' = 1.30 X Q design /24.2

1.3x53.74/24.2

Db' = 2.89 m^3/sec

Thus the theoretical mean scour depth

MSD = 1.34x(Db^2/Ksf)^(1/3)

Where 'Ksf' = 2.4 (as per IRC-78,2000 clause 703.2.2.1)

There fore NSD = 1.34x(2.89^2 /2.4)^(1/3)

2.03 M from HFL.

The scour level for abutment = H.F.L. - 1.27 X N.S.D.(as per IRC-78,2000 clause 703.3.2.)

= 560.715 -1.27X2.029

The scour level for abutment = 558.138 M

(Foundation level is 2m below scour depth in soil OR Rock level which ever is higher)

Foundation level for abutment = 550.702 M

Formation level calculations -

a)	HFL at Proposed site=	560.715	m
b)	Vertical clearance as per IRC -5	0.9	m
c)	Afflux	0.2	m
d)	Depth of deck	2.166	m
e)	Depth of wearing coat	0.075	m

5 **Formation level by HFL Consideration (a+b+c+d+e) =** 564.056 **m**

6 **Formation level by Profile Improvements = 564.056 m**

Location - Des Ch- 170+435

Calculation of Discharge By Area Velocity Method at **Proposed Site.**

H.F.L 560.715 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff(m)	Perimeter (m)	Area(Sqm)
12.00	560.702		0.013		0.000	
10.00	560.382	2	0.333	0.320	2.025	0.348
8.00	559.941	2	0.774	0.441	2.048	1.120
6.00	559.321	2	1.394	0.620	2.094	2.219
4.00	558.881	2	1.834	0.440	2.048	3.267
2.00	558.758	2	1.957	0.123	2.004	3.795
0.00	558.637	2	2.078	0.121	2.004	4.039
2.00	558.749	2	1.966	0.112	2.003	4.047
4.00	558.869	2	1.846	0.120	2.004	3.815
6.00	559.381	2	1.334	0.512	2.064	3.231
8.00	559.911	2	0.804	0.530	2.069	2.175
10.00	560.371	2	0.344	0.460	2.052	1.163
12.00	560.691	2	0.024	0.320	2.025	0.370
		avg.Depth =	1.131		24.441	29.589

Discharge Calculation by Area Velocity method

Using Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)
A = 29.589 Sqm
P = 24.441 M
Avg. depth of flow = 1.131 m
R=A/P
R = 29.59/24.44
1.21
S = 0.00298333
n = 0.04
V = 6x0^0.5/0.04
V = 1.55053446 m/sec

Q=A*V
Q = 1.55x29.59
Q = 45.879 m^3/sec

Location - Des Ch- 170+435

Calculation of Discharge By Area Velocity Method at **300U/S**

H.F.L 561.605 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff	Perimeter	Area
12.00	561.577		0.028		0.000	
10.00	561.327	2	0.278	0.250	2.016	0.307
8.00	561.007	2	0.598	0.320	2.025	0.882
6.00	560.587	2	1.018	0.420	2.044	1.634
4.00	560.167	2	1.438	0.420	2.044	2.483
2.00	559.847	2	2.078	0.640	2.100	3.604
0.00	559.527	2	1.758	0.320	2.025	3.860
2.00	559.837	2	1.768	0.010	2.000	3.526
4.00	560.147	2	1.458	0.310	2.024	3.245
6.00	560.557	2	1.048	0.410	2.042	2.532
8.00	560.967	2	0.638	0.410	2.042	1.704
10.00	561.277	2	0.328	0.310	2.024	0.972
12.00	561.527	2	0.078	0.250	2.016	0.408
		avg.Depth =	0.963		24.400	25.156

Discharge Calculation by Area Velocity method

Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 25.156 Sqm

P = 24.400 M

depth of 0.963 m

R=A/P

R = 25.16/24.4

1.03

S = 0.0029833

n = 0.04

V = 1.03^0.66x0^0.5/0.04

V = 1.3926728 m/sec

Q=A*V

Q = 1.39x25.16

Q = 35.034 m^3/sec

Location - Des Ch- 170+435

Calculation of Discharge By Area Velocity Method at **300D/S**

H.F.L 559.815 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff	Perimeter	Area
12.00	559.787		0.028		0.000	
10.00	559.337	2	0.478	0.450	2.050	0.512
8.00	558.817	2	0.998	0.520	2.066	1.501
6.00	558.297	2	1.518	0.520	2.066	2.558
4.00	557.977	2	1.838	0.320	2.025	3.377
2.00	557.857	2	1.958	0.120	2.004	3.799
0.00	557.737	2	2.078	0.120	2.004	4.040
2.00	557.847	2	1.968	0.110	2.003	4.049
4.00	557.957	2	1.858	0.110	2.003	3.829
6.00	558.367	2	1.448	0.410	2.042	3.340
8.00	558.877	2	0.938	0.510	2.064	2.424
10.00	559.287	2	0.528	0.410	2.042	1.481
12.00	559.737	2	0.078	0.450	2.050	0.614
		avg.Depth =	1.209		24.419	31.524

Discharge Calculation by Area Velocity method

Using Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 31.524 Sqm

P = 24.419 M

depth of 1.209 m

R=A/P

R = 1.52/24.42

1.29

S = 0.002983

n = 0.04

V = 1.29^0.66x0^0.5/0.04

V = 1.618146 m/sec

Q=A*V

Q = ..62x31.52

Q = 51.011 m^3/sec

Location - Des Ch- 170+435

L - Section of River/nalla

Chainage (M)	G .L (M)
-300.000	559.527
-280.000	559.457
-260.000	559.387
-240.000	559.317
-220.000	559.247
-200.000	559.197
-180.000	559.147
-160.000	559.097
-140.000	559.047
-120.000	558.997
-100.000	558.927
-80.000	558.877
-60.000	558.827
-40.000	558.777
-20.000	558.727
0.000	558.637
20.000	558.577
40.000	558.517
60.000	558.457
80.000	558.397
100.000	558.337
120.000	558.277
140.000	558.217
160.000	558.157
180.000	558.097
200.000	558.037
220.000	557.977
240.000	557.917
260.000	557.857
280.000	557.797
300.000	557.737

Slope = (559.527-557.74)/(300--300)
0.002983

DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2

At DES CH- 170+435

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

INDEX

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

INTRODUCTION

This design note present the detailed calculations for abutment having POT/PTFE bearings. Design note contains the typical design of abutment cap, abutment, pile cap and pile. In the analysis, the forces have been worked out at the pile cap bottom level for pile cap design and at the top of pile cap for abutment shaft design.

This design is applicable for abutment

Abutment Nos.	Road Top Level	GROUND LEVEL	Pile cap bottom	DIFF
	(M)	(M)	(M)	(M)
A1 & A2	564.056	560.702	558.402	5.654

DESIGN DATA

Span Arrangement C/C of exp. Joint	=	**25**	m
Deck Width	=	**18**	m
Carriageway Width	=	**11**	m
Structural system	=	simply supported	
construction type	=	RCC	
Effective Span	=	**24.00**	m
Expansion gap in abutment	=	**40**	mm
No of Lane considered for design	=	**4**	
Bearing type	=	**POT PTFE Bearing**	
Skew Angle	=	**0**	Degree

SALIENT REDUCED LEVELS

Deck Top Level	=	564.056
Soffit Level	=	562.756
Abutment Cap Top Level	=	562.706
Abutment Cap Bottom Level	=	562.206
HFL	=	560.715
Pile cap bottom Level	=	558.402
Scour Level	=	558.138

DETAILS OF STRUCTURE & OTHER PARAMETERS

Type of structure		**RCC**	
Depth of Superstructure	=	**1.810**	m
Thickness of wearing coat	=	**0.075**	m
Camber in both direction	=	2.50%	
Expansion joint Type	=	**Strip seal**	
Impact (including Congestion Factor)	=	1.323	
Thickness of Return	=	**0.5**	m

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

MATERIAL PARAMETERS

Concrete — **Refer Table 6.5, IRC:112-2019**

Grade of concrete for sub structure and foundation		=	**M25**	
Cube strength of concrete at 28 days	f_{ck}	=	**25**	MPa
Design value of concrete compressive strength	f_{cd}	=	$\alpha f_{ck}/\gamma_m$	
		α =	0.67	
For Basic Combination	f_{cd}	=	11.17	MPa
For Accidental Combination	f_{cd}	=	13.96	MPa
For Seismic Combination	f_{cd}	=	11.17	MPa
Modulus of Elasticity	E_c	=	30000	MPa
Mean value of axial tensile strength of concrete	f_{ctm}	=	2.2	MPa
Wet Density **2.00** t/m3	Dry Density	=	**2.50**	t/m^3

Reinforcing Steel

Grade		=	**Fe500**	
Characteristics yield strength	f_{yk}	=	500	MPa
Design yield strength	f_{yd}	=	f_{yk}/γ_m	
For Basic Combination	f_{yd}	=	434.8	MPa
For Accidental Combination	f_{yd}	=	500.0	MPa
For Seismic Combination	f_{yd}	=	434.8	MPa
Modulus of Elasticity	E_s	=	**2.00E+05**	Mpa
	Ecm	=	**3.00E+04**	Mpa
Density		=	**7.85**	t/m3
Soil Wet density **1.00** t/m3	Soil Dry Density	=	**2.00**	t/m3

'(As per STAAD Output)

21 m span Reactions (KN)			
Bearing No.	**DL**	**SIDL1 (WC)**	**SIDL2 (CB)**
1	437	51	156
2	483	43	-19
3	469	50	5
4	479	43	-28
5	448	53	159
	2316	**240**	**273**

Partial Safety Factor for Materials

Material	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
Concrete	1.50	1.20	1.50
Steel	1.15	1.00	1.15

Cl 6.4.2.8, IRC:112-2011
Cl 6.2.2, IRC:112-2011

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL N	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

LIVE LOAD CALCULATIONS

1. MAX. MOMENT CASE

a) 70 R 1lane loading

17 17 17 7 12 8

1

1.37 3.05 1.37 2.13 1.51 11.11

RA RB

0.50 24.00 0.50

Ra	=	1937.82	/	24.00	=	80.7 t
		Impact	1.323		=	106.8 t
RB	=					19.26 t

b) Class A 1 lane loading

11.4 11.4 6.8 6.8 6.8

1.2 4.3 3.0 3.0 3.0 10.0

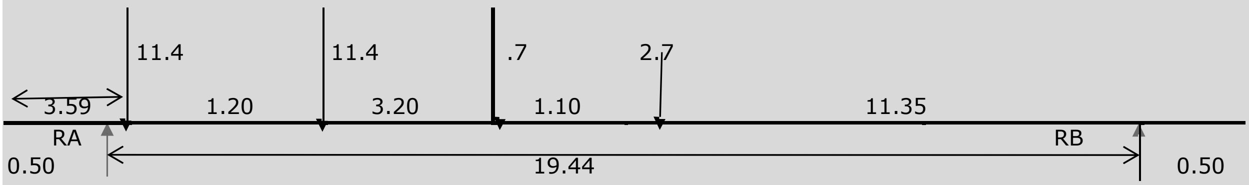
RA RB

0.50 24.00 0.50

Ra =	939.32	/	24.00	=	39.1 t
		Impact	1.323	=	51.8 t
RB =				=	10.9 t

2. MAX. REACTION/ TRANSVERSE MOMENT CASE

b) Class A 1 lane loading



Ra =	420.63	/		19.44	=	21.64	t
			Impact	1.323	=	28.62	t
RB =					=	6.6	t

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

PARTIAL SAFETY FACTORS

Ultimate Limit State

Partial Safety for Verification of Structural Strength **Table B.1, Annex B, IRC:6-2017**

Also refer IRC Amendment dated August, 2019

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturnin g or Sliding or Uplift Effect	Restoring or Resisting Effect
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 Permanent Loads:						
1.1 Dead Load, SIDL except surfacing, Backfill Weight,Settlement, Creep and shrinkage effect	1.1	0.9	1	1	1.1	0.9
1.2 Surfacing	1.35	1.0	1.0	1.0	1.35	1.0
1.3 Prestressing and secondary effect of prestress	Refer Note No. 5					
1.4 Earth Pressure due to Backfill	1.50	1	1.0	1	1.0	1
2 Variable Loads:						
2.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:						
a) Leading Load	1.5	0	0.75	0	-	-
b) Accompanying Load	1.15	0	0.2	0	0.2	0
c) Construction Live Load	1.35	0	1.0	0	1.0	0
2.2 Thermal Loads						
a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	0.5	0	0.5	0
2.3 Wind Load						
a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	-	-	-	-
2.4 Live Load Surcharge (as accompanying	1.2	0	-	-	-	-
3 Accidental Effects:						
3.1 Vehicle Collision	-	-	1.0	-	-	-
3.2 Barge Impact	-	-	1.0	-	-	-
3.3 Impact due to floating bodies	-	-	1.0	-	-	-
4 Seismic Effect						
a) During Service	-	-	-	-	1.5	-
b) During Construction	-	-	-	-	0.75	-
5 Construction Condition:						
5.1 Counter Weights:						
a) When density or self weight is well defined	-	0.9	-	1.0	-	1.0
b) When density or self weight is not wel defined	-	0.8	-	1.0	-	1.0
5.2 Construction dead loads(such as wt. of launching girder, truss or cantilever construction equipments	1.10	0.90	1.1	0.9	1.1	0.9
5.3 Wind						
a) As Leading Load	1.50	0	-	-	-	-
b) As Accompanying Load	1.20	0	-	-	-	-
6 Hydraulic Loads (Accompanying Load):						
6.1 Water Current Forces	1.0	0	1.0	0	1.0	-
6.2 Wave Pressure	1.0	0	1.0	0	1.0	-
6.3 Hydrodynamic Effect	-	-	-	-	1.0	-
6.4 Buoyancy	1.0	-	1.0	-	1.0	-

Partial Safety for Verification of Structural Strength **Table B.2, Annex B, IRC:6-2017**

Also refer IRC Amendment dated August, 2019

Loads	**Partial Safety Factor**		
	Basic Combination	**Accidental Combination**	**Seismic Combination**
(1)	**(2)**	**(3)**	**(4)**
1 Permanent Loads:			
1.1 Dead Load, snow load (if present) SIDL except surfacing			
a) Adding to the effect of variable loads	1.35	1.00	1.35
b) Relieving the effect of variable loads	1.00	1.00	1.00
1.2 Surfacing:			
a) Adding to the effect of variable loads	1.75	1.00	1.75
b) Relieving the effect of variable loads	1.00	1.00	1.00
1.3 Prestressing and secondary effect of prestress	Refer Note No. 2		
1.4 Backfill Weight			
(a) When Causing Adverse Effect	1.35	1.00	1.00
(b) When Causing Relieving Effect	1.00	1.00	1.00
1.5 Earth Pressure			
a) Adding to the effect of loads	1.50	0.00	1.00
b) Relieving the effect of loads	1.00	1.00	1.00
2 Variable Loads:			
2.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.50	0.75	-
b) Accompanying Load	1.15	0.20	0.20
c) Construction Live Load	1.35	1.00	1.00
2.2 Wind during service and construction			
a) Leading Load	1.50	-	-
b) Accompanying Load	0.90	-	-
2.3 Live Load Surcharge (as accompanying load)	1.20	0.20	0.20
2.4 Construction dead loads(such as wt. of launching girder, truss or cantilever construction equipments	1.35	1.00	1.35
2.5 Thermal Load			
a) Leading Load	1.50	-	-
b) Accompanying Load	0.90	0.50	0.50
3 Accidental Effects:			
i) Vehicle Collision	-	1.00	-
ii) Barge Impact	-	1.00	-
iii) Impact due to floating bodies	-	1.00	-
4 Seismic Effect			
a) During Service	-	-	1.50
b) During Construction	-	-	0.75
5 Hydraulic Loads (Accompanying Load):			
5.1 Water Current Forces	1.00	1.00	1.00
5.2 Wave Pressure	1.00	1.00	1.00
5.3 Hydrodynamic Effect	-	-	1.00
5.4 Buoyancy	0.15	0.15	1.00

Serviceability Limit State
Partial Safety for Verification of Serviceability Limit State

Table B.3, Annex B, IRC:6-2017

Also refer IRC Amendment dated August, 2019

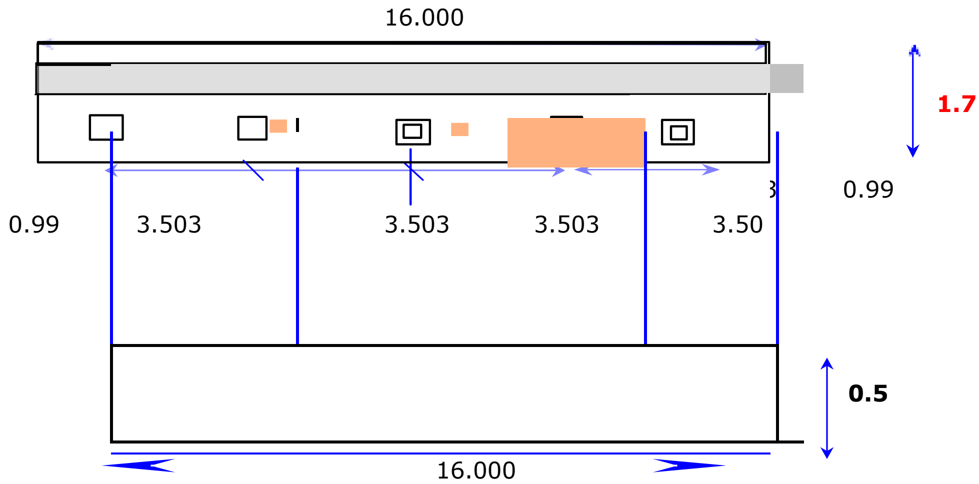
Loads	**Partial Safety Factor**		
	Rare Combination	**Frequent Combination**	**Quasi-permanent Combination**
(1)	**(2)**	**(3)**	**(4)**
1 Permanent Loads:			
1.1 Dead Load, Snow Load(if any), Backfill, SIDL except surfacing	1.00	1.00	1.00
1.2 Surfacing	1.00	1.00	1.00
a) Adding the effect of variable Loads	1.20	1.20	1.20
b) Relieving the effect of variable Loads	1.00	1.00	1.00
1.3 Earth Pressure	1.00	1.00	1.00
1.4 Prestress and secondary effect of prestressing	Refer Note no. 4		
1.5 Shrinkage and Creep Effects	1.00	1.00	1.00
2 Settlement Effects			
a) Adding to the permanent loads	1.00	1.00	1.00
b) Opposing the permanent loads	0.00	0.00	0.00
3 Variable Loads:			
3.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.00	0.75	-
b) Accompanying Load	0.75	0.20	0.00
3.2 Thermal Loads:			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load	0.60	0.50	0.50
3.3 Wind			
a) Leading Load	1.00	0.60	-
b) Accompanying Load	0.60	0.50	0.00
3.4 Live Load Surcharge as Accompanying load	0.80	0.00	0.00
4 Hydraulic Loads (Accompanying Load):			
4.1 Water Current	1.00	1.00	-
4.2 Wave Pressure	1.00	1.00	-
4.3 Buoyancy	0.15	0.15	0.15

Partial Safety for Checking the Base Pressure and Design of Foundation

Also refer IRC Amendment dated August, 2019 **Table B.4, Annex B, IRC:6-2017**

Load	Partial Safety Factor			
	Combination-1	Combination-2	Combination-3	Combination-4
(1)	(2)	(3)	(4)	(5)
1. Permanent Loads:				
1.1 Dead Load, Snow Load (if any), SIDL except surfacing and Back fill				
a) When causing adverse effects	1.35	1.00	1.35	1.00
b) When causing Relieving effects	1.00	1.00	1.00	1.00
1.2 SIDL surfacing				
a) When causing adverse effects	1.75	1.00	1.75	1.00
b) When causing Relieving effects	1.00	1.00	1.00	1.00
1.3 Prestress Effect	Refer Note 4			
1.4 Settlement Effect	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
1.5 Earth Pressure				
a) Adding to the effect of loads	1.50	1.30	1.00	1.00
b) Relieving to the effect of loads	1.00	0.85	1.00	1.00
2. Variable Loads:				
2.1 All carriageway loads and associated loads (braking, tractive and centrifugal) and footway live load				
a) Leading Load	1.50	1.30	0.75 or 0	0.75 or 0
b) Accompanying Load	1.15	1.00	0.20	0.20
c) Construction Dead Load	1.35	1.00	1.35	1.00
2.2 Thermal load as accompanying load	0.90	0.80	0.50	0.50
2.3 Wind Load				
a) Leading Load	1.50	1.30	-	-
b) Accompanying Load	0.90	0.80	0.00	0.00
2.4 Live load surcharge as Accompanying Load (if applicable)				
3. Accidental Effect or Seismic Effect				
a) During Service	-	-	1.50	1.00
b) During Construction	-	-	0.75	0.50
4. Construction Dead Load (Such as Wt. of launching girder, truss or cantilever construction equipments)	1.35	1.00	1.35	1.00
5. Hydraulic Loads:				
5.1 Water Current	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
5.2 Wave Pressure	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
5.3 Hydodynamic effect	-	-	1.0 or 0	-
6. Buoyancy:				
a) For Base Pressure	1.00	1.00	1.00	1.00
b) For Structural Design	0.15	0.15	0.15	0.15

ABUTMENT CAP LOAD CALCULATION



Abutment cap is fully resting on abutment wall, so provide min. reinforcement.
cl. 16.5.1.1 (1) of IRC :112-2011

$A_{S.min} = 0.26\, f_{ctm}\, b_t\, d / f_{yk} >= 0.0013\, b_t\, d$

f_{ctm}	2.2	
b_t	1700	
d	527	
f_{yk}	500	
$0.26\, f_{ctm}\, b_t\, d / f_{yk}$	1025	mm^2
$0.0013\, b_t\, d$	1165	mm^2
Provide	1165	mm^2

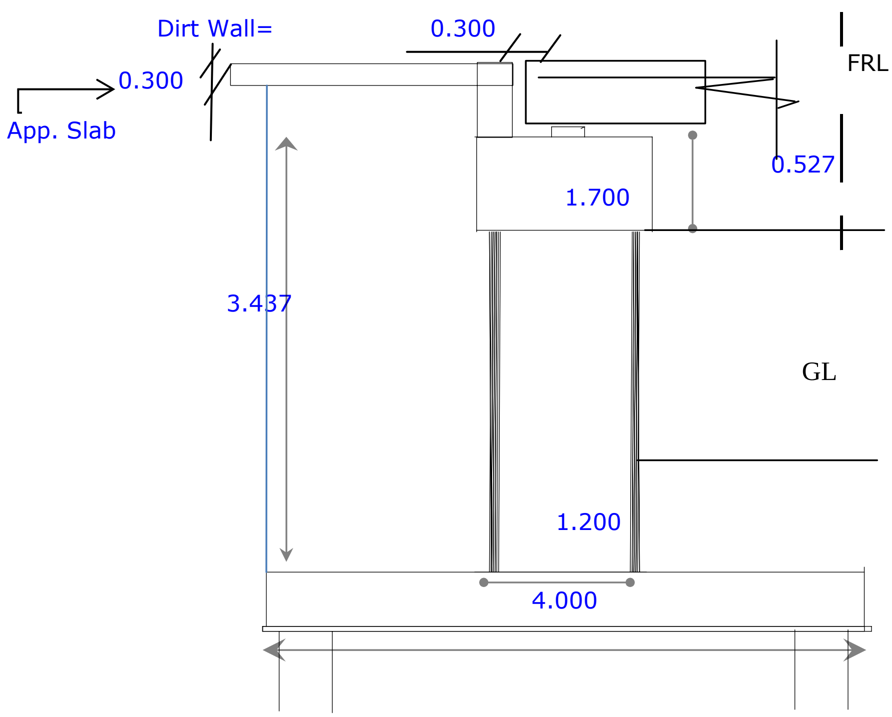
16 ϕ @	**150**	**mm c/c**	**1340**	**mm^2**	**at top and bottom**
			OK		
12 ϕ @	**150**	**mm c/c**	**754**	**mm^2**	**as distribution in the form of stirrup**
			OK		

Project	Preparation of DPR for Manu - Simlung section of NH-44A (86 Kms) in state of tripura on EPC mode.	Designed by:	KB
Client	NHIDCL	Checked by:	-
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	15/03/2021 (R0)

LOAD CALCULATION FOR ABUTMENT & PILE CAP

SALIENT REDUCED LEVELS

Deck Top Level	=	564.056	m
Bearing Top Level	=	562.756	m
Abutment Cap Top Level	=	562.706	m
Abutment Cap Bottom Level	=	562.206	m
Abutment Bottom Level	=	560.202	m
Depth of Pile cap	=	1.8	m
GL	=	560.702	m
Pile cap bottom Level	=	558.402	m
HFL	=	560.715	m
LBL	=	558.637	m
Expansion Gap	=	0.040	m
Width of abutment	=	**1.200**	m
Length of the abut	=	**18.000**	m
Length of Pile cap	=	**18.000**	m
Width of Pile cap	=	**4.850**	m
Thickness of Wearing coat (W/c)	=	0.075	m
Height of Deck+Girder	=	1.810	m
Thickness of bearing	=	**0.100**	m
Height of Pedestal	=	**0.250**	m
Total Height from w/c to Abut Cap top	=	2.135	m
Span EJ to EJ	=	25.000	m



5.322
0.770

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OFABUTMENTS A1 & A2	Date & Rev.	

LOAD CALCULATIONS

Taking Moments about founding level

		RIGHT SPAN	LEFT SPAN	L (Long)	L (Trans)	ML	Mt	
				m	m	t-m	t-m	
Dead Load		236.33		0.00	0.00	0.00	0.00	
SIDL1 w/c		24.49		0.00	0.00	0.00	0.00	
SIDL 2 exl w/c		27.86		0.00	0.00	0.00	0.00	
LL1 (Max Reaction)								
70 R + 2Class A		115.33		0.00	1.875	0.00	216.25	2.103
2 70 R		116.20		0.00	3.080	0.00	357.90	2.910
70 R		58.10		0.00	4.905	0.00	284.99	4.905
Class 4 A		114.46		0.00	1.075	0.00	123.05	0.950
70 R + Class A		86.72		0.00	4.201	0.00	364.30	3.958
LL2 (Max Moment)								
70 R + 2Class A		210.30		0.00	1.875	0.00	394.32	2.103
2 70 R		213.56		0.00	3.080	0.00	657.78	2.910
70 R		106.78		0.00	4.905	0.00	523.77	4.905
Class 4 A		207.04		0.00	1.075	0.00	222.57	0.950
70 R + Class A		158.54		0.00	4.201	0.00	666.04	3.958
Horizontal Force Due to braking at				POT PTFE Bearing		Fixed abut		
	μ =	0.05	(as per IRC 6:2017)	Fh/2 + μ(Rg+Rq) OR Fh - μ(Rg+Rq)	**@foundation**		**abut Bottom**	
	Fh	Rg	Rq	**H**	**Lev**	**ML**	**Lev**	**ML**
	t	t	t	t	m	t-m	m	t-m
70 R + 2Class A		288.67	210.30	24.95	5.24	130.66	3.44	85.75
Class 2 70R	20.43	288.67	213.56	35.33	5.24	185.01	3.44	121.42
Class 70 R	20.00	288.67	106.78	29.77	5.24	155.92	3.44	102.33
Class 4 A	15.51	288.67	207.04	32.54	5.24	170.42	3.44	111.84
70 R + Class A	20.49	288.67	158.54	32.61	5.24	170.76	3.44	112.07

Horizontal braking force	=	35.33	t			
ML @ foundation	=	185.01	tm			
ML @ abut bottom	=	121.42	tm			
@foundation	P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)	Fh(t)
LL1B	3	185	0	35.33	0.00	20.43
LL2B	0	0	0			
LL3B	3	171	0	32.61	0.00	20.49
@abutment bottom	P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)	Fh(t)
LL1B	3	121	0	35.33	0.00	20.43
LL2B	0	0	0			
LL3B	3	112	0	32.61	0.00	20.49

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

WIND FORCES ON SUPER STRUCTURE

REF: IRC 6-2017 CL NO:209.2

Basic wind speed	=	47	m/s	Plain terrain			
Design wind speed	=	39.59	m/s	at height	10.00 m		**27.80 m/s**
Design wind pressure P_Z	=	940.60	N/m^2	at height	10.00 m		**463.70 N/m^2**
$F_T = P_Z A_1 G C_D$	=	374	Kg/m^2	G =	**2.00**	**C_D =**	**1.95**
F_L =	=	93.48	Kg/m^2				
$F_V = P_Z A_3 G C_L$	=	144	Kg/m^2	G =	**2.00**	**C_L =**	**0.75**

Up ward or downward vertical wind Load

F_V = 12.50 x **16.000** x 143.82 = 28.76 t

WIND FORCES ON LIVE LOAD

Basic wind speed	=	0	m/s	Plain terrain			
Design wind speed	=	0.00	m/s	at height	10.00 m		**27.80 m/s**
Design wind pressure P_Z	=	0.00	N/m^2	at height	10.00 m		**463.70 N/m^2**
$F_T = P_Z A_1 G C_D$	=	0	Kg/m^2	G =	**2.00**	**C_D =**	**1.20**
F_L =	=	0.00	Kg/m^2				
$F_V = P_Z A_3 G C_L$	=	0	Kg/m^2	G =	**2.00**	**C_L =**	**0.75**

WIND FORCES ON SUB STRUCTURE

Basic wind speed	=	47	m/s	Plain terrain			
Design wind speed	=	39.59	m/s	at height	10.00 m		**27.80 m/s**
Design wind pressure P_Z	=	940.60	N/m^2	at height	10.00 m		**463.70 N/m^2**

REF: IRC 6-2017 CL NO:209.4

$F_T = P_Z A_1 G C_D$	=	96	Kg/m^2	G =	**2.00**	**C_D =**	**0.50**
F_L =	=	23.97	Kg/m^2				
$F_V = P_Z A_3 G C_L$	=	144	Kg/m^2	G =	**2.00**	**C_L =**	**0.75**

TRANSVERSE DIRECTION		**Moments about FL**			**Abutment Bottom**	
DESCRITPTION		**H**	**Lev**	**Mt**	**Lev**	**Mt**
		t	**M**	**t-m**	**M**	**t-m**
WIND ON SUPER STR ACT @	114.94	11.29	6.18	69.75	4.38	49.44
WIND ON MOVING LOAD @	117.39	0.00	8.62	0.00	6.82	0.00
WIND ON abutment CAP @	113.49	0.09	4.72	0.41	2.92	0.25
WIND ON abutment @	112.15	0.21	3.38	0.70	1.58	0.33
	TOTAL	**11.58**		**70.86**		**50.01**

LONGITUDINAL DIRECTION		**Moments about FL**			**Abutment Bottom**	
DESCRITPTION		**H**	**Lev**	**Mt**	**Lev**	**Mt**
		t	**M**	**t-m**	**M**	**t-m**
WIND ON SUPER STR ACT @	114.94	4.71	6.18	43.05	4.38	34.57
WIND ON MOVING LOAD @	117.39	0.00	8.62	0.00	6.82	0.00
WIND ON abutment CAP @	113.49	0.71	4.72	5.25	2.92	3.97
WIND ON abutment @	112.15	0.05	3.38	0.18	1.58	0.08
	TOTAL	**5.53**		**48.85**		**38.89**

DEAD WEIGHT OF ABUTMENT CAP WITH DIRT WALL

	Nos	L	B	H	Qty	wt	L. A.	ML (tm)
		m	m	m	m3	t		
Abut. Cap	1	16.000	1.70	0.527	14.33	35.84	0.00	0.00
Dirt wall	1	16.000	0.30	2.135	10.25	25.62	-0.70	-17.93
Pedestals (5 nos)	5	**0.800**	**0.800**	**0.400**	1.28	3.20	0.00	0.00
DL+SIDL (approach span) load	1	16.000		5.2	**0.92** t/m2	37.70	-0.70	-26.39
LL (approach span) LL surcharge(1.2m)	1	16.000		5.150	**2.40** t/m2	98.88	-0.70	-69.22
Total						**201.23**		**-59.49**

DEAD WEIGHT OF ABUTMENT & FOUNDATION

	L	B	H	LWL wt	HFL wt	LA C/L of abut / found(m)	LWL ML	HFL ML
	m	m	m	t	t		(t.m)	(t.m)
Abut. Stem	16.000	1.00	2.16	86.40	69.12	0.00	0.00	0.00
	16.000	1.00	0.50	20.00	16.00	0.00	0.00	0.00
Foundation	16.000	4.85	1.80	349.20	279.36	0.00	0.00	0.00
Return wall	1.00	1.925	2.66	12.81	10.25	-1.46	-18.74	-14.99
	1.00	1.925	0.77	3.71	2.96	-1.46	-5.42	-4.34
	1.00	1.925	1.89	9.10	7.28	-1.46	-13.30	-10.64
Soil Above the Foundation	15.000	1.925	2.29	132.07	66.04	-1.46	-193.16	-96.58
	15.000	1.925	0.77	44.47	22.23	-1.46	-65.03	-32.52
	15.000	1.925	1.89	109.15	54.57	-1.46	-159.63	-79.81
Total				**766.90**	**527.81**		**-455.28**	**-238.88**
					239.09			**-216.40**

Earth pressure		At foundation		At abut. Bottom	
		LWL	HFL	LWL	HFL
Height	m	7.122	7.122	5.32	5.32
Dry unit wt. of soil	t/m3	2.00		2.00	
Wet unit wt. of soil	t/m3		1.00		1.00
Coulomb's theory Ka (Normal case)					
Angle of friction	ϕ	**30.00**			
Angle of deflection	δ	**20.00**			
wall inclination to horizontal	α	**90.00**			
soil surcharge inclination to horizontal	β	**0.00**			
Ka (Normal case)		0.279			
Coulomb's theory Ka (Seismic case)					
Seismic Zone		III			
α_h		0.0800			
α_v		0.0533			
$\theta = \tan^{-1}(\alpha_h/(1+\_\alpha_v))$		0.0758			
		0.0843			
Coefficient of active earth pressure (Seismic case)		0.344			
Coefficient of active earth pressure		0.279	0.279	0.279	0.279
Live load surcharge	m	**1.20**	**1.20**	**1.20**	**1.20**
Active earth pressure		3.98	1.99	2.97	1.49
Pressure due to live load surcharge		0.67	0.34	0.67	0.34
Force due to live load surcharge	t/m	76	38	57	29
Force due to active earth pressure	t/m	227	113	127	63
Moment due to live load surcharge	t.m/m	272	136	152	76
Moment due to active earth pressure	t.m/m	678	339	283	142

Dynamic increment due to earth pressure As per Cl. 219.5.4 & 214.1.2 of IRC 6-2017		At foundation		At abut. Bottom	
		LWL	HFL	LWL	HFL
Coefficient of active earth pressure		0.000	0.000	0.000	0.000
Live load surcharge	m	**1.20**	**1.20**	**1.20**	**1.20**
Active earth pressure		0.00	0.00	0.00	0.00
Pressure due to live load surcharge		0.00	0.00	0.00	0.00
Force due to live load surcharge	t/m	0	0	0	0
Force due to active earth pressure	t/m	0	0	0	0
Moment due to live load surcharge	t.m/m	0	0	0	0
Moment due to active earth pressure	t.m/m	0	0	0	0

Fundamental Time Period of Vibration due to Seismic Waves :

According to **Annexure D (Clause 219.5)** IRC 6 :2017 -

T	=	2.0 x sqrt(D/(1000*F))

Where,

T	=	Fundamental Time Period Of Vibration
D	=	Appropriate dead Load of the superstructure and Live load in KN
F	=	Horizontal Force in KN required to be applied at the centre of mass of superstructure for 1 mm horizontal deflection at the top of the 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 Longitudinal direction

			Longitudinal Direction		Transverse Direction		
	F	=	$d*(3EI)/L^3$	Unit	$d*(3EI)/L^3$	Unit	
	d	=	0.001	m	0.001	m	
	L	=	4.460	m	5.037	m	
	E	=	3.00E+07	KN/m2	3.00E+07	KN/m2	
	I	=	1.000	m4	256.000	m4	
	F	=	1014.467	KN	#######	KN	
	D	=	2829.000	KN	3248.012	KN	(DL+0.2*LL)
	T	***=***	***0.11***	***sec***	***0.01***	***sec***	
Seismic Zone		=	III		III		
Zone Factor Z		=	0.16		0.16		
Importance Factor I		=	1.2		1.2		
Response Reduction Factor		=	3		3		
Soil Strata		=	Type II	Medium soil			
Sa/g			2.5		2.5		
Horizontal Acceleration Coefficient (Ah) Z/2*Sa/g*I/R		=	0.08		0.08		

For design of foundation seismic loads are increased by 35%   As per Cl. 219.8 of IRC 6-2017

Seismic Force Calculations		**For Foundation**		
		Horizontal	**Vertical (2/3 of Horizontal)**	
Long Seismic Coefficient		0.108	0.072	(including over strength factor)
Trans Seismic Coefficient		0.108	0.072	(including over strength factor)
Seismic		For design of foundation seismic loads are increased by 35%		

						@ Foundation		
	V (t)	**H Comp**	**V Comp**	**Acting At**	**Ecc (For H)**	**ML Due to H**	**Moment Due to V**	
							ML	**MT**
DL	472.2	51.0	34.0	114.0	5.2	267.1	0.0	0.0
SIDL1	48.9	5.3	3.5	114.0	5.2	27.7	0.0	0.0
SIDL2	55.7	6.0	4.0	114.0	5.2	31.5	0.0	0.0
Abt. but Cap+dirt wall	201.2	21.7	14.5	114.4	5.59	121.4	0.0	0.0
abut	106.4	11.5	7.7	111.9	3.1	36.0	0.0	0.0
return wall	25.6	2.8	1.8	113.2	4.5	12.3	0.0	0.0
Soil above found	285.7	30.9	20.6	113.2	4.5	137.6	0.0	0.0
LL1	42.7	4.6	3.1	114.0	5.2	24.2	0.0	9.5
LL2	42.7	4.6	3.1	114.0	5.2	24.2	0.0	9.5
LL3	31.7	3.4	2.3	114.0	5.2	17.9	0.0	9.6

Longitudinal seismic

	V (t)	ML (t.m)	MT (t.m)
DL	78.56	574.40	0.00
SIDL1	3.52	27.67	0.00
SIDL2	4.01	31.48	0.00
LL1	3.08	24.16	9.47
LL2	3.08	24.16	9.47
LL3	2.28	17.93	9.59

Tranverse seismic

	V (t)	ML (t.m)	MT (t.m)
DL	78.56	0.00	574.40
SIDL1	3.52	0.00	27.67
SIDL2	4.01	0.00	31.48
LL1	3.08	0.00	33.63
LL2	3.08	0.00	33.63
LL3	2.28	0.00	27.53

Combination of Orthogonal Seismic Force

		V (t)	**ML (t.m)**	**MT (t.m)**	**PSF**	**V (t)**	**ML (t.m)**	**MT (t.m)**
DL		78.56	746.72	0.00	1.00	**78.6**	**746.7**	**0.0**
SIDL1		3.52	35.98	0.00	1.00	**3.5**	**36.0**	**0.0**
SIDL2		4.01	40.92	0.00	1.00	**4.0**	**40.9**	**0.0**
LL1		3.08	34.25	9.47	1.00	**3.1**	**34.2**	**9.5**
LL2		3.08	34.25	9.47	1.00	**3.1**	**34.2**	**9.5**
LL3		2.28	26.19	9.59	1.00	**2.3**	**26.2**	**9.6**
DL		78.56	0.00	746.72	1.00	**78.6**	**0.0**	**746.7**
SIDL1		3.52	0.00	35.98	1.00	**3.5**	**0.0**	**36.0**
SIDL2		4.01	0.00	40.92	1.00	**4.0**	**0.0**	**40.9**
LL1		3.08	2.84	40.88	1.00	**3.1**	**2.8**	**40.9**
LL2		3.08	2.84	40.88	1.00	**3.1**	**2.8**	**40.9**
LL3		2.28	2.88	32.91	1.00	**2.3**	**2.9**	**32.9**

	V (t)	ML (t.m)	MT (t.m)
DL+SIDL1+SIDL2+LL1	89.17	857.87	9.47
DL+SIDL1+SIDL2+LL2	89.17	857.87	9.47
DL+SIDL1+SIDL2+LL3	88.37	849.81	9.59
DL+SIDL1+SIDL2+LL1	89.17	2.84	864.50
DL+SIDL1+SIDL2+LL2	89.17	2.84	864.50
DL+SIDL1+SIDL2+LL3	88.37	2.88	856.53
DL+SIDL1+SIDL2+LL1	89	858	9
DL+SIDL1+SIDL2+LL2	89	858	9
DL+SIDL1+SIDL2+LL3	89	3	865

Seismic Force Calculations					**For abutment**			
		Horizontal	**Vertical (2/3 of Horizontal)**					
Long Seismic Coefficient		0.080	0.053	***Refer Seismic Calculations Appendex 1***				
Trans Seismic Coefficient		0.080	0.053					
Seismic								
						@ Stem Bottom		
	V (t)	**H Comp**	**V Comp**	**Acting At**	**Ecc (For H)**	**ML Due to H**	**Moment Due to V**	
							ML	**MT**
DL	472.2	37.8	25.2	114.0	3.4	129.8	0.0	0.0
SIDL1	48.9	3.9	2.6	114.0	3.4	13.5	0.0	0.0
SIDL2	55.7	4.5	3.0	114.0	3.4	15.3	0.0	0.0
abut Cap	201.2	16.1	10.7	114.4	3.8	60.9	0.0	0.0
abut Stem	106.4	8.5	5.7	111.9	1.3	11.3	0.0	0.0
LL1	42.7	3.4	2.3	114.0	3.4	11.7	0.0	7.0
LL2	42.7	3.4	2.3	114.0	3.4	11.7	0.0	7.0
LL3	31.7	2.5	1.7	114.0	3.4	8.7	0.0	7.1

Longitudinal seismic

	V (t)	ML (t.m)	MT (t.m)
DL	41.59	202	0.00
SIDL1	2.61	13.45	0.00
SIDL2	2.97	15.30	0.00
LL1	2.28	11.74	7.02
LL2	2.28	11.74	7.02
LL3	1.69	8.72	7.10

Tranverse seismic

	V (t)	ML (t.m)	MT (t.m)
DL	41.59	0.00	202.09
SIDL1	2.61	0.00	13.45
SIDL2	2.97	0.00	15.30
LL1	2.28	0.00	18.76
LL2	2.28	0.00	18.76
LL3	1.69	0.00	15.82

Combination of Orthogonal Seismic Force

		V (t)	**ML (t.m)**	**MT (t.m)**	**PSF**	**V (t)**	**ML (t.m)**	**MT (t.m)**
DL		41.59	262.72	0.00	1.00	**41.6**	**262.7**	**0.0**
SIDL1		2.61	17.49	0.00	1.00	**2.6**	**17.5**	**0.0**
SIDL2		2.97	19.89	0.00	1.00	**3.0**	**19.9**	**0.0**
LL1		2.28	17.37	7.02	1.00	**2.3**	**17.4**	**7.0**
LL2		2.28	17.37	7.02	1.00	**2.3**	**17.4**	**7.0**
LL3		1.69	13.47	7.10	1.00	**1.7**	**13.5**	**7.1**
DL		41.59	0.00	262.72	1.00	**41.6**	**0.0**	**262.7**
SIDL1		2.61	0.00	17.49	1.00	**2.6**	**0.0**	**17.5**
SIDL2		2.97	0.00	19.89	1.00	**3.0**	**0.0**	**19.9**
LL1		2.28	2.10	22.28	1.00	**2.3**	**2.1**	**22.3**
LL2		2.28	2.10	22.28	1.00	**2.3**	**2.1**	**22.3**
LL3		1.69	2.13	18.44	1.00	**1.7**	**2.1**	**18.4**

	V (t)	ML (t.m)	MT (t.m)
DL+SIDL1+SIDL2+LL1	49.45	317.48	7.02
DL+SIDL1+SIDL2+LL2	49.45	317.48	7.02
DL+SIDL1+SIDL2+LL3	48.86	313.57	7.10
DL+SIDL1+SIDL2+LL1	49.45	2.10	322.39
DL+SIDL1+SIDL2+LL2	49.45	2.10	322.39
DL+SIDL1+SIDL2+LL3	48.86	2.13	318.54
DL+SIDL1+SIDL2+LL1	49	317	7
DL+SIDL1+SIDL2+LL2	49	317	7
DL+SIDL1+SIDL2+LL3	49	2	322

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date &Rev.	

COMBINATION FOR DESIGN OF FOUNDATION & BASE PRESSURE (ULS)

Following load combinations are con As per Annex B of IRC:112-2011

1 Combination 1

2 Combination 2

3 Seismic Combination

4 Combination for base pressure check

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	Dead Load (due to superstructure+substructure+foundtion		1204	-515	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		201	-59	0	0	0
4	ABUT + RETURN WALL		132	-37	0	0	0
5	FOUNDATION		349	0	0	0	0
6	SOIL ABOVE FDN		286	-418	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	214	0	658	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	159	0	666	0	0
12	LL1B	Live Load Moment due to braking	3	185	0	35.33	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.08	0
14	LL3B	Live Load Moment due to braking	3	171	0	32.61	0
15	W1	Wind vertically down without LL	29	5	71	5.47	11.58
16	W2	Wind vertically up without LL	-29	5	71	5.47	11.58
17	W3	Wind vertically down with LL	29	49	71	5.53	11.58
18	W4	Wind vertically up with LL	-29	49	71	5.53	11.58
19	S1	Seimic	89	858	9	133.7	0
20	S2	Seimic	89	3	865	0.0	133.7
21	S3	Seimic	-89	858	9	133.7	0
22	S4	Seimic	-89	3	865	0.0	133.7
23	HFL		-239	216	0	0.0	0.0
24	Active earth pressure LWL		0	678	0	226.7	0.0
25	LL surcharge LWL		0	272	0	76.4	0.0
26	Active earth pressure HFL		0	339	0	113.4	0.0
27	LL surcharge HFL		0	136	0	38.2	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0.0
29	LL surcharge LWL		0	0	0	0	0.0
30	Active earth pressure HFL		0	0	0	0	0.0
31	LL surcharge HFL		0	0	0	0	0.0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date &Rev.	

	Combination 1				**Combination 2**				**Seismic Combination**				**Combination for base pressure check**		
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)	P(t)	ML (tm)	MT (tm)
DL	1.35	1626	-635	-283	1.00	1204	-470	-209	1.25	1506	-588	-262	1204	-470	-209
SIDL1	1.75	43	0	0	1.00	24	0	0	1.75	43	0	0	24	0	0
SIDL2	1.35	38	0	0	1.00	28	0	0	1.25	35	0	0	28	0	0
LL1	1.50	320	401	901	1.30	278	348	781	0.20	43	54	120	214	268	601
LL2	1.50	252	431	969	1.30	219	374	840	0.20	34	58	129	168	288	646
LL3	1.50	238	406	913	1.30	206	352	791	0.20	32	54	122	159	271	608
LL1B	1.50	4	254	113	1.30	3	220	98	0.20	1	34	15	3	169	75
LL2B	1.50	0	0	0	1.30	0	0	0	0.20	0	0	0	0	0	0
LL3B	1.50	4	234	104	1.30	3	203	90	0.20	1	31	14	3	156	69
W1	0.90	26	30	60	0.80	23	27	54	0.00	0	0	0	29	34	67
W2	0.90	-26	30	60	0.80	-23	27	54	0.00	0	0	0	-29	34	67
W3	0.90	26	66	76	0.80	23	59	68	0.00	0	0	0	29	73	85
W4	0.90	-26	66	76	0.80	-23	59	68	0.00	0	0	0	-29	73	85
S1	0.00	0	0	0	0.00	0	0	0	1.50	134	1181	536	89	788	358
S2	0.00	0	0	0	0.00	0	0	0	1.50	134	531	1186	89	354	791
S3	0.00	0	0	0	0.00	0	0	0	1.50	-134	1181	536	-89	788	358
S4	0.00	0	0	0	0.00	0	0	0	1.50	-134	531	1186	-89	354	791
HFL	1.00	-239	198	88	1.00	-239	198	88	1.00	-239	198	88	-239	198	88
EP	1.00	0	620	276	0.85	0	527	234	1.00	0	620	276	0	620	276
LL S.	1.20	0	298	133	1.00	0	249	111	0.20	0	50	22	0	249	111
EP.HFL	1.00	0	310	138	0.85	0	263	117	1.00	0	310	138	0	310	138
LL.S.HFL	1.20	0	149	66	1.00	0	124	55	0.20	0	25	11	0	124	55
Active earth pressure LWL					Dynamic increment in earth pressure due to seismic				1.00	0	0	0	0	0	0
LL surcharge LWL									0.20	0	0	0	0	0	0
Active earth pressure HFL									1.00	0	0	0	0	0	0
LL surcharge HFL									0.20	0	0	0	0	0	0

Case 1 Combination 1

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1706	-15	-7
Case 2 DL+SIDL1+SIDL2+LL1	2031	938	1140
Case 3 DL+SIDL1+SIDL2+LL2	1959	714	1095
Case 4 DL+SIDL1+SIDL2+LL3	1948	923	1143
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1732	15	53
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	2057	1004	1216
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1985	781	1171
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1974	989	1219
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1681	15	53
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	2005	1004	1216
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1933	781	1171
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1922	989	1219

HFL			
Case 1 DL+SIDL1+SIDL2+HFL	1467	-127	-57
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1792	677	1024
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1720	453	979
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1709	662	1027
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1493	-97	4
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1817	743	1100
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1746	519	1055
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1735	728	1103
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	1441	-97	4
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1766	743	1100
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1694	519	1055
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1683	728	1103

MAXIMUM REACTION CASE	2057	1004	1216
MAXIMUM LONGITUDINAL MOMENT CASE	2057	1004	1216
MAXIMUM TRANSVERSE MOMENT CASE	1974	989	1219

Case 2 Combination 2

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1257	56	25
Case 2 DL+SIDL1+SIDL2+LL1	1538	872	1015
Case 3 DL+SIDL1+SIDL2+LL2	1476	679	976
Case 4 DL+SIDL1+SIDL2+LL3	1466	860	1017
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1280	83	79
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1561	931	1082
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1499	738	1043
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1489	919	1085
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1234	83	79
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1515	931	1082
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1453	738	1043
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1443	919	1085

HFL			
Case 1 DL+SIDL1+SIDL2+HFL	1018	-9	-4
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1299	683	930
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1236	489	891
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1227	670	932
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1041	18	49
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1322	741	998
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1260	548	959
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1250	729	1000
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	995	18	49
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1276	741	998
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1213	548	959
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1204	729	1000

MAXIMUM REACTION CASE	1561	931	1082
MAXIMUM LONGITUDINAL MOMENT CASE	1561	931	1082
MAXIMUM TRANSVERSE MOMENT CASE	1489	919	1085

Case 3 Seismic Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
Normal	t	t-m	t-m
Downward seismic in longitudinal direction			
Case 1 DL+SIDL1+SIDL2+ seismic	1717	1213	551
Case 2 DL+SIDL1+SIDL2+LL1+ seismic	1760	1350	708
Case 3 DL+SIDL1+SIDL2+LL2+ seismic	1751	1320	702
Case 4 DL+SIDL1+SIDL2+LL3+ seismic	1749	1348	708
Downward seismic in transverse direction			
Case 5 DL+SIDL1+SIDL2+ seismic	1717	563	1201
Case 6 DL+SIDL1+SIDL2+LL1+ seismic	1760	700	1358
Case 7 DL+SIDL1+SIDL2+LL2+ seismic	1751	670	1352
Case 8 DL+SIDL1+SIDL2+LL3+ seismic	1749	698	1358
Upward seismic in longitudinal direction			
Case 9 DL+SIDL1+SIDL2+ seismic	1449	1213	551
Case 10 DL+SIDL1+SIDL2+LL1+ seismic	1493	1350	708
Case 11 DL+SIDL1+SIDL2+LL2+ seismic	1483	1320	702
Case 12 DL+SIDL1+SIDL2+LL3+ seismic	1482	1348	708
Upward seismic in transverse direction			
Case 13 DL+SIDL1+SIDL2+ seismic	1449	563	1201
Case 14 DL+SIDL1+SIDL2+LL1+ seismic	1493	700	1358
Case 15 DL+SIDL1+SIDL2+LL2+ seismic	1483	670	1352
Case 16 DL+SIDL1+SIDL2+LL3+ seismic	1482	698	1358
HFL CASE			
Downward seismic in longitudinal direction			
Case 1 DL+SIDL1+SIDL2+ seismic+HFL	1478	1101	501
Case 2 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1521	1213	647
Case 3 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1512	1183	641
Case 4 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1510	1211	647
Downward seismic in transverse direction			
Case 5 DL+SIDL1+SIDL2+ seismic+HFL	1478	451	1151
Case 6 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1521	563	1297
Case 7 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1512	223	1291
Case 8 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1510	561	1297
Upward seismic in longitudinal direction			
Case 9 DL+SIDL1+SIDL2+ seismic+HFL	1210	1101	501
Case 10 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1254	1213	647
Case 11 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1244	1183	641
Case 12 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1243	1211	647
Upward seismic in transverse direction			
Case 13 DL+SIDL1+SIDL2+ seismic+HFL	1210	451	1151
Case 14 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1254	563	1297
Case 15 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1244	533	1291
Case 16 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1243	561	1297

MAXIMUM REACTION CASE	1760	1350	708
MAXIMUM LONGITUDINAL MOMENT CASE	1760	1350	708
MAXIMUM TRANSVERSE MOMENT CASE	1749	698	1358

Case 4 Combination for base pressure check

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	1257	149	66
Case 2	DL+SIDL1+SIDL2+LL1	1473	834	853
Case 3	DL+SIDL1+SIDL2+LL2	1425	686	823
Case 4	DL+SIDL1+SIDL2+LL3	1418	825	855
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	1286	183	133
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	1502	908	938
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	1454	759	908
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	1447	898	940
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	1228	183	133
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	1444	908	938
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	1396	759	908
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	1389	898	940
Downward seismic in longitudinal direction				
Case 13	DL+SIDL1+SIDL2+ seismic	1346	937	424
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	1562	1622	1211
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	1514	1473	1181
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	1507	1612	1213
Downward seismic in transverse direction				
Case 17	DL+SIDL1+SIDL2+ seismic	1346	504	857
Case 18	DL+SIDL1+SIDL2+LL1+ seismic	1562	1189	1644
Case 19	DL+SIDL1+SIDL2+LL2+ seismic	1514	1040	1614
Case 20	DL+SIDL1+SIDL2+LL3+ seismic	1507	1179	1646
Upward seismic in longitudinal direction				
Case 21	DL+SIDL1+SIDL2+ seismic	1168	937	424
Case 22	DL+SIDL1+SIDL2+LL1+ seismic	1384	1622	1211
Case 23	DL+SIDL1+SIDL2+LL2+ seismic	1336	1473	1181
Case 24	DL+SIDL1+SIDL2+LL3+ seismic	1329	1612	1213
Upward seismic in transverse direction				
Case 25	DL+SIDL1+SIDL2+ seismic	1168	504	857
Case 26	DL+SIDL1+SIDL2+LL1+ seismic	1384	1189	1644
Case 27	DL+SIDL1+SIDL2+LL2+ seismic	1336	1040	1614
Case 28	DL+SIDL1+SIDL2+LL3+ seismic	1329	1179	1646

HFL				
Case 1	DL+SIDL1+SIDL2+HFL	1018	37	17
Case 2	DL+SIDL1+SIDL2+LL1+HFL	1234	598	748
Case 3	DL+SIDL1+SIDL2+LL2+HFL	1186	449	718
Case 4	DL+SIDL1+SIDL2+LL3+HFL	1179	588	750
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	1046	71	84
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1263	672	833
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1215	523	803
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1208	662	834
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	989	71	84
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1205	672	833
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1157	325	803
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1150	662	834
Downward seismic in longitudinal direction				
Case 13	DL+SIDL1+SIDL2+ seismic+HFL	1107	825	374
Case 14	DL+SIDL1+SIDL2+LL1+ seismic+HFL	1323	1386	1106
Case 15	DL+SIDL1+SIDL2+LL2+ seismic+HFL	1275	1237	1075
Case 16	DL+SIDL1+SIDL2+LL3+ seismic+HFL	1268	1376	1107
Downward seismic in transverse direction				
Case 17	DL+SIDL1+SIDL2+ seismic+HFL	1107	391	807
Case 18	DL+SIDL1+SIDL2+LL1+ seismic+HFL	1323	952	1539

Case 19 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1275	803	1509
Case 20 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1268	943	1541
Upward seismic in longitudinal direction			
Case 21 DL+SIDL1+SIDL2+ seismic+HFL	929	825	374
Case 22 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1145	1386	1106
Case 23 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1097	1237	1075
Case 24 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1090	1376	1107
Upward seismic in transverse direction			
Case 25 DL+SIDL1+SIDL2+ seismic+HFL	929	391	807
Case 26 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1145	952	1539
Case 27 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1097	803	1509
Case 28 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1090	943	1541

MAXIMUM REACTION CASE	1562	1622	1211
MAXIMUM LONGITUDINAL MOMENT CASE	1562	1622	1211
MAXIMUM TRANSVERSE MOMENT CASE	1507	1179	1646

1 Normal			
Load Case	**Factored Forces/Moments**		
	V	**ML**	**MT**
	t	**t-m**	**t-m**
Case 1 Normal max. Vertical load	**1473**	**834**	**853**
Case 2 Normal max. longitudinal moment	**1473**	**834**	**853**
Case 3 Normal max. transverse moment	**1418**	**825**	**855**

2 Seismic / wind			
Load Case	**Factored Forces/Moments**		
	V	**ML**	**MT**
	t	**t-m**	**t-m**
Case 1 Seismic/wind max. Vertical load	**1562**	**1622**	**1211**
Case 2 Seismic/wind max. longitudinal moment	**1562**	**1622**	**1211**
Case 3 Seismic/wind max. transverse moment	**1507**	**1179**	**1646**

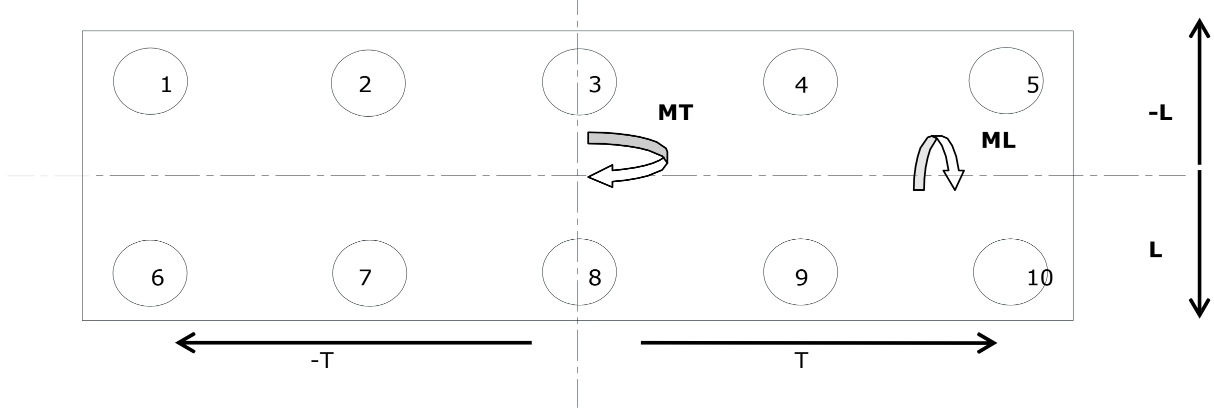
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date &Rev.	

Load on Pile for Base Pressure Check

		V	ML	MT
		t	t-m	t-m
DL+SIDL1+SIDL2	Case 1	1473	834	853
DL+SIDL1+SIDL2+LL1	Case 2	1473	834	853
DL+SIDL1+SIDL2+LL2	Case 3	1418	825	855
DL+SIDL1+SIDL2+Seismic	Case 4	1562	1622	1211
DL+SIDL1+SIDL2+LL1+Seismic	Case 5	1562	1622	1211
DL+SIDL1+SIDL2+LL2+Seismic	Case 6	1507	1179	1646

Diameter of Pile	=	1.200	m	
Shift	=	0.000	m	
Vertical Capacity of Pile	=	4200.000	T	As per Geotechnical Report
	=	9.000	m	Length below cutoff for A1
		10.000	m	Length below cutoff for A2

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_{L}2$	$_{T}2$	Z_L	Z_T
1	-1.800	-7.200	3.240	51.840	-18.000	-36.000
2	-1.800	-3.600	3.240	12.960	-18.000	-72.000
3	-1.800	0.000	3.240	0.000	-18.000	0.000
4	-1.800	3.600	3.240	12.960	-18.000	72.000
5	-1.800	7.200	3.240	51.840	-18.000	36.000
6	1.800	-7.200	3.240	51.840	18.000	-36.000
7	1.800	-3.600	3.240	12.960	18.000	-72.000
8	1.800	0.000	3.240	0.000	18.000	0.000
9	1.800	3.600	3.240	12.960	18.000	72.000
10	1.800	7.200	3.240	51.840	18.000	36.000

I_{LL} = **32.40** Sq.m

I_{TT} = **259.20** Sq.m

Normal case :- Lateral force

Case 1 **Horizontal force** **650.933** t **Force per Pile =** **65.1** t **OK**

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	147.29	-46.36	-23.70	0.00	0.00	77.23	OK
2	147.29	-46.36	-11.85	0.00	0.00	89.08	OK
3	147.29	-46.36	0.00	0.00	0.00	100.94	OK
4	147.29	-46.36	11.85	0.00	0.00	112.79	OK
5	147.29	-46.36	23.70	0.00	0.00	124.64	OK
6	147.29	46.36	-23.70	0.00	0.00	169.95	OK
7	147.29	46.36	-11.85	0.00	0.00	181.80	OK
8	147.29	46.36	0.00	0.00	0.00	193.65	OK
9	147.29	46.36	11.85	0.00	0.00	205.50	OK
10	147.29	46.36	23.70	0.00	0.00	217.36	OK

Case 2

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	147.29	-46.36	-23.70	0.00	0.00	77.23	OK
2	147.29	-46.36	-11.85	0.00	0.00	89.08	OK
3	147.29	-46.36	0.00	0.00	0.00	100.94	OK
4	147.29	-46.36	11.85	0.00	0.00	112.79	OK
5	147.29	-46.36	23.70	0.00	0.00	124.64	OK
6	147.29	46.36	-23.70	0.00	0.00	169.95	OK
7	147.29	46.36	-11.85	0.00	0.00	181.80	OK
8	147.29	46.36	0.00	0.00	0.00	193.65	OK
9	147.29	46.36	11.85	0.00	0.00	205.50	OK
10	147.29	46.36	23.70	0.00	0.00	217.36	OK

Case 3

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	141.79	-45.82	-23.75	0.00	0.00	72.22	OK
2	141.79	-45.82	-11.88	0.00	0.00	84.10	OK
3	141.79	-45.82	0.00	0.00	0.00	95.97	OK
4	141.79	-45.82	11.88	0.00	0.00	107.85	OK
5	141.79	-45.82	23.75	0.00	0.00	119.72	OK
6	141.79	45.82	-23.75	0.00	0.00	163.86	OK
7	141.79	45.82	-11.88	0.00	0.00	175.74	OK
8	141.79	45.82	0.00	0.00	0.00	187.61	OK
9	141.79	45.82	11.88	0.00	0.00	199.49	OK
10	141.79	45.82	23.75	0.00	0.00	211.37	OK

Seismic Case :- Lateral force

Case 4	**Horizontal force =**	**696.150**	t	**Force per Pile =**	**55.7**	**t**	**OK**

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	156.21	-90.11	-33.64	0.00	0.00	32.46	OK
2	156.21	-90.11	-16.82	0.00	0.00	49.28	OK
3	156.21	-90.11	0.00	0.00	0.00	66.10	OK
4	156.21	-90.11	16.82	0.00	0.00	82.92	OK
5	156.21	-90.11	33.64	0.00	0.00	99.74	OK
6	156.21	90.11	-33.64	0.00	0.00	212.69	OK
7	156.21	90.11	-16.82	0.00	0.00	229.50	OK
8	156.21	90.11	0.00	0.00	0.00	246.32	OK
9	156.21	90.11	16.82	0.00	0.00	263.14	OK
10	156.21	90.11	33.64	0.00	0.00	279.96	OK

Case 5

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	156.21	-90.11	-33.64	0.00	0.00	32.46	OK
2	156.21	-90.11	-16.82	0.00	0.00	49.28	OK
3	156.21	-90.11	0.00	0.00	0.00	66.10	OK
4	156.21	-90.11	16.82	0.00	0.00	82.92	OK
5	156.21	-90.11	33.64	0.00	0.00	99.74	OK
6	156.21	90.11	-33.64	0.00	0.00	212.69	OK
7	156.21	90.11	-16.82	0.00	0.00	229.50	OK
8	156.21	90.11	0.00	0.00	0.00	246.32	OK
9	156.21	90.11	16.82	0.00	0.00	263.14	OK
10	156.21	90.11	33.64	0.00	0.00	279.96	OK

Case 6

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	150.71	-65.50	-45.72	0.00	0.00	39.49	OK
2	150.71	-65.50	-22.86	0.00	0.00	62.35	OK
3	150.71	-65.50	0.00	0.00	0.00	85.21	OK
4	150.71	-65.50	22.86	0.00	0.00	108.07	OK
5	150.71	-65.50	45.72	0.00	0.00	130.93	OK
6	150.71	65.50	-45.72	0.00	0.00	170.49	OK
7	150.71	65.50	-22.86	0.00	0.00	193.35	OK
8	150.71	65.50	0.00	0.00	0.00	216.21	OK
9	150.71	65.50	22.86	0.00	0.00	239.07	OK
10	150.71	65.50	45.72	0.00	0.00	261.93	OK

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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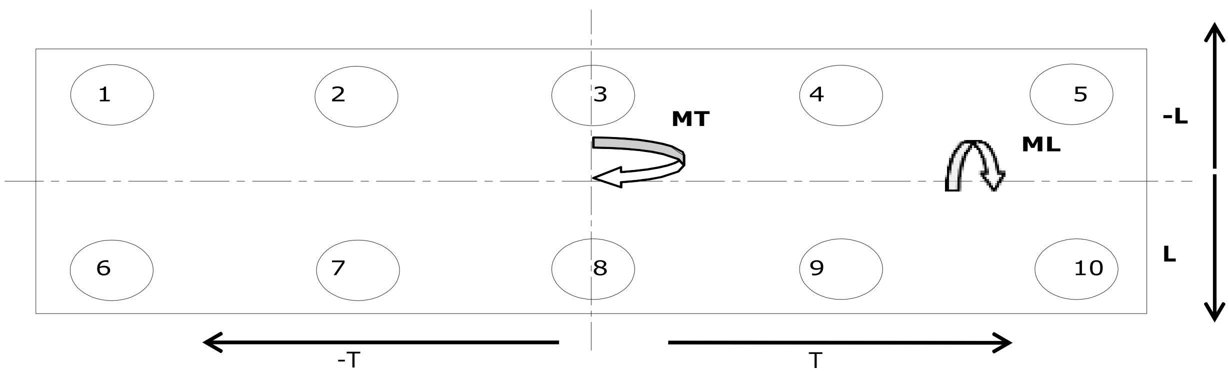
Load Calculations for Design of Pile (ULS)

		V	ML	MT
		t	t-m	t-m
Max. vertical load Combination 1	Case 1	2057	1004	1216
Max. longitudinal moment Combination 1	Case 2	2057	1004	1216
Max. transverse moment Combination 1	Case 3	1974	989	1219
Max. vertical load Combination 2	Case 4	1561	931	1082
Max. longitudinal moment Combination 2	Case 5	1561	931	1082
Max. transverse moment Combination 2	Case 6	1489	919	1085
Max. vertical load seismic/accidental combination	Case 7	1760	1350	708
Max. longitudinal moment seismic/accidental combination	Case 8	1760	1350	708
Max. transverse moment seismic/accidental combination	Case 9	1749	698	1358

Diameter of Pile = 1.200 m
Shift = 0.000 m

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_L$2	$_T$2	Z_L	Z_T
1	1.235	-7.881	1.526	62.116	73.021	-39.407
2	-0.368	-3.941	0.135	15.529	-245.437	-78.814
3	-1.970	0.000	3.882	0.000	-45.781	0.000
4	-3.573	3.941	12.768	15.529	-25.245	78.814
5	-5.176	7.881	26.791	62.116	-17.427	39.407
6	5.176	-7.881	26.791	62.116	17.427	-39.407
7	3.573	-3.941	12.768	15.529	25.245	-78.814
8	1.970	0.000	3.882	0.000	45.781	0.000
9	0.368	3.941	0.135	15.529	245.437	78.814
10	-1.235	7.881	1.526	62.116	-73.021	39.407

I_{LL} = **90.20** Sq.m
I_{TT} = **310.58** Sq.m

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Case 1

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	205.7	13.7	-30.9	0.0	0.0	188.5
2	205.7	-4.1	-15.4	0.0	0.0	186.1
3	205.7	-21.9	0.0	0.0	0.0	183.7
4	205.7	-39.8	15.4	0.0	0.0	181.3
5	205.7	-57.6	30.9	0.0	0.0	178.9
6	205.7	57.6	-30.9	0.0	0.0	232.4
7	205.7	39.8	-15.4	0.0	0.0	230.0
8	205.7	21.9	0.0	0.0	0.0	227.6
9	205.7	4.1	15.4	0.0	0.0	225.2
10	205.7	-13.7	30.9	0.0	0.0	222.8

Case 2

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	205.7	13.7	-30.9	0.0	0.0	188.5
2	205.7	-4.1	-15.4	0.0	0.0	186.1
3	205.7	-21.9	0.0	0.0	0.0	183.7
4	205.7	-39.8	15.4	0.0	0.0	181.3
5	205.7	-57.6	30.9	0.0	0.0	178.9
6	205.7	57.6	-30.9	0.0	0.0	232.4
7	205.7	39.8	-15.4	0.0	0.0	230.0
8	205.7	21.9	0.0	0.0	0.0	227.6
9	205.7	4.1	15.4	0.0	0.0	225.2
10	205.7	-13.7	30.9	0.0	0.0	222.8

Case 3

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	197.4	13.6	-30.9	0.0	0.0	180.0
2	197.4	-4.0	-15.5	0.0	0.0	177.9
3	197.4	-21.6	0.0	0.0	0.0	175.8
4	197.4	-39.2	15.5	0.0	0.0	173.7
5	197.4	-56.8	30.9	0.0	0.0	171.6
6	197.4	56.8	-30.9	0.0	0.0	223.2
7	197.4	39.2	-15.5	0.0	0.0	221.1
8	197.4	21.6	0.0	0.0	0.0	219.0
9	197.4	4.0	15.5	0.0	0.0	216.9
10	197.4	-13.6	30.9	0.0	0.0	214.8

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Case 4

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	156.1	12.8	-27.5	0.0	0.0	141.4
2	156.1	-3.8	-13.7	0.0	0.0	138.6
3	156.1	-20.3	0.0	0.0	0.0	135.7
4	156.1	-36.9	13.7	0.0	0.0	132.9
5	156.1	-53.4	27.5	0.0	0.0	130.1
6	156.1	53.4	-27.5	0.0	0.0	182.0
7	156.1	36.9	-13.7	0.0	0.0	179.2
8	156.1	20.3	0.0	0.0	0.0	176.4
9	156.1	3.8	13.7	0.0	0.0	173.6
10	156.1	-12.8	27.5	0.0	0.0	170.8

Case 5

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	156.1	12.8	-27.5	0.0	0.0	141.4
2	156.1	-3.8	-13.7	0.0	0.0	138.6
3	156.1	-20.3	0.0	0.0	0.0	135.7
4	156.1	-36.9	13.7	0.0	0.0	132.9
5	156.1	-53.4	27.5	0.0	0.0	130.1
6	156.1	53.4	-27.5	0.0	0.0	182.0
7	156.1	36.9	-13.7	0.0	0.0	179.2
8	156.1	20.3	0.0	0.0	0.0	176.4
9	156.1	3.8	13.7	0.0	0.0	173.6
10	156.1	-12.8	27.5	0.0	0.0	170.8

Case 6

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	148.9	12.6	-27.5	0.0	0.0	134.0
2	148.9	-3.7	-13.8	0.0	0.0	131.4
3	148.9	-20.1	0.0	0.0	0.0	128.9
4	148.9	-36.4	13.8	0.0	0.0	126.3
5	148.9	-52.7	27.5	0.0	0.0	123.7
6	148.9	52.7	-27.5	0.0	0.0	174.1
7	148.9	36.4	-13.8	0.0	0.0	171.6
8	148.9	20.1	0.0	0.0	0.0	169.0
9	148.9	3.7	13.8	0.0	0.0	166.4
10	148.9	-12.6	27.5	0.0	0.0	163.9

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Case 7

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	176.0	18.5	-18.0	0.0	0.0	176.5
2	176.0	-5.5	-9.0	0.0	0.0	161.5
3	176.0	-29.5	0.0	0.0	0.0	146.5
4	176.0	-53.5	9.0	0.0	0.0	131.5
5	176.0	-77.5	18.0	0.0	0.0	116.5
6	176.0	77.5	-18.0	0.0	0.0	235.5
7	176.0	53.5	-9.0	0.0	0.0	220.5
8	176.0	29.5	0.0	0.0	0.0	205.5
9	176.0	5.5	9.0	0.0	0.0	190.5
10	176.0	-18.5	18.0	0.0	0.0	175.5

Case 8

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	176.0	18.5	-18.0	0.0	0.0	176.5
2	176.0	-5.5	-9.0	0.0	0.0	161.5
3	176.0	-29.5	0.0	0.0	0.0	146.5
4	176.0	-53.5	9.0	0.0	0.0	131.5
5	176.0	-77.5	18.0	0.0	0.0	116.5
6	176.0	77.5	-18.0	0.0	0.0	235.5
7	176.0	53.5	-9.0	0.0	0.0	220.5
8	176.0	29.5	0.0	0.0	0.0	205.5
9	176.0	5.5	9.0	0.0	0.0	190.5
10	176.0	-18.5	18.0	0.0	0.0	175.5

Case 9

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	174.9	9.6	-34.5	0.0	0.0	150.0
2	174.9	-2.8	-17.2	0.0	0.0	154.8
3	174.9	-15.3	0.0	0.0	0.0	159.7
4	174.9	-27.7	17.2	0.0	0.0	164.5
5	174.9	-40.1	34.5	0.0	0.0	169.3
6	174.9	40.1	-34.5	0.0	0.0	180.5
7	174.9	27.7	-17.2	0.0	0.0	185.3
8	174.9	15.3	0.0	0.0	0.0	190.2
9	174.9	2.8	17.2	0.0	0.0	195.0
10	174.9	-9.6	34.5	0.0	0.0	199.8

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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Calculation of Depth of Fixity As per IS 2911, Annexure C

Stiffness factor	T	=	5√(EI/K1)	m	For pile in sand and normally loaded Clays
Stiffness factor	R	=	4√(EI/BK2)	m	For pile in preloaded clays
	E	=	30000	MN/m2	
	I	=	0.1018	m4	
	ŋh	=	3.3008	MN/m3	
	K	=	4.86	MN/m3	
	T	=	3.920		OK
	R	=	4.784		
Pile length over sand layer,	L1	=	0	m	
Case I	L1/R	=	0		
Case II	L1/T	=	0		
Case I	Lf/R	=	0		(for fixed head pile)
Case II	Lf/T	=	2.2		
Case I	Depth of Fixity, Lf	=	0.000	m	
Case II	Depth of Fixity, Lf	=	8.62	m	
	L1+Lf	=	8.623	m	
Reduction Factor	m	=	0.85		
	MT	=	Q (L1 + Lf)/2*m		(for fixed head pile)
		=	3.665	Q	

Moment on pile =		3.665 Q							
	Combination 1			Combination 2			Seismic/Accidental Combination		
	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)
MAX	**232.40**	38	141	**182.05**	33	120	**235.52**	45	165
MIN	**171.56**	38	139	**123.74**	32	118	**116.51**	42	154

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Moments & shear force for pile cap

Width of abut.	=	1.00	m
Length of abut.		16.00	
Dia. Of pile	=	1.20	m
Length of Pile cap	=	16.00	m
Width of Pile cap	=	4.85	m
Thickness of pile cap	=	1.80	m
Unit wt. of concrete	=	2.50	t/m^3
Unit wt. of Soil	=	2.00	t/m^3
Thickness of soil above pile cap	=	0.50	m
Downward force & moment due to pile cap		1.20	0.00

Transverse direction	L	B	H	Unit Weight	Load (t)	Moment (t.m)
Self wt. of pile cap	0.00	4.85	1.80	2.50	0.00	0.00
Wt. due to soil	0.00	4.85	0.50	2.00	0.00	0.00
Longitudinal direction	L	B	H	Unit Weight	Load (t)	Moment (t.m)
Self wt. of pile cap	1.93	16.00	1.80	2.50	138.60	133.40
Wt. due to soil	1.93	16.00	0.50	2.00	30.80	29.65

	Combination 1			Combination 2			Seismic/Accidental Combination		
	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)
LL	1104	58 /m	73 /m	853	43 /m	54 /m	1029	54 /m	67 /m
TT	837	173 /m	/m	641	132 /m	/m	794	164 /m	/m
Max	1104	934	1161	853	683	860	1029	859	1071

ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 25 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd}	=	11.17	N/mm^2	Basic Combination
f_{cd}	=	13.96	N/mm^2	Accidental Combination
f_{cd}	=	11.17	N/mm^2	Seismic Combination
E_c	=	30000.00	MPa	

Grade of steel f_Y = 500.00 N/mm^2

f_{Yd}	=	434.78	N/mm^2	Basic Combination
f_{Yd}	=	500.00	N/mm^2	Accidental Combination
f_{Yd}	=	434.78	N/mm^2	Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = fcd*b*(3/7$xu_{,lim}$ + 2/3*4/7$xu_{,lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu_{lim}/d)*(1-0.416*xu_{lim}/d)

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.15	4.99	4.15

Here R_{lim} is in MPa

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b = 4850 mm

Depth of section D = 1800 mm

Clear cover = 75 mm

Moment on the section	**Moment at face of support**		
	Combination (1)	**Seismic Combi.**	**Combination (2)**
Actual moment (KNm)	11393	8407	8438
Grade of Concrete	25	25	25
Grade of steel fy	500	500	500
b	4850	4850	4850
D	1800	1800	1800
c	75	75	75
d	1696.5	1696.5	1696.5
f_{cd}	11.17	11.17	11.17
f_{Yd}	435	435	435
$xu_{,lim}/d$	0.62	0.62	0.62
$R_{sls} = M_{u,sls}/bd2$	4.15	4.15	4.15
$M_{u,Lim}$ (KNm)	57862	57862	57862
	OK	**OK**	**OK**
Ast Req.	8037	5866	5889
Dia of bar (main tension) (mm)	25	25	25
Spacing (mm)	120	120	120
+ dia of bar (main tension) (mm)	25	25	25
Spacing (mm)	120	120	120
Ast provided (sq mm)	39679	39679	39679
Dia of bar(main compresion at top mm)	12	12	12
Spacing (mm)	120	120	120
Area of main compresion (mm^2)	4571	4571	4571
f_{ctm}	2.2	2.2	2.2
f_{yk}	435	435	435
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	10825	10825	10825
	OK	**OK**	**OK**
As.max = 0.025 Ac (main tension)	218250	218250	218250
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**	**OK**	**OK**
As.max = 0.04 Ac (tension + compresion)	349200	349200	349200
x (mm)	394	394	394
x/d	0.232	0.232	0.232
	OK	**OK**	**OK**
z (mm)	1533	1533	1533
MR (KNm)	52887	52887	52887
	OK	**OK**	**OK**
Shear on the section			
Actual shear V_{Ed} (KN)	5107	4670	3811
Actual shear stress (N/mm2)	0.621	0.568	0.463
Max shear capacity, 0.135 fck(1-fck/310)	3.10	3.10	3.10
	OK	**OK**	**OK**
Min shear capacity, 0.0924 fck(1-fck/310)	2.12	2.12	2.12
$\theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	5.77	5.27	4.29
Min angle of inclination, θ (deg)	21.8	21.8	21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.343	1.343	1.343
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			

V(min) = 0.031 K^(3/2) fck^(1/2)	0.241	0.286	0.286
cl. 10.3.1 of IRC :112-2011			
r1 = $A_{sl}/(b_w\ d)$ <= 0.02	0.005	0.005	0.005
	OK	**OK**	**OK**
0.12 K (80 r1 $f_{ck})^{0.33}$	0.341	0.341	0.341
Axial compressive force N_{Ed} (KN)	0.0	0	0.0
$S_{cp} = N_{Ed} / A_c <= 0.2 f_{cd}$	0.0	0.0	0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d$ >=($V_{min} + 0.15\ S_{cp})\ b_w\ d$ (KN)	2802	2802	2802
	PROVIDE SHEAR R/F	**PROVIDE SHEAR R/F**	**PROVIDE SHEAR R/F**
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010			
n = 0.6 (1 - fck / 310)	0.552	0.552	0.552
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011			
0.5 b_w d n f_{cd}	25341	25341	25341
	OK	**OK**	**OK**
No. of Links for shear R/f (Distribution)	2	2	2
Dia. of bar for shear reinf.	16	16	16
S(mm)	200	200	200
^{A}SW1	402	402	402
	OK	**OK**	**OK**
No. of link for shear reinf.	8	8	8
Dia. of bar for shear reinf.	10	10	10
S = Asw x 0.9 x d x cot θ x fy / V_E	150	150	150
^{A}SW2	628	628	628
^{A}SW	1030	1030	1030
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011			
$S_{l.max}$ = 0.75 d	600	600	600
	OK	**OK**	**OK**
z (mm)	1533	1533	1533
^{f}ywd	435	435	435
cl. 10.3.3.2 Eq. 10.7 of IRC :112-2011			
$V_{Rd.s} = A_{SW}\ z\ f_{ywd}$ cot θ / S (KN)	11446	9427	9427
	OK	**OK**	**OK**
$_{acw}$ = ($s_{cp} = N_{Ed} / A_c = 0$)	1.0	1.0	1.0
ν_1	0.6	0.6	0.6
cl. 10.3.3.2 Eq. 10.8 of IRC :112-2011			
VRd.max = acw bw z n1 fcd (KN)	49808	49808	49808
	OK	**OK**	**OK**
cl. 10.3.3.2 Eq. 10.10 of IRC :112-2011			
ASW.max <= 0.5 acw n1 fcd bw S / fywd	5605	5605	5605
	OK	**OK**	**OK**
cl. 10.3.1 of IRC :112-2011			
rw = ASW/(S bw sina)	0.0014	0.0014	0.0014
cl. 10.3.3.5 of IRC :112-2011			
rw,min = (0.072 fck^0.5) / fyk	0.0008	0.0008	0.0008
	OK	**OK**	**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checked	RJ
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COMBINATION FOR DESIGN OF FOUNDATION & BASE PRESSURE (SLS)

Following load combinations are co As per Annex B of IRC:112-2011

1 Rare Combination

2 Quasi Permanent Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	DL	Dead Load (due to superstructure+substructure+found.	1204	-515	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		201	-59	0	0	0
4	ABUT + RETURN WALL		132	-37	0	0	0
5	FDN		349	0	0	0	0
6	SOIL ABOVE FDN		286	-418	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	214	0	658	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	159	0	666	0	0
12	LL1B	Live Load Moment due to braking	3	185	0	35.33	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.08	0
14	LL3B	Live Load Moment due to braking	3	171	0	32.61	0
15	W1	Wind vertically down without LL	29	5	71	5.47	11.58
16	W2	Wind vertically up without LL	-29	5	71	5.47	11.58
17	W3	Wind vertically down with LL	29	49	71	5.53	11.58
18	W4	Wind vertically up with LL	-29	49	71	5.53	11.58
19	S1	Seimic	0	0	0	0	0
20	S2		0	0	0	0	0
21	S3		0	0	0	0	0
22	S4		0	0	0	0	0
23	HFL		-239	216	0	0.0	0.0
24	Active earth pressure LWL		0	678	0	226.7	0.0
25	LL surcharge LWL		0	272	0	76.4	0.0
26	Active earth pressure HFL		0	339	0	113.4	0.0
27	LL surcharge HFL		0	136	0	38.2	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0
29	LL surcharge LWL		0	0	0	0	0
30	Active earth pressure HFL		0	0	0	0	0
31	LL surcharge HFL		0	0	0	0	0

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	Rare Combination				**Quasi Permanent Combination**			
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)
DL	1.00	1204	-470	-209	1.00	1204	-470	-209
SIDL1	1.00	24	0	0	1.00	24	0	0
SIDL2	1.00	28	0	0	1.00	28	0	0
LL1	1.00	214	268	601	0.00	0	0	0
LL2	1.00	168	288	646	0.00	0	0	0
LL3	1.00	159	271	608	0.00	0	0	0
LL1B	1.00	3	169	75	0.00	0	0	0
LL2B	1.00	0	0	0	0.00	0	0	0
LL3B	1.00	3	156	69	0.00	0	0	0
W1	0.60	17	20	40	0.00	0	0	0
W2	0.60	-17	20	40	0.00	0	0	0
W3	0.60	17	44	51	0.00	0	0	0
W4	0.60	-17	44	51	0.00	0	0	0
S1	0.00	0	0	0	0.00	0	0	0
S2	0.00	0	0	0	0.00	0	0	0
S3	0.00	0	0	0	0.00	0	0	0
S4	0.00	0	0	0	0.00	0	0	0
HFL	1.00	-239	198	88	1.00	-239	198	88
EP	1.00	0	620	276	1.00	0	620	276
LL S.	0.80	0	199	89	0.00	0	0	0
EP HFL	1.00	0	310	138	1.00	0	310	138
LL.S.HFL	0.80	0	99	44	0.00	0	0	0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
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Case 1 Rare Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1257	149	66
Case 2 DL+SIDL1+SIDL2+LL1	1473	785	831
Case 3 DL+SIDL1+SIDL2+LL2	1425	636	801
Case 4 DL+SIDL1+SIDL2+LL3	1418	775	833
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1274	170	107
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1490	829	882
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1442	680	852
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1435	819	884
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1239	170	107
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1456	829	882
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1408	680	852
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1401	819	884
HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	1018	37	17
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1234	573	737
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1186	424	707
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1179	564	739
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1035	57	57
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1251	617	788
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1203	468	758
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1196	608	790
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	1000	57	57
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1217	617	788
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1169	468	758
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1162	608	790

MAXIMUM REACTION CASE	1490	829	882
MAXIMUM LONGITUDINAL MOMENT CASE	1490	829	882
MAXIMUM TRANSVERSE MOMENT CASE	1435	819	884

Case 2 Quasi Permanent Combination

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	1257	149	66
Case 2	DL+SIDL1+SIDL2+LL1	1257	149	66
Case 3	DL+SIDL1+SIDL2+LL2	1257	149	66
Case 4	DL+SIDL1+SIDL2+LL3	1257	149	66
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	1257	149	66
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	1257	149	66
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	1257	149	66
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	1257	149	66
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	1257	149	66
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	1257	149	66
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	1257	149	66
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	1257	149	66

HFL CASE				
Case 1	DL+SIDL1+SIDL2+HFL	1018	37	17
Case 2	DL+SIDL1+SIDL2+LL1+HFL	1018	37	17
Case 3	DL+SIDL1+SIDL2+LL2+HFL	1018	37	17
Case 4	DL+SIDL1+SIDL2+LL3+HFL	1018	37	17
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	1018	37	17
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1018	37	17
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1018	37	17
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1018	37	17
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	1018	37	17
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1018	37	17
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1018	37	17
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1018	37	17

MAXIMUM REACTION CASE	1257	149	66
MAXIMUM LONGITUDINAL MOMENT CASE	1257	149	66
MAXIMUM TRANSVERSE MOMENT CASE	1257	149	66

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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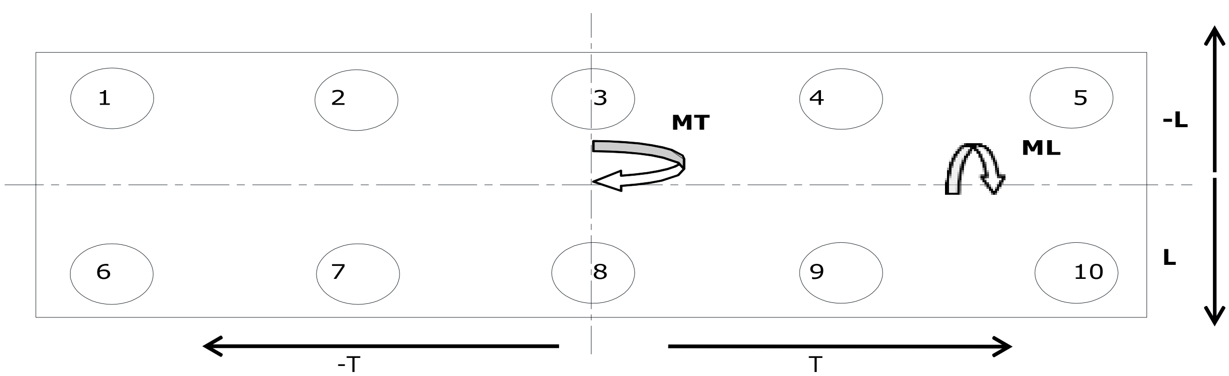
Load Calculations for Design of Pile (SLS)

	V	ML	MT
	t	t-m	t-m
Case 1	1490	829	882
Case 2	1490	829	882
Case 3	1435	819	884
Case 4	1257	149	66
Case 5	1257	149	66
Case 6	1257	149	66

Diameter of Pile = 1.200 m
Shift = 0.000 m

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	L^2	T^2	Z_L	Z_T
1	1.235	-7.881	1.526	62.116	73.021	-39.407
2	-0.368	-3.941	0.135	15.529	-245.437	-78.814
3	-1.970	0.000	3.882	0.000	-45.781	0.000
4	-3.573	3.941	12.768	15.529	-25.245	78.814
5	-5.176	7.881	26.791	62.116	-17.427	39.407
6	5.176	-7.881	26.791	62.116	17.427	-39.407
7	3.573	-3.941	12.768	15.529	25.245	-78.814
8	1.970	0.000	3.882	0.000	45.781	0.000
9	0.368	3.941	0.135	15.529	245.437	78.814
10	-1.235	7.881	1.526	62.116	-73.021	39.407

I_{LL} = **90.20** Sq.m
I_{TT} = **310.58** Sq.m

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Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date &Rev.	

Case 1

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	149.0	11.4	-22.4	0.0	0.0	138.0
2	149.0	-3.4	-11.2	0.0	0.0	134.5
3	149.0	-18.1	0.0	0.0	0.0	130.9
4	149.0	-32.8	11.2	0.0	0.0	127.4
5	149.0	-47.6	22.4	0.0	0.0	123.8
6	149.0	47.6	-22.4	0.0	0.0	174.2
7	149.0	32.8	-11.2	0.0	0.0	170.7
8	149.0	18.1	0.0	0.0	0.0	167.1
9	149.0	3.4	11.2	0.0	0.0	163.6
10	149.0	-11.4	22.4	0.0	0.0	160.1

Case 2

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	149.0	11.4	-22.4	0.0	0.0	138.0
2	149.0	-3.4	-11.2	0.0	0.0	134.5
3	149.0	-18.1	0.0	0.0	0.0	130.9
4	149.0	-32.8	11.2	0.0	0.0	127.4
5	149.0	-47.6	22.4	0.0	0.0	123.8
6	149.0	47.6	-22.4	0.0	0.0	174.2
7	149.0	32.8	-11.2	0.0	0.0	170.7
8	149.0	18.1	0.0	0.0	0.0	167.1
9	149.0	3.4	11.2	0.0	0.0	163.6
10	149.0	-11.4	22.4	0.0	0.0	160.1

Case 3

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	143.5	11.2	-22.4	0.0	0.0	132.3
2	143.5	-3.3	-11.2	0.0	0.0	129.0
3	143.5	-17.9	0.0	0.0	0.0	125.6
4	143.5	-32.4	11.2	0.0	0.0	122.3
5	143.5	-47.0	22.4	0.0	0.0	118.9
6	143.5	47.0	-22.4	0.0	0.0	168.1
7	143.5	32.4	-11.2	0.0	0.0	164.8
8	143.5	17.9	0.0	0.0	0.0	161.4
9	143.5	3.3	11.2	0.0	0.0	158.1
10	143.5	-11.2	22.4	0.0	0.0	154.7

Case 4

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	125.7	2.0	-1.7	0.0	0.0	126.0
2	125.7	-0.6	-0.8	0.0	0.0	124.2
3	125.7	-3.3	0.0	0.0	0.0	122.4
4	125.7	-5.9	0.8	0.0	0.0	120.6
5	125.7	-8.6	1.7	0.0	0.0	118.8
6	125.7	8.6	-1.7	0.0	0.0	132.6
7	125.7	5.9	-0.8	0.0	0.0	130.7
8	125.7	3.3	0.0	0.0	0.0	128.9
9	125.7	0.6	0.8	0.0	0.0	127.1
10	125.7	-2.0	1.7	0.0	0.0	125.3

Case 5

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	125.7	2.0	-1.7	0.0	0.0	126.0
2	125.7	-0.6	-0.8	0.0	0.0	124.2
3	125.7	-3.3	0.0	0.0	0.0	122.4
4	125.7	-5.9	0.8	0.0	0.0	120.6
5	125.7	-8.6	1.7	0.0	0.0	118.8
6	125.7	8.6	-1.7	0.0	0.0	132.6
7	125.7	5.9	-0.8	0.0	0.0	130.7
8	125.7	3.3	0.0	0.0	0.0	128.9
9	125.7	0.6	0.8	0.0	0.0	127.1
10	125.7	-2.0	1.7	0.0	0.0	125.3

Case 6

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	125.7	2.0	-1.7	0.0	0.0	126.0
2	125.7	-0.6	-0.8	0.0	0.0	124.2
3	125.7	-3.3	0.0	0.0	0.0	122.4
4	125.7	-5.9	0.8	0.0	0.0	120.6
5	125.7	-8.6	1.7	0.0	0.0	118.8
6	125.7	8.6	-1.7	0.0	0.0	132.6
7	125.7	5.9	-0.8	0.0	0.0	130.7
8	125.7	3.3	0.0	0.0	0.0	128.9
9	125.7	0.6	0.8	0.0	0.0	127.1
10	125.7	-2.0	1.7	0.0	0.0	125.3

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Moment on pile =	3.665 Q					
	Rare Combination			Quasi Permanent Combination		
	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)
MAX	**174.20**	33	122	**132.56**	23	83
MIN	**118.94**	33	121	**118.79**	23	83

Moments & shear force for pile cap

Width of abut.	=	1.00	m
Length of Abutment	=	16.00	m
Dia. Of pile	=	1.20	m
Length of Pile cap	=	16.00	m
Width of Pile cap	=	4.85	m
Thickness of pile cap	=	1.80	m
Unit wt. of concrete	=	2.50	t/m^3
Unit wt. of Soil	=	2.00	t/m^3
Thickness of soil above pile cap	=	0.50	m
Downward force & moment due to pile cap		1.20	0.00

Transverse direction	**L**	**B**	**H**	**Unit Weight**	**Load (t)**	**Moment (t.m)**
Self wt. of pile cap	0.00	4.85	1.80	2.50	0.00	0.00
Wt. due to soil	0.00	4.85	0.50	2.00	0.00	0.00
Longitudinal direction	**L**	**B**	**H**	**Unit Weight**	**Load (t)**	**Moment (t.m)**
Self wt. of pile cap	1.93	16.00	1.80	2.50	138.60	133.40
Wt. due to soil	1.93	16.00	0.50	2.00	30.80	29.65

DIRECTION	**Rare Combination**			**Quasi Permanent Combination**		
	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)
LL	814	40 /m	51 /m	645	30 /m	38 /m
TT	617	127 /m	/m	514	106 /m	/m
Max	814	644	813	645	514	611

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SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	25	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	12.00	N/mm^2	Rare Combination
	f_{cd}	=	12.00	N/mm^2	Frequent Combination
	f_{cd}	=	9.00	N/mm^2	Quasi Permanent Comb.
	E_c	=	30000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	300.00	N/mm^2	Rare Combination
	f_{Yd}	=	300.00	N/mm^2	Frequent Combination
	f_{Yd}	=	300.00	N/mm^2	Quasi Permanent Comb.

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.5*fcd*(xu_{lim}/d)*(1-0.33*xu_{lim}/d)$

	Rare Combination	Frequent Combination	Quasi Perm.
$xu_{,lim}/d$	0.70	0.70	0.70
$R_{lim} = M_{u,Lim}/bd^2$	3.22	3.22	2.42

Here R_{lim} is in MPa

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b = 16000 mm

Depth of section D = 4850 mm

Clear cover = 75 mm

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHID CL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OFABUTMENTS A1 & A2	Date &Rev.	

Moment on the section	**Moment at face of support**		
	Rare Combination		**Quasi Permanent Combination**
Actual moment (KNm)	7978		5998
Grade of Concrete	25		25
Grade of steel fy	500		500
b	16000		16000
D	4850		4850
c	75		75
d	4762.5		4762.5
f_{cd}	12.00		9.00
f_{Yd}	300		300
$xu_{,lim}/d$	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.22		2.42
$M_{u,Lim}$ (KNm)	1168546		876410
	OK		**OK**
Ast Req.	5591		4203
Dia of bar (main tension) (mm)	25		25
Spacing (mm)	120		120
+ dia of bar (main tension) (mm)	25		25
Spacing (mm)	120		120
Ast provided (sq mm)	8181		8181
Dia of bar(main compresion at top mm)	12		12
Spacing (mm)	120		120
Area of main compresion (mm^2)	15080		15080
f_{ctm}	2.2		2.2
x (mm)	26		34
x/d	0.005		0.007
	OK		**OK**
z (mm)	4754		4751
MR (KNm)	11668		11661
	OK		**OK**
$\sigma_{sc} = M/(A_s z)$	205		154
	OK		**OK**
$\sigma_{ca} = M/(0.5 z b x_u)$	8.20		4.63
	OK		**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Calculation of crack width	**Moment at face of support**		
n_1	8		8
n_2	8		8
$\phi_{eq} = (n_1 \phi_1^2 + n_2 \phi_2^2) / (n_1 \phi_1 + n_2 \phi_2)$	25		25
cl. 12.3.4 (3) of IRC :112-2011			
c	50		50
k1	0.2		0.2
k2	0.5		0.5
For skew slab refer eq. 12.10 of IRC :112-2011			
$\rho_{p.eff} = A_s / A_{c,eff}$	0.002		0.002
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 \phi) / \rho_{p.eff} \}$	625		625
cl. 12.3.4 (3) of IRC :112-2011			
k_t	0.5		0.5
$f_{ct,eff}$	2.90		2.90
E_s	200000		200000
E_{cm}	30000		30000
$\alpha_e = E_s / E_{cm}$	6.67		6.67
$(\varepsilon_{sm} - \varepsilon_{cm}) = (\sigma_{sc} - k_t f_{ct,eff} (1 + \alpha_e \rho_{p,eff}) / \rho_{p,eff}) / E_s$	0.0006		0.0005
cl. 12.3.4 (2) of IRC :112-2011			
$w_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$	0.29		0.29
cl. 12.3.4 (1) of IRC :112-2011			
	OK		**OK**

CHECK FOR SAFETY OF SECTION OF PILE

		Unit	Rare Combination		Quasi Permanent	
			Max.	Min.	Max.	Min.
Loads	P	KN	1742	1189	1326	1188
Moments	M	KNm	1216	1206	831	831
Dia of Section	D	mm	1200	1200	1200	1200
Radius of Section	R	mm	600	600	600	600
Effective Cover	C	mm	100	100	100	100
Effective Radius	R-C	mm	500	500	500	500
Modular Ratio	m		11.2	11.2	11.2	11.2
No. of Bars		Nos.	28	28	28	28
Dia of Bar		mm	25	25	25	25
+No of Bars		Nos.	28	28	28	28
+No of Bars		mm	25	25	25	25
Area of Steel	Ast	mm2	2.75E+04	2.75E+04	2.75E+04	2.75E+04
Area of Section	Ac	mm2	1.13E+06	1.13E+06	1.13E+06	1.13E+06
% of Steel	p	%	2.43	2.43	2.43	2.43
Net Area of Concrete	Anet	mm2	1.10E+06	1.10E+06	1.10E+06	1.10E+06
Transformed Area		mm2	1.41E+06	1.41E+06	1.41E+06	1.41E+06
Transformed MI		mm4	1.72E+11	1.72E+11	1.72E+11	1.72E+11
Section Modulus		mm3	2.86E+08	2.86E+08	2.86E+08	2.86E+08
Actual Stress						
P/A	$\sigma_{cc,cal}$	Mpa	1.23	0.84	0.94	0.84
M/Z	$\sigma_{cbc,cal}$	Mpa	4.24	4.21	2.90	2.90
Permissible Stress						
	σ_{cc}	Mpa	6.25	6.25	6.25	6.25
	σ_{cbc}	Mpa	8.33	8.33	8.33	8.33
Check for safety of Section						
$\frac{\sigma_{cc,cal}}{\sigma_{cc}} + \frac{\sigma_{cbc,cal}}{\sigma_{cbc}}$		Mpa	0.71	0.64	0.50	0.48
			ok	ok	ok	ok
Check for Cracked/Uncracked Section						
$\sigma_{cc,cal} - \sigma_{cbc,cal}$		Mpa	-3.01	-3.37	-1.96	-2.06
Permissible Tensile Stress in concrete		Mpa	-3.50	-3.50	-3.50	-3.50
Section is to be designed as			**UNCRACKED**	**UNCRACKED**	**UNCRACKED**	**UNCRACKED**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

COMBINATION FOR DESIGN OF ABUTMENT (ULS)

Following load combinations are con As per Annex B of IRC:112-2011

1 Basic Combination

2 Seismic Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	Dead Load (due to superstructure+substructure+foundation		544	-59	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		201	-59	0	0	0
4	ABUT + RETURN WALL		106	0	0	0	0
5	FDN		0	0	0	0	0
6	SOIL ABOVE FDN		0	0	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	214	0	658	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	159	0	666	0	0
12	LL1B	Live Load Moment due to braking	3	121	0	35.33	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.09	0
14	LL3B	Live Load Moment due to braking	3	112	0	32.61	0
15	W1	Wind vertically down without LL	29	4	50	5.47	11.58
16	W2	Wind vertically up without LL	-29	4	50	5.47	11.58
17	W3	Wind vertically down with LL	29	39	50	5.53	11.58
18	W4	Wind vertically up with LL	-29	39	50	5.53	11.58
19	S1	Seimic	49	317	7	74.2	0
20	S2		49	2	322	0.0	74.2
21	S3		-49	317	7	74.2	0
22	S4		-49	2	322	0.0	74.2
23	HFL		-21	0	0	0.0	0.0
24	Active earth pressure LWL		0	283	0	126.6	0.0
25	LL surcharge LWL		0	152	0	57.1	0.0
26	Active earth pressure HFL		0	142	0	63.3	0.0
27	LL surcharge HFL		0	76	0	28.5	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0.0
29	LL surcharge LWL		0	0	0	0	0.0
30	Active earth pressure HFL		0	0	0	0	0.0
31	LL surcharge HFL		0	0	0	0	0.0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

	Basic Combination				Seismic Combination			
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)
DL	1.35	734	-73	-33	1.35	734	-73	-33
SIDL1	1.75	43	0	0	1.75	43	0	0
SIDL2	1.35	38	0	0	1.35	38	0	0
LL1	1.50	320	401	901	0.20	43	54	120
LL2	1.50	252	431	969	0.20	34	58	129
LL3	1.50	238	406	913	0.20	32	54	122
LL1B	1.50	4	166	74	0.20	1	22	10
LL2B	1.50	0	0	0	0.20	0	0	0
LL3B	1.50	4	154	68	0.20	1	20	9
W1	0.90	26	22	43	0.00	0	0	0
W2	0.90	-26	22	43	0.00	0	0	0
W3	0.90	26	50	55	0.00	0	0	0
W4	0.90	-26	50	55	0.00	0	0	0
S1	0.00	0	0	0	1.50	74	439	203
S2	0.00	0	0	0	1.50	74	200	443
S3	0.00	0	0	0	1.50	-74	439	203
S4	0.00	0	0	0	1.50	-74	200	443
HFL	1.00	-21	0	0	1.00	-21	0	0
EP	1.00	0	259	115	1.00	0	259	115
LL S.	1.20	0	167	74	0.20	0	28	12
EP HFL	1.00	0	129	58	1.00	0	129	58
LL.S.HFL	1.20	0	83	37	0.20	0	14	6

	Dynamic incr. in earth press.(Seismic)	PSF	P (t)	ML (tm)	MT (tm)
Active earth pressure LWL		1.00	0	0	0
LL surcharge LWL		0.20	0	0	0
Active earth pressure HFL		1.00	0	0	0
LL surcharge HFL		0.20	0	0	0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Case 1 **Basic Combination**

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	815	185	82
Case 2	DL+SIDL1+SIDL2+LL1	1139	919	1132
Case 3	DL+SIDL1+SIDL2+LL2	1067	783	1126
Case 4	DL+SIDL1+SIDL2+LL3	1056	912	1138
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	841	207	125
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	1165	970	1187
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	1093	833	1181
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	1082	962	1193
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	789	207	125
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	1113	970	1187
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	1041	833	1181
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	1031	962	1193
HFL CASE				
Case 1	DL+SIDL1+SIDL2+HFL	793	56	25
Case 2	DL+SIDL1+SIDL2+LL1+HFL	1118	707	1037
Case 3	DL+SIDL1+SIDL2+LL2+HFL	1046	571	1031
Case 4	DL+SIDL1+SIDL2+LL3+HFL	1035	699	1043
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	819	78	67
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1144	757	1093
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1072	621	1086
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1061	749	1098
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	768	78	67
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1092	757	1093
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1020	621	1086
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1009	749	1098

MAXIMUM REACTION CASE	1165	970	1187
MAXIMUM LONGITUDINAL MOMENT CASE	1165	970	1187
MAXIMUM TRANSVERSE MOMENT CASE	1082	962	1193

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Case 2 **Seismic Combination**

Load Case		Factored Forces/Moments		
		V	ML	MT
Normal		t	t-m	t-m
Downward seismic in longitudinal direction				
Case 1	DL+SIDL1+SIDL2+ seismic	889	624	286
Case 2	DL+SIDL1+SIDL2+LL1+ seismic	932	728	428
Case 3	DL+SIDL1+SIDL2+LL2+ seismic	923	710	427
Case 4	DL+SIDL1+SIDL2+LL3+ seismic	921	727	429
Downward seismic in transverse direction				
Case 5	DL+SIDL1+SIDL2+ seismic	889	385	526
Case 6	DL+SIDL1+SIDL2+LL1+ seismic	932	488	668
Case 7	DL+SIDL1+SIDL2+LL2+ seismic	923	470	667
Case 8	DL+SIDL1+SIDL2+LL3+ seismic	921	487	669
Upward seismic in longitudinal direction				
Case 9	DL+SIDL1+SIDL2+ seismic	741	624	286
Case 10	DL+SIDL1+SIDL2+LL1+ seismic	784	728	428
Case 11	DL+SIDL1+SIDL2+LL2+ seismic	774	710	427
Case 12	DL+SIDL1+SIDL2+LL3+ seismic	773	727	429
Upward seismic in transverse direction				
Case 13	DL+SIDL1+SIDL2+ seismic	741	385	526
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	784	488	668
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	774	470	667
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	773	487	669

HFL CASE

Downward seismic in longitudinal direction				
Case 1	DL+SIDL1+SIDL2+ seismic	868	495	228
Case 2	DL+SIDL1+SIDL2+LL1+ seismic	911	585	364
Case 3	DL+SIDL1+SIDL2+LL2+ seismic	901	567	364
Case 4	DL+SIDL1+SIDL2+LL3+ seismic	900	584	365
Downward seismic in transverse direction				
Case 5	DL+SIDL1+SIDL2+ seismic	868	255	468
Case 6	DL+SIDL1+SIDL2+LL1+ seismic	911	345	604
Case 7	DL+SIDL1+SIDL2+LL2+ seismic	901	327	603
Case 8	DL+SIDL1+SIDL2+LL3+ seismic	900	344	605
Upward seismic in longitudinal direction				
Case 9	DL+SIDL1+SIDL2+ seismic	719	495	228
Case 10	DL+SIDL1+SIDL2+LL1+ seismic	763	585	364
Case 11	DL+SIDL1+SIDL2+LL2+ seismic	753	567	364
Case 12	DL+SIDL1+SIDL2+LL3+ seismic	752	584	365
Upward seismic in transverse direction				
Case 13	DL+SIDL1+SIDL2+ seismic	719	255	468
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	763	345	604
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	753	327	603
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	752	344	605

MAXIMUM REACTION CASE	932	728	428
MAXIMUM LONGITUDINAL MOMENT CASE	932	728	428
MAXIMUM TRANSVERSE MOMENT CASE	921	487	669

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

COMBINATION FOR DESIGN OF ABUTMENT (SLS)

Following load combinations are conAs per Annex B of IRC:112-2011

1 Rare Combination

2 Quasi Permanent Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	DL	Dead Load (due to superstructure+substructure+found.	544	-59	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		201	-59	0	0	0
4	ABUT + RETURN WALL		106	0	0	0	0
5	FDN		0	0	0	0	0
6	SOIL ABOVE FDN		0	0	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	214	0	658	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	159	0	666	0	0
12	LL1B	Live Load Moment due to braking	3	121	0	35.33	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.09	0
14	LL3B	Live Load Moment due to braking	3	112	0	32.61	0
15	W1	Wind vertically down without LL	29	4	50	5.47	11.58
16	W2	Wind vertically up without LL	-29	4	50	5.47	11.58
17	W3	Wind vertically down with LL	29	39	50	5.53	11.58
18	W4	Wind vertically up with LL	-29	39	50	5.53	11.58
19	S1	Seimic	0	0	0	0	0
20	S2		0	0	0	0	0
21	S3		0	0	0	0	0
22	S4		0	0	0	0	0
23	HFL		-21	0	0	0	0
24	Active earth pressure LWL		0	283	0	126.6	0.0
25	LL surcharge LWL		0	152	0	57.1	0.0
26	Active earth pressure HFL		0	142	0	63.3	0.0
27	LL surcharge HFL		0	76	0	28.5	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0
29	LL surcharge LWL		0	0	0	0	0
30	Active earth pressure HFL		0	0	0	0	0
31	LL surcharge HFL		0	0	0	0	0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

	Rare Combination					**Quasi Permanent Combination**			
	PSF	P (t)	ML (tm)	MT (tm)		PSF	P (t)	ML (tm)	MT (tm)
DL	1.00	544	-54	-24		1.00	544	-54	-24
SIDL1	1.00	24	0	0		1.00	24	0	0
SIDL2	1.00	28	0	0		1.00	28	0	0
LL1	1.00	214	268	601		0.00	0	0	0
LL2	1.00	168	288	646		0.00	0	0	0
LL3	1.00	159	271	608		0.00	0	0	0
LL1B	1.00	3	111	49		0.00	0	0	0
LL2B	1.00	0	0	0		0.00	0	0	0
LL3B	1.00	3	102	46		0.00	0	0	0
W1	0.60	17	14	28		0.00	0	0	0
W2	0.60	-17	14	28		0.00	0	0	0
W3	0.60	17	34	37		0.00	0	0	0
W4	0.60	-17	34	37		0.00	0	0	0
S1	0.00	0	0	0		0.00	0	0	0
S2	0.00	0	0	0		0.00	0	0	0
S3	0.00	0	0	0		0.00	0	0	0
S4	0.00	0	0	0		0.00	0	0	0
HFL	1.00	-21	0	0		1.00	-21	0	0
EP	1.00	0	259	115		1.00	0	259	115
LL S.	0.80	0	111	49		0.00	0	0	0
EP HFL	1.00	0	129	58		1.00	0	129	58
LL.S.HFL	0.80	0	56	25		0.00	0	0	0
Active earth pressure LWL					Dynamic incr. in earth press.(Seismic)	1.00	0	0	0
LL surcharge LWL						0.20	0	0	0
Active earth pressure HFL						1.00	0	0	0
LL surcharge HFL						0.20	0	0	0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Case 1 Rare Combination

Load Case		Factored Forces/Moments	
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	596	204	91
Case 2 DL+SIDL1+SIDL2+LL1	812	694	791
Case 3 DL+SIDL1+SIDL2+LL2	765	603	786
Case 4 DL+SIDL1+SIDL2+LL3	757	689	794
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	614	219	119
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	830	727	828
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	782	636	823
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	775	722	831
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	579	219	119
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	795	727	828
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	747	636	823
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	740	722	831

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	575	75	33
Case 2 DL+SIDL1+SIDL2+LL1+HFL	791	509	708
Case 3 DL+SIDL1+SIDL2+LL2+HFL	743	418	704
Case 4 DL+SIDL1+SIDL2+LL3+HFL	736	504	712
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	592	89	62
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	808	542	745
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	761	452	741
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	753	537	749
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	558	89	62
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	774	542	745
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	726	452	741
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	719	537	749

MAXIMUM REACTION CASE	830	727	828
MAXIMUM LONGITUDINAL MOMENT CASE	830	727	828
MAXIMUM TRANSVERSE MOMENT CASE	775	722	831

Case 2 Quasi Permanent Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	596	204	91
Case 2 DL+SIDL1+SIDL2+LL1	596	204	91
Case 3 DL+SIDL1+SIDL2+LL2	596	204	91
Case 4 DL+SIDL1+SIDL2+LL3	596	204	91
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	596	204	91
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	596	204	91
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	596	204	91
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	596	204	91
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	596	204	91
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	596	204	91
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	596	204	91
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	596	204	91

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	575	75	33
Case 2 DL+SIDL1+SIDL2+LL1+HFL	575	75	33
Case 3 DL+SIDL1+SIDL2+LL2+HFL	575	75	33
Case 4 DL+SIDL1+SIDL2+LL3+HFL	575	75	33
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	575	75	33
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	575	75	33
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	575	75	33
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	575	75	33
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	575	75	33
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	575	75	33
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	575	75	33
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	575	75	33

MAXIMUM REACTION CASE	596	204	91
MAXIMUM LONGITUDINAL MOMENT CASE	596	204	91
MAXIMUM TRANSVERSE MOMENT CASE	596	204	91

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checkedby:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OFABUTMENTS A1 & A2	Date & Rev.	

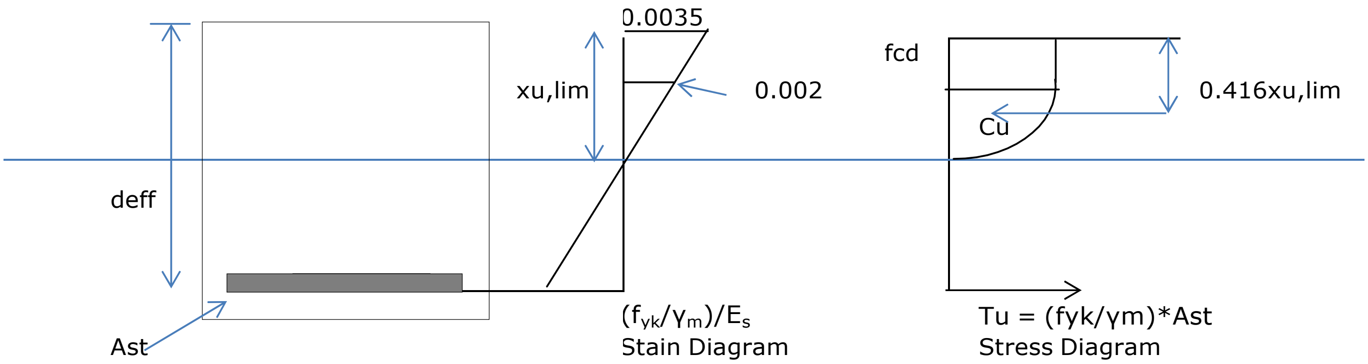
CALCULATION OF DIRT WALL FORCES

Height of dirt wall	2.135	m
Thickness of dirt wall	0.3	m
Thickness of approach slab	0.3	m
Thickness of wearing coat on approach slab	0.075	m
Unit wt. of soil	2.00	t/m3
Unit wt. of concrete	2.50	t/m3
Unit wt. of wearing coat	2.20	t/m3
Earth Pressure considered	Y	
Coefficient of active earth pressure	0.279	
Live load surcharge	1.2	m
Active earth pressure	1.19	t/m^2 per meter
Pressure due to live load surcharge	0.67	t/m^2 per meter
Force due to live load surcharge	1.43	t per meter
Force due to active earth pressure	1.27	t per meter
Moment due to live load surcharge	1.53	t.m
Moment due to active earth pressure Ignoring vertical load	1.14	t.m

	unit	actual value	ULS basic PSF	ULS basic Comb.	SLS Rare PSF	SLS Rare comb.	SLS Quasi permanent	SLS Quasi permanent
Moment due to live load surcharge	t.m per meter	1.53	1.20	1.83	0.80	1.22	0.00	0.00
Moment due to active earth pressure	t.m per meter	1.14	1.50	1.71	1.00	1.14	1.00	1.14
	t.m per meter			**3.55**		**2.36**		**1.14**
Force due to live load surcharge	t per meter	1.43	1.20	1.72	0.80	1.15	0.00	0.00
Force due to active earth pressure	t per meter	1.27	1.50	1.91	1.00	1.27	1.00	1.27
	t per meter			**3.63**		**2.42**		**1.27**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR DIRT WALL



ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	25	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	11.17	N/mm^2	Basic Combination
	f_{cd}	=	13.96	N/mm^2	Accidental Combination
	f_{cd}	=	11.17	N/mm^2	Seismic Combination
	E_c	=	30000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	435	N/mm^2	Basic Combination
	f_{Yd}	=	500.00	N/mm^2	Accidental Combination
	f_{Yd}	=	435	N/mm^2	Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = fcd*b*(3/7xu,$_{lim}$ + 2/3*4/7xu,$_{lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.8095fcd*(xu $_{lim}$/d)*(1-0.416*xu $_{lim}$/d)

	Basic Comb	Accidental Comb	Seismic Comb
xu,$_{lim}$/d	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.15	4.99	4.15

Here R_{lim} is in MPa

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	mm

Moment on the section	**Moment at face of support**		
	Basic Combination		
Actual moment (KNm)	35		
Grade of Concrete	25		
Grade of steel fy	500		
b	1000		
D	300		
c	50		
d	234.0		
f_{cd}	11.17		
f_{Yd}	435		
$x_{u,lim}/d$	0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.15		
$M_{u,Lim}$ (KNm)	227		
	OK		
Ast Req.	353		
Dia of bar (main tension) (mm)	16		
Spacing (mm)	150		
+ dia of bar (main tension) (mm)	0		
Spacing (mm)	150		
Ast provided (sq mm)	1340		
Dia of bar(main compresion at top mm)	12		
Spacing (mm)	150		
Area of main compresion (mm^2)	754		
f_{ctm}	2.2		
f_{yk}	435		
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	308		
	OK		
As.max = 0.025 Ac (main tension)	7500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**		
As.max = 0.04 Ac (tension + compresion)	12000		
x (mm)	64		
x/d	0.276		
	OK		
z (mm)	207		
MR (KNm)	121		
	OK		

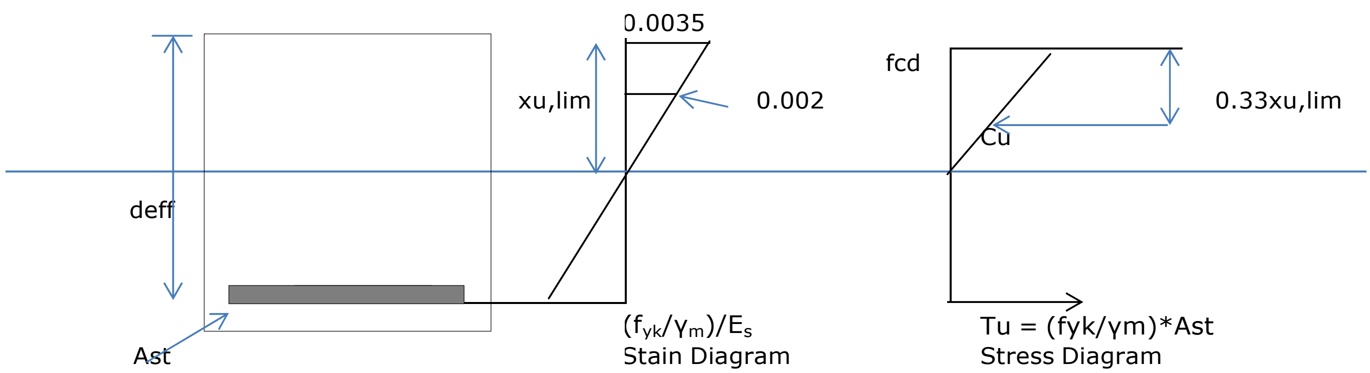
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Shear on the section

Actual shear V_{Ed} (KN)	36		
Actual shear stress (N/mm2)	0.152		
Max shear capacity, 0.135 fck(1-fck/310)	3.10		
	OK		
Min shear capacity, 0.0924 fck(1-fck/310)	2.12		
θ = 0.5 x $\sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	1.40		
Min angle of inclination, θ (deg)	21.8		
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.925		
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
V(min) = 0.031 K^(3/2) fck^(1/2)	0.414		
cl. 10.3.1 of IRC :112-2011			
r1 = $A_{sl}/(b_w\ d)$ <= 0.02	0.006		
	OK		
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.516		
Axial compressive force N_{Ed} (KN)	0.0		
$S_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d >= (V_{min} + 0.15\ S_{cp})\ b_w\ d$ (KN)	121		
	NO SHEAR R/F REQ.		
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010			
n = 0.6 (1 - fck / 310)	0.552		
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011			
$0.5\ b_w\ d\ n\ f_{cd}$	721		
	OK		
No. of Links for shear R/f (Distribution)	0		
Dia. of bar for shear reinf.	10		
S(mm)	150		
A_{SW1}	0		
	OK		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF SERVICEABILITY LIMIT STATE FOR DIRT WALL



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	25	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	12.00	N/mm^2	Rare Combination
	f_{cd}	=	12.00	N/mm^2	Frequent Combination
	f_{cd}	=	9.00	N/mm^2	Quasi Permanent Comb.
	E_c	=	30000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	300.00	N/mm^2	Rare Combination
	f_{Yd}	=	300.00	N/mm^2	Frequent Combination
	f_{Yd}	=	300.00	N/mm^2	Quasi Permanent Comb.

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = 0.5*fcd*(xu $_{lim}$/d)*(1-0.33*xu $_{lim}$/d)

	Rare Combination	Frequent Combination	Quasi Perm.
$xu_{,lim}/d$	0.70	0.70	0.70
$R_{lim} = M_{u,Lim}/bd^2$	3.22	3.22	2.42

Here R_{lim} is in MPa

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	mm

Moment on the section	**Moment at face of support**		
	Rare Combination		**Quasi Permanent Combination**
Actual moment (KNm)	23		11
Grade of Concrete	25		25
Grade of steel fy	500		500
b	1000		1000
D	300		300
c	50		50
d	234.0		234.0
f_{cd}	12.00		9.00
f_{Yd}	300		300
$x_{u,lim}/d$	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.22		2.42
$M_{u,Lim}$ (KNm)	176		132
	OK		**OK**
Ast Req.	339		162
Dia of bar (main tension) (mm)	16		16
Spacing (mm)	150		150
+ dia of bar (main tension) (mm)	0		0
Spacing (mm)	150		150
Ast provided (sq mm)	1340		1340
Dia of bar(main compresion at top mm)	12		12
Spacing (mm)	150		150
Area of main compresion (mm^2)	754		754
f_{ctm}	2.2		2.2
x (mm)	67		89
x/d	0.286		0.382
	OK		**OK**
z (mm)	212		204
MR (KNm)	85		82
	OK		**OK**
$\sigma_{sc} = M/(A_s z)$	82		41
	OK		**OK**
$\sigma_{ca} = M/(0.5 z b x_u)$	3.27		1.23
	OK		**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Calculation of crack width	**Moment at face of support**		
n_1	7		7
n_2	7		7
$\phi_{eq} = (n_1\phi_1^2 + n_2 \phi_2^2) / (n_1 \phi_1 + n_2 \phi_2)$	16		16
cl. 12.3.4 (3) of IRC :112-2011			
c	50		50
k1	0.8		0.8
k2	0.5		0.5
For skew slab refer eq. 12.10 of IRC :112-2011			
$\rho_{p.eff} = A_s / A_{c,eff}$	0.009		0.009
$S_{r,max} = \{ 3.4\, c + (0.425\, k_1\, k_2\, \phi) / \rho_{p.eff} \}$	474		474
cl. 12.3.4 (3) of IRC :112-2011			
k_t	0.5		0.5
$f_{ct,eff}$	2.90		2.90
E_s	200000		200000
E_{cm}	30000		30000
$\alpha_e = E_s / E_{cm}$	6.67		6.67
$(\varepsilon_{sm} - \varepsilon_{cm}) = (\sigma_{sc} - k_t\, f_{ct,eff}(1+\alpha_e\, \rho_{p,eff}) / \rho_{p,eff}) / E_s$	0.0002		0.0001
cl. 12.3.4 (2) of IRC :112-2011			
$W_k = S_{r,max}\,(\varepsilon_{sm} - \varepsilon_{cm})$	0.12		0.06
cl. 12.3.4 (1) of IRC :112-2011			
	OK		**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

APPENDEX - I

Fundamental Time Period of Vibration due to Seismic Waves :

According to **Annexure D (Clause 219.5)** IRC 6 :2017 -

T = 2.0 x sqrt(D/(1000*F))

Where,

T = Fundamental Time Period Of Vibration

D = Appropriate dead Load of the superstructure and Live load in KN

F = Horizontal Force in KN required to be applied at the centre of mass of superstructure for 1 mm horizontal deflection at the top of the 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 Longitudinal direction

			Longitudinal Direction		Transverse Direction	
	F	=	$d*(3EI)/L^3$	Unit	$d*(3EI)/L^3$	Unit
	d	=	0.001	m	0.001	m
	L	=	4.460	m	5.037	m
	E	=	3.00E+07	KN/m2	3.00E+07	KN/m2
	I	=	1.000	m4	256.000	m4
	F	=	1014.467	KN	180287.917	KN
	D	=	2829.000	KN	3248.012	KN
	T	**=**	***0.11***	***sec***	***0.01***	***sec***
Seismic Zone		=	III		III	
Zone Factor Z		=	0.16		0.16	
Importance Factor I		=	1.2		1.2	
Response Reduction Factor		=	3		3	
Soil Strata		=	Type II	Medium soil		
Sa/g			2.5		2.5	
Horizontal Acceleration Coefficient (Ah) Z/2*Sa/g*I/R		=	0.08		0.08	

APPENDEX - II DESIGN CURVE OF PILE SHAFT FOR MAXIMUM BENDING MOMENTS

SLENDERNESS CHECK AND CHECK FOR SECOND ORDER EFFECTS

Slenderness check as per IRC 112,Cl.8.3.2

lx/ly <=2.0 & ly/lx <=2.0 — as per eq. 8.1

$(e_x / h_{eq}) / (e_y / b_{eq}) <= 0.20$ OR — as per eq. 8.2

$(e_y / b_{eq}) / (e_x / h_{eq}) <= 0.20$ — From table 11.1:IRC 112

lex	=	12934.61	mm	ley	=	12934.61	mm	
Ixx	=	1.0E+11	mm4	Iyy	=	1.0E+11	mm4	
A	=	1130973	mm2	A	=	1130973	mm2	
$i_y=\sqrt{I/A}$	=	300.0	mm	$i_x=\sqrt{I/A}$	=	300.0	mm	Radius of gyration
b_{eq}	=	86.6	mm	h_{eq}	=	86.6	mm	
l_x	=	43.12		l_y	=	43.12		

Check for Slenderness

1.0	**l_x / l_y**	**=**	**1.00**	**<=2**	Condition Satisfied	from eq 8.1 IRC 112
	l_y / l_x	**=**	**1.00**	**<=2**	Condition Satisfied	

2.0	Design Cases		Case-1	Case-2	Case-3	Case-4	from eq 8.2 IRC 112
	e_x	=	605.87	812.0	657.1	956.3	
	e_y	=	605.87	812.0	657.1	956.3	
	$(e_x/h_{eq}) / (e_y/b_{eq})$	=	1.00	1.00	1.00	1.00	
	$(e_y/b_{eq}) / (e_x/h_{eq})$	=	1.00	1.00	1.00	1.00	

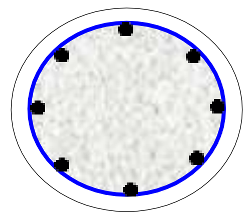
Hence Check for Bending is required

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

<u>Design of Pile Shaft Subjected to Axial Load & Maximum Bending Moments-</u>

<u>Given Data</u>

Pile Size



Diameter (D) = 1200 mm

Area of Pile (Ag) = 1.13E+06 mm2

Section R/f

	Equivalent Dia (mm)	Nos.	Area
Outer Peripheri	37	26	27488.936
	37	0	0.00

PROVIDE				
	28	X	25	Dia
+	28	X	25	Dia
+	0	X	25	Dia

Ast Provided	=	27488.936	mm2	**OK**
Total No. of Longitudinal Bar	=	26	Nos.	
Total Ast	=	27488.936	mm2	
% of Reinforcement (Pt)	=	2.43	%	
Effective Spacing of Bars	=	119.54	mm	**OK**
Clear Cover	=	75	mm	
Dia of Tie Bar	=	12	mm	
Effective Cover (d')	=	105	mm	
d'/D ratio	=	0.088		

<u>Transverse Reinforcement</u>

As per Clause 16.2.3 of IRC 112:2011

Minimum Diameter of Tie Bars = 0.25 x 25 = 6.25 mm

or 8 mm whichever is greater

Adopt 8 mm dia Helical Reinforcement

Pitch of Lateral Ties shall not exceed

= 12 x 25 = 300 mm

or 1200 mm

or 200 mm whichever is less

or 150 mm As per IRC 78-2014

Adopt 150 mm c/c spacing

Provide 8mm dia bar @ 150c/c as Spiral Helical Tie Bar beyond Point of Fixity

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Ductile Detailing as per IRC:112-2019, Clause 17.2.1

Confinement Reinforcement

nk = $\frac{N_{ED}}{Acfck}$ = $\frac{3372165}{2.83E+07}$ = 0.12 > 0.06

IF nk > 0.064 , Confinement R/f shall be provided as per Clause 17.2.1.4 of IRC:112-2019

IF nk < 0.064 , Confinement R/f shall be provided as per Clause 17.2.2 of IRC:112-2019

Adopt Spacing of Hoops = 125 mm

As per Cl. 17.2.1.3 of IRC 112:2019

Spacing of Hoops

SL	<= 5	x	25	=	125	mm	OK
	<= 0.2	x	1042	=	208.4	mm	OK

Dsp = 1050 mm

Dia of Spiral Provided = 10 mm

ω_{wd} = ρ_w fyd/fcd

where ρ_w = $\frac{4*Asp}{Dsp*SL}$

Asp	=	78.54	mm2
SL	=	125	mm c/c
Dsp	=	1050	mm
ρ_w	=	0.002	
$\omega_{wd,c}$	=	0.093	

Minimum Confining Reinforcement: as per Clause 17.2.1.2 of IRC:112-2019

$\omega_{wd,c}$ >= max (1.4*ωw.req, 0.18)

$\omega_{w,req}$ = $\frac{0.37Ac*nk}{Acc}$ + $\frac{0.13*fyd(\rho L-0.01)}{fcd}$

Ac	=	1.13E+06	
Acc	=	8.66E+05	mm^2
nk	=	0.12	
ρL	=	0.02431	
$\omega_{w,req}$	=	0.13005	
$\omega_{wd,c}$	=	0.18207	

105.00962

$\omega_{wd,c}$ = 6.990 OK

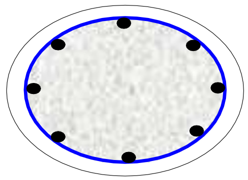
Material Property

Concrete Grade	=	**M25**	
Steel Grade	=	**Fe500**	
Characteristic Compressive Strength of Concrete at 28 days,fck	=	25.00	N/mm^2
Design strength of concrete, fcd=0.446fck	=	11.17	N/mm^2
Yield Strength of Reinforcement Steel ,fy	=	500	N/mm^2
Design Yield Strength of Reinforcement Steel ,fyd	=	434.78	N/mm^2
Modulus of Elasticity of Concrete (Ec)	=	25000.0	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2
Factor of Safety For Concrete	=	1.5	
Factor of Safety For Steel	=	1.15	
Maximum Strain in Concrete,εcu	=	0.0035	
Yield Strain in Concrete, ε_{cd}	=	0.002	
Yield Strain in Steel,$\varepsilon_{st}(\varepsilon_{yd})$	=	0.002174	
Max. Strain in steel, ε_{stu}	=	0.004174	

Summary of Design Forces at Pile Fixity:

Load Cases		Axial Load (KN)	Initial Resultant Moment (KN-m)	Final Design Moment (KN-m)
		Pu	M	Mu
Normal Dry Case	Max	2279.83	690.64	690.64
	Min	1213.90	580.42	580.42
Seismic Case	Max	2310.50	646.71	646.71
	Min	1142.94	603.53	603.53

DESIGN OF RECTANGULAR SECTION FOR ABUTMENT SHAFT - ULTIMATE LIMIT STATE



Section dimensions of pier shaft

Length, B = 1200 mm (equivalent length of pier shaft)
Thickness,D = 0 mm

Material properties

fck = 25.00 Mpa
fyk = 500 Mpa
Es = 200000 Mpa

Design axial resistance of section

N_{Rd} = Ac * fcd + As * fyd

fcd = α_{cc} xf_{ck} /γ_m α_{cc} = 0.67

= 11.167 Mpa γ_m = 1.5

fyd = fyk/γ_s γ_s = 1.15

= 434.7826 Mpa

N_{Rd} = 11951.71 KN

Reinforcement Details

Reinf.	Dia.(mm)	Spacing (mm)	Cover (mm)	From (mm)	To (mm)	Y_{CG} (mm)	Nos.
As1	25	120	75	0	0	0.00	28.00
As2	25	75	75	0	0	0.00	28.00

Total reinforcement

As3 (Along length Tension face) = 0.00 mm^2
As4 (Along length Compression face) = 0.00 mm^2
As2 (Along width Tension face) = 13744.47 mm^2
As1 (Along width Compression face) = 13744.47 mm^2
Total As = **27488.9 mm^2**
Total As = **mm^2**
= **2.43 %**

Formula used for interaction diagram

Pu = Cc +Cs
Mu = Mc + Ms

Cc = 0.361*fck*Xu*b for Xu ≤ D
= 0.447*fck*(1-4*g/21)*b*D for Xu ≥ D

g = $16 / (7Xu / D-3)^2$

$Cs = \sum (fsi - fci)\, Asi$

$fci = 0.00$ for $\varepsilon_{si} \leq 0$

$0.447\, fck$ for $\varepsilon_{si} \geq 0.002$

$0.447 fck\ \ 2^* (\varepsilon_{si}/0.002) - (\varepsilon_{si}/0.002)^2$ otherwise

$fsi = -0.87\, fy$ for $\varepsilon_{si} \leq -0.00217$

$\varepsilon_{si} * Es$ for $0.00217 \geq \varepsilon_{si} > -0.00217$

$0.87fy$ for $\varepsilon_{si} > 0.00217$

$Mc = Cc * (0.5D - x)$

$Ms = \sum Csi * yi$

$x = 0.416\, Xu$ for $Xu \leq D$

$= (0.5 - 8^*g/49)^* D/(1-4^*g/21)$ for $Xu \geq D$

Where x = Centroid of stress block area from most compressed edge.

$\varepsilon_{si} = \dfrac{0.0035 * \ Xu - D/2 + y_i}{Xu}$ for $Xu \leq D$

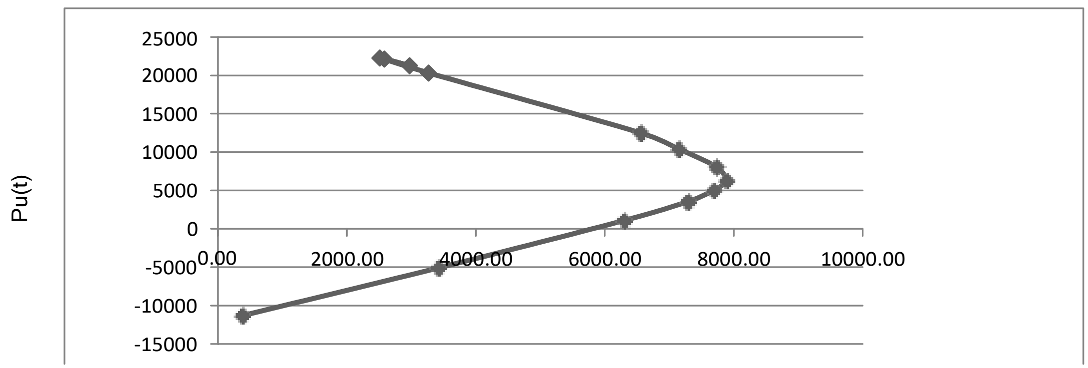
$= \dfrac{0.002^* \ 1 + y_i - D/14}{Xu - 3D/7}$ for $Xu > D$

Where y_i = Distance of ith row of steel from the centroidal axis measured positive in the direction towards the highly compressed edge.

Along traffic direction

Xu/D	=	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
D(mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Xu (mm)	=	60	120	240	360	480	600	720	840	960	1080	1200	1320	1440
	<	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
g (Mpa)	=	2.278391	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.366864	1.469238	1	0.72431	0.54869684
Cc (KN)	=	649.8	1299.6	2599.2	3898.8	5198.4	6498.0	7797.6	9097.2	10396.8	11696.4	13026.9	13871.9	14410.2
y1 (compr. face in mm)	=	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5
y1 (tension face in mm)	=	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5
y2 (compr. face in mm)	=	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5
y2 (tension face in mm)	=	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5
ε_{si}(compr. face in mm)	=	-0.0023	0.000598	0.002049	0.002533	0.002774	0.00292	0.003016	0.003085	0.003137	0.003178	0.00321	0.00303	0.00289614
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.0607	-0.0286	-0.01255	-0.0072	-0.00452	-0.00292	-0.00185	-0.001085	-0.000512	-6.64E-05	0.00029	0.000545	0.00073349
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{s2}(compr. face in mm)	=	-0.00522	-0.00086	0.00132	0.002047	0.00241	0.002628	0.002773	0.002877	0.002955	0.003016	0.003064	0.002905	0.00278812
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{s2} (tension face in mm)	=	-1.52158	-1.07676	-0.45388	-0.12235	-0.00499	-0.02464	-0.104108	-0.166229	-0.133827	0.070275	0.52325	0.000669	0.00084151
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	5.682941	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175
fsi(comp.face in Mpa)	=	-435	119.5833	409.7917	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	3.007786	5.259408	6.69367547
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-369.9306	-217.0833	-102.4479	-13.29	58.04167	108.9716	146.697531
fc2 (comp.face in Mpa)	=	0	0	9.882378	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175
fs2(comp.face in Mpa)	=	-435	-172.083	263.9583	409.3056	435	435	435	435	435	435	435	435	435
fc2 (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	11.175	11.175	6.22549	7.42552588
fs2 (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-435	-435	-435	435.00	435	133.7943	168.302469
Cs (KN)	=	-11957.7	-6378.7	-1493.4	-330.2	-153.6	-153.6	293.6	1344.0	2131.8	8646.6	9116.1	7414.7	7893.0
Mc (KN-m)	=	373.7	714.9	1300.0	1755.4	2081.0	2276.9	2343.0	2279.4	2086.0	1762.9	1313.6	951.5	720.8
Ms (KN-m)	=	0.00	2701.95	5000.61	5533.30	5612.85	5612.85	5389.04	4863.31	4469.02	1503.47	1268.48	2018.24	1790.29
Pu (KN)	**=**	**-11307.9**	**-5079.1**	**1105.8**	**3568.6**	**5044.8**	**6344.4**	**8091.2**	**10441.2**	**12528.6**	**20343.0**	**22142.9**	**21286.6**	**22303.1**
Mu (KN-m)	**=**	**373.7**	**3416.8**	**6300.6**	**7288.7**	**7693.9**	**7889.7**	**7732.1**	**7142.7**	**6555.0**	**3266.4**	**2582.1**	**2969.7**	**2511.1**

Mu (KN-m)	**Pu (KN)**
373.7	-11307.9
3416.83	-5079.09
6300.62	1105.81
7288.69	3568.63
7693.87	5044.81
7889.75	6344.41
7732.06	8091.18
7142.70	10441.18
6555.03	12528.58
3266.35	20342.96
2582.11	22142.94



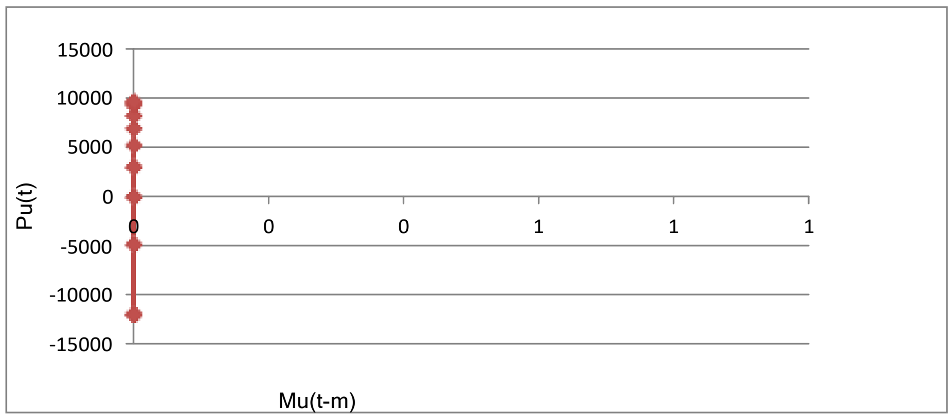
2969.71	21286.55
2511.08	22303.14

Interaction diagram Mu(t-m)

Along transverse direction

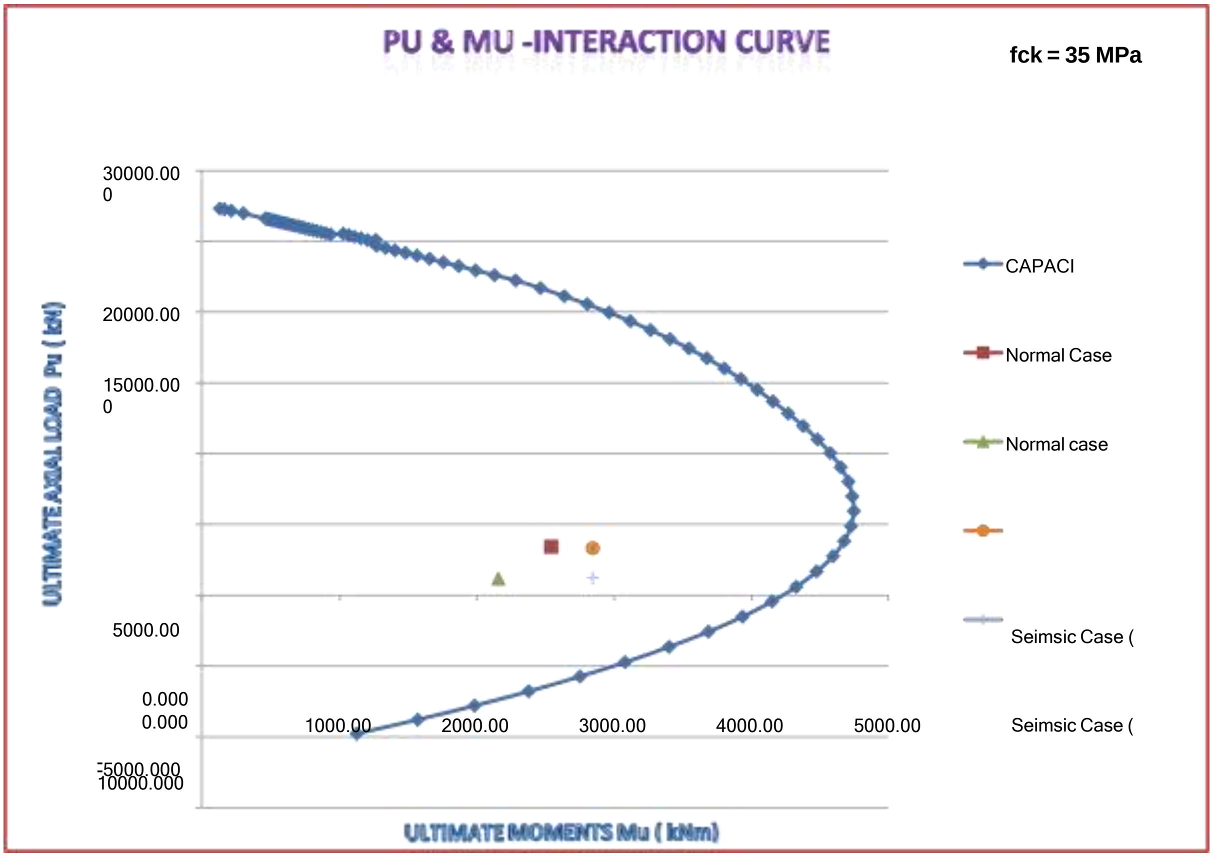
Xu/D	=	0.025	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
D(mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Xu (mm)	=	30	120	240	360	480	600	720	840	960	1080	1200	1320	1440
	<	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
g (Mpa)		2.004856	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.366864	1.469238	1	0.72431	0.54869684
Cc (KN)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yi (compr. face in mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
yi (tension face in mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
ε_{si}(compr. face in mm)	=	-0.0665	-0.014	-0.00525	-0.00233	-0.00088	0	0.000583	0.001	0.001313	0.001556	0.00175	0.001787	0.00181481
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.0665	-0.014	-0.00525	-0.00233	-0.00088	0	0.000583	0.001	0.001313	0.001556	0.001750	0.001787	0.00181481
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	0	0	0	0	0	5.568099	8.38125	9.854517	10.62315	11.00039	11.04853	11.0791924
fsi(comp.face in Mpa)	=	-435	-435	-435	-435	-175	0	116.6667	200	262.5	311.1111	350	357.4468	362.962963
fci (tension face in Mpa)	=	0	0	0	0	0	0	5.568099	8.38125	9.854517	10.62315	11.00039	11.04853	11.0791924
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-175	0	116.6667	200	262.5	311.1111	350	357.4468	362.962963
Cs (KN)	=	-11957.7	-11957.7	-11957.7	-11957.7	-4810.6	0.0	3054.0	5267.4	6945.0	8260.1	9318.7	9522.1	9672.9
Mc KN-m)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ms (KN-m)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu (KN)	**=**	**-11957.7**	**-11957.7**	**-11957.7**	**-11957.7**	**-4810.6**	**0.0**	**3054.0**	**5267.4**	**6945.0**	**8260.1**	**9318.7**	**9522.1**	**9672.9**
Mu (KN-m)	**=**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Mu (KN-M)	**Pu (KN)**
0.00	-11957.69
0.00	-11957.69
0.00	-11957.69
0.00	-11957.69
0.00	-4810.56
0.00	0.00
0.00	3053.98
0.00	5267.40
0.00	6944.96
0.00	8260.09
0.00	9318.74
0.00	9522.12
0.00	9672.91



Interaction diagram

The abodemanddemandthe section ve figure presents a typical axial force - bending moment interaction curve for pile section at top for given amount of reinforcement. The as due to various load cases as presented in table are shown by filled circles. This provides a graphical representation of capacity of the due to various load cases. Since demand points are within the interaction curve, on is safe for the present load cases.



ANNEXURE IIA:- DESIGN CURVE OF PILE SHAFT FOR MAXIMUM BENDING MOMENTS (CURTAILMENT)

APPENDEX - III DESIGN CURVE OF ABUTMENT SHAFT FOR MAXIMUM BENDING MOMENTS

SLENDERNESS CHECK AND CHECK FOR SECOND ORDER EFFECTS

Slenderness check as per IRC 112,Cl.8.3.2- page 74

$l_x/l_y <= 2.0$ & $l_y/l_x <= 2.0$ — as per eq. 8.1

$(e_x / h_{eq}) / (e_y / b_{eq}) <= 0.20$ OR $(e_y / b_{eq}) / (e_x / h_{eq}) <= 0.20$ — as per eq. 8.2

Type of Bearings = POT PTFE Bearing

Effective Length = 1.4

l	=	2.66 m Clear Height of Pier				
b_{eq}	=	16000 mm				
h_{eq}	=	1000 mm				
lex	=	3724 mm	ley	=	3724 mm
Ixx	=	3.4E+14 mm4	Iyy	=	1.3E+12
A	=	1.60E+07 mm2	A	=	1.60E+07 mm2
$i_y=\sqrt{I/A}$	=	4618.8 mm	$i_x=\sqrt{I/A}$	=	288.7 mm
b_{eq}	=	16000 mm	h_{eq}	=	1000 mm
l_x	=	0.8	l_y	=	12.9

Check for Biaxial Bending

1.0	**l_x / l_y**	**=**	**0.06**	**<=2**	Condition Satisfied	from eq 8.1 IRC 112
	l_y / l_x	**=**	**16.00**	**>2**	Condition not Satisfied	

2.0	Design Cases		Case-1	Case-2	Case-3	from eq 8.2 IRC 112
	e_x	=	832.44	832.44	888.72	
	e_y	=	1019.31	1019.31	1102.21	
	$(e_x/h_{eq}) / (e_y/b_{eq})$	=	13.07	13.07	12.90	
	$(e_y/b_{eq}) / (e_x/h_{eq})$	=	0.08	0.08	0.08	

Hence Check for Biaxial Bending is required

3.0 **Check for Second Order Effect**

Second order effect may be ignored og the slenderness ratio is less than

l_{lim}	=	$20ABC / \sqrt{n}$	Concrete Grade		M25	
A	=	$1/(1+0.2\Phi_{eff})$	0.7			
Φ_{eff}	=	$\Phi(\infty,t_0)$	1.68	M_{0Eqp} =	First Order BM in Quasi Permanent Combinations	
				M_{0Ed} =	First Order BM in Design Load Combinations	
B	=	$\sqrt{(1+2\omega)}$	1.1	ω =	$A_s f_{yd} / A_c f_{cd}$	Reinforcement Ratio
C	=	$1.7-r_m$	0.7	r_m =	M_{01}/M_{02}	Moment Ratio
n	=	$N_{Ed} / (A_c f_{cd})$		M_{01}, M_{02} =	First Order End Moments at two ends of Member	

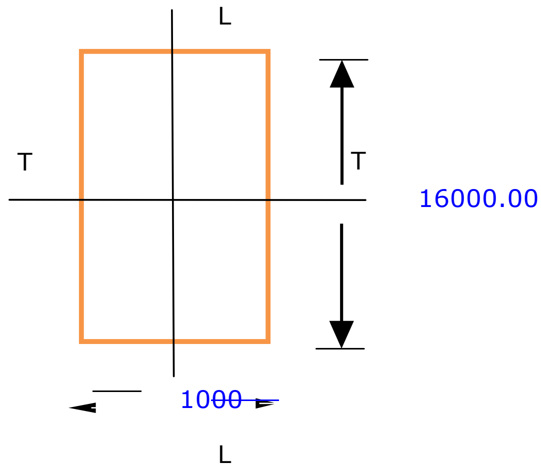
As per Cl. 11.2.1 IRC-112-2011 initial dimensioning A, B C can be taken as 0.7, 1.1 and 0.7 respectively

	N_{Ed}	=	1164.90	1164.90	1082.38
	A_c	=	1.60E+07	1.60E+07	1.60E+07
	f_{cd}	=	11.17	11.17	11.17
	n	=	0.0652	0.0652	0.0606
Long	M_{0Eqp}	=	204.19	204.19	204.19
Long	M_{0Ed}	=	969.71	969.71	961.93
	Φ_{eff}	=	0.35	0.35	0.36
	A	=	0.93	0.93	0.93
	l_{lim}	=	56.33	56.33	58.44
	l_x	=	0.8	0.8	0.8
	Check	=	**Second Order Effects shall be Ignored in x Direction**		
Trans	M_{0Eqp}	=	90.91	90.91	90.91
Trans	M_{0Ed}	=	1187.40	1187.40	1193.01
	Φ_{eff}	=	0.13	0.13	0.13
	A	=	0.97	0.97	0.98
	l_{lim}	=	58.80	58.80	61.00
	l_y	=	12.9	12.9	12.9
	Check	=	**Second Order Effects shall be Ignored in y Direction**		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

CHECKING OF STRESS IN WALL TYPE ABUTMENT SHAFTY

Given Data :



Abutment Size:

	Width (B)	=	1000	mm
	Depth (D)	=	16000.00	mm
	Area (Ac)	=	1.60E+07	mm2
	Length (Lo)	=	**2.660**	m

Section Reinforcement:

Dia. Of Bars	=	25	mm
Nos. of Bars Along Width (B)	=	6	Nos.
Nos. of Bars Along Depth (D)	=	130	Nos.
Total Nos. of Bars	=	272	Nos.
Total Ast	=	133518	mm^2
% of Reinforcement (Pt)	=	0.83	%
Clear Cover	=	50	mm
Dia of Tie bar	=	12	mm
D/B	=	16.00	Wall Type Abutment

Vertical Reinforcement For Wall Type Abutment as per IRC: 112-2019 , Clause 16.3.1

Minimum Vertical Reinforcement	=	0.0012	Ac	on each Face	
	=	19200	mm^2		
Provided Vertical Reinforcement	=	66759	mm^2		**OK**
Maximum Vertical Reinforcement	=	0.02	Ac	on each face	
	=	320000	mm^2		**OK**
Spacing between Vertical Reinf.	=	123	mm		**<200 mm OK**

Horizontal Reinforcement for Wall Type Abutment as per IRC: 112-2019 , Clause 16.3.2

Horizontal r/f should be	=	0.2500	x	133517.7	=	33379.42
maximum of following	=	0.001	x	1.60E+07	=	16000.00
Minimum Horizontal Reinf. =		33379	mm^2			
Dia of bar	=	20	mm			**OK**
Min dia of bar	=	0.25Ø	mm		=	6.25 mm
	or	8	mm			
Maximum Spacing between bars	<=	300	mm c/c			

Provide 2 L 25 dia@ 130 c/c = 40176 mm^2

OK

35582

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Ductile Detailing as per IRC:112-2019, Clause 17.2.1

Confinement Reinforcement

nk = $\frac{N_{ED}}{A_c f_{ck}}$ = $\frac{11427689}{4.00E+08}$ = 0.03 < 0.064

IF nk > 0.064 , Confinement R/f shall be provided as per Clause 17.2.1.4 of IRC:112-2019

IF nk < 0.064 , Confinement R/f shall be provided as per Clause 17.2.2 of IRC:112-2019

Specing of Transverse Ties

	SL	<=	5	x	25	=	125	mm
		<=	0.2	x	876	=	175.2	mm
Provide	SL	=	125	mm	OK			

	ω_{wd}	=	ρ_w fyd/fcd				
where	ρ_w	=	$\frac{Asw}{SL*b}$				
	Asw	=	25	dia	2L	=	981.748 mm^2
	SL	=	150	mm c/c			
	b	=	1000	mm			
	ρ_w	=	0.00654				
	ω_{wd}	=	0.2548	OK			

Minimum Confining Reinforcement: as per Clause 17.2.1.2 of IRC:112-2019

ω_{wd}	=	max (ωw.req, 0.12)
$\omega_{w,req}$	=	$\frac{0.37Ac*nk}{Acc} + \frac{0.13*fyd(\rho L-0.01)}{fcd}$
Ac	=	1.60E+07
Acc	=	13907376 mm^2
nk	=	0.03
ρL	=	0.00834
$\omega_{w,req}$	=	0.00378
ω_{wd}	=	0.12000

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

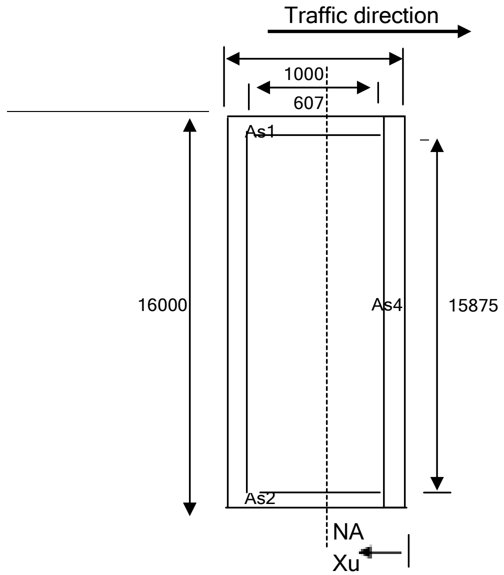
Material Property

Concrete Grade	=	**M25**	
Steel Grade	=	**Fe500**	
Characteristic Compressive Strength of Concrete at 28 days,fck	=	25.00	N/mm^2
Design strength of concrete, fcd=0.446fck	=	11.17	N/mm^2
Yield Strength of Reinforcement Steel ,fy	=	500	N/mm^2
Design Yield Strength of Reinforcement Steel ,fyd	=	434.78	N/mm^2
Modulus of Elasticity of Concrete (Ec)	=	25000.0	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2
Factor of Safety For Concrete	=	1.5	
Factor of Safety For Steel	=	1.15	
Maximum Strain in Concrete, ε_{cu}	=	0.0035	
Yield Strain in Concrete, ε_{cd}	=	0.002	
Yield Strain in Steel, ε_{st} (ε_{yd})	=	0.002174	
Max. Strain in steel, ε_{stu}	=	0.004174	

Summary of Design Forces at Abutment Shaft Bottom :

Load Cases	Axial Load (kN)	Initial Moment (kNm)		Final Design Moment (kNm)	
	Pu or N_{Ed}	Mx(MT)	My(ML)	Mux	Muy
Normal Case 1	**11427.7**	**11648.4**	**9512.8**	11648.37	9512.81
Normal Case 2	**11427.7**	**11648.4**	**9512.8**	11648.37	9512.81
Normal Case 3	**10618.2**	**11703.4**	**9436.5**	11703.43	9436.53
Seismic Case 4	**9144.2**	**4200.4**	**7141.2**	4200.36	7141.19
Seismic Case 5	**9144.2**	**4200.4**	**7141.2**	4200.36	7141.19
Seismic Case 6	**9036.3**	**6559.7**	**4779.1**	6559.66	4779.06

DESIGN OF RECTANGULAR SECTION FOR ABUTMENT SHAFT - ULTIMATE LIMIT STATE



Section dimensions of pier shaft

Length, B = 16000 mm (equivalent length of pier shaft)
Thickness,D = 1000 mm

Material properties

fck = 25.00 Mpa
fyk = 500 Mpa
Es = 200000 Mpa

Design axial resistance of section

N_{Rd} = Ac * fcd + As * fyd

fcd = α_{cc} xf_{ck} /γ_m α_{cc} = 0.67
= 11.167 Mpa γ_m = 1.5
fyd = fyk/γ_s γ_s = 1.15
= 434.7826 Mpa
N_{Rd} = 236717.8 KN

Reinforcement Details

Reinf.	Dia.(mm)	Spacing (mm)	Cover (mm)	From (mm)	To (mm)	Y_{CG} (mm)	Nos.
As1	25	134	50	196.5	803.5	401.75	6.00
As2	25	134	50	197	804	401.75	6.00
As3	25	134	50	62.5	15938	7968.75	130.00
As4	25	134	50	62.5	15938	7968.75	130.00

Total reinforcement

As3 (Along length Tension face) = 63813.60 mm^2
As4 (Along length Compression face) = 63813.60 mm^2
As2 (Along width Tension face) = 2945.24 mm^2
As1 (Along width Compression face) = 2945.24 mm^2
Total As = 133517.7 mm^2

= 0.83 %

Formula used for interaction diagram

Pu = Cc +Cs
Mu = Mc + Ms

Cc = 0.361*fck*Xu*b   for Xu ≤ D
= 0.447*fck*(1-4*g/21)*b*D   for Xu ≥ D

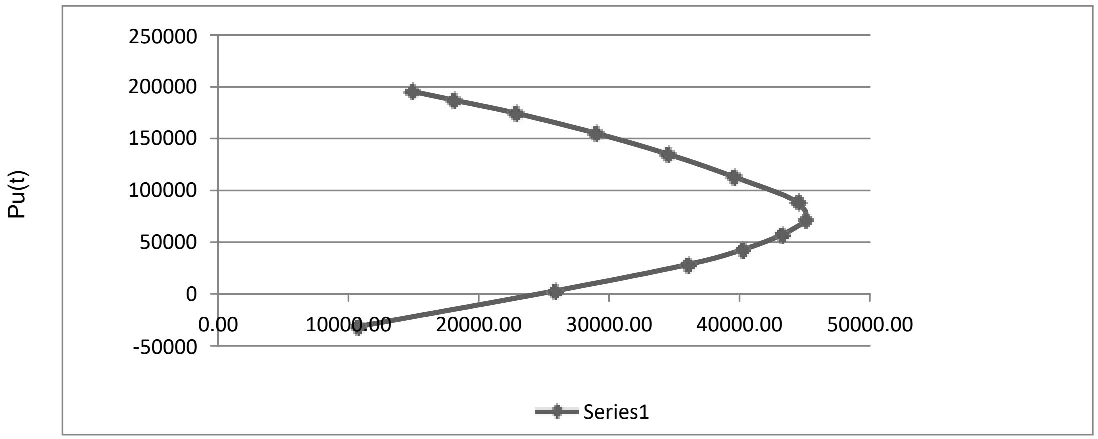
g = $16 / (7Xu / D-3)^2$

Cs	=	$\sum$ (fsi - fci) Asi	
fci	=	0.00	for $\varepsilon_{si} \leq 0$
		0.447 fck	for $\varepsilon_{si} \geq 0.002$
		0.447fck 2* $(\varepsilon_{si}/0.002)-(\varepsilon_{si}/0.002)^2$	otherwise
fsi	=	-0.87 fy	for $\varepsilon_{si} \leq -0.00217$
		ε_{si} * Es	for $0.00217 \geq \varepsilon_{si} > -0.00217$
		0.87fy	for $\varepsilon_{si} > 0.00217$
Mc	=	Cc * (0.5D -x)	
Ms	=	$\sum$ Csi * yi	
x	=	0.416 Xu	for Xu ≤ D
	=	(0.5 - 8*g /49)* D/(1-4*g/21)	for Xu ≥ D
Where x	=	Centroid of stress block area from most compressed edge.	
ε_{si}	=	$\frac{0.0035 * Xu- D/2 +y_i}{Xu}$	for Xu ≤ D
	=	$0.002* 1+ \frac{y_i - D/14}{Xu - 3D/7}$	for Xu > D
Where y_i	=	Distance of ith row of steel from the centroidal axis measured positive in the direction towards the highly compressed edge.	

Along traffic direction

Xu/D	=	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
D(mm)	=	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Xu (mm)	=	50	100	200	300	400	500	600	700	800	900	1000	1100	1200
	<	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
g (Mpa)	=	2.278391	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.3668639	1.469238	1	0.72431	0.548697
Cc (KN)	=	7220.0	14440.0	28880.0	43320.0	57760.0	72200.0	86640.0	101080.0	115520.0	129960.0	144742.9	154132.1	160113.0
yi (compr. face in mm)	=	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5
yi (tension face in mm)	=	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5
ε_{si}(compr. face in mm)	=	-0.000875	0.001313	0.002406	0.002771	0.002953	0.003063	0.003135	0.003188	0.0032266	0.003257	0.003281	0.00309	0.002949
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.062125	-0.02931	-0.012906	-0.00744	-0.0047	-0.00306	-0.001969	-0.001188	-0.000602	-0.000146	0.000219	0.000484	0.000681
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	9.854517	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175
fsi(comp.face in Mpa)	=	-175	262.5	435	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	2.310846	4.754608	6.311267
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-393.75	-237.5	-120.3125	-29.17	43.75	96.80851	136.1111
Cs (KN)	=	-38926.3	-11636.7	-713.1	-713.1	-713.1	-713.1	1919.2	11890.1	19368.2	25184.6	29690.2	32920.1	35328.8
Mc (KN-m)	=	3459.8	6619.3	12037.2	16253.7	19268.7	21082.4	21694.7	21105.5	19314.9	16323.0	12163.3	8810.0	6673.9
Ms (KN-m)	=	7258.8	19198.0	23977.1	23977.1	23977.1	23977.1	22825.4	18463.2	15191.5	12646.8	10675.6	9262.5	8208.7
Pu (KN)	**=**	**-31706.3**	**2803.3**	**28166.9**	**42606.9**	**57046.9**	**71486.9**	**88559.2**	**112970.1**	**134888.2**	**155144.6**	**174433.0**	**187052.2**	**195441.7**
Mu (KN-m)	**=**	**10718.6**	**25817.3**	**36014.2**	**40230.7**	**43245.8**	**45059.5**	**44520.1**	**39568.7**	**34506.4**	**28969.8**	**22838.9**	**18072.5**	**14882.7**

Mu (KN-m)	**Pu (KN)**
10718.6	-31706.3
25817.29	2803.30
36014.25	28166.88
40230.73	42606.88
43245.80	57046.88
45059.46	71486.88
44520.08	88559.19
39568.67	112970.07
34506.42	134888.23
28969.80	155144.57
22838.89	174433.04
18072.51	187052.17
14882.67	195441.75

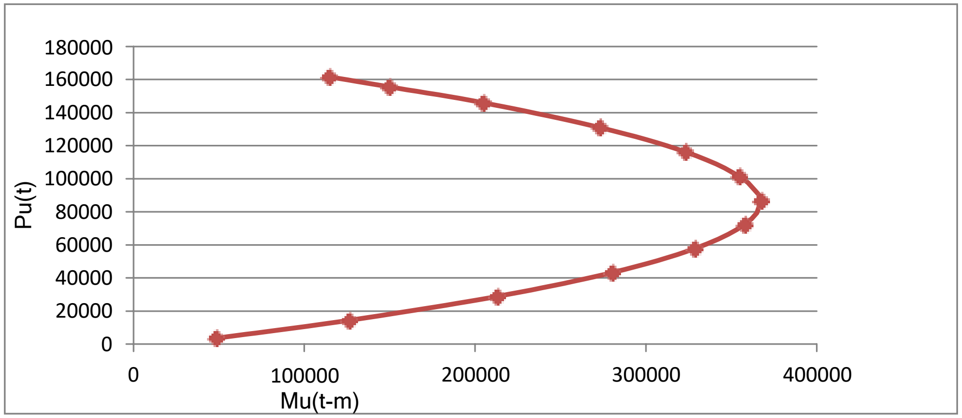


Interaction diagram Mu(t-m)

Along transverse direction

Xu/D	=	0.025	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
D(mm)	=	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Xu (mm)	=	400	1600	3200	4800	6400	8000	9600	11200	12800	14400	16000	17600	19200
	<	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
g (Mpa)		2.004856	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.3668639	1.469238	1	0.72431	0.548697
Cc (KN)	=	3610.0	14440.0	28880.0	43320.0	57760.0	72200.0	86640.0	101080.0	115520.0	129960.0	144742.9	154132.1	160113.0
yi (compr. face in mm)	=	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5
yi (tension face in mm)	=	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5
ε_{si}(compr. face in mm)	=	0.002953	0.003363	0.003432	0.003454	0.003466	0.003473	0.003477	0.00348	0.0034829	0.003485	0.003486	0.003265	0.003101
	>	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.135953	-0.03136	-0.013932	-0.00812	-0.00522	-0.00347	-0.002311	-0.00148	-0.000858	-0.000374	0.000014	0.00031	0.000529
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175
fsi(comp.face in Mpa)	=	435	435	435	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	0.152261	3.191124	5.126858
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-435	-296.0938	-171.582	-74.73958	2.734375	61.9016	105.7292
Cs (KN)	=	-32.9	-32.9	-32.9	-32.9	-32.9	-32.9	-32.9	376.2	742.9	1028.1	1255.9	1421.2	1544.6
Mc KN-m)	=	28279.3	105908.7	192594.9	260058.6	308299.8	337318.4	347114.5	337688.1	309039.1	261167.6	194612.2	140959.5	106783.1
Ms (KN-m)	=	20077.5	20077.5	20077.5	20077.5	20077.5	20077.5	20077.5	16830.2	13919.3	11655.4	9847.8	8535.6	7556.3
Pu (KN)	**=**	**3577.1**	**14407.1**	**28847.1**	**43287.1**	**57727.1**	**72167.1**	**86607.1**	**101456.2**	**116262.9**	**130988.1**	**145998.7**	**155553.3**	**161657.5**
Mu (KN-m)	**=**	**48356.8**	**125986.2**	**212672.4**	**280136.1**	**328377.3**	**357395.9**	**367192.0**	**354518.2**	**322958.5**	**272823.0**	**204460.0**	**149495.1**	**114339.4**

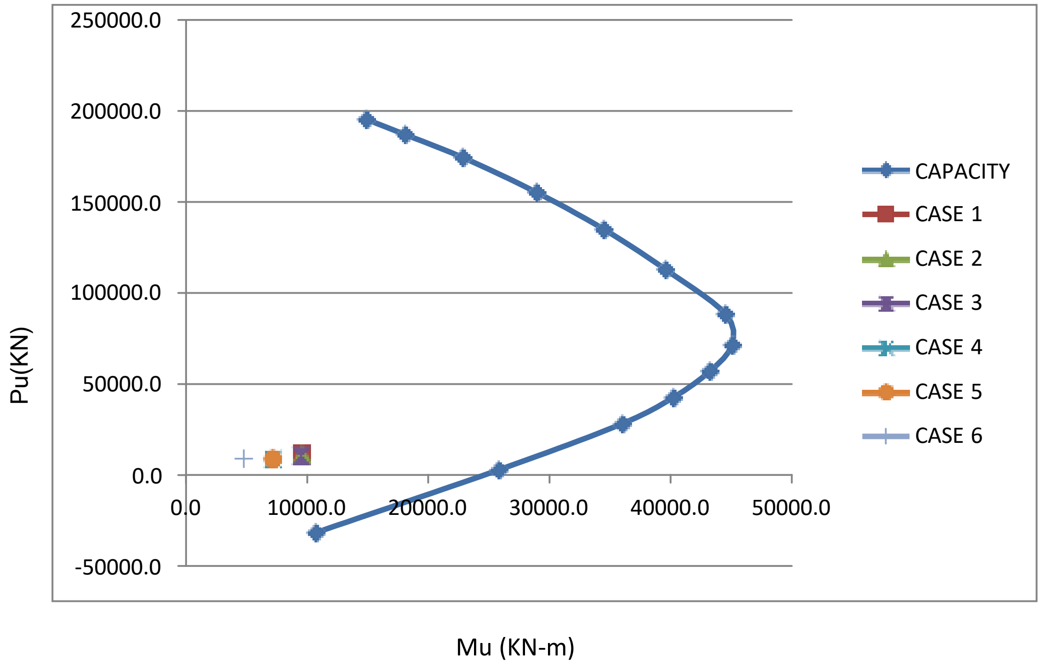
Mu (KN-M)	**Pu (KN)**
48356.79	3577.09
125986.23	14407.09
212672.44	28847.09
280136.12	43287.09
328377.27	57727.09
357395.90	72167.09
367191.99	86607.09
354518.23	101456.20
322958.45	116262.92
272822.99	130988.14
204460.01	145998.73
149495.12	155553.27
114339.38	161657.52



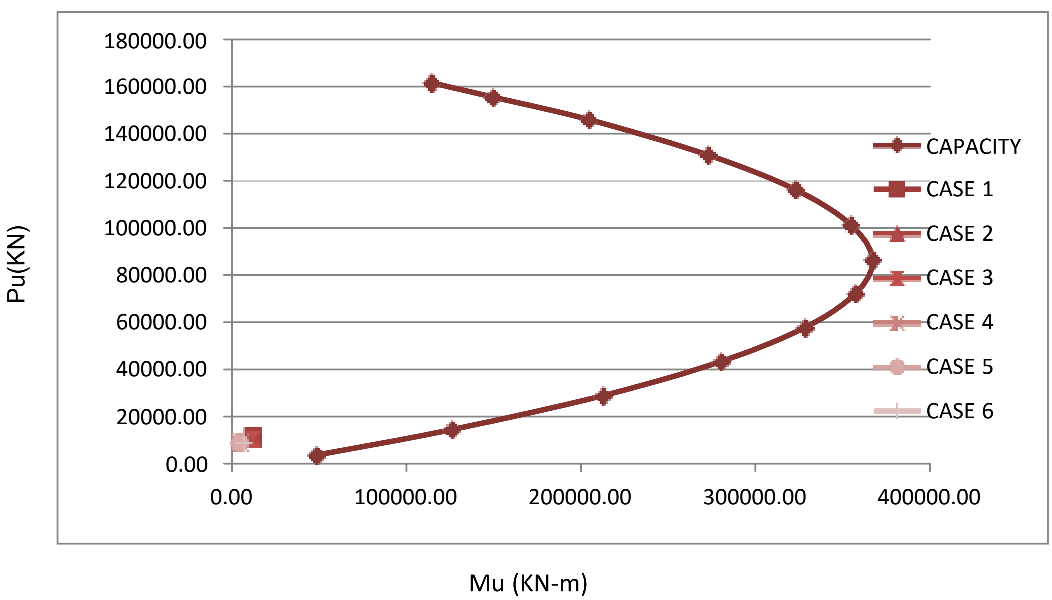
Interaction diagram

Load Cases	Axial Load (kN)	Final Design Moment (kNm)		Permissible Moment (kNm)		Max. Tensile Stress in Steel (N/mm^2)		N_{ED}/N_{RD}	a	$\left(\frac{Mux}{Mux1}\right)^a + \left(Muy1\right)^a$	**Section Status**
	Pu or N_{Ed}	Mux	Muy	Mux1	Muy1	Fsx	Fsy				
Normal Case 1	11427.7	11648.4	9512.8	104629.91	29284.57	434.8	434.8	0.05	1.00	0.44	**SAFE**
Normal Case 2	11427.7	11648.4	9512.8	104629.91	28959.11	434.8	434.8	0.05	1.00	0.44	**SAFE**
Normal Case 3	10618.2	11703.4	9436.5	98827.21	28959.11	434.8	434.8	0.04	1.00	0.44	**SAFE**
Seismic Case 4	9144.2	4200.4	7141.2	88262.21	28366.55	434.8	434.8	0.04	1.00	0.30	**SAFE**
Seismic Case 5	9144.2	4200.4	7141.2	88262.21	28366.55	434.8	434.8	0.04	1.00	0.30	**SAFE**
Seismic Case 6	9036.3	6559.7	4779.1	87488.51	28323.16	434.8	434.8	0.04	1.00	0.24	**SAFE**

Pu-Mu Interaction Curve
Along the Traffic Direction



Pu-Mu Interaction Curve
Across the Traffic Direction



Calculation of Creep Coeffiecient *(As per Annexure A2, A2.5, IRC:112-2011)*

$\Phi(t,t_0)$	=	$\beta_c(t,t_0).\Phi_0$		=	**1.68**	
Where,						
Φ_0	=	$\Phi_{RH}\ \beta(f_{cm})\ \beta(t_0).$		=	1.71	
t	=	Age of concrete in days at time the time considered =		=	25550	days
t_0	=	is the age of Concrete in days at time of loading		=	90	days
Φ_{RH}	=	$1+(1-RH/100)/(0.1*h_0^{1/3})$	for fcm <= 45	=	1.38	
RH	=	Relative Humidity		=	63	%
fck	=	Characteristic Compressive Strength		=	25	MPa
fcm	=	Mean Compressive Strength		=	35	MPa
$\beta(f_{cm})$	=	$18.78/\sqrt{f_{cm}}$		=	3.17	
$\beta(t_0).$	=	$1/(0.1+t_0^{0.2})$		=	0.39	
h_0	=	Notional side of Member	2Ac/u	=	941.2	mm
w	=	Width of Section		=	16000	mm
h	=	Depth of Section		=	1000	mm
Ac	=	Cross Sectional Area, mm2		=	1.6E+07	mm2
u	=	Perimeter in Contact with atmosphere		=	34000	mm
$\beta_c(t,t_0)$	=	$[(t-t_0) / (\beta H + t - t_0)]^{0.3}$		=	0.983	
$(t-t_0)$	=	Actual duration of loading		=	25460	days
βH	=	$1.5(1+(1.2\ RH/RH_0)^{18})h_0 + 250$	<= 1500 fcm = 45	=	1500.0	
RH_0	=			=	100	%

AT Des Ch-174+710

Hydraulic calculation

Tamenglong- Mahur Road

Location - Des Ch- 174+710

1 Discharge:-

a) Discharge from catchment area

Dicken's Discharge 'Q' = C x $M^{3/4}$ as per SP-13-2004 Clause 4.2.

Where 'C' = 19 (Clause 4.2 of SP-13 ,C = 19 where the annual rain fall is >120 cm.)

Catchment Area at Site'M' = 10 Sq. Km. Refer catchment sheet Enclosed

Q = C x M3/4

Q = (19X (10)^3/4)

Q = 106.84 m^3/sec

b) Discharge By Area -Velocity Method

Cross section considered as per SP-13-2004 Clause 3.3(Table -3.1)

Section	Q(m3/sec)	Velocity (m/sec)	HFL (in Meter)	Avg flow depth
At 300 m d/s	118.0813247	2.24	509.45	2.000
At Proposed site	92.44	2.02	510.35	1.706
At 300 m u/s	79.39830514	1.91	511.24	1.56

Max discharge from area velocity method 92.44 m3/sec

Max discharge from Dickens formula 106.84 m3/sec

max discharge - 106.84 m^3/sec

Discharge =	Q =AV		
	A = Q/V		
Linear water way required =	Lx D =Q/V		
	L = Q/(VxD)		
	107/(2.02x1.71)		

2 **Linear water way required =** **30.987296 M**

Provide 1 Span of 25 m

Calculation for design velocity -

The length of bridge proposed =	25	M
The average flow depth below H.F.L. =	1.71	M
No of piers proposed =	0	Nos
Thickness of proposed pier =	1.2	M
Width of Abutment in flow area	0.4	M
Thus Clear water way avilable =	(25-0X1.2- 2 x0.4)	
	24.2	M

Thus the design velocity = Q/ A

V= (106.84)/(24.2X1.71)

V= 2.59 M/Sec

The Design velocity **2.59 m/sec**

3 **Afflux**

The theoritical Afflux at proposed site shall be calculated using Moles worth formula

a =	((V^2 / 17.88) - 0.015) X ((A/a)^2 - 1)
Where as	
A=	Area of cross section at H.F.L.
	site as compared to the u/s & d/s areas)
a =	Area of clear water way under the proposed bridge in sqm.
V =	Velocity in m/sec
A =	45.7481048 Sqm
a =	1.70646153846151X24.2
	41.3 Sqm
V =	2.59 m/sec
Afflux =	((2.59^2 / 17.88) - 0.015) X ((45.75/41.3)^2 -1)
	0.081760933 m
I.e.	81.76093272 mm

Consider afflux is 200 mm.

4 Scour Depth

For the design of foundation in accordance with the provisions of IRC-78,2000 clause 703.1.1.
above discharge has been further increased by 30% for Calculation of scour depth.

Considering the available linear water way at bridge as = 24.2 M

Thus the discharge per unit width 'Db' = 1.30 X Q design /24.2

1.3x106.84/24.2

Db' = 5.74 m^3/sec

Thus the theoretical mean scour depth

MSD = 1.34x(Db^2/Ksf)^(1/3)

Where 'Ksf' = 2.4 (as per IRC-78,2000 clause 703.2.2.1)

There fore NSD = 1.34x(5.74^2 /2.4)^(1/3)

3.21 M from HFL.

The scour level for abutment = H.F.L. - 1.27 X N.S.D.(as per IRC-78,2000 clause 703.3.2.)

= 510.353 -1.27X3.208

The scour level for abutment = 506.278 M

(Foundation level is 2m below scour depth in soil OR Rock level which ever is higher)

Foundation level for abutment = 500.349 M

Formation level calculations -

a)	HFL at Proposed site=	510.353	m
b)	Vertical clearance as per IRC -5	0.9	m
c)	Afflux	0.2	m
d)	Depth of deck	2.166	m
e)	Depth of wearing coat	0.075	m

5 **Formation level by HFL Consideration (a+b+c+d+e) =** 513.694 **m**

6 **Formation level by Profile Improvements = 513.694 m**

Location - Des Ch- 174+710

Calculation of Discharge By Area Velocity Method at **Proposed Site.**

H.F.L 510.353 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff(m)	Perimeter (m)	Area(Sqm)
12.00	510.349		0.004		0.000	
10.00	510.029	2	0.324	0.320	2.025	0.330
8.00	509.288	2	1.065	0.741	2.133	1.435
6.00	508.668	2	1.685	0.620	2.094	2.815
4.00	507.228	2	3.125	1.440	2.464	5.369
2.00	507.105	2	3.248	0.123	2.004	6.379
0.00	506.984	2	3.369	0.121	2.004	6.623
2.00	507.096	2	3.257	0.112	2.003	6.631
4.00	507.216	2	3.137	0.120	2.004	6.400
6.00	508.728	2	1.625	1.512	2.507	5.366
8.00	509.358	2	0.995	0.630	2.097	2.683
10.00	510.018	2	0.335	0.660	2.106	1.365
12.00	510.338	2	0.015	0.320	2.025	0.352
		avg.Depth =	1.706		25.466	45.748

Discharge Calculation by Area Velocity method

Using Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 45.748 Sqm

P = 25.466 M

Avg. depth of flow = 1.706 m

R=A/P

R = 45.75/25.47

1.8

S = 0.00298333

n = 0.04

V = 6x0^0.5/0.04

V = 2.02056776 m/sec

Q=A*V

Q = 2.02x45.75

Q = 92.437 m^3/sec

Location - Des Ch- 174+710

Calculation of Discharge By Area Velocity Method at **300U/S**

H.F.L 511.243 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff	Perimeter	Area
12.00	511.224		0.019		0.000	
10.00	510.774	2	0.469	0.450	2.050	0.494
8.00	510.254	2	0.989	0.520	2.066	1.482
6.00	509.534	2	1.709	0.720	2.126	2.783
4.00	508.914	2	2.329	0.620	2.094	4.133
2.00	508.394	2	3.369	1.040	2.254	6.060
0.00	507.874	2	2.849	0.520	2.066	6.321
2.00	508.384	2	2.859	0.010	2.000	5.708
4.00	508.894	2	2.349	0.510	2.064	5.291
6.00	509.504	2	1.739	0.610	2.091	4.181
8.00	510.214	2	1.029	0.710	2.122	2.853
10.00	510.724	2	0.519	0.510	2.064	1.573
12.00	511.174	2	0.069	0.450	2.050	0.595
		avg.Depth =	1.561		25.048	41.474

Discharge Calculation by Area Velocity method

Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 41.474 Sqm

P = 25.048 M

depth of 1.561 m

R=A/P

R = 41.47/25.05

1.66

S = 0.0029833

n = 0.04

V = 1.66^0.66x0^0.5/0.04

V = 1.9143897 m/sec

Q=A*V

Q = 1.91x41.47

Q = 79.398 m^3/sec

Location - Des Ch- 174+710

Calculation of Discharge By Area Velocity Method at **300D/S**

H.F.L 509.453 M

Chainage	Bed Level	Distance	Depth Below H.F.L	Vertical Diff	Perimeter	Area
12.00	509.434		0.019		0.000	
10.00	508.584	2	0.869	0.850	2.173	0.926
8.00	507.764	2	1.689	0.820	2.162	2.661
6.00	507.044	2	2.409	0.720	2.126	4.227
4.00	506.524	2	2.929	0.520	2.066	5.427
2.00	506.204	2	3.249	0.320	2.025	6.217
0.00	506.084	2	3.369	0.120	2.004	6.624
2.00	506.194	2	3.259	0.110	2.003	6.633
4.00	506.404	2	3.049	0.210	2.011	6.325
6.00	507.014	2	2.439	0.610	2.091	5.613
8.00	507.724	2	1.729	0.710	2.122	4.295
10.00	508.534	2	0.919	0.810	2.158	2.752
12.00	509.384	2	0.069	0.850	2.173	1.031
		avg.Depth =	2.000		25.114	52.732

Discharge Calculation by Area Velocity method

Using Mannings formula

V = (1/n)X(R)^ (2/3)X(s)^ (1/2)

A = 52.732 Sqm

P = 25.114 M

depth of 2.000 m

R=A/P

R = 2.73/25.11

2.1

S = 0.002983

n = 0.04

V = 2.1^0.66x0^0.5/0.04

V = 2.239262 m/sec

Q=A*V

Q = 2.24x52.73

Q = 118.081 m^3/sec

Location - Des Ch- 174+710

L - Section of River/nalla

Chainage (M)	G .L (M)
-300.000	507.874
-280.000	507.804
-260.000	507.734
-240.000	507.664
-220.000	507.594
-200.000	507.544
-180.000	507.494
-160.000	507.444
-140.000	507.394
-120.000	507.344
-100.000	507.274
-80.000	507.224
-60.000	507.174
-40.000	507.124
-20.000	507.074
0.000	506.984
20.000	506.924
40.000	506.864
60.000	506.804
80.000	506.744
100.000	506.684
120.000	506.624
140.000	506.564
160.000	506.504
180.000	506.444
200.000	506.384
220.000	506.324
240.000	506.264
260.000	506.204
280.000	506.144
300.000	506.084

Slope = (507.874-506.08)/(300--300)
0.002983

DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2

AT DES CH-174+710

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

INDEX

INTRODUCTION

This design note present the detailed calculations for abutment having POT/PTFE bearings. Design note contains the typical design of abutment cap, abutment, pile cap and pile. In the analysis, the forces have been worked out at the pile cap bottom level for pile cap design and at the top of pile cap for abutment shaft design.

This design is applicable for abutment

Abutment Nos.	Road Top Level	GROUND LEVEL	Pile cap bottom	DIFF
	(M)	(M)	(M)	(M)
A1 & A2	513.694	510.349	508.049	5.645

DESIGN DATA

Span Arrangement C/C of exp. Joint	=	**25**	m
Deck Width	=	**18**	m
Carriageway Width	=	**11**	m
Structural system	=	simply supported	
construction type	=	RCC	
Effective Span	=	**24.00**	m
Expansion gap in abutment	=	**40**	mm
No of Lane considered for design	=	**4**	
Bearing type	=	**POT PTFE Bearing**	
Skew Angle	=	**0**	Degree

SALIENT REDUCED LEVELS

Deck Top Level	=	513.694
Soffit Level	=	512.394
Abutment Cap Top Level	=	512.344
Abutment Cap Bottom Level	=	511.844
HFL	=	510.359
Pile cap bottom Level	=	508.049
Scour Level	=	506.278

DETAILS OF STRUCTURE & OTHER PARAMETERS

Type of structure		**RCC**	
Depth of Superstructure	=	**1.810**	m
Thickness of wearing coat	=	**0.075**	m
Camber in both direction	=	2.50%	
Expansion joint Type	=	**Strip seal**	
Impact (including Congestion Factor)	=	1.323	
Thickness of Return	=	**0.5**	m

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode.	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

MATERIAL PARAMETERS

Concrete — **Refer Table 6.5, IRC:112-2019**

Grade of concrete for sub structure and foundation = **M25**

Cube strength of concrete at 28 days f_{ck} = **25** MPa

Design value of concrete compressive strength f_{cd} = $\alpha f_{ck}/\gamma_m$

α = 0.67

For Basic Combination f_{cd} = 11.17 MPa

For Accidental Combination f_{cd} = 13.96 MPa

For Seismic Combination f_{cd} = 11.17 MPa

Modulus of Elasticity E_c = 30000 MPa

Mean value of axial tensile strength of concrete f_{ctm} = 2.2 MPa

Wet Density **2.00** t/m3 Dry Density = **2.50** t/m^3

Reinforcing Steel

Grade = **Fe500**

Characteristics yield strength f_{yk} = 500 MPa

Design yield strength f_{yd} = f_{yk}/γ_m

For Basic Combination f_{yd} = 434.8 MPa

For Accidental Combination f_{yd} = 500.0 MPa

For Seismic Combination f_{yd} = 434.8 MPa

Modulus of Elasticity E_s = **2.00E+05** Mpa

Ecm = **3.00E+04** Mpa

Density = **7.85** t/m3

Soil Wet density **1.00** t/m3 Soil Dry Density = **2.00** t/m3

'(As per STAAD Output)

21 m span Reactions (KN)			
Bearing No.	**DL**	**SIDL1 (WC)**	**SIDL2 (CB)**
1	437	51	156
2	483	43	-19
3	469	50	5
4	479	43	-28
5	448	53	159
	2316	**240**	**273**

Partial Safety Factor for Materials

Material	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
Concrete	1.50	1.20	1.50
Steel	1.15	1.00	1.15

Cl 6.4.2.8, IRC:112-2011

Cl 6.2.2, IRC:112-2011

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL N	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

LIVE LOAD CALCULATIONS

1. MAX. MOMENT CASE

a) 70 R 1lane loading

17 17 17 7 12 8

1

1.37 3.05 1.37 2.13 1.51 11.11

RA RB

0.50 24.00 0.50

Ra = 1937.82 / 24.00 = 80.7 t

Impact 1.323 = 106.8 t

RB = 19.26 t

b) Class A 1 lane loading

11.4 11.4 6.8 6.8 6.8

1.2 4.3 3.0 3.0 3.0 10.0

RA RB

0.50 24.00 0.50

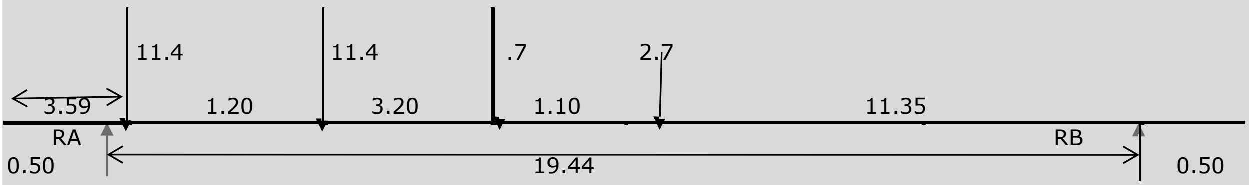
Ra = 939.32 / 24.00 = 39.1 t

Impact 1.323 = 51.8 t

RB = = 10.9 t

2. MAX. REACTION/ TRANSVERSE MOMENT CASE

b) Class A 1 lane loading



Ra =	420.63	/	19.44		=	21.64	t
		Impact	1.323		=	28.62	t
RB =					=	6.6	t

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

PARTIAL SAFETY FACTORS

Ultimate Limit State

Partial Safety for Verification of Structural Strength **Table B.1, Annex B, IRC:6-2017**

Also refer IRC Amendment dated August, 2019

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
	Overturnin g or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturnin g or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturnin g or Sliding or Uplift Effect	Restoring or Resisting Effect
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 Permanent Loads:						
1.1 Dead Load, SIDL except surfacing, Backfill Weight,Settlement, Creep and shrinkage effect	1.1	0.9	1	1	1.1	0.9
1.2 Surfacing	1.35	1.0	1.0	1.0	1.35	1.0
1.3 Prestressing and secondary effect of prestress	Refer Note No. 5					
1.4 Earth Pressure due to Backfill	1.50	1	1.0	1	1.0	1
2 Variable Loads:						
2.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:						
a) Leading Load	1.5	0	0.75	0	-	-
b) Accompanying Load	1.15	0	0.2	0	0.2	0
c) Construction Live Load	1.35	0	1.0	0	1.0	0
2.2 Thermal Loads						
a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	0.5	0	0.5	0
2.3 Wind Load						
a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	-	-	-	-
2.4 Live Load Surcharge (as accompanying	1.2	0	-	-	-	-
3 Accidental Effects:						
3.1 Vehicle Collision	-	-	1.0	-	-	-
3.2 Barge Impact	-	-	1.0	-	-	-
3.3 Impact due to floating bodies	-	-	1.0	-	-	-
4 Seismic Effect						
a) During Service	-	-	-	-	1.5	-
b) During Construction	-	-	-	-	0.75	-
5 Construction Condition:						
5.1 Counter Weights:						
a) When density or self weight is well defined	-	0.9	-	1.0	-	1.0
b) When density or self weight is not wel defined	-	0.8	-	1.0	-	1.0
5.2 Construction dead loads(such as wt. of launching girder, truss or cantilever construction equipments	1.10	0.90	1.1	0.9	1.1	0.9
5.3 Wind						
a) As Leading Load	1.50	0	-	-	-	-
b) As Accompanying Load	1.20	0	-	-	-	-
6 Hydraulic Loads (Accompanying Load):						
6.1 Water Current Forces	1.0	0	1.0	0	1.0	-
6.2 Wave Pressure	1.0	0	1.0	0	1.0	-
6.3 Hydrodynamic Effect	-	-	-	-	1.0	-
6.4 Buoyancy	1.0	-	1.0	-	1.0	-

Partial Safety for Verification of Structural Strength **Table B.2, Annex B, IRC:6-2017**

Also refer IRC Amendment dated August, 2019

Loads	Partial Safety Factor		
	Basic Combination	Accidental Combination	Seismic Combination
(1)	(2)	(3)	(4)
1 Permanent Loads:			
1.1 Dead Load, snow load (if present) SIDL except surfacing			
a) Adding to the effect of variable loads	1.35	1.00	1.35
b) Relieving the effect of variable loads	1.00	1.00	1.00
1.2 Surfacing:			
a) Adding to the effect of variable loads	1.75	1.00	1.75
b) Relieving the effect of variable loads	1.00	1.00	1.00
1.3 Prestressing and secondary effect of prestress	Refer Note No. 2		
1.4 Backfill Weight			
(a) When Causing Adverse Effect	1.35	1.00	1.00
(b) When Causing Relieving Effect	1.00	1.00	1.00
1.5 Earth Pressure			
a) Adding to the effect of loads	1.50	0.00	1.00
b) Relieving the effect of loads	1.00	1.00	1.00
2 Variable Loads:			
2.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.50	0.75	-
b) Accompanying Load	1.15	0.20	0.20
c) Construction Live Load	1.35	1.00	1.00
2.2 Wind during service and construction			
a) Leading Load	1.50	-	-
b) Accompanying Load	0.90	-	-
2.3 Live Load Surcharge (as accompanying load)	1.20	0.20	0.20
2.4 Construction dead loads(such as wt. of launching girder, truss or cantilever construction equipments	1.35	1.00	1.35
2.5 Thermal Load			
a) Leading Load	1.50	-	-
b) Accompanying Load	0.90	0.50	0.50
3 Accidental Effects:			
i) Vehicle Collision	-	1.00	-
ii) Barge Impact	-	1.00	-
iii) Impact due to floating bodies	-	1.00	-
4 Seismic Effect			
a) During Service	-	-	1.50
b) During Construction	-	-	0.75
5 Hydraulic Loads (Accompanying Load):			
5.1 Water Current Forces	1.00	1.00	1.00
5.2 Wave Pressure	1.00	1.00	1.00
5.3 Hydrodynamic Effect	-	-	1.00
5.4 Buoyancy	0.15	0.15	1.00

Serviceability Limit State
Partial Safety for Verification of Serviceability Limit State

Table B.3, Annex B, IRC:6-2017

Also refer IRC Amendment dated August, 2019

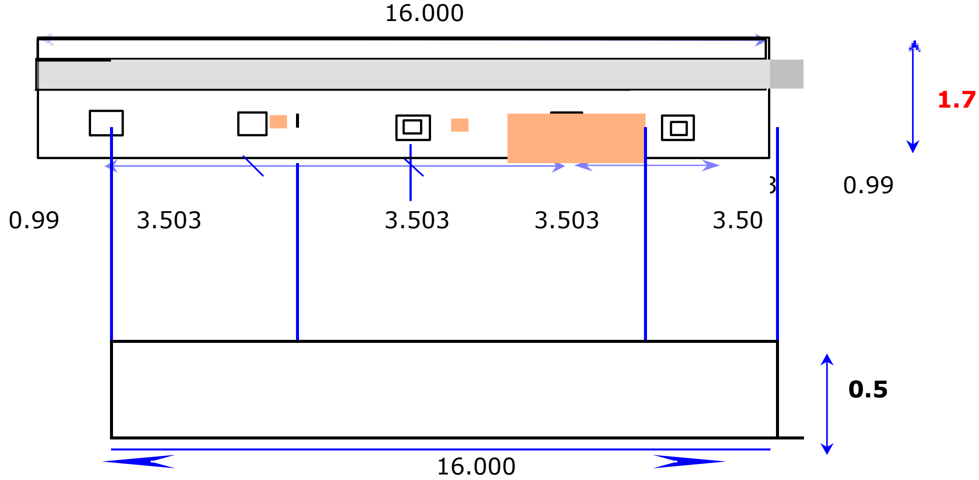
Loads	**Partial Safety Factor**		
	Rare Combination	**Frequent Combination**	**Quasi-permanent Combination**
(1)	**(2)**	**(3)**	**(4)**
1 Permanent Loads:			
1.1 Dead Load, Snow Load(if any), Backfill, SIDL except surfacing	1.00	1.00	1.00
1.2 Surfacing	1.00	1.00	1.00
a) Adding the effect of variable Loads	1.20	1.20	1.20
b) Relieving the effect of variable Loads	1.00	1.00	1.00
1.3 Earth Pressure	1.00	1.00	1.00
1.4 Prestress and secondary effect of prestressing	Refer Note no. 4		
1.5 Shrinkage and Creep Effects	1.00	1.00	1.00
2 Settlement Effects			
a) Adding to the permanent loads	1.00	1.00	1.00
b) Opposing the permanent loads	0.00	0.00	0.00
3 Variable Loads:			
3.1 Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:			
a) Leading Load	1.00	0.75	-
b) Accompanying Load	0.75	0.20	0.00
3.2 Thermal Loads:			
a) Leading Load	1.00	0.60	0.00
b) Accompanying Load	0.60	0.50	0.50
3.3 Wind			
a) Leading Load	1.00	0.60	-
b) Accompanying Load	0.60	0.50	0.00
3.4 Live Load Surcharge as Accompanying load	0.80	0.00	0.00
4 Hydraulic Loads (Accompanying Load):			
4.1 Water Current	1.00	1.00	-
4.2 Wave Pressure	1.00	1.00	-
4.3 Buoyancy	0.15	0.15	0.15

Partial Safety for Checking the Base Pressure and Design of Foundation

Also refer IRC Amendment dated August, 2019 **Table B.4, Annex B, IRC:6-2017**

Load	**Partial Safety Factor**			
	Combination-1	**Combination-2**	**Combination-3**	**Combination-4**
(1)	**(2)**	**(3)**	**(4)**	**(5)**
1. Permanent Loads:				
1.1 Dead Load, Snow Load (if any), SIDL except surfacing and Back fill				
a) When causing adverse effects	1.35	1.00	1.35	1.00
b) When causing Relieving effects	1.00	1.00	1.00	1.00
1.2 SIDL surfacing				
a) When causing adverse effects	1.75	1.00	1.75	1.00
b) When causing Relieving effects	1.00	1.00	1.00	1.00
1.3 Prestress Effect	Refer Note 4			
1.4 Settlement Effect	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
1.5 Earth Pressure				
a) Adding to the effect of loads	1.50	1.30	1.00	1.00
b) Relieving to the effect of loads	1.00	0.85	1.00	1.00
2. Variable Loads:				
2.1 All carriageway loads and associated loads (braking, tractive and centrifugal) and footway live load				
a) Leading Load	1.50	1.30	0.75 or 0	0.75 or 0
b) Accompanying Load	1.15	1.00	0.20	0.20
c) Construction Dead Load	1.35	1.00	1.35	1.00
2.2 Thermal load as accompanying load	0.90	0.80	0.50	0.50
2.3 Wind Load				
a) Leading Load	1.50	1.30	-	-
b) Accompanying Load	0.90	0.80	0.00	0.00
2.4 Live load surcharge as Accompanying Load (if applicable)				
3. Accidental Effect or Seismic Effect				
a) During Service	-	-	1.50	1.00
b) During Construction	-	-	0.75	0.50
4. Construction Dead Load (Such as Wt. of launching girder, truss or cantilever construction equipments)	1.35	1.00	1.35	1.00
5. Hydraulic Loads:				
5.1 Water Current	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
5.2 Wave Pressure	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
5.3 Hydodynamic effect	-	-	1.0 or 0	-
6. Buoyancy:				
a) For Base Pressure	1.00	1.00	1.00	1.00
b) For Structural Design	0.15	0.15	0.15	0.15

ABUTMENT CAP LOAD CALCULATION



Abutment cap is fully resting on abutment wall, so provide min. reinforcement.
cl. 16.5.1.1 (1) of IRC :112-2011

$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk}$ >= $0.0013\ b_t\ d$

f_{ctm}	2.2	
b_t	1700	
d	527	
f_{yk}	500	
$0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk}$	1025	mm^2
$0.0013\ b_t\ d$	1165	mm^2
Provide	1165	mm^2

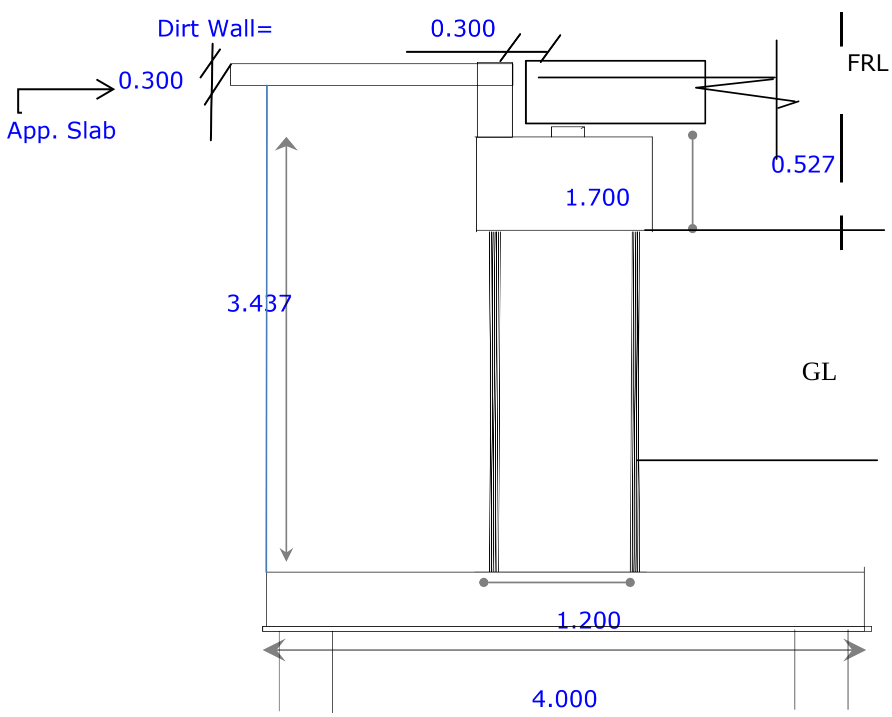
16 ϕ @	150	**mm c/c**	**1340** **OK**	**mm^2**	**at top and bottom**
12 ϕ @	150	**mm c/c**	**754** **OK**	**mm^2**	**as distribution in the form of stirrup**

Project	Preparation of DPR for Manu - Simlung section of NH-44A (86 Kms) in state of tripura on EPC mode.	Designed by:	KB
Client	NHIDCL	Checked by:	-
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	15/03/2021 (R0)

LOAD CALCULATION FOR ABUTMENT & PILE CAP

SALIENT REDUCED LEVELS

Deck Top Level	=	513.694	m
Bearing Top Level	=	512.394	m
Abutment Cap Top Level	=	512.344	m
Abutment Cap Bottom Level	=	511.844	m
Abutment Bottom Level	=	509.849	m
Depth of Pile cap	=	1.8	m
GL	=	510.349	m
Pile cap bottom Level	=	508.049	m
HFL	=	510.359	m
LBL	=	506.984	m
Expansion Gap	=	0.040	m
Width of abutment	=	**1.200**	m
Length of the abut	=	**18.000**	m
Length of Pile cap	=	**18.000**	m
Width of Pile cap	=	**4.850**	m
Thickness of Wearing coat (W/c)	=	0.075	m
Height of Deck+Girder	=	1.810	m
Thickness of bearing	=	**0.100**	m
Height of Pedestal	=	**0.250**	m
Total Height from w/c to Abut Cap top	=	2.135	m
Span EJ to EJ	=	25.000	m



5.322
0.770

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OFABUTMENTS A1 & A2	Date & Rev.	

LOAD CALCULATIONS

Taking Moments about founding level

		RIGHT SPAN	LEFT SPAN	L (Long)	L (Trans)	ML	Mt	
				m	m	t-m	t-m	
Dead Load		236.33		0.00	0.00	0.00	0.00	
SIDL1 w/c		24.49		0.00	0.00	0.00	0.00	
SIDL 2 exl w/c		27.86		0.00	0.00	0.00	0.00	
LL1 (Max Reaction)								
70 R + 2Class A		115.33		0.00	1.875	0.00	216.25	2.103
2 70 R		116.20		0.00	3.080	0.00	357.90	2.910
70 R		58.10		0.00	4.905	0.00	284.99	4.905
Class 4 A		114.46		0.00	1.075	0.00	123.05	0.950
70 R + Class A		86.72		0.00	4.201	0.00	364.30	3.958
LL2 (Max Moment)								
70 R + 2Class A		210.30		0.00	1.875	0.00	394.32	2.103
2 70 R		213.56		0.00	3.080	0.00	657.78	2.910
70 R		106.78		0.00	4.905	0.00	523.77	4.905
Class 4 A		207.04		0.00	1.075	0.00	222.57	0.950
70 R + Class A		158.54		0.00	4.201	0.00	666.04	3.958

Horizontal Force Due to braking at				POT PTFE Bearing		Fixed abut		
	µ =	0.05	(as per IRC 6:2017)	Fh/2 + µ(Rg+Rq) OR Fh - µ(Rg+Rq)	**@foundation**		**abut Bottom**	
	Fh	Rg	Rq	H	Lev	ML	Lev	ML
	t	t	t	t	m	t-m	m	t-m
70 R + 2Class A		288.67	210.30	24.95	5.24	130.66	3.44	85.75
Class 2 70R	20.43	288.67	213.56	35.33	5.24	185.01	3.44	121.42
Class 70 R	20.00	288.67	106.78	29.77	5.24	155.92	3.44	102.33
Class 4 A	15.51	288.67	207.04	32.54	5.24	170.42	3.44	111.84
70 R + Class A	20.49	288.67	158.54	32.61	5.24	170.76	3.44	112.07

Horizontal braking force	=	35.33	t
ML @ foundation	=	185.01	tm
ML @ abut bottom	=	121.42	tm

@foundation	P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)	Fh(t)
LL1B	3	185	0	35.33	0.00	20.43
LL2B	0	0	0			
LL3B	3	171	0	32.61	0.00	20.49
@abutment bottom	P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)	Fh(t)
LL1B	3	121	0	35.33	0.00	20.43
LL2B	0	0	0			
LL3B	3	112	0	32.61	0.00	20.49

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

WIND FORCES ON SUPER STRUCTURE REF: IRC 6-2017 CL NO:209.2

Basic wind speed	=	47 m/s	Plain terrain				
Design wind speed	=	39.59 m/s	at height	10.00 m			**27.80 m/s**
Design wind pressure P_Z	=	940.60 N/m^2	at height	10.00 m			**463.70 N/m^2**
$F_T = P_Z A_1 G C_D$	=	374 Kg/m^2		G =	**2.00**	**C_D =**	**1.95**
F_L =	=	93.48 Kg/m^2					
$F_V = P_Z A_3 G C_L$	=	144 Kg/m^2		G =	**2.00**	**C_L =**	**0.75**

Up ward or downward vertical wind Load

F_V = 12.50 x **16.000** x 143.82 = 28.76 t

WIND FORCES ON LIVE LOAD

Basic wind speed	=	0 m/s	Plain terrain				
Design wind speed	=	0.00 m/s	at height	10.00 m			**27.80 m/s**
Design wind pressure P_Z	=	0.00 N/m^2	at height	10.00 m			**463.70 N/m^2**
$F_T = P_Z A_1 G C_D$	=	0 Kg/m^2		G =	**2.00**	**C_D =**	**1.20**
F_L =	=	0.00 Kg/m^2					
$F_V = P_Z A_3 G C_L$	=	0 Kg/m^2		G =	**2.00**	**C_L =**	**0.75**

WIND FORCES ON SUB STRUCTURE

Basic wind speed	=	47 m/s	Plain terrain				
Design wind speed	=	39.59 m/s	at height	10.00 m			**27.80 m/s**
Design wind pressure P_Z	=	940.60 N/m^2	at height	10.00 m			**463.70 N/m^2**

REF: IRC 6-2017 CL NO:209.4

$F_T = P_Z A_1 G C_D$	=	96 Kg/m^2	G =	**2.00**	**C_D =**	**0.50**
F_L =	=	23.97 Kg/m^2				
$F_V = P_Z A_3 G C_L$	=	144 Kg/m^2	G =	**2.00**	**C_L =**	**0.75**

TRANSVERSE DIRECTION		**Moments about FL**			**Abutment Bottom**	
DESCRITPTION		**H**	**Lev**	**Mt**	**Lev**	**Mt**
		t	**M**	**t-m**	**M**	**t-m**
WIND ON SUPER STR ACT @	114.94	11.29	6.18	69.75	4.38	49.44
WIND ON MOVING LOAD @	117.39	0.00	8.62	0.00	6.82	0.00
WIND ON abutment CAP @	113.49	0.09	4.72	0.41	2.92	0.25
WIND ON abutment @	112.15	0.21	3.38	0.70	1.58	0.33
	TOTAL	**11.58**		**70.86**		**50.01**

LONGITUDINAL DIRECTION		**Moments about FL**			**Abutment Bottom**	
DESCRITPTION		**H**	**Lev**	**Mt**	**Lev**	**Mt**
		t	**M**	**t-m**	**M**	**t-m**
WIND ON SUPER STR ACT @	114.94	4.71	6.18	43.05	4.38	34.57
WIND ON MOVING LOAD @	117.39	0.00	8.62	0.00	6.82	0.00
WIND ON abutment CAP @	113.49	0.71	4.72	5.25	2.92	3.97
WIND ON abutment @	112.15	0.05	3.38	0.18	1.58	0.08
	TOTAL	**5.53**		**48.85**		**38.89**

DEAD WEIGHT OF ABUTMENT CAP WITH DIRT WALL

	Nos	L	B	H	Qty	wt	L. A.	ML (tm)
		m	m	m	m3	t		
Abut. Cap	1	16.000	1.70	0.527	14.33	35.84	0.00	0.00
Dirt wall	1	16.000	0.30	2.135	10.25	25.62	-0.70	-17.93
Pedestals (5 nos)	5	**0.800**	**0.800**	**0.400**	1.28	3.20	0.00	0.00
DL+SIDL (approach span) load	1	16.000		5.2	**0.92** t/m2	37.70	-0.70	-26.39
LL (approach span) LL surcharge(1.2m)	1	16.000		5.150	**2.40** t/m2	98.88	-0.70	-69.22
Total						**201.23**		**-59.49**

DEAD WEIGHT OF ABUTMENT & FOUNDATION

	L	B	H	LWL wt	HFL wt	LA C/L of abut / found(m)	LWL ML	HFL ML
	m	m	m	t	t		(t.m)	(t.m)
Abut. Stem	16.000	1.00	2.16	86.40	69.12	0.00	0.00	0.00
	16.000	1.00	0.50	20.00	16.00	0.00	0.00	0.00
Foundation	16.000	4.85	1.80	349.20	279.36	0.00	0.00	0.00
Return wall	1.00	1.925	2.66	12.81	10.25	-1.46	-18.74	-14.99
	1.00	1.925	0.77	3.71	2.96	-1.46	-5.42	-4.34
	1.00	1.925	1.89	9.10	7.28	-1.46	-13.30	-10.64
Soil Above the Foundation	15.000	1.925	2.29	132.07	66.04	-1.46	-193.16	-96.58
	15.000	1.925	0.77	44.47	22.23	-1.46	-65.03	-32.52
	15.000	1.925	1.89	109.15	54.57	-1.46	-159.63	-79.81
Total				**766.90**	**527.81**		**-455.28**	**-238.88**
					239.09			**-216.40**

Earth pressure		At foundation		At abut. Bottom	
		LWL	HFL	LWL	HFL
Height	m	7.122	7.122	5.32	5.32
Dry unit wt. of soil	t/m3	2.00		2.00	
Wet unit wt. of soil	t/m3		1.00		1.00
Coulomb's theory Ka (Normal case)					
Angle of friction	ϕ	**30.00**			
Angle of deflection	δ	**20.00**			
wall inclination to horizontal	α	**90.00**			
soil surcharge inclination to horizontal	β	**0.00**			
Ka (Normal case)		0.279			
Coulomb's theory Ka (Seismic case)					
Seismic Zone		III			
α_h		0.0800			
α_v		0.0533			
$\theta = \tan^{-1}(\alpha_h/(1+\alpha_v))$		0.0758			
		0.0843			
Coefficient of active earth pressure (Seismic case)		0.344			
Coefficient of active earth pressure		0.279	0.279	0.279	0.279
Live load surcharge	m	**1.20**	**1.20**	**1.20**	**1.20**
Active earth pressure		3.98	1.99	2.97	1.49
Pressure due to live load surcharge		0.67	0.34	0.67	0.34
Force due to live load surcharge	t/m	76	38	57	29
Force due to active earth pressure	t/m	227	113	127	63
Moment due to live load surcharge	t.m/m	272	136	152	76
Moment due to active earth pressure	t.m/m	678	339	283	142

Dynamic increment due to earth pressure		At foundation		At abut. Bottom	
As per Cl. 219.5.4 & 214.1.2 of IRC 6-2017		LWL	HFL	LWL	HFL
Coefficient of active earth pressure		0.000	0.000	0.000	0.000
Live load surcharge	m	**1.20**	**1.20**	**1.20**	**1.20**
Active earth pressure		0.00	0.00	0.00	0.00
Pressure due to live load surcharge		0.00	0.00	0.00	0.00
Force due to live load surcharge	t/m	0	0	0	0
Force due to active earth pressure	t/m	0	0	0	0
Moment due to live load surcharge	t.m/m	0	0	0	0
Moment due to active earth pressure	t.m/m	0	0	0	0

Fundamental Time Period of Vibration due to Seismic Waves :

According to **Annexure D (Clause 219.5)** IRC 6 :2017 -

T = 2.0 x sqrt(D/(1000*F))

Where,

T	=	Fundamental Time Period Of Vibration
D	=	Appropriate dead Load of the superstructure and Live load in KN
F	=	Horizontal Force in KN required to be applied at the centre of mass of superstructure for 1 mm horizontal deflection at the top of the 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 Longitudinal direction

			Longitudinal Direction		Transverse Direction		
	F	=	$d*(3EI)/L^3$	Unit	$d*(3EI)/L^3$	Unit	
	d	=	0.001	m	0.001	m	
	L	=	4.460	m	5.037	m	
	E	=	3.00E+07	KN/m2	3.00E+07	KN/m2	
	I	=	1.000	m4	256.000	m4	
	F	=	1014.467	KN	#######	KN	
	D	=	2829.000	KN	3248.012	KN	(DL+0.2*LL)
	T	***=***	***0.11***	***sec***	***0.01***	***sec***	
Seismic Zone		=	III		III		
Zone Factor Z		=	0.16		0.16		
Importance Factor I		=	1.2		1.2		
Response Reduction Factor		=	3		3		
Soil Strata		=	Type II	Medium soil			
Sa/g			2.5		2.5		
Horizontal Acceleration Coefficient (Ah) Z/2*Sa/g*I/R		=	0.08		0.08		

For design of foundation seismic loads are increased by 35% As per Cl. 219.8 of IRC 6-2017

Seismic Force Calculations		**For Foundation**		
		Horizontal	**Vertical (2/3 of Horizontal)**	
Long Seismic Coefficient		0.108	0.072	(including over strength factor)
Trans Seismic Coefficient		0.108	0.072	(including over strength factor)

Seismic For design of foundation seismic loads are increased by 35%

						@ Foundation		
	V (t)	**H Comp**	**V Comp**	**Acting At**	**Ecc (For H)**	**ML Due to H**	**Moment Due to V**	
							ML	**MT**
DL	472.2	51.0	34.0	114.0	5.2	267.1	0.0	0.0
SIDL1	48.9	5.3	3.5	114.0	5.2	27.7	0.0	0.0
SIDL2	55.7	6.0	4.0	114.0	5.2	31.5	0.0	0.0
Abt. but Cap+dirt wall	201.2	21.7	14.5	114.4	5.59	121.4	0.0	0.0
abut	106.4	11.5	7.7	111.9	3.1	36.0	0.0	0.0
return wall	25.6	2.8	1.8	113.2	4.5	12.3	0.0	0.0
Soil above found	285.7	30.9	20.6	113.2	4.5	137.6	0.0	0.0
LL1	42.7	4.6	3.1	114.0	5.2	24.2	0.0	9.5
LL2	42.7	4.6	3.1	114.0	5.2	24.2	0.0	9.5
LL3	31.7	3.4	2.3	114.0	5.2	17.9	0.0	9.6

Longitudinal seismic

	V (t)	ML (t.m)	MT (t.m)
DL	78.56	574.40	0.00
SIDL1	3.52	27.67	0.00
SIDL2	4.01	31.48	0.00
LL1	3.08	24.16	9.47
LL2	3.08	24.16	9.47
LL3	2.28	17.93	9.59

Tranverse seismic

	V (t)	ML (t.m)	MT (t.m)
DL	78.56	0.00	574.40
SIDL1	3.52	0.00	27.67
SIDL2	4.01	0.00	31.48
LL1	3.08	0.00	33.63
LL2	3.08	0.00	33.63
LL3	2.28	0.00	27.53

Combination of Orthogonal Seismic Force

		V (t)	**ML (t.m)**	**MT (t.m)**	**PSF**	**V (t)**	**ML (t.m)**	**MT (t.m)**
DL		78.56	746.72	0.00	1.00	**78.6**	**746.7**	**0.0**
SIDL1		3.52	35.98	0.00	1.00	**3.5**	**36.0**	**0.0**
SIDL2		4.01	40.92	0.00	1.00	**4.0**	**40.9**	**0.0**
LL1		3.08	34.25	9.47	1.00	**3.1**	**34.2**	**9.5**
LL2		3.08	34.25	9.47	1.00	**3.1**	**34.2**	**9.5**
LL3		2.28	26.19	9.59	1.00	**2.3**	**26.2**	**9.6**
DL		78.56	0.00	746.72	1.00	**78.6**	**0.0**	**746.7**
SIDL1		3.52	0.00	35.98	1.00	**3.5**	**0.0**	**36.0**
SIDL2		4.01	0.00	40.92	1.00	**4.0**	**0.0**	**40.9**
LL1		3.08	2.84	40.88	1.00	**3.1**	**2.8**	**40.9**
LL2		3.08	2.84	40.88	1.00	**3.1**	**2.8**	**40.9**
LL3		2.28	2.88	32.91	1.00	**2.3**	**2.9**	**32.9**

	V (t)	ML (t.m)	MT (t.m)
DL+SIDL1+SIDL2+LL1	89.17	857.87	9.47
DL+SIDL1+SIDL2+LL2	89.17	857.87	9.47
DL+SIDL1+SIDL2+LL3	88.37	849.81	9.59
DL+SIDL1+SIDL2+LL1	89.17	2.84	864.50
DL+SIDL1+SIDL2+LL2	89.17	2.84	864.50
DL+SIDL1+SIDL2+LL3	88.37	2.88	856.53
DL+SIDL1+SIDL2+LL1	89	858	9
DL+SIDL1+SIDL2+LL2	89	858	9
DL+SIDL1+SIDL2+LL3	89	3	865

Seismic Force Calculations					For abutment			
		Horizontal	Vertical (2/3 of Horizontal)					
Long Seismic Coefficient		0.080	0.053	***Refer Seismic Calculations Appendex 1***				
Trans Seismic Coefficient		0.080	0.053					
Seismic								
						@ Stem Bottom		
	V (t)	**H Comp**	**V Comp**	**Acting At**	**Ecc (For H)**	**ML Due to H**	**Moment Due to V**	
							ML	**MT**
DL	472.2	37.8	25.2	114.0	3.4	129.8	0.0	0.0
SIDL1	48.9	3.9	2.6	114.0	3.4	13.5	0.0	0.0
SIDL2	55.7	4.5	3.0	114.0	3.4	15.3	0.0	0.0
abut Cap	201.2	16.1	10.7	114.4	3.8	60.9	0.0	0.0
abut Stem	106.4	8.5	5.7	111.9	1.3	11.3	0.0	0.0
LL1	42.7	3.4	2.3	114.0	3.4	11.7	0.0	7.0
LL2	42.7	3.4	2.3	114.0	3.4	11.7	0.0	7.0
LL3	31.7	2.5	1.7	114.0	3.4	8.7	0.0	7.1

Longitudinal seismic

	V (t)	ML (t.m)	MT (t.m)
DL	41.59	202	0.00
SIDL1	2.61	13.45	0.00
SIDL2	2.97	15.30	0.00
LL1	2.28	11.74	7.02
LL2	2.28	11.74	7.02
LL3	1.69	8.72	7.10

Tranverse seismic

	V (t)	ML (t.m)	MT (t.m)
DL	41.59	0.00	202.09
SIDL1	2.61	0.00	13.45
SIDL2	2.97	0.00	15.30
LL1	2.28	0.00	18.76
LL2	2.28	0.00	18.76
LL3	1.69	0.00	15.82

Combination of Orthogonal Seismic Force

		V (t)	ML (t.m)	MT (t.m)	PSF	V (t)	ML (t.m)	MT (t.m)
DL		41.59	262.72	0.00	1.00	**41.6**	**262.7**	**0.0**
SIDL1		2.61	17.49	0.00	1.00	**2.6**	**17.5**	**0.0**
SIDL2		2.97	19.89	0.00	1.00	**3.0**	**19.9**	**0.0**
LL1		2.28	17.37	7.02	1.00	**2.3**	**17.4**	**7.0**
LL2		2.28	17.37	7.02	1.00	**2.3**	**17.4**	**7.0**
LL3		1.69	13.47	7.10	1.00	**1.7**	**13.5**	**7.1**
DL		41.59	0.00	262.72	1.00	**41.6**	**0.0**	**262.7**
SIDL1		2.61	0.00	17.49	1.00	**2.6**	**0.0**	**17.5**
SIDL2		2.97	0.00	19.89	1.00	**3.0**	**0.0**	**19.9**
LL1		2.28	2.10	22.28	1.00	**2.3**	**2.1**	**22.3**
LL2		2.28	2.10	22.28	1.00	**2.3**	**2.1**	**22.3**
LL3		1.69	2.13	18.44	1.00	**1.7**	**2.1**	**18.4**

	V (t)	ML (t.m)	MT (t.m)
DL+SIDL1+SIDL2+LL1	49.45	317.48	7.02
DL+SIDL1+SIDL2+LL2	49.45	317.48	7.02
DL+SIDL1+SIDL2+LL3	48.86	313.57	7.10
DL+SIDL1+SIDL2+LL1	49.45	2.10	322.39
DL+SIDL1+SIDL2+LL2	49.45	2.10	322.39
DL+SIDL1+SIDL2+LL3	48.86	2.13	318.54
DL+SIDL1+SIDL2+LL1	49	317	7
DL+SIDL1+SIDL2+LL2	49	317	7
DL+SIDL1+SIDL2+LL3	49	2	322

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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COMBINATION FOR DESIGN OF FOUNDATION & BASE PRESSURE (ULS)

Following load combinations are con As per Annex B of IRC:112-2011

1 Combination 1

2 Combination 2

3 Seismic Combination

4 Combination for base pressure check

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	Dead Load (due to superstructure+substructure+foundtion		1204	-515	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		201	-59	0	0	0
4	ABUT + RETURN WALL		132	-37	0	0	0
5	FOUNDATION		349	0	0	0	0
6	SOIL ABOVE FDN		286	-418	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	214	0	658	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	159	0	666	0	0
12	LL1B	Live Load Moment due to braking	3	185	0	35.33	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.08	0
14	LL3B	Live Load Moment due to braking	3	171	0	32.61	0
15	W1	Wind vertically down without LL	29	5	71	5.47	11.58
16	W2	Wind vertically up without LL	-29	5	71	5.47	11.58
17	W3	Wind vertically down with LL	29	49	71	5.53	11.58
18	W4	Wind vertically up with LL	-29	49	71	5.53	11.58
19	S1	Seimic	89	858	9	133.7	0
20	S2	Seimic	89	3	865	0.0	133.7
21	S3	Seimic	-89	858	9	133.7	0
22	S4	Seimic	-89	3	865	0.0	133.7
23	HFL		-239	216	0	0.0	0.0
24	Active earth pressure LWL		0	678	0	226.7	0.0
25	LL surcharge LWL		0	272	0	76.4	0.0
26	Active earth pressure HFL		0	339	0	113.4	0.0
27	LL surcharge HFL		0	136	0	38.2	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0.0
29	LL surcharge LWL		0	0	0	0	0.0
30	Active earth pressure HFL		0	0	0	0	0.0
31	LL surcharge HFL		0	0	0	0	0.0

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	Combination 1				**Combination 2**				**Seismic Combination**				**Combination for base pressure check**		
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)	P(t)	ML (tm)	MT (tm)
DL	1.35	1626	-635	-283	1.00	1204	-470	-209	1.25	1506	-588	-262	1204	-470	-209
SIDL1	1.75	43	0	0	1.00	24	0	0	1.75	43	0	0	24	0	0
SIDL2	1.35	38	0	0	1.00	28	0	0	1.25	35	0	0	28	0	0
LL1	1.50	320	401	901	1.30	278	348	781	0.20	43	54	120	214	268	601
LL2	1.50	252	431	969	1.30	219	374	840	0.20	34	58	129	168	288	646
LL3	1.50	238	406	913	1.30	206	352	791	0.20	32	54	122	159	271	608
LL1B	1.50	4	254	113	1.30	3	220	98	0.20	1	34	15	3	169	75
LL2B	1.50	0	0	0	1.30	0	0	0	0.20	0	0	0	0	0	0
LL3B	1.50	4	234	104	1.30	3	203	90	0.20	1	31	14	3	156	69
W1	0.90	26	30	60	0.80	23	27	54	0.00	0	0	0	29	34	67
W2	0.90	-26	30	60	0.80	-23	27	54	0.00	0	0	0	-29	34	67
W3	0.90	26	66	76	0.80	23	59	68	0.00	0	0	0	29	73	85
W4	0.90	-26	66	76	0.80	-23	59	68	0.00	0	0	0	-29	73	85
S1	0.00	0	0	0	0.00	0	0	0	1.50	134	1181	536	89	788	358
S2	0.00	0	0	0	0.00	0	0	0	1.50	134	531	1186	89	354	791
S3	0.00	0	0	0	0.00	0	0	0	1.50	-134	1181	536	-89	788	358
S4	0.00	0	0	0	0.00	0	0	0	1.50	-134	531	1186	-89	354	791
HFL	1.00	-239	198	88	1.00	-239	198	88	1.00	-239	198	88	-239	198	88
EP	1.00	0	620	276	0.85	0	527	234	1.00	0	620	276	0	620	276
LL S.	1.20	0	298	133	1.00	0	249	111	0.20	0	50	22	0	249	111
EP.HFL	1.00	0	310	138	0.85	0	263	117	1.00	0	310	138	0	310	138
LL.S.HFL	1.20	0	149	66	1.00	0	124	55	0.20	0	25	11	0	124	55
Active earth pressure LWL					Dynamic increment in earth pressure due to seismic				1.00	0	0	0	0	0	0
LL surcharge LWL									0.20	0	0	0	0	0	0
Active earth pressure HFL									1.00	0	0	0	0	0	0
LL surcharge HFL									0.20	0	0	0	0	0	0

Case 1 Combination 1

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1706	-15	-7
Case 2 DL+SIDL1+SIDL2+LL1	2031	938	1140
Case 3 DL+SIDL1+SIDL2+LL2	1959	714	1095
Case 4 DL+SIDL1+SIDL2+LL3	1948	923	1143
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1732	15	53
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	2057	1004	1216
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1985	781	1171
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1974	989	1219
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1681	15	53
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	2005	1004	1216
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1933	781	1171
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1922	989	1219

HFL			
Case 1 DL+SIDL1+SIDL2+HFL	1467	-127	-57
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1792	677	1024
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1720	453	979
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1709	662	1027
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1493	-97	4
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1817	743	1100
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1746	519	1055
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1735	728	1103
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	1441	-97	4
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1766	743	1100
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1694	519	1055
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1683	728	1103

MAXIMUM REACTION CASE	2057	1004	1216
MAXIMUM LONGITUDINAL MOMENT CASE	2057	1004	1216
MAXIMUM TRANSVERSE MOMENT CASE	1974	989	1219

Case 2 Combination 2

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1257	56	25
Case 2 DL+SIDL1+SIDL2+LL1	1538	872	1015
Case 3 DL+SIDL1+SIDL2+LL2	1476	679	976
Case 4 DL+SIDL1+SIDL2+LL3	1466	860	1017
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1280	83	79
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1561	931	1082
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1499	738	1043
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1489	919	1085
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1234	83	79
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1515	931	1082
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1453	738	1043
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1443	919	1085

HFL			
Case 1 DL+SIDL1+SIDL2+HFL	1018	-9	-4
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1299	683	930
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1236	489	891
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1227	670	932
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1041	18	49
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1322	741	998
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1260	548	959
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1250	729	1000
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	995	18	49
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1276	741	998
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1213	548	959
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1204	729	1000

MAXIMUM REACTION CASE	1561	931	1082
MAXIMUM LONGITUDINAL MOMENT CASE	1561	931	1082
MAXIMUM TRANSVERSE MOMENT CASE	1489	919	1085

Case 3 Seismic Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
Normal	t	t-m	t-m
Downward seismic in longitudinal direction			
Case 1 DL+SIDL1+SIDL2+ seismic	1717	1213	551
Case 2 DL+SIDL1+SIDL2+LL1+ seismic	1760	1350	708
Case 3 DL+SIDL1+SIDL2+LL2+ seismic	1751	1320	702
Case 4 DL+SIDL1+SIDL2+LL3+ seismic	1749	1348	708
Downward seismic in transverse direction			
Case 5 DL+SIDL1+SIDL2+ seismic	1717	563	1201
Case 6 DL+SIDL1+SIDL2+LL1+ seismic	1760	700	1358
Case 7 DL+SIDL1+SIDL2+LL2+ seismic	1751	670	1352
Case 8 DL+SIDL1+SIDL2+LL3+ seismic	1749	698	1358
Upward seismic in longitudinal direction			
Case 9 DL+SIDL1+SIDL2+ seismic	1449	1213	551
Case 10 DL+SIDL1+SIDL2+LL1+ seismic	1493	1350	708
Case 11 DL+SIDL1+SIDL2+LL2+ seismic	1483	1320	702
Case 12 DL+SIDL1+SIDL2+LL3+ seismic	1482	1348	708
Upward seismic in transverse direction			
Case 13 DL+SIDL1+SIDL2+ seismic	1449	563	1201
Case 14 DL+SIDL1+SIDL2+LL1+ seismic	1493	700	1358
Case 15 DL+SIDL1+SIDL2+LL2+ seismic	1483	670	1352
Case 16 DL+SIDL1+SIDL2+LL3+ seismic	1482	698	1358
HFL CASE			
Downward seismic in longitudinal direction			
Case 1 DL+SIDL1+SIDL2+ seismic+HFL	1478	1101	501
Case 2 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1521	1213	647
Case 3 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1512	1183	641
Case 4 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1510	1211	647
Downward seismic in transverse direction			
Case 5 DL+SIDL1+SIDL2+ seismic+HFL	1478	451	1151
Case 6 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1521	563	1297
Case 7 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1512	223	1291
Case 8 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1510	561	1297
Upward seismic in longitudinal direction			
Case 9 DL+SIDL1+SIDL2+ seismic+HFL	1210	1101	501
Case 10 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1254	1213	647
Case 11 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1244	1183	641
Case 12 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1243	1211	647
Upward seismic in transverse direction			
Case 13 DL+SIDL1+SIDL2+ seismic+HFL	1210	451	1151
Case 14 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1254	563	1297
Case 15 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1244	533	1291
Case 16 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1243	561	1297

MAXIMUM REACTION CASE	1760	1350	708
MAXIMUM LONGITUDINAL MOMENT CASE	1760	1350	708
MAXIMUM TRANSVERSE MOMENT CASE	1749	698	1358

Case 4 Combination for base pressure check

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	1257	149	66
Case 2	DL+SIDL1+SIDL2+LL1	1473	834	853
Case 3	DL+SIDL1+SIDL2+LL2	1425	686	823
Case 4	DL+SIDL1+SIDL2+LL3	1418	825	855
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	1286	183	133
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	1502	908	938
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	1454	759	908
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	1447	898	940
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	1228	183	133
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	1444	908	938
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	1396	759	908
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	1389	898	940
Downward seismic in longitudinal direction				
Case 13	DL+SIDL1+SIDL2+ seismic	1346	937	424
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	1562	1622	1211
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	1514	1473	1181
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	1507	1612	1213
Downward seismic in transverse direction				
Case 17	DL+SIDL1+SIDL2+ seismic	1346	504	857
Case 18	DL+SIDL1+SIDL2+LL1+ seismic	1562	1189	1644
Case 19	DL+SIDL1+SIDL2+LL2+ seismic	1514	1040	1614
Case 20	DL+SIDL1+SIDL2+LL3+ seismic	1507	1179	1646
Upward seismic in longitudinal direction				
Case 21	DL+SIDL1+SIDL2+ seismic	1168	937	424
Case 22	DL+SIDL1+SIDL2+LL1+ seismic	1384	1622	1211
Case 23	DL+SIDL1+SIDL2+LL2+ seismic	1336	1473	1181
Case 24	DL+SIDL1+SIDL2+LL3+ seismic	1329	1612	1213
Upward seismic in transverse direction				
Case 25	DL+SIDL1+SIDL2+ seismic	1168	504	857
Case 26	DL+SIDL1+SIDL2+LL1+ seismic	1384	1189	1644
Case 27	DL+SIDL1+SIDL2+LL2+ seismic	1336	1040	1614
Case 28	DL+SIDL1+SIDL2+LL3+ seismic	1329	1179	1646

HFL				
Case 1	DL+SIDL1+SIDL2+HFL	1018	37	17
Case 2	DL+SIDL1+SIDL2+LL1+HFL	1234	598	748
Case 3	DL+SIDL1+SIDL2+LL2+HFL	1186	449	718
Case 4	DL+SIDL1+SIDL2+LL3+HFL	1179	588	750
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	1046	71	84
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1263	672	833
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1215	523	803
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1208	662	834
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	989	71	84
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1205	672	833
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1157	325	803
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1150	662	834
Downward seismic in longitudinal direction				
Case 13	DL+SIDL1+SIDL2+ seismic+HFL	1107	825	374
Case 14	DL+SIDL1+SIDL2+LL1+ seismic+HFL	1323	1386	1106
Case 15	DL+SIDL1+SIDL2+LL2+ seismic+HFL	1275	1237	1075
Case 16	DL+SIDL1+SIDL2+LL3+ seismic+HFL	1268	1376	1107
Downward seismic in transverse direction				
Case 17	DL+SIDL1+SIDL2+ seismic+HFL	1107	391	807
Case 18	DL+SIDL1+SIDL2+LL1+ seismic+HFL	1323	952	1539

Case 19 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1275	803	1509
Case 20 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1268	943	1541
Upward seismic in longitudinal direction			
Case 21 DL+SIDL1+SIDL2+ seismic+HFL	929	825	374
Case 22 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1145	1386	1106
Case 23 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1097	1237	1075
Case 24 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1090	1376	1107
Upward seismic in transverse direction			
Case 25 DL+SIDL1+SIDL2+ seismic+HFL	929	391	807
Case 26 DL+SIDL1+SIDL2+LL1+ seismic+HFL	1145	952	1539
Case 27 DL+SIDL1+SIDL2+LL2+ seismic+HFL	1097	803	1509
Case 28 DL+SIDL1+SIDL2+LL3+ seismic+HFL	1090	943	1541

MAXIMUM REACTION CASE	1562	1622	1211
MAXIMUM LONGITUDINAL MOMENT CASE	1562	1622	1211
MAXIMUM TRANSVERSE MOMENT CASE	1507	1179	1646

1 Normal

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Case 1 Normal max. Vertical load	**1473**	**834**	**853**
Case 2 Normal max. longitudinal moment	**1473**	**834**	**853**
Case 3 Normal max. transverse moment	**1418**	**825**	**855**

2 Seismic / wind

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Case 1 Seismic/wind max. Vertical load	**1562**	**1622**	**1211**
Case 2 Seismic/wind max. longitudinal moment	**1562**	**1622**	**1211**
Case 3 Seismic/wind max. transverse moment	**1507**	**1179**	**1646**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date &Rev.	

Load on Pile for Base Pressure Check

		V	ML	MT
		t	t-m	t-m
DL+SIDL1+SIDL2	Case 1	1473	834	853
DL+SIDL1+SIDL2+LL1	Case 2	1473	834	853
DL+SIDL1+SIDL2+LL2	Case 3	1418	825	855
DL+SIDL1+SIDL2+Seismic	Case 4	1562	1622	1211
DL+SIDL1+SIDL2+LL1+Seismic	Case 5	1562	1622	1211
DL+SIDL1+SIDL2+LL2+Seismic	Case 6	1507	1179	1646

Diameter of Pile = 1.200 m

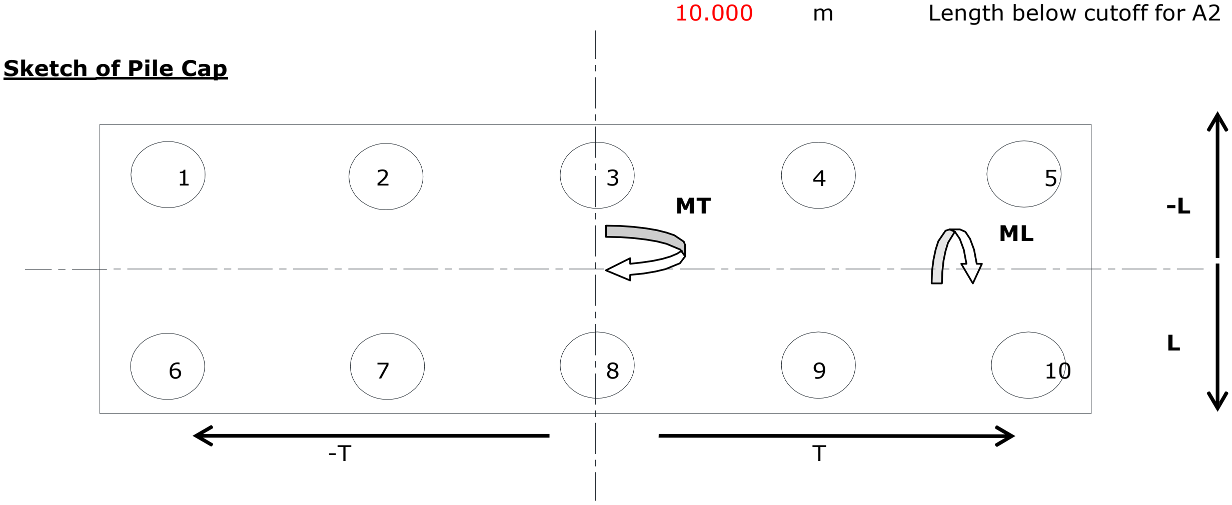
Shift = 0.000 m

Vertical Capacity of Pile = 4200.000 T As per Geotechnical Report

= 9.000 m Length below cutoff for A1

10.000 m Length below cutoff for A2

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	L^2	T^2	Z_L	Z_T
1	-1.800	-7.200	3.240	51.840	-18.000	-36.000
2	-1.800	-3.600	3.240	12.960	-18.000	-72.000
3	-1.800	0.000	3.240	0.000	-18.000	0.000
4	-1.800	3.600	3.240	12.960	-18.000	72.000
5	-1.800	7.200	3.240	51.840	-18.000	36.000
6	1.800	-7.200	3.240	51.840	18.000	-36.000
7	1.800	-3.600	3.240	12.960	18.000	-72.000
8	1.800	0.000	3.240	0.000	18.000	0.000
9	1.800	3.600	3.240	12.960	18.000	72.000
10	1.800	7.200	3.240	51.840	18.000	36.000

I_{LL} = **32.40** Sq.m

I_{TT} = **259.20** Sq.m

Normal case :- Lateral force

Case 1 **Horizontal force** **650.933** t **Force per Pile =** **65.1** t **OK**

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	Due to Shift M_T/Z_T (T)	Total Load (T)	Inference
1	147.29	-46.36	-23.70	0.00	0.00	77.23	OK
2	147.29	-46.36	-11.85	0.00	0.00	89.08	OK
3	147.29	-46.36	0.00	0.00	0.00	100.94	OK
4	147.29	-46.36	11.85	0.00	0.00	112.79	OK
5	147.29	-46.36	23.70	0.00	0.00	124.64	OK
6	147.29	46.36	-23.70	0.00	0.00	169.95	OK
7	147.29	46.36	-11.85	0.00	0.00	181.80	OK
8	147.29	46.36	0.00	0.00	0.00	193.65	OK
9	147.29	46.36	11.85	0.00	0.00	205.50	OK
10	147.29	46.36	23.70	0.00	0.00	217.36	OK

Case 2

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	Due to Shift M_T/Z_T (T)	Total Load (T)	Inference
1	147.29	-46.36	-23.70	0.00	0.00	77.23	OK
2	147.29	-46.36	-11.85	0.00	0.00	89.08	OK
3	147.29	-46.36	0.00	0.00	0.00	100.94	OK
4	147.29	-46.36	11.85	0.00	0.00	112.79	OK
5	147.29	-46.36	23.70	0.00	0.00	124.64	OK
6	147.29	46.36	-23.70	0.00	0.00	169.95	OK
7	147.29	46.36	-11.85	0.00	0.00	181.80	OK
8	147.29	46.36	0.00	0.00	0.00	193.65	OK
9	147.29	46.36	11.85	0.00	0.00	205.50	OK
10	147.29	46.36	23.70	0.00	0.00	217.36	OK

Case 3

Pile No.	P_T / N (T)	M_L / Z_L (T)	M_T / Z_T (T)	Due to Shift M_L/Z_L (T)	Due to Shift M_T/Z_T (T)	Total Load (T)	Inference
1	141.79	-45.82	-23.75	0.00	0.00	72.22	OK
2	141.79	-45.82	-11.88	0.00	0.00	84.10	OK
3	141.79	-45.82	0.00	0.00	0.00	95.97	OK
4	141.79	-45.82	11.88	0.00	0.00	107.85	OK
5	141.79	-45.82	23.75	0.00	0.00	119.72	OK
6	141.79	45.82	-23.75	0.00	0.00	163.86	OK
7	141.79	45.82	-11.88	0.00	0.00	175.74	OK
8	141.79	45.82	0.00	0.00	0.00	187.61	OK
9	141.79	45.82	11.88	0.00	0.00	199.49	OK
10	141.79	45.82	23.75	0.00	0.00	211.37	OK

Seismic Case :- Lateral force

Case 4	**Horizontal force =**	**696.150**	t	**Force per Pile =**	**55.7**	**t**	**OK**

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	156.21	-90.11	-33.64	0.00	0.00	32.46	OK
2	156.21	-90.11	-16.82	0.00	0.00	49.28	OK
3	156.21	-90.11	0.00	0.00	0.00	66.10	OK
4	156.21	-90.11	16.82	0.00	0.00	82.92	OK
5	156.21	-90.11	33.64	0.00	0.00	99.74	OK
6	156.21	90.11	-33.64	0.00	0.00	212.69	OK
7	156.21	90.11	-16.82	0.00	0.00	229.50	OK
8	156.21	90.11	0.00	0.00	0.00	246.32	OK
9	156.21	90.11	16.82	0.00	0.00	263.14	OK
10	156.21	90.11	33.64	0.00	0.00	279.96	OK

Case 5

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	156.21	-90.11	-33.64	0.00	0.00	32.46	OK
2	156.21	-90.11	-16.82	0.00	0.00	49.28	OK
3	156.21	-90.11	0.00	0.00	0.00	66.10	OK
4	156.21	-90.11	16.82	0.00	0.00	82.92	OK
5	156.21	-90.11	33.64	0.00	0.00	99.74	OK
6	156.21	90.11	-33.64	0.00	0.00	212.69	OK
7	156.21	90.11	-16.82	0.00	0.00	229.50	OK
8	156.21	90.11	0.00	0.00	0.00	246.32	OK
9	156.21	90.11	16.82	0.00	0.00	263.14	OK
10	156.21	90.11	33.64	0.00	0.00	279.96	OK

Case 6

Pile	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total	Inference
No.				M_L/Z_L	M_T/Z_T	Load	
	(T)	(T)	(T)	(T)	(T)	(T)	
1	150.71	-65.50	-45.72	0.00	0.00	39.49	OK
2	150.71	-65.50	-22.86	0.00	0.00	62.35	OK
3	150.71	-65.50	0.00	0.00	0.00	85.21	OK
4	150.71	-65.50	22.86	0.00	0.00	108.07	OK
5	150.71	-65.50	45.72	0.00	0.00	130.93	OK
6	150.71	65.50	-45.72	0.00	0.00	170.49	OK
7	150.71	65.50	-22.86	0.00	0.00	193.35	OK
8	150.71	65.50	0.00	0.00	0.00	216.21	OK
9	150.71	65.50	22.86	0.00	0.00	239.07	OK
10	150.71	65.50	45.72	0.00	0.00	261.93	OK

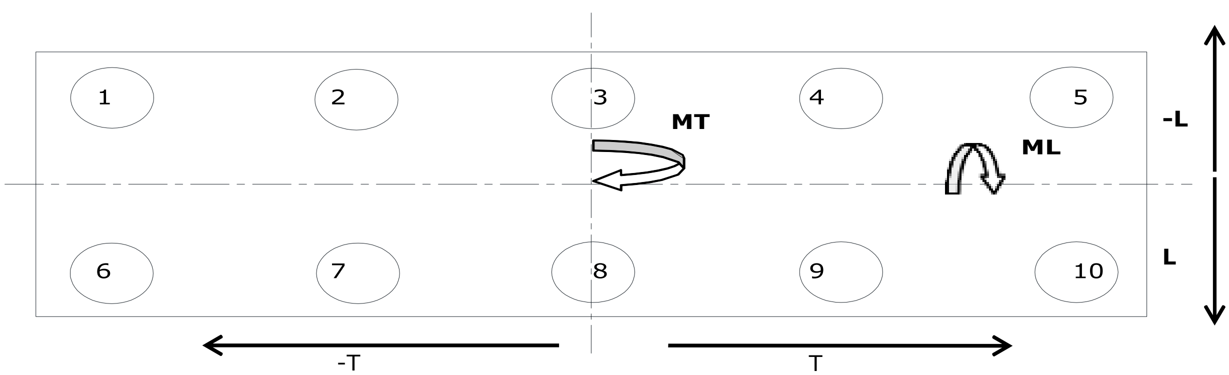
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date &Rev.	

Load Calculations for Design of Pile (ULS)

		V	**ML**	**MT**
		t	**t-m**	**t-m**
Max. vertical load Combination 1	Case 1	2057	1004	1216
Max. longitudinal moment Combination 1	Case 2	2057	1004	1216
Max. transverse moment Combination 1	Case 3	1974	989	1219
Max. vertical load Combination 2	Case 4	1561	931	1082
Max. longitudinal moment Combination 2	Case 5	1561	931	1082
Max. transverse moment Combination 2	Case 6	1489	919	1085
Max. vertical load seismic/accidental combination	Case 7	1760	1350	708
Max. longitudinal moment seismic/accidental combination	Case 8	1760	1350	708
Max. transverse moment seismic/accidental combination	Case 9	1749	698	1358

Diameter of Pile = 1.200 m
Shift = 0.000 m

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	$_L2$	$_T2$	Z_L	Z_T
1	1.235	-7.881	1.526	62.116	73.021	-39.407
2	-0.368	-3.941	0.135	15.529	-245.437	-78.814
3	-1.970	0.000	3.882	0.000	-45.781	0.000
4	-3.573	3.941	12.768	15.529	-25.245	78.814
5	-5.176	7.881	26.791	62.116	-17.427	39.407
6	5.176	-7.881	26.791	62.116	17.427	-39.407
7	3.573	-3.941	12.768	15.529	25.245	-78.814
8	1.970	0.000	3.882	0.000	45.781	0.000
9	0.368	3.941	0.135	15.529	245.437	78.814
10	-1.235	7.881	1.526	62.116	-73.021	39.407

I_{LL} = **90.20** Sq.m
I_{TT} = **310.58** Sq.m

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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Case 1

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	205.7	13.7	-30.9	0.0	0.0	188.5
2	205.7	-4.1	-15.4	0.0	0.0	186.1
3	205.7	-21.9	0.0	0.0	0.0	183.7
4	205.7	-39.8	15.4	0.0	0.0	181.3
5	205.7	-57.6	30.9	0.0	0.0	178.9
6	205.7	57.6	-30.9	0.0	0.0	232.4
7	205.7	39.8	-15.4	0.0	0.0	230.0
8	205.7	21.9	0.0	0.0	0.0	227.6
9	205.7	4.1	15.4	0.0	0.0	225.2
10	205.7	-13.7	30.9	0.0	0.0	222.8

Case 2

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	205.7	13.7	-30.9	0.0	0.0	188.5
2	205.7	-4.1	-15.4	0.0	0.0	186.1
3	205.7	-21.9	0.0	0.0	0.0	183.7
4	205.7	-39.8	15.4	0.0	0.0	181.3
5	205.7	-57.6	30.9	0.0	0.0	178.9
6	205.7	57.6	-30.9	0.0	0.0	232.4
7	205.7	39.8	-15.4	0.0	0.0	230.0
8	205.7	21.9	0.0	0.0	0.0	227.6
9	205.7	4.1	15.4	0.0	0.0	225.2
10	205.7	-13.7	30.9	0.0	0.0	222.8

Case 3

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	197.4	13.6	-30.9	0.0	0.0	180.0
2	197.4	-4.0	-15.5	0.0	0.0	177.9
3	197.4	-21.6	0.0	0.0	0.0	175.8
4	197.4	-39.2	15.5	0.0	0.0	173.7
5	197.4	-56.8	30.9	0.0	0.0	171.6
6	197.4	56.8	-30.9	0.0	0.0	223.2
7	197.4	39.2	-15.5	0.0	0.0	221.1
8	197.4	21.6	0.0	0.0	0.0	219.0
9	197.4	4.0	15.5	0.0	0.0	216.9
10	197.4	-13.6	30.9	0.0	0.0	214.8

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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Case 4

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	156.1	12.8	-27.5	0.0	0.0	141.4
2	156.1	-3.8	-13.7	0.0	0.0	138.6
3	156.1	-20.3	0.0	0.0	0.0	135.7
4	156.1	-36.9	13.7	0.0	0.0	132.9
5	156.1	-53.4	27.5	0.0	0.0	130.1
6	156.1	53.4	-27.5	0.0	0.0	182.0
7	156.1	36.9	-13.7	0.0	0.0	179.2
8	156.1	20.3	0.0	0.0	0.0	176.4
9	156.1	3.8	13.7	0.0	0.0	173.6
10	156.1	-12.8	27.5	0.0	0.0	170.8

Case 5

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	156.1	12.8	-27.5	0.0	0.0	141.4
2	156.1	-3.8	-13.7	0.0	0.0	138.6
3	156.1	-20.3	0.0	0.0	0.0	135.7
4	156.1	-36.9	13.7	0.0	0.0	132.9
5	156.1	-53.4	27.5	0.0	0.0	130.1
6	156.1	53.4	-27.5	0.0	0.0	182.0
7	156.1	36.9	-13.7	0.0	0.0	179.2
8	156.1	20.3	0.0	0.0	0.0	176.4
9	156.1	3.8	13.7	0.0	0.0	173.6
10	156.1	-12.8	27.5	0.0	0.0	170.8

Case 6

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	148.9	12.6	-27.5	0.0	0.0	134.0
2	148.9	-3.7	-13.8	0.0	0.0	131.4
3	148.9	-20.1	0.0	0.0	0.0	128.9
4	148.9	-36.4	13.8	0.0	0.0	126.3
5	148.9	-52.7	27.5	0.0	0.0	123.7
6	148.9	52.7	-27.5	0.0	0.0	174.1
7	148.9	36.4	-13.8	0.0	0.0	171.6
8	148.9	20.1	0.0	0.0	0.0	169.0
9	148.9	3.7	13.8	0.0	0.0	166.4
10	148.9	-12.6	27.5	0.0	0.0	163.9

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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Case 7

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	176.0	18.5	-18.0	0.0	0.0	176.5
2	176.0	-5.5	-9.0	0.0	0.0	161.5
3	176.0	-29.5	0.0	0.0	0.0	146.5
4	176.0	-53.5	9.0	0.0	0.0	131.5
5	176.0	-77.5	18.0	0.0	0.0	116.5
6	176.0	77.5	-18.0	0.0	0.0	235.5
7	176.0	53.5	-9.0	0.0	0.0	220.5
8	176.0	29.5	0.0	0.0	0.0	205.5
9	176.0	5.5	9.0	0.0	0.0	190.5
10	176.0	-18.5	18.0	0.0	0.0	175.5

Case 8

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	176.0	18.5	-18.0	0.0	0.0	176.5
2	176.0	-5.5	-9.0	0.0	0.0	161.5
3	176.0	-29.5	0.0	0.0	0.0	146.5
4	176.0	-53.5	9.0	0.0	0.0	131.5
5	176.0	-77.5	18.0	0.0	0.0	116.5
6	176.0	77.5	-18.0	0.0	0.0	235.5
7	176.0	53.5	-9.0	0.0	0.0	220.5
8	176.0	29.5	0.0	0.0	0.0	205.5
9	176.0	5.5	9.0	0.0	0.0	190.5
10	176.0	-18.5	18.0	0.0	0.0	175.5

Case 9

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	174.9	9.6	-34.5	0.0	0.0	150.0
2	174.9	-2.8	-17.2	0.0	0.0	154.8
3	174.9	-15.3	0.0	0.0	0.0	159.7
4	174.9	-27.7	17.2	0.0	0.0	164.5
5	174.9	-40.1	34.5	0.0	0.0	169.3
6	174.9	40.1	-34.5	0.0	0.0	180.5
7	174.9	27.7	-17.2	0.0	0.0	185.3
8	174.9	15.3	0.0	0.0	0.0	190.2
9	174.9	2.8	17.2	0.0	0.0	195.0
10	174.9	-9.6	34.5	0.0	0.0	199.8

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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Calculation of Depth of Fixity As per IS 2911, Annexure C

Stiffness factor	T	=	5√(EI/K1)	m	For pile in sand and normally loaded Clays
Stiffness factor	R	=	4√(EI/BK2)	m	For pile in preloaded clays
	E	=	30000	MN/m2	
	I	=	0.1018	m4	
	ŋh	=	3.3008	MN/m3	
	K	=	4.86	MN/m3	
	T	=	3.920		OK
	R	=	4.784		
Pile length over sand layer,	L1	=	0	m	
Case I	L1/R	=	0		
Case II	L1/T	=	0		
Case I	Lf/R	=	0		(for fixed head pile)
Case II	Lf/T	=	2.2		
Case I	Depth of Fixity, Lf	=	0.000	m	
Case II	Depth of Fixity, Lf	=	8.62	m	
	L1+Lf	=	8.623	m	
Reduction Factor	m	=	0.85		
	MT	=	Q (L1 + Lf)/2*m		(for fixed head pile)
		=	3.665	Q	

Moment on pile =		3.665	Q						
	Combination 1			Combination 2			Seismic/Accidental Combination		
	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)
MAX	**232.40**	38	141	**182.05**	33	120	**235.52**	45	165
MIN	**171.56**	38	139	**123.74**	32	118	**116.51**	42	154

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Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OFABUTMENTS A1 & A2	Date & Rev.	

Moments & shear force for pile cap

Width of abut.	=	1.00	m
Length of abut.		16.00	
Dia. Of pile	=	1.20	m
Length of Pile cap	=	16.00	m
Width of Pile cap	=	4.85	m
Thickness of pile cap	=	1.80	m
Unit wt. of concrete	=	2.50	t/m^3
Unit wt. of Soil	=	2.00	t/m^3
Thickness of soil above pile cap	=	0.50	m

Downward force & moment due to pile cap 1.20 0.00

Transverse direction	L	B	H	Unit Weight	Load (t)	Moment (t.m)
Self wt. of pile cap	0.00	4.85	1.80	2.50	0.00	0.00
Wt. due to soil	0.00	4.85	0.50	2.00	0.00	0.00
Longitudinal direction	L	B	H	Unit Weight	Load (t)	Moment (t.m)
Self wt. of pile cap	1.93	16.00	1.80	2.50	138.60	133.40
Wt. due to soil	1.93	16.00	0.50	2.00	30.80	29.65

	Combination 1			Combination 2			Seismic/Accidental Combination		
	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)
LL	1104	58 /m	73 /m	853	43 /m	54 /m	1029	54 /m	67 /m
TT	837	173 /m	/m	641	132 /m	/m	794	164 /m	/m
Max	1104	934	1161	853	683	860	1029	859	1071

ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	25	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	11.17	N/mm^2	Basic Combination
	f_{cd}	=	13.96	N/mm^2	Accidental Combination
	f_{cd}	=	11.17	N/mm^2	Seismic Combination
	E_c	=	30000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	434.78	N/mm^2	Basic Combination
	f_{Yd}	=	500.00	N/mm^2	Accidental Combination
	f_{Yd}	=	434.78	N/mm^2	Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = $fcd*b*(3/7xu_{,lim} + 2/3*4/7xu_{,lim})$

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.8095fcd*(xu_{lim}/d)*(1-0.416*xu_{lim}/d)$

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.15	4.99	4.15

Here R_{lim} is in MPa

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	4850	mm
Depth of section D	=	1800	mm
Clear cover	=	75	mm

Moment on the section	Moment at face of support		
	Combination (1)	Seismic Combi.	Combination (2)
Actual moment (KNm)	11393	8407	8438
Grade of Concrete	25	25	25
Grade of steel fy	500	500	500
b	4850	4850	4850
D	1800	1800	1800
c	75	75	75
d	1696.5	1696.5	1696.5
f_{cd}	11.17	11.17	11.17
f_{Yd}	435	435	435
$xu_{,lim}/d$	0.62	0.62	0.62
$R_{sls} = M_{u,sls}/bd2$	4.15	4.15	4.15
$M_{u,Lim}$ (KNm)	57862	57862	57862
	OK	**OK**	**OK**
Ast Req.	8037	5866	5889
Dia of bar (main tension) (mm)	25	25	25
Spacing (mm)	120	120	120
+ dia of bar (main tension) (mm)	25	25	25
Spacing (mm)	120	120	120
Ast provided (sq mm)	39679	39679	39679
Dia of bar(main compresion at top mm)	12	12	12
Spacing (mm)	120	120	120
Area of main compresion (mm^2)	4571	4571	4571
f_{ctm}	2.2	2.2	2.2
f_{yk}	435	435	435
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	10825	10825	10825
	OK	**OK**	**OK**
As.max = 0.025 Ac (main tension)	218250	218250	218250
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**	**OK**	**OK**
As.max = 0.04 Ac (tension + compresion)	349200	349200	349200
x (mm)	394	394	394
x/d	0.232	0.232	0.232
	OK	**OK**	**OK**
z (mm)	1533	1533	1533
MR (KNm)	52887	52887	52887
	OK	**OK**	**OK**
Shear on the section			
Actual shear V_{Ed} (KN)	5107	4670	3811
Actual shear stress (N/mm2)	0.621	0.568	0.463
Max shear capacity, 0.135 fck(1-fck/310)	3.10	3.10	3.10
	OK	**OK**	**OK**
Min shear capacity, 0.0924 fck(1-fck/310)	2.12	2.12	2.12
$\theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	5.77	5.27	4.29
Min angle of inclination, θ (deg)	21.8	21.8	21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.343	1.343	1.343
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			

V(min) = 0.031 K^(3/2) fck^(1/2)	0.241	0.286	0.286
cl. 10.3.1 of IRC :112-2011			
r1 = $A_{sl}/(b_w\ d)$ <= 0.02	0.005	0.005	0.005
	OK	**OK**	**OK**
0.12 K (80 r1 $f_{ck})^{0.33}$	0.341	0.341	0.341
Axial compressive force N_{Ed} (KN)	0.0	0	0.0
$_{Scp}$ = N_{Ed} / A_c <= 0.2 f_{cd}	0.0	0.0	0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d$ >=(V_{min} + 0.15 S_{cp}) b_w d (KN)	2802	2802	2802
	PROVIDE SHEAR R/F	**PROVIDE SHEAR R/F**	**PROVIDE SHEAR R/F**
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010			
n = 0.6 (1 - fck / 310)	0.552	0.552	0.552
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011			
0.5 b_w d n f_{cd}	25341	25341	25341
	OK	**OK**	**OK**
No. of Links for shear R/f (Distribution)	2	2	2
Dia. of bar for shear reinf.	16	16	16
S(mm)	200	200	200
^{A}SW1	402	402	402
	OK	**OK**	**OK**
No. of link for shear reinf.	8	8	8
Dia. of bar for shear reinf.	10	10	10
S = Asw x 0.9 x d x cot θ x fy / V_E	150	150	150
^{A}SW2	628	628	628
^{A}SW	1030	1030	1030
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011			
$S_{l.max}$ = 0.75 d	600	600	600
	OK	**OK**	**OK**
z (mm)	1533	1533	1533
^{f}ywd	435	435	435
cl. 10.3.3.2 Eq. 10.7 of IRC :112-2011			
$V_{Rd.s}$ = A_{SW} z f_{ywd} cot θ / S (KN)	11446	9427	9427
	OK	**OK**	**OK**
$_{acw}$ = (s_{cp} = N_{Ed} / A_c = 0)	1.0	1.0	1.0
ν_1	0.6	0.6	0.6
cl. 10.3.3.2 Eq. 10.8 of IRC :112-2011			
VRd.max = acw bw z n1 fcd (KN)	49808	49808	49808
	OK	**OK**	**OK**
cl. 10.3.3.2 Eq. 10.10 of IRC :112-2011			
ASW.max <= 0.5 acw n1 fcd bw S / fywd	5605	5605	5605
	OK	**OK**	**OK**
cl. 10.3.1 of IRC :112-2011			
rw = ASW/(S bw sina)	0.0014	0.0014	0.0014
cl. 10.3.3.5 of IRC :112-2011			
rw,min = (0.072 fck^0.5) / fyk	0.0008	0.0008	0.0008
	OK	**OK**	**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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COMBINATION FOR DESIGN OF FOUNDATION & BASE PRESSURE (SLS)

Following load combinations are co As per Annex B of IRC:112-2011

1 Rare Combination

2 Quasi Permanent Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	DL	Dead Load (due to superstructure+substructure+found.	1204	-515	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		201	-59	0	0	0
4	ABUT + RETURN WALL		132	-37	0	0	0
5	FDN		349	0	0	0	0
6	SOIL ABOVE FDN		286	-418	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	214	0	658	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	159	0	666	0	0
12	LL1B	Live Load Moment due to braking	3	185	0	35.33	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.08	0
14	LL3B	Live Load Moment due to braking	3	171	0	32.61	0
15	W1	Wind vertically down without LL	29	5	71	5.47	11.58
16	W2	Wind vertically up without LL	-29	5	71	5.47	11.58
17	W3	Wind vertically down with LL	29	49	71	5.53	11.58
18	W4	Wind vertically up with LL	-29	49	71	5.53	11.58
19	S1	Seimic	0	0	0	0	0
20	S2		0	0	0	0	0
21	S3		0	0	0	0	0
22	S4		0	0	0	0	0
23	HFL		-239	216	0	0.0	0.0
24	Active earth pressure LWL		0	678	0	226.7	0.0
25	LL surcharge LWL		0	272	0	76.4	0.0
26	Active earth pressure HFL		0	339	0	113.4	0.0
27	LL surcharge HFL		0	136	0	38.2	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0
29	LL surcharge LWL		0	0	0	0	0
30	Active earth pressure HFL		0	0	0	0	0
31	LL surcharge HFL		0	0	0	0	0

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	Rare Combination				**Quasi Permanent Combination**			
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)
DL	1.00	1204	-470	-209	1.00	1204	-470	-209
SIDL1	1.00	24	0	0	1.00	24	0	0
SIDL2	1.00	28	0	0	1.00	28	0	0
LL1	1.00	214	268	601	0.00	0	0	0
LL2	1.00	168	288	646	0.00	0	0	0
LL3	1.00	159	271	608	0.00	0	0	0
LL1B	1.00	3	169	75	0.00	0	0	0
LL2B	1.00	0	0	0	0.00	0	0	0
LL3B	1.00	3	156	69	0.00	0	0	0
W1	0.60	17	20	40	0.00	0	0	0
W2	0.60	-17	20	40	0.00	0	0	0
W3	0.60	17	44	51	0.00	0	0	0
W4	0.60	-17	44	51	0.00	0	0	0
S1	0.00	0	0	0	0.00	0	0	0
S2	0.00	0	0	0	0.00	0	0	0
S3	0.00	0	0	0	0.00	0	0	0
S4	0.00	0	0	0	0.00	0	0	0
HFL	1.00	-239	198	88	1.00	-239	198	88
EP	1.00	0	620	276	1.00	0	620	276
LL S.	0.80	0	199	89	0.00	0	0	0
EP HFL	1.00	0	310	138	1.00	0	310	138
LL.S.HFL	0.80	0	99	44	0.00	0	0	0

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Case 1 Rare Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1257	149	66
Case 2 DL+SIDL1+SIDL2+LL1	1473	785	831
Case 3 DL+SIDL1+SIDL2+LL2	1425	636	801
Case 4 DL+SIDL1+SIDL2+LL3	1418	775	833
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1274	170	107
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1490	829	882
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1442	680	852
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1435	819	884
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1239	170	107
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1456	829	882
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1408	680	852
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1401	819	884
HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	1018	37	17
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1234	573	737
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1186	424	707
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1179	564	739
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1035	57	57
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1251	617	788
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1203	468	758
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1196	608	790
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	1000	57	57
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1217	617	788
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1169	468	758
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1162	608	790

MAXIMUM REACTION CASE	1490	829	882
MAXIMUM LONGITUDINAL MOMENT CASE	1490	829	882
MAXIMUM TRANSVERSE MOMENT CASE	1435	819	884

Case 2 Quasi Permanent Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	1257	149	66
Case 2 DL+SIDL1+SIDL2+LL1	1257	149	66
Case 3 DL+SIDL1+SIDL2+LL2	1257	149	66
Case 4 DL+SIDL1+SIDL2+LL3	1257	149	66
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	1257	149	66
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	1257	149	66
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	1257	149	66
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	1257	149	66
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	1257	149	66
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	1257	149	66
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	1257	149	66
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	1257	149	66

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	1018	37	17
Case 2 DL+SIDL1+SIDL2+LL1+HFL	1018	37	17
Case 3 DL+SIDL1+SIDL2+LL2+HFL	1018	37	17
Case 4 DL+SIDL1+SIDL2+LL3+HFL	1018	37	17
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	1018	37	17
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1018	37	17
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1018	37	17
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1018	37	17
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	1018	37	17
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	1018	37	17
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	1018	37	17
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	1018	37	17

MAXIMUM REACTION CASE	1257	149	66
MAXIMUM LONGITUDINAL MOMENT CASE	1257	149	66
MAXIMUM TRANSVERSE MOMENT CASE	1257	149	66

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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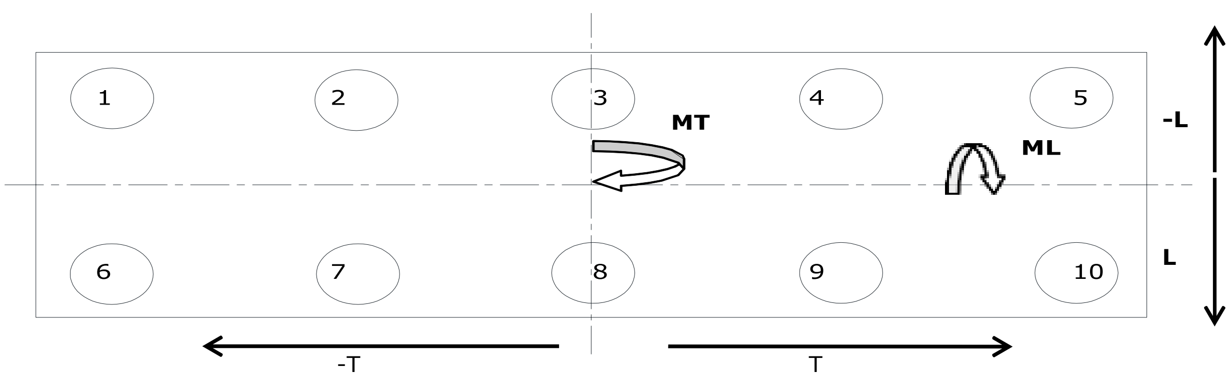
Load Calculations for Design of Pile (SLS)

	V	ML	MT
	t	t-m	t-m
Case 1	1490	829	882
Case 2	1490	829	882
Case 3	1435	819	884
Case 4	1257	149	66
Case 5	1257	149	66
Case 6	1257	149	66

Diameter of Pile = 1.200 m
Shift = 0.000 m

Sketch of Pile Cap



No. of Piles = 10

Pile No.	Dist.(L)	Dist. (T)	L^2	T^2	Z_L	Z_T
1	1.235	-7.881	1.526	62.116	73.021	-39.407
2	-0.368	-3.941	0.135	15.529	-245.437	-78.814
3	-1.970	0.000	3.882	0.000	-45.781	0.000
4	-3.573	3.941	12.768	15.529	-25.245	78.814
5	-5.176	7.881	26.791	62.116	-17.427	39.407
6	5.176	-7.881	26.791	62.116	17.427	-39.407
7	3.573	-3.941	12.768	15.529	25.245	-78.814
8	1.970	0.000	3.882	0.000	45.781	0.000
9	0.368	3.941	0.135	15.529	245.437	78.814
10	-1.235	7.881	1.526	62.116	-73.021	39.407

I_{LL} = **90.20** Sq.m
I_{TT} = **310.58** Sq.m

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Case 1

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	149.0	11.4	-22.4	0.0	0.0	138.0
2	149.0	-3.4	-11.2	0.0	0.0	134.5
3	149.0	-18.1	0.0	0.0	0.0	130.9
4	149.0	-32.8	11.2	0.0	0.0	127.4
5	149.0	-47.6	22.4	0.0	0.0	123.8
6	149.0	47.6	-22.4	0.0	0.0	174.2
7	149.0	32.8	-11.2	0.0	0.0	170.7
8	149.0	18.1	0.0	0.0	0.0	167.1
9	149.0	3.4	11.2	0.0	0.0	163.6
10	149.0	-11.4	22.4	0.0	0.0	160.1

Case 2

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	149.0	11.4	-22.4	0.0	0.0	138.0
2	149.0	-3.4	-11.2	0.0	0.0	134.5
3	149.0	-18.1	0.0	0.0	0.0	130.9
4	149.0	-32.8	11.2	0.0	0.0	127.4
5	149.0	-47.6	22.4	0.0	0.0	123.8
6	149.0	47.6	-22.4	0.0	0.0	174.2
7	149.0	32.8	-11.2	0.0	0.0	170.7
8	149.0	18.1	0.0	0.0	0.0	167.1
9	149.0	3.4	11.2	0.0	0.0	163.6
10	149.0	-11.4	22.4	0.0	0.0	160.1

Case 3

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	143.5	11.2	-22.4	0.0	0.0	132.3
2	143.5	-3.3	-11.2	0.0	0.0	129.0
3	143.5	-17.9	0.0	0.0	0.0	125.6
4	143.5	-32.4	11.2	0.0	0.0	122.3
5	143.5	-47.0	22.4	0.0	0.0	118.9
6	143.5	47.0	-22.4	0.0	0.0	168.1
7	143.5	32.4	-11.2	0.0	0.0	164.8
8	143.5	17.9	0.0	0.0	0.0	161.4
9	143.5	3.3	11.2	0.0	0.0	158.1
10	143.5	-11.2	22.4	0.0	0.0	154.7

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
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Case 4

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	125.7	2.0	-1.7	0.0	0.0	126.0
2	125.7	-0.6	-0.8	0.0	0.0	124.2
3	125.7	-3.3	0.0	0.0	0.0	122.4
4	125.7	-5.9	0.8	0.0	0.0	120.6
5	125.7	-8.6	1.7	0.0	0.0	118.8
6	125.7	8.6	-1.7	0.0	0.0	132.6
7	125.7	5.9	-0.8	0.0	0.0	130.7
8	125.7	3.3	0.0	0.0	0.0	128.9
9	125.7	0.6	0.8	0.0	0.0	127.1
10	125.7	-2.0	1.7	0.0	0.0	125.3

Case 5

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	125.7	2.0	-1.7	0.0	0.0	126.0
2	125.7	-0.6	-0.8	0.0	0.0	124.2
3	125.7	-3.3	0.0	0.0	0.0	122.4
4	125.7	-5.9	0.8	0.0	0.0	120.6
5	125.7	-8.6	1.7	0.0	0.0	118.8
6	125.7	8.6	-1.7	0.0	0.0	132.6
7	125.7	5.9	-0.8	0.0	0.0	130.7
8	125.7	3.3	0.0	0.0	0.0	128.9
9	125.7	0.6	0.8	0.0	0.0	127.1
10	125.7	-2.0	1.7	0.0	0.0	125.3

Case 6

Pile No.	P_T / N	M_L / Z_L	M_T / Z_T	Due to Shift		Total
				M_L/Z_L	M_T/Z_T	Load
	(T)	(T)	(T)	(T)	(T)	(T)
1	125.7	2.0	-1.7	0.0	0.0	126.0
2	125.7	-0.6	-0.8	0.0	0.0	124.2
3	125.7	-3.3	0.0	0.0	0.0	122.4
4	125.7	-5.9	0.8	0.0	0.0	120.6
5	125.7	-8.6	1.7	0.0	0.0	118.8
6	125.7	8.6	-1.7	0.0	0.0	132.6
7	125.7	5.9	-0.8	0.0	0.0	130.7
8	125.7	3.3	0.0	0.0	0.0	128.9
9	125.7	0.6	0.8	0.0	0.0	127.1
10	125.7	-2.0	1.7	0.0	0.0	125.3

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Moment on pile =	3.665 Q					
	Rare Combination			Quasi Permanent Combination		
	P (t)	Q (t)	M (t.m)	P (t)	Q (t)	M (t.m)
MAX	**174.20**	33	122	**132.56**	23	83
MIN	**118.94**	33	121	**118.79**	23	83

Moments & shear force for pile cap

Width of abut.	=	1.00	m
Length of Abutment	=	16.00	m
Dia. Of pile	=	1.20	m
Length of Pile cap	=	16.00	m
Width of Pile cap	=	4.85	m
Thickness of pile cap	=	1.80	m
Unit wt. of concrete	=	2.50	t/m^3
Unit wt. of Soil	=	2.00	t/m^3
Thickness of soil above pile cap	=	0.50	m
Downward force & moment due to pile cap		1.20	0.00

Transverse direction	**L**	**B**	**H**	**Unit Weight**	**Load (t)**	**Moment (t.m)**
Self wt. of pile cap	0.00	4.85	1.80	2.50	0.00	0.00
Wt. due to soil	0.00	4.85	0.50	2.00	0.00	0.00
Longitudinal direction	**L**	**B**	**H**	**Unit Weight**	**Load (t)**	**Moment (t.m)**
Self wt. of pile cap	1.93	16.00	1.80	2.50	138.60	133.40
Wt. due to soil	1.93	16.00	0.50	2.00	30.80	29.65

DIRECTION	**Rare Combination**			**Quasi Permanent Combination**		
	Max. Reaction from Pile	Shear (t)	Moment (t.m)	Max. Reaction from Pile	Shear (t)	Moment (t.m)
LL	814	40 /m	51 /m	645	30 /m	38 /m
TT	617	127 /m	/m	514	106 /m	/m
Max	814	644	813	645	514	611

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SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	25	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	12.00	N/mm^2	Rare Combination
	f_{cd}	=	12.00	N/mm^2	Frequent Combination
	f_{cd}	=	9.00	N/mm^2	Quasi Permanent Comb.
	E_c	=	30000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	300.00	N/mm^2	Rare Combination
	f_{Yd}	=	300.00	N/mm^2	Frequent Combination
	f_{Yd}	=	300.00	N/mm^2	Quasi Permanent Comb.

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.5*fcd*(xu_{lim}/d)*(1-0.33*xu_{lim}/d)$

	Rare Combination	Frequent Combination	Quasi Perm.
$xu_{,lim}/d$	0.70	0.70	0.70
$R_{lim} = M_{u,Lim}/bd^2$	3.22	3.22	2.42

Here R_{lim} is in MPa

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b = 16000 mm

Depth of section D = 4850 mm

Clear cover = 75 mm

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHID CL	Checked	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OFABUTMENTS A1 & A2	Date &Rev.	

Moment on the section	**Moment at face of support**		
	Rare Combination		**Quasi Permanent Combination**
Actual moment (KNm)	7978		5998
Grade of Concrete	25		25
Grade of steel fy	500		500
b	16000		16000
D	4850		4850
c	75		75
d	4762.5		4762.5
f_{cd}	12.00		9.00
f_{Yd}	300		300
$x_{u,lim}/d$	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.22		2.42
$M_{u,Lim}$ (KNm)	1168546		876410
	OK		**OK**
Ast Req.	5591		4203
Dia of bar (main tension) (mm)	25		25
Spacing (mm)	120		120
+ dia of bar (main tension) (mm)	25		25
Spacing (mm)	120		120
Ast provided (sq mm)	8181		8181
Dia of bar(main compresion at top mm)	12		12
Spacing (mm)	120		120
Area of main compresion (mm^2)	15080		15080
f_{ctm}	2.2		2.2
x (mm)	26		34
x/d	0.005		0.007
	OK		**OK**
z (mm)	4754		4751
MR (KNm)	11668		11661
	OK		**OK**
$\sigma_{sc} = M/(A_s z)$	205		154
	OK		**OK**
$\sigma_{ca} = M/(0.5 z b x_u)$	8.20		4.63
	OK		**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Calculation of crack width	**Moment at face of support**		
n_1	8		8
n_2	8		8
$\phi_{eq} = (n_1 \phi_1^2 + n_2 \phi_2^2) / (n_1 \phi_1 + n_2 \phi_2)$	25		25
cl. 12.3.4 (3) of IRC :112-2011			
c	50		50
k1	0.2		0.2
k2	0.5		0.5
For skew slab refer eq. 12.10 of IRC :112-2011			
$\rho_{p.eff} = A_s / A_{c,eff}$	0.002		0.002
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 \phi) / \rho_{p.eff} \}$	625		625
cl. 12.3.4 (3) of IRC :112-2011			
k_t	0.5		0.5
$f_{ct,eff}$	2.90		2.90
E_s	200000		200000
E_{cm}	30000		30000
$\alpha_e = E_s / E_{cm}$	6.67		6.67
$(\varepsilon_{sm} - \varepsilon_{cm}) = (\sigma_{sc} - k_t f_{ct,eff} (1 + \alpha_e \rho_{p,eff}) / \rho_{p,eff}) / E_s$	0.0006		0.0005
cl. 12.3.4 (2) of IRC :112-2011			
$W_k = S_{r,max} (\varepsilon_{sm} - \varepsilon_{cm})$	0.29		0.29
cl. 12.3.4 (1) of IRC :112-2011			
	OK		**OK**

CHECK FOR SAFETY OF SECTION OF PILE

		Unit	Rare Combination		Quasi Permanent	
			Max.	Min.	Max.	Min.
Loads	P	KN	1742	1189	1326	1188
Moments	M	KNm	1216	1206	831	831
Dia of Section	D	mm	1200	1200	1200	1200
Radius of Section	R	mm	600	600	600	600
Effective Cover	C	mm	100	100	100	100
Effective Radius	R-C	mm	500	500	500	500
Modular Ratio	m		11.2	11.2	11.2	11.2
No. of Bars		Nos.	28	28	28	28
Dia of Bar		mm	25	25	25	25
+No of Bars		Nos.	28	28	28	28
+No of Bars		mm	25	25	25	25
Area of Steel	Ast	mm2	2.75E+04	2.75E+04	2.75E+04	2.75E+04
Area of Section	Ac	mm2	1.13E+06	1.13E+06	1.13E+06	1.13E+06
% of Steel	p	%	2.43	2.43	2.43	2.43
Net Area of Concrete	Anet	mm2	1.10E+06	1.10E+06	1.10E+06	1.10E+06
Transformed Area		mm2	1.41E+06	1.41E+06	1.41E+06	1.41E+06
Transformed MI		mm4	1.72E+11	1.72E+11	1.72E+11	1.72E+11
Section Modulus		mm3	2.86E+08	2.86E+08	2.86E+08	2.86E+08
Actual Stress						
P/A	$\sigma_{cc,cal}$	Mpa	1.23	0.84	0.94	0.84
M/Z	$\sigma_{cbc,cal}$	Mpa	4.24	4.21	2.90	2.90
Permissible Stress						
	σ_{cc}	Mpa	6.25	6.25	6.25	6.25
	σ_{cbc}	Mpa	8.33	8.33	8.33	8.33
Check for safety of Section						
	$\frac{\sigma_{cc,cal}}{\sigma_{cc}} + \frac{\sigma_{cbc,cal}}{\sigma_{cbc}}$	Mpa	0.71	0.64	0.50	0.48
			ok	ok	ok	ok
Check for Cracked/Uncracked Section						
	$\sigma_{cc,cal} - \sigma_{cbc,cal}$	Mpa	-3.01	-3.37	-1.96	-2.06
Permissible Tensile Stress in concrete		Mpa	-3.50	-3.50	-3.50	-3.50
Section is to be designed as			UNCRACKED	UNCRACKED	UNCRACKED	UNCRACKED

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

COMBINATION FOR DESIGN OF ABUTMENT (ULS)

Following load combinations are con As per Annex B of IRC:112-2011

1 Basic Combination

2 Seismic Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	Dead Load (due to superstructure+substructure+foundation		544	-59	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		201	-59	0	0	0
4	ABUT + RETURN WALL		106	0	0	0	0
5	FDN		0	0	0	0	0
6	SOIL ABOVE FDN		0	0	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	214	0	658	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	159	0	666	0	0
12	LL1B	Live Load Moment due to braking	3	121	0	35.33	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.09	0
14	LL3B	Live Load Moment due to braking	3	112	0	32.61	0
15	W1	Wind vertically down without LL	29	4	50	5.47	11.58
16	W2	Wind vertically up without LL	-29	4	50	5.47	11.58
17	W3	Wind vertically down with LL	29	39	50	5.53	11.58
18	W4	Wind vertically up with LL	-29	39	50	5.53	11.58
19	S1	Seimic	49	317	7	74.2	0
20	S2		49	2	322	0.0	74.2
21	S3		-49	317	7	74.2	0
22	S4		-49	2	322	0.0	74.2
23	HFL		-21	0	0	0.0	0.0
24	Active earth pressure LWL		0	283	0	126.6	0.0
25	LL surcharge LWL		0	152	0	57.1	0.0
26	Active earth pressure HFL		0	142	0	63.3	0.0
27	LL surcharge HFL		0	76	0	28.5	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0.0
29	LL surcharge LWL		0	0	0	0	0.0
30	Active earth pressure HFL		0	0	0	0	0.0
31	LL surcharge HFL		0	0	0	0	0.0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

	Basic Combination				Seismic Combination			
	PSF	P (t)	ML (tm)	MT (tm)	PSF	P (t)	ML (tm)	MT (tm)
DL	1.35	734	-73	-33	1.35	734	-73	-33
SIDL1	1.75	43	0	0	1.75	43	0	0
SIDL2	1.35	38	0	0	1.35	38	0	0
LL1	1.50	320	401	901	0.20	43	54	120
LL2	1.50	252	431	969	0.20	34	58	129
LL3	1.50	238	406	913	0.20	32	54	122
LL1B	1.50	4	166	74	0.20	1	22	10
LL2B	1.50	0	0	0	0.20	0	0	0
LL3B	1.50	4	154	68	0.20	1	20	9
W1	0.90	26	22	43	0.00	0	0	0
W2	0.90	-26	22	43	0.00	0	0	0
W3	0.90	26	50	55	0.00	0	0	0
W4	0.90	-26	50	55	0.00	0	0	0
S1	0.00	0	0	0	1.50	74	439	203
S2	0.00	0	0	0	1.50	74	200	443
S3	0.00	0	0	0	1.50	-74	439	203
S4	0.00	0	0	0	1.50	-74	200	443
HFL	1.00	-21	0	0	1.00	-21	0	0
EP	1.00	0	259	115	1.00	0	259	115
LL S.	1.20	0	167	74	0.20	0	28	12
EP HFL	1.00	0	129	58	1.00	0	129	58
LL.S.HFL	1.20	0	83	37	0.20	0	14	6

	Dynamic incr. in earth press.(Seismic)	PSF	P (t)	ML (tm)	MT (tm)
Active earth pressure LWL		1.00	0	0	0
LL surcharge LWL		0.20	0	0	0
Active earth pressure HFL		1.00	0	0	0
LL surcharge HFL		0.20	0	0	0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Case 1 **Basic Combination**

Load Case		Factored Forces/Moments		
		V	ML	MT
		t	t-m	t-m
Normal				
Case 1	DL+SIDL1+SIDL2	815	185	82
Case 2	DL+SIDL1+SIDL2+LL1	1139	919	1132
Case 3	DL+SIDL1+SIDL2+LL2	1067	783	1126
Case 4	DL+SIDL1+SIDL2+LL3	1056	912	1138
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	841	207	125
Case 6	DL+SIDL1+SIDL2+LL1+ Wind	1165	970	1187
Case 7	DL+SIDL1+SIDL2+LL2+ Wind	1093	833	1181
Case 8	DL+SIDL1+SIDL2+LL3+ Wind	1082	962	1193
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	789	207	125
Case 10	DL+SIDL1+SIDL2+LL1+ Wind	1113	970	1187
Case 11	DL+SIDL1+SIDL2+LL2+ Wind	1041	833	1181
Case 12	DL+SIDL1+SIDL2+LL3+ Wind	1031	962	1193
HFL CASE				
Case 1	DL+SIDL1+SIDL2+HFL	793	56	25
Case 2	DL+SIDL1+SIDL2+LL1+HFL	1118	707	1037
Case 3	DL+SIDL1+SIDL2+LL2+HFL	1046	571	1031
Case 4	DL+SIDL1+SIDL2+LL3+HFL	1035	699	1043
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind+HFL	819	78	67
Case 6	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1144	757	1093
Case 7	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1072	621	1086
Case 8	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1061	749	1098
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+HFL	768	78	67
Case 10	DL+SIDL1+SIDL2+LL1+ Wind+HFL	1092	757	1093
Case 11	DL+SIDL1+SIDL2+LL2+ Wind+HFL	1020	621	1086
Case 12	DL+SIDL1+SIDL2+LL3+ Wind+HFL	1009	749	1098

MAXIMUM REACTION CASE	1165	970	1187
MAXIMUM LONGITUDINAL MOMENT CASE	1165	970	1187
MAXIMUM TRANSVERSE MOMENT CASE	1082	962	1193

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Case 2 **Seismic Combination**

Load Case		Factored Forces/Moments		
		V	ML	MT
Normal		t	t-m	t-m
Downward seismic in longitudinal direction				
Case 1	DL+SIDL1+SIDL2+ seismic	889	624	286
Case 2	DL+SIDL1+SIDL2+LL1+ seismic	932	728	428
Case 3	DL+SIDL1+SIDL2+LL2+ seismic	923	710	427
Case 4	DL+SIDL1+SIDL2+LL3+ seismic	921	727	429
Downward seismic in transverse direction				
Case 5	DL+SIDL1+SIDL2+ seismic	889	385	526
Case 6	DL+SIDL1+SIDL2+LL1+ seismic	932	488	668
Case 7	DL+SIDL1+SIDL2+LL2+ seismic	923	470	667
Case 8	DL+SIDL1+SIDL2+LL3+ seismic	921	487	669
Upward seismic in longitudinal direction				
Case 9	DL+SIDL1+SIDL2+ seismic	741	624	286
Case 10	DL+SIDL1+SIDL2+LL1+ seismic	784	728	428
Case 11	DL+SIDL1+SIDL2+LL2+ seismic	774	710	427
Case 12	DL+SIDL1+SIDL2+LL3+ seismic	773	727	429
Upward seismic in transverse direction				
Case 13	DL+SIDL1+SIDL2+ seismic	741	385	526
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	784	488	668
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	774	470	667
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	773	487	669

HFL CASE

Downward seismic in longitudinal direction				
Case 1	DL+SIDL1+SIDL2+ seismic	868	495	228
Case 2	DL+SIDL1+SIDL2+LL1+ seismic	911	585	364
Case 3	DL+SIDL1+SIDL2+LL2+ seismic	901	567	364
Case 4	DL+SIDL1+SIDL2+LL3+ seismic	900	584	365
Downward seismic in transverse direction				
Case 5	DL+SIDL1+SIDL2+ seismic	868	255	468
Case 6	DL+SIDL1+SIDL2+LL1+ seismic	911	345	604
Case 7	DL+SIDL1+SIDL2+LL2+ seismic	901	327	603
Case 8	DL+SIDL1+SIDL2+LL3+ seismic	900	344	605
Upward seismic in longitudinal direction				
Case 9	DL+SIDL1+SIDL2+ seismic	719	495	228
Case 10	DL+SIDL1+SIDL2+LL1+ seismic	763	585	364
Case 11	DL+SIDL1+SIDL2+LL2+ seismic	753	567	364
Case 12	DL+SIDL1+SIDL2+LL3+ seismic	752	584	365
Upward seismic in transverse direction				
Case 13	DL+SIDL1+SIDL2+ seismic	719	255	468
Case 14	DL+SIDL1+SIDL2+LL1+ seismic	763	345	604
Case 15	DL+SIDL1+SIDL2+LL2+ seismic	753	327	603
Case 16	DL+SIDL1+SIDL2+LL3+ seismic	752	344	605

MAXIMUM REACTION CASE	932	728	428
MAXIMUM LONGITUDINAL MOMENT CASE	932	728	428
MAXIMUM TRANSVERSE MOMENT CASE	921	487	669

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

COMBINATION FOR DESIGN OF ABUTMENT (SLS)

Following load combinations are conAs per Annex B of IRC:112-2011

1 Rare Combination

2 Quasi Permanent Combination

			P (t)	ML (tm)	MT (tm)	HL(t)	HT(t)
1	DL	Dead Load (due to superstructure+substructure+found.	544	-59	0	0	0
2	DL_SUP		236	0	0	0	0
3	ABUT CAP + DIRT WALL		201	-59	0	0	0
4	ABUT + RETURN WALL		106	0	0	0	0
5	FDN		0	0	0	0	0
6	SOIL ABOVE FDN		0	0	0	0	0
7	SIDL1	Super-imposed Dead Load due to wearing course	24	0	0	0	0
8	SIDL2	Super-imposed Dead Load other than wearing course	28	0	0	0	0
9	LL1	Live Load Maximum Reaction Case	214	0	658	0	0
10	LL2	Live Load Maximum Longitudinal Moment Case	168	0	707	0	0
11	LL3	Live Load Maximum Transverse Moment Case	159	0	666	0	0
12	LL1B	Live Load Moment due to braking	3	121	0	35.33	0
13	LL2B	Live Load Moment due to braking	0	0	0	33.09	0
14	LL3B	Live Load Moment due to braking	3	112	0	32.61	0
15	W1	Wind vertically down without LL	29	4	50	5.47	11.58
16	W2	Wind vertically up without LL	-29	4	50	5.47	11.58
17	W3	Wind vertically down with LL	29	39	50	5.53	11.58
18	W4	Wind vertically up with LL	-29	39	50	5.53	11.58
19	S1	Seimic	0	0	0	0	0
20	S2		0	0	0	0	0
21	S3		0	0	0	0	0
22	S4		0	0	0	0	0
23	HFL		-21	0	0	0	0
24	Active earth pressure LWL		0	283	0	126.6	0.0
25	LL surcharge LWL		0	152	0	57.1	0.0
26	Active earth pressure HFL		0	142	0	63.3	0.0
27	LL surcharge HFL		0	76	0	28.5	0.0
28	Active earth pressure LWL	Dynamic increment in earth pressure due to seismic	0	0	0	0	0
29	LL surcharge LWL		0	0	0	0	0
30	Active earth pressure HFL		0	0	0	0	0
31	LL surcharge HFL		0	0	0	0	0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

	Rare Combination					Quasi Permanent Combination			
	PSF	P (t)	ML (tm)	MT (tm)		PSF	P (t)	ML (tm)	MT (tm)
DL	1.00	544	-54	-24		1.00	544	-54	-24
SIDL1	1.00	24	0	0		1.00	24	0	0
SIDL2	1.00	28	0	0		1.00	28	0	0
LL1	1.00	214	268	601		0.00	0	0	0
LL2	1.00	168	288	646		0.00	0	0	0
LL3	1.00	159	271	608		0.00	0	0	0
LL1B	1.00	3	111	49		0.00	0	0	0
LL2B	1.00	0	0	0		0.00	0	0	0
LL3B	1.00	3	102	46		0.00	0	0	0
W1	0.60	17	14	28		0.00	0	0	0
W2	0.60	-17	14	28		0.00	0	0	0
W3	0.60	17	34	37		0.00	0	0	0
W4	0.60	-17	34	37		0.00	0	0	0
S1	0.00	0	0	0		0.00	0	0	0
S2	0.00	0	0	0		0.00	0	0	0
S3	0.00	0	0	0		0.00	0	0	0
S4	0.00	0	0	0		0.00	0	0	0
HFL	1.00	-21	0	0		1.00	-21	0	0
EP	1.00	0	259	115		1.00	0	259	115
LL S.	0.80	0	111	49		0.00	0	0	0
EP HFL	1.00	0	129	58		1.00	0	129	58
LL.S.HFL	0.80	0	56	25		0.00	0	0	0
Active earth pressure LWL					Dynamic incr. in earth press.(Seismic)	1.00	0	0	0
LL surcharge LWL						0.20	0	0	0
Active earth pressure HFL						1.00	0	0	0
LL surcharge HFL						0.20	0	0	0

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Case 1 Rare Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	596	204	91
Case 2 DL+SIDL1+SIDL2+LL1	812	694	791
Case 3 DL+SIDL1+SIDL2+LL2	765	603	786
Case 4 DL+SIDL1+SIDL2+LL3	757	689	794
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	614	219	119
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	830	727	828
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	782	636	823
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	775	722	831
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	579	219	119
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	795	727	828
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	747	636	823
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	740	722	831

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	575	75	33
Case 2 DL+SIDL1+SIDL2+LL1+HFL	791	509	708
Case 3 DL+SIDL1+SIDL2+LL2+HFL	743	418	704
Case 4 DL+SIDL1+SIDL2+LL3+HFL	736	504	712
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	592	89	62
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	808	542	745
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	761	452	741
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	753	537	749
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	558	89	62
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	774	542	745
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	726	452	741
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	719	537	749

MAXIMUM REACTION CASE	830	727	828
MAXIMUM LONGITUDINAL MOMENT CASE	830	727	828
MAXIMUM TRANSVERSE MOMENT CASE	775	722	831

Case 2 Quasi Permanent Combination

Load Case	Factored Forces/Moments		
	V	ML	MT
	t	t-m	t-m
Normal			
Case 1 DL+SIDL1+SIDL2	596	204	91
Case 2 DL+SIDL1+SIDL2+LL1	596	204	91
Case 3 DL+SIDL1+SIDL2+LL2	596	204	91
Case 4 DL+SIDL1+SIDL2+LL3	596	204	91
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind	596	204	91
Case 6 DL+SIDL1+SIDL2+LL1+ Wind	596	204	91
Case 7 DL+SIDL1+SIDL2+LL2+ Wind	596	204	91
Case 8 DL+SIDL1+SIDL2+LL3+ Wind	596	204	91
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind	596	204	91
Case 10 DL+SIDL1+SIDL2+LL1+ Wind	596	204	91
Case 11 DL+SIDL1+SIDL2+LL2+ Wind	596	204	91
Case 12 DL+SIDL1+SIDL2+LL3+ Wind	596	204	91

HFL CASE			
Case 1 DL+SIDL1+SIDL2+HFL	575	75	33
Case 2 DL+SIDL1+SIDL2+LL1+HFL	575	75	33
Case 3 DL+SIDL1+SIDL2+LL2+HFL	575	75	33
Case 4 DL+SIDL1+SIDL2+LL3+HFL	575	75	33
Downward Wind Condition			
Case 5 DL+SIDL1+SIDL2 + Wind+HFL	575	75	33
Case 6 DL+SIDL1+SIDL2+LL1+ Wind+HFL	575	75	33
Case 7 DL+SIDL1+SIDL2+LL2+ Wind+HFL	575	75	33
Case 8 DL+SIDL1+SIDL2+LL3+ Wind+HFL	575	75	33
Upward Wind Condition			
Case 9 DL+SIDL1+SIDL2 + Wind+HFL	575	75	33
Case 10 DL+SIDL1+SIDL2+LL1+ Wind+HFL	575	75	33
Case 11 DL+SIDL1+SIDL2+LL2+ Wind+HFL	575	75	33
Case 12 DL+SIDL1+SIDL2+LL3+ Wind+HFL	575	75	33

MAXIMUM REACTION CASE	596	204	91
MAXIMUM LONGITUDINAL MOMENT CASE	596	204	91
MAXIMUM TRANSVERSE MOMENT CASE	596	204	91

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designedby:	
Client	NHIDCL	Checkedby:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OFABUTMENTS A1 & A2	Date & Rev.	

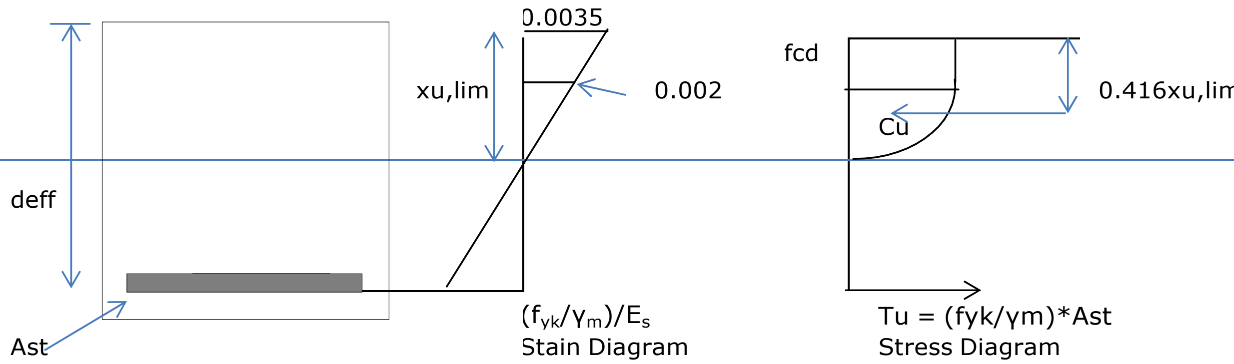
CALCULATION OF DIRT WALL FORCES

Height of dirt wall	2.135	m
Thickness of dirt wall	0.3	m
Thickness of approach slab	0.3	m
Thickness of wearing coat on approach slab	0.075	m
Unit wt. of soil	2.00	t/m3
Unit wt. of concrete	2.50	t/m3
Unit wt. of wearing coat	2.20	t/m3
Earth Pressure considered	Y	
Coefficient of active earth pressure	0.279	
Live load surcharge	1.2	m
Active earth pressure	1.19	t/m^2 per meter
Pressure due to live load surcharge	0.67	t/m^2 per meter
Force due to live load surcharge	1.43	t per meter
Force due to active earth pressure	1.27	t per meter
Moment due to live load surcharge	1.53	t.m
Moment due to active earth pressure Ignoring vertical load	1.14	t.m

	unit	actual value	ULS basic PSF	ULS basic Comb.	SLS Rare PSF	SLS Rare comb.	SLS Quasi permanent	SLS Quasi permanent
Moment due to live load surcharge	t.m per meter	1.53	1.20	1.83	0.80	1.22	0.00	0.00
Moment due to active earth pressure	t.m per meter	1.14	1.50	1.71	1.00	1.14	1.00	1.14
	t.m per meter			**3.55**		**2.36**		**1.14**
Force due to live load surcharge	t per meter	1.43	1.20	1.72	0.80	1.15	0.00	0.00
Force due to active earth pressure	t per meter	1.27	1.50	1.91	1.00	1.27	1.00	1.27
	t per meter			**3.63**		**2.42**		**1.27**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR DIRT WALL



ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	25	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	11.17	N/mm^2	Basic Combination
	f_{cd}	=	13.96	N/mm^2	Accidental Combination
	f_{cd}	=	11.17	N/mm^2	Seismic Combination
	E_c	=	30000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	435	N/mm^2	Basic Combination
	f_{Yd}	=	500.00	N/mm^2	Accidental Combination
	f_{Yd}	=	435	N/mm^2	Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = $fcd*b*(3/7xu_{,lim} + 2/3*4/7xu_{,lim})$

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.8095fcd*(xu_{lim}/d)*(1-0.416*xu_{lim}/d)$

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.15	4.99	4.15

Here R_{lim} is in MPa

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 in state of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	mm

Moment on the section	**Moment at face of support**		
	Basic Combination		
Actual moment (KNm)	35		
Grade of Concrete	25		
Grade of steel fy	500		
b	1000		
D	300		
c	50		
d	234.0		
f_{cd}	11.17		
f_{Yd}	435		
$x_{u,lim}/d$	0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.15		
$M_{u,Lim}$ (KNm)	227		
	OK		
Ast Req.	353		
Dia of bar (main tension) (mm)	16		
Spacing (mm)	150		
+ dia of bar (main tension) (mm)	0		
Spacing (mm)	150		
Ast provided (sq mm)	1340		
Dia of bar(main compresion at top mm)	12		
Spacing (mm)	150		
Area of main compresion (mm^2)	754		
f_{ctm}	2.2		
f_{yk}	435		
cl. 16.6.1 (2) of IRC :112-2011			
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	308		
	OK		
As.max = 0.025 Ac (main tension)	7500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**		
As.max = 0.04 Ac (tension + compresion)	12000		
x (mm)	64		
x/d	0.276		
	OK		
z (mm)	207		
MR (KNm)	121		
	OK		

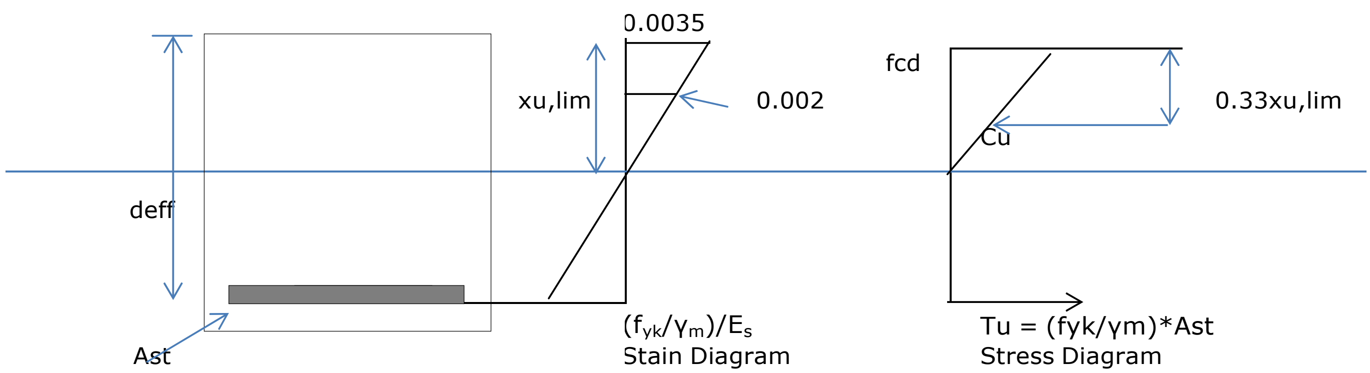
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Shear on the section

Actual shear V_{Ed} (KN)	36		
Actual shear stress (N/mm2)	0.152		
Max shear capacity, 0.135 fck(1-fck/310)	3.10		
	OK		
Min shear capacity, 0.0924 fck(1-fck/310)	2.12		
$\theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	1.40		
Min angle of inclination, θ (deg)	21.8		
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.925		
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
V(min) = 0.031 K^(3/2) fck^(1/2)	0.414		
cl. 10.3.1 of IRC :112-2011			
$r1 = A_{sl}/(b_w\ d) <= 0.02$	0.006		
	OK		
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.516		
Axial compressive force N_{Ed} (KN)	0.0		
$S_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d >= (V_{min} + 0.15\ S_{cp})\ b_w\ d$ (KN)	121		
	NO SHEAR R/F REQ.		
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010			
n = 0.6 (1 - fck / 310)	0.552		
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011			
$0.5\ b_w\ d\ n\ f_{cd}$	721		
	OK		
No. of Links for shear R/f (Distribution)	0		
Dia. of bar for shear reinf.	10		
S(mm)	150		
$^{A}SW1$	0		
	OK		

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF SERVICEABILITY LIMIT STATE FOR DIRT WALL



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	25	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	12.00	N/mm^2	Rare Combination
	f_{cd}	=	12.00	N/mm^2	Frequent Combination
	f_{cd}	=	9.00	N/mm^2	Quasi Permanent Comb.
	E_c	=	30000.00	MPa	
Grade of steel	f_Y	=	500.00	N/mm^2	
	f_{Yd}	=	300.00	N/mm^2	Rare Combination
	f_{Yd}	=	300.00	N/mm^2	Frequent Combination
	f_{Yd}	=	300.00	N/mm^2	Quasi Permanent Comb.

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.5*fcd*(xu_{lim}/d)*(1-0.33*xu_{lim}/d)$

	Rare Combination	Frequent Combination	Quasi Perm.
$xu_{,lim}/d$	0.70	0.70	0.70
$R_{lim} = M_{u,Lim}/bd^2$	3.22	3.22	2.42

Here R_{lim} is in MPa

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

VERIFICATION OF STRUCTURAL STRENGTH FOR PILE CAP

Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	50	mm

Moment on the section	**Moment at face of support**		
	Rare Combination		**Quasi Permanent Combination**
Actual moment (KNm)	23		11
Grade of Concrete	25		25
Grade of steel fy	500		500
b	1000		1000
D	300		300
c	50		50
d	234.0		234.0
f_{cd}	12.00		9.00
f_{Yd}	300		300
$x_{u,lim}/d$	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	3.22		2.42
$M_{u,Lim}$ (KNm)	176		132
	OK		**OK**
Ast Req.	339		162
Dia of bar (main tension) (mm)	16		16
Spacing (mm)	150		150
+ dia of bar (main tension) (mm)	0		0
Spacing (mm)	150		150
Ast provided (sq mm)	1340		1340
Dia of bar(main compresion at top mm)	12		12
Spacing (mm)	150		150
Area of main compresion (mm^2)	754		754
f_{ctm}	2.2		2.2
x (mm)	67		89
x/d	0.286		0.382
	OK		**OK**
z (mm)	212		204
MR (KNm)	85		82
	OK		**OK**
$\sigma_{sc} = M/(A_s z)$	82		41
	OK		**OK**
$\sigma_{ca} = M/(0.5 z b x_u)$	3.27		1.23
	OK		**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Calculation of crack width	**Moment at face of support**		
n_1	7		7
n_2	7		7
$\phi_{eq} = (n_1\phi_1^2 + n_2\phi_2^2) / (n_1\phi_1 + n_2\phi_2)$	16		16
cl. 12.3.4 (3) of IRC :112-2011			
c	50		50
k1	0.8		0.8
k2	0.5		0.5
For skew slab refer eq. 12.10 of IRC :112-2011			
$\rho_{p.eff} = A_s / A_{c,eff}$	0.009		0.009
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 \phi) / \rho_{p.eff} \}$	474		474
cl. 12.3.4 (3) of IRC :112-2011			
k_t	0.5		0.5
$f_{ct,eff}$	2.90		2.90
E_s	200000		200000
E_{cm}	30000		30000
$\alpha_e = E_s / E_{cm}$	6.67		6.67
$(\varepsilon_{sm} - \varepsilon_{cm}) = (\sigma_{sc} - k_t f_{ct,eff}(1 + \alpha_e \rho_{p,eff}) / \rho_{p,eff}) / E_s$	0.0002		0.0001
cl. 12.3.4 (2) of IRC :112-2011			
$W_k = S_{r,max}(\varepsilon_{sm} - \varepsilon_{cm})$	0.12		0.06
cl. 12.3.4 (1) of IRC :112-2011			
	OK		**OK**

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

APPENDEX - I

Fundamental Time Period of Vibration due to Seismic Waves :

According to **Annexure D (Clause 219.5)** IRC 6 :2017 -

T = 2.0 x sqrt(D/(1000*F))

Where,

T = Fundamental Time Period Of Vibration

D = Appropriate dead Load of the superstructure and Live load in KN

F = Horizontal Force in KN required to be applied at the centre of mass of superstructure for 1 mm horizontal deflection at the top of the 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 Longitudinal direction

			Longitudinal Direction		Transverse Direction	
	F	=	$d*(3EI)/L^3$	Unit	$d*(3EI)/L^3$	Unit
	d	=	0.001	m	0.001	m
	L	=	4.460	m	5.037	m
	E	=	3.00E+07	KN/m2	3.00E+07	KN/m2
	I	=	1.000	m4	256.000	m4
	F	=	1014.467	KN	180287.917	KN
	D	=	2829.000	KN	3248.012	KN
	T	***=***	***0.11***	***sec***	***0.01***	***sec***
Seismic Zone		=	III		III	
Zone Factor Z		=	0.16		0.16	
Importance Factor I		=	1.2		1.2	
Response Reduction Factor		=	3		3	
Soil Strata		=	Type II	Medium soil		
Sa/g			2.5		2.5	
Horizontal Acceleration Coefficient (Ah) Z/2*Sa/g*I/R		=	0.08		0.08	

APPENDEX - II DESIGN CURVE OF PILE SHAFT FOR MAXIMUM BENDING MOMENTS

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Project	NHIDCL	Checked by:	RJ
Project	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

SLENDERNESS CHECK AND CHECK FOR SECOND ORDER EFFECTS

Slenderness check as per IRC 112,Cl.8.3.2

lx/ly <=2.0 & ly/lx <=2.0 — as per eq. 8.1

$(e_x / h_{eq}) / (e_y / b_{eq}) <= 0.20$ OR — as per eq. 8.2

$(e_y / b_{eq}) / (e_x / h_{eq}) <= 0.20$ — From table 11.1:IRC 112

lex	=	12934.61 mm	ley	=	12934.61 mm	
Ixx	=	1.0E+11 mm4	Iyy	=	1.0E+11 mm4	
A	=	1130973 mm2	A	=	1130973 mm2	
$i_y=\sqrt{I/A}$	=	300.0 mm	$i_x=\sqrt{I/A}$	=	300.0 mm	Radius of gyration
b_{eq}	=	86.6 mm	h_{eq}	=	86.6 mm	
l_x	=	43.12	l_y	=	43.12	

Check for Slenderness

1.0	**l_x / l_y**	**=**	**1.00**	**<=2**	Condition Satisfied	from eq 8.1 IRC 112
	l_y / l_x	**=**	**1.00**	**<=2**	Condition Satisfied	

2.0	Design Cases		Case-1	Case-2	Case-3	Case-4	from eq 8.2 IRC 112
	e_x	=	605.87	812.0	657.1	956.3	
	e_y	=	605.87	812.0	657.1	956.3	
	$(e_x/h_{eq}) / (e_y/b_{eq})$	=	1.00	1.00	1.00	1.00	
	$(e_y/b_{eq}) / (e_x/h_{eq})$	=	1.00	1.00	1.00	1.00	

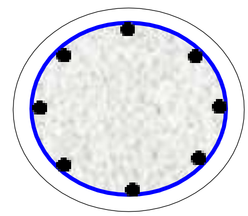
Hence Check for Bending is required

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

<u>Design of Pile Shaft Subjected to Axial Load & Maximum Bending Moments-</u>

<u>Given Data</u>

Pile Size



Diameter (D)	=	1200	mm
Area of Pile (Ag)	=	1.13E+06	mm2

Section R/f

	Equivalent Dia (mm)	Nos.	Area
Outer Peripheri	37	26	27488.936
	37	0	0.00

PROVIDE

	28	X	25	Dia
+	28	X	25	Dia
+	0	X	25	Dia

Ast Provided	=	27488.936	mm2	**OK**
Total No. of Longitudinal Bar	=	26	Nos.	
Total Ast	=	27488.936	mm2	
% of Reinforcement (Pt)	=	2.43	%	
Effective Spacing of Bars	=	119.54	mm	**OK**
Clear Cover	=	75	mm	
Dia of Tie Bar	=	12	mm	
Effective Cover (d')	=	105	mm	
d'/D ratio	=	0.088		

<u>Transverse Reinforcement</u>

As per Clause 16.2.3 of IRC 112:2011

Minimum Diameter of Tie Bars = 0.25 x 25 = 6.25 mm

or 8 mm whichever is greater

Adopt 8 mm dia Helical Reinforcement

Pitch of Lateral Ties shall not exceed

= 12 x 25 = 300 mm

or 1200 mm

or 200 mm whichever is less

or 150 mm As per IRC 78-2014

Adopt 150 mm c/c spacing

Provide 8mm dia bar @ 150c/c as Spiral Helical Tie Bar beyond Point of Fixity

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Ductile Detailing as per IRC:112-2019, Clause 17.2.1

Confinement Reinforcement

$nk = \frac{N_{ED}}{Acfck} = \frac{3372165}{2.83E+07} = 0.12 > 0.06$

IF nk > 0.064 , Confinement R/f shall be provided as per Clause 17.2.1.4 of IRC:112-2019

IF nk < 0.064 , Confinement R/f shall be provided as per Clause 17.2.2 of IRC:112-2019

Adopt Spacing of Hoops = 125 mm

As per Cl. 17.2.1.3 of IRC 112:2019

Spacing of Hoops

SL	<=	5 x	25	=	125	mm	OK
	<=	0.2 x	1042	=	208.4	mm	OK

Dsp = 1050 mm

Dia of Spiral Provided = 10 mm

$\omega_{wd} = \rho_w\, f_{yd}/f_{cd}$

where $\rho_w = \frac{4*Asp}{Dsp*SL}$

Asp	=	78.54	mm2
SL	=	125	mm c/c
Dsp	=	1050	mm
ρ_w	=	0.002	
$\omega_{wd,c}$	=	0.093	

Minimum Confining Reinforcement: as per Clause 17.2.1.2 of IRC:112-2019

$\omega_{wd,c}$ >= max (1.4*ωw.req, 0.18)

$\omega_{w,req} = \frac{0.37Ac*nk}{Acc} + \frac{0.13*fyd(\rho L-0.01)}{fcd}$

Ac	=	1.13E+06	
Acc	=	8.66E+05	mm^2
nk	=	0.12	
ρL	=	0.02431	
$\omega_{w,req}$	=	0.13005	
$\omega_{wd,c}$	=	0.18207	

105.00962

$\omega_{wd,c}$ = 6.990 OK

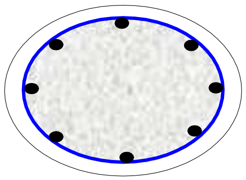
Material Property

Concrete Grade	=	**M25**	
Steel Grade	=	**Fe500**	
Characteristic Compressive Strength of Concrete at 28 days,fck	=	25.00	N/mm^2
Design strength of concrete, fcd=0.446fck	=	11.17	N/mm^2
Yield Strength of Reinforcement Steel ,fy	=	500	N/mm^2
Design Yield Strength of Reinforcement Steel ,fyd	=	434.78	N/mm^2
Modulus of Elasticity of Concrete (Ec)	=	25000.0	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2
Factor of Safety For Concrete	=	1.5	
Factor of Safety For Steel	=	1.15	
Maximum Strain in Concrete,εcu	=	0.0035	
Yield Strain in Concrete, ε_{cd}	=	0.002	
Yield Strain in Steel,ε_{st}(ε_{yd})	=	0.002174	
Max. Strain in steel, ε_{stu}	=	0.004174	

Summary of Design Forces at Pile Fixity:

Load Cases		Axial Load (KN)	Initial Resultant Moment (KN-m)	Final Design Moment (KN-m)
		Pu	M	Mu
Normal Dry Case	Max	2279.83	690.64	690.64
	Min	1213.90	580.42	580.42
Seismic Case	Max	2310.50	646.71	646.71
	Min	1142.94	603.53	603.53

DESIGN OF RECTANGULAR SECTION FOR ABUTMENT SHAFT - ULTIMATE LIMIT STATE



Section dimensions of pier shaft

Length, B = 1200 mm (equivalent length of pier shaft)
Thickness,D = 0 mm

Material properties
fck = 25.00 Mpa
fyk = 500 Mpa
Es = 200000 Mpa

Design axial resistance of section
N_{Rd} = Ac * fcd + As * fyd
fcd = $\alpha_{cc} x f_{ck} / \gamma_m$ α_{cc} = 0.67
= 11.167 Mpa γ_m = 1.5
fyd = fyk/γ_s γ_s = 1.15
= 434.7826 Mpa
N_{Rd} = 11951.71 KN

Reinforcement Details

Reinf.	Dia.(mm)	Spacing (mm)	Cover (mm)	From (mm)	To (mm)	Y_{CG} (mm)	Nos.
As1	25	120	75	0	0	0.00	28.00
As2	25	75	75	0	0	0.00	28.00

Total reinforcement

As3 (Along length Tension face) = 0.00 mm^2
As4 (Along length Compression face) = 0.00 mm^2
As2 (Along width Tension face) = 13744.47 mm^2
As1 (Along width Compression face) = 13744.47 mm^2
Total As = **27488.9 mm^2**
Total As = **mm^2**
= **2.43 %**

Formula used for interaction diagram

Pu = Cc +Cs
Mu = Mc + Ms

Cc = 0.361*fck*Xu*b for Xu $\leq$ D
= 0.447*fck*(1-4*g/21)*b*D for Xu $\geq$ D

g = $16 / (7Xu / D-3)^2$

$Cs = \sum (fsi - fci)\ Asi$

$fci = 0.00$ for $\varepsilon_{si} \le 0$

$= 0.447\ fck$ for $\varepsilon_{si} \ge 0.002$

$= 0.447fck\ \ 2*(\varepsilon_{si}/0.002)-(\varepsilon_{si}/0.002)^2$ otherwise

$fsi = -0.87\ fy$ for $\varepsilon_{si} \le -0.00217$

$= \varepsilon_{si} * Es$ for $0.00217 \ge \varepsilon_{si} > -0.00217$

$= 0.87fy$ for $\varepsilon_{si} > 0.00217$

$Mc = Cc * (0.5D - x)$

$Ms = \sum Csi * yi$

$x = 0.416\ Xu$ for $Xu \le D$

$= (0.5 - 8*g/49)*D/(1-4*g/21)$ for $Xu \ge D$

Where x = Centroid of stress block area from most compressed edge.

$\varepsilon_{si} = \dfrac{0.0035 *\ \ Xu - D/2 + y_i}{Xu}$ for $Xu \le D$

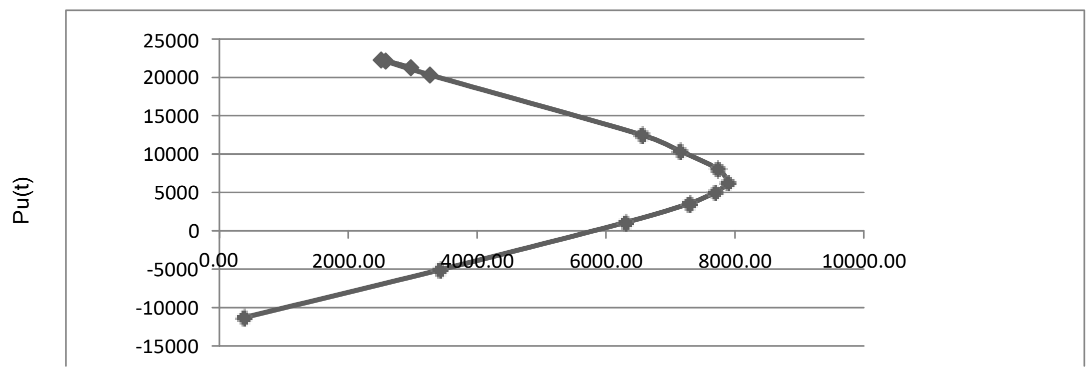
$= \dfrac{0.002 *\ \ 1 + y_i - D/14}{Xu - 3D/7}$ for $Xu > D$

Where y_i = Distance of ith row of steel from the centroidal axis measured positive in the direction towards the highly compressed edge.

Along traffic direction

Xu/D	=	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
D(mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Xu (mm)	=	60	120	240	360	480	600	720	840	960	1080	1200	1320	1440
	<	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
g (Mpa)	=	2.278391	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.366864	1.469238	1	0.72431	0.54869684
Cc (KN)	=	649.8	1299.6	2599.2	3898.8	5198.4	6498.0	7797.6	9097.2	10396.8	11696.4	13026.9	13871.9	14410.2
y1 (compr. face in mm)	=	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5	500.5
y1 (tension face in mm)	=	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5	-500.5
y2 (compr. face in mm)	=	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5	450.5
y2 (tension face in mm)	=	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5	-450.5
ε_{si}(compr. face in mm)	=	-0.0023	0.000598	0.002049	0.002533	0.002774	0.00292	0.003016	0.003085	0.003137	0.003178	0.00321	0.00303	0.00289614
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.0607	-0.0286	-0.01255	-0.0072	-0.00452	-0.00292	-0.00185	-0.001085	-0.000512	-6.64E-05	0.00029	0.000545	0.00073349
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{s2}(compr. face in mm)	=	-0.00522	-0.00086	0.00132	0.002047	0.00241	0.002628	0.002773	0.002877	0.002955	0.003016	0.003064	0.002905	0.00278812
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{s2} (tension face in mm)	=	-1.52158	-1.07676	-0.45388	-0.12235	-0.00499	-0.02464	-0.104108	-0.166229	-0.133827	0.070275	0.52325	0.000669	0.00084151
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	5.682941	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175
fsi(comp.face in Mpa)	=	-435	119.5833	409.7917	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	3.007786	5.259408	6.69367547
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-369.9306	-217.0833	-102.4479	-13.29	58.04167	108.9716	146.697531
fc2 (comp.face in Mpa)	=	0	0	9.882378	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175
fs2(comp.face in Mpa)	=	-435	-172.083	263.9583	409.3056	435	435	435	435	435	435	435	435	435
fc2 (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	11.175	11.175	6.22549	7.42552588
fs2 (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-435	-435	-435	435.00	435	133.7943	168.302469
Cs (KN)	=	-11957.7	-6378.7	-1493.4	-330.2	-153.6	-153.6	293.6	1344.0	2131.8	8646.6	9116.1	7414.7	7893.0
Mc (KN-m)	=	373.7	714.9	1300.0	1755.4	2081.0	2276.9	2343.0	2279.4	2086.0	1762.9	1313.6	951.5	720.8
Ms (KN-m)	=	0.00	2701.95	5000.61	5533.30	5612.85	5612.85	5389.04	4863.31	4469.02	1503.47	1268.48	2018.24	1790.29
Pu (KN)	**=**	**-11307.9**	**-5079.1**	**1105.8**	**3568.6**	**5044.8**	**6344.4**	**8091.2**	**10441.2**	**12528.6**	**20343.0**	**22142.9**	**21286.6**	**22303.1**
Mu (KN-m)	**=**	**373.7**	**3416.8**	**6300.6**	**7288.7**	**7693.9**	**7889.7**	**7732.1**	**7142.7**	**6555.0**	**3266.4**	**2582.1**	**2969.7**	**2511.1**

Mu (KN-m)	**Pu (KN)**
373.7	-11307.9
3416.83	-5079.09
6300.62	1105.81
7288.69	3568.63
7693.87	5044.81
7889.75	6344.41
7732.06	8091.18
7142.70	10441.18
6555.03	12528.58
3266.35	20342.96
2582.11	22142.94



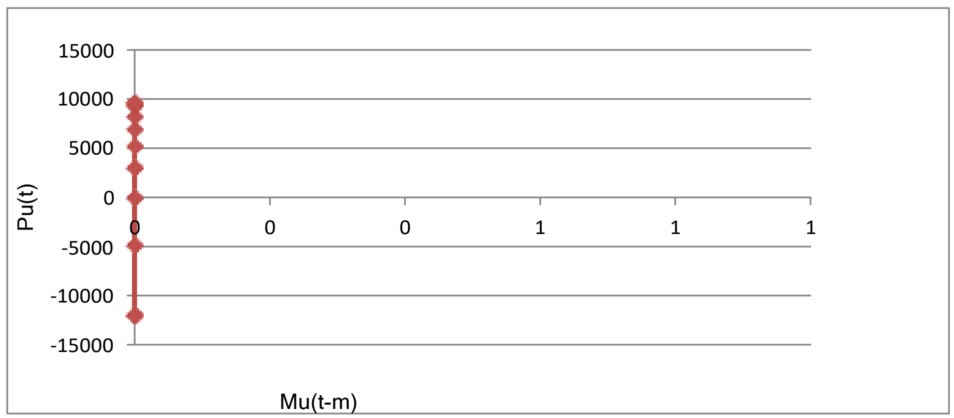
2969.71	21286.55
2511.08	22303.14

Interaction diagram Mu(t-m)

Along transverse direction

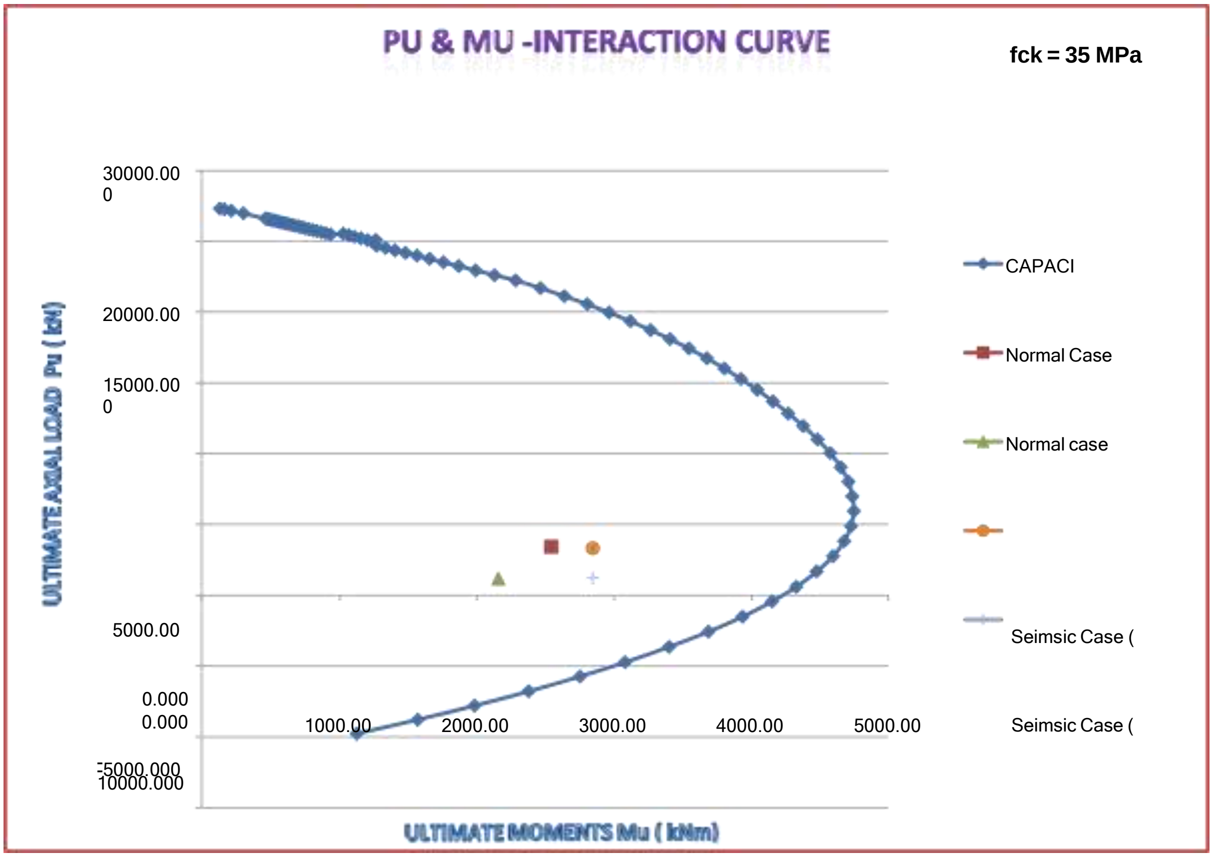
Xu/D	=	0.025	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
D(mm)	=	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Xu (mm)	=	30	120	240	360	480	600	720	840	960	1080	1200	1320	1440
	<	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
g (Mpa)		2.004856	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.366864	1.469238	1	0.72431	0.54869684
Cc (KN)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yi (compr. face in mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
yi (tension face in mm)	=	0	0	0	0	0	0	0	0	0	0	0	0	0
ε_{si}(compr. face in mm)	=	-0.0665	-0.014	-0.00525	-0.00233	-0.00088	0	0.000583	0.001	0.001313	0.001556	0.00175	0.001787	0.00181481
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.0665	-0.014	-0.00525	-0.00233	-0.00088	0	0.000583	0.001	0.001313	0.001556	0.001750	0.001787	0.00181481
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	0	0	0	0	0	5.568099	8.38125	9.854517	10.62315	11.00039	11.04853	11.0791924
fsi(comp.face in Mpa)	=	-435	-435	-435	-435	-175	0	116.6667	200	262.5	311.1111	350	357.4468	362.962963
fci (tension face in Mpa)	=	0	0	0	0	0	0	5.568099	8.38125	9.854517	10.62315	11.00039	11.04853	11.0791924
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-175	0	116.6667	200	262.5	311.1111	350	357.4468	362.962963
Cs (KN)	=	-11957.7	-11957.7	-11957.7	-11957.7	-4810.6	0.0	3054.0	5267.4	6945.0	8260.1	9318.7	9522.1	9672.9
Mc KN-m)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ms (KN-m)	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu (KN)	**=**	**-11957.7**	**-11957.7**	**-11957.7**	**-11957.7**	**-4810.6**	**0.0**	**3054.0**	**5267.4**	**6945.0**	**8260.1**	**9318.7**	**9522.1**	**9672.9**
Mu (KN-m)	**=**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Mu (KN-M)	Pu (KN)
0.00	-11957.69
0.00	-11957.69
0.00	-11957.69
0.00	-11957.69
0.00	-4810.56
0.00	0.00
0.00	3053.98
0.00	5267.40
0.00	6944.96
0.00	8260.09
0.00	9318.74
0.00	9522.12
0.00	9672.91



Interaction diagram

The abodemand demand the section ve figure presents a typical axial force - bending moment interaction curve for pile section at top for given amount of reinforcement. The as due to various load cases as presented in table are shown by filled circles. This provides a graphical representation of capacity of the due to various load cases. Since demand points are within the interaction curve,
on is safe for the present load cases.



ANNEXURE IIA:- DESIGN CURVE OF PILE SHAFT FOR MAXIMUM BENDING MOMENTS (CURTAILMENT)

APPENDEX - III DESIGN CURVE OF ABUTMENT SHAFT FOR MAXIMUM BENDING MOMENTS

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

SLENDERNESS CHECK AND CHECK FOR SECOND ORDER EFFECTS

Slenderness check as per IRC 112,Cl.8.3.2- page 74

lx/ly <=2.0 & ly/lx <=2.0 — as per eq. 8.1

$(e_x / h_{eq}) / (e_y / b_{eq}) <= 0.20$ OR $(e_y / b_{eq}) / (e_x / h_{eq}) <= 0.20$ — as per eq. 8.2

Type of Bearings = POT PTFE Bearing

Effective Length = 1.4

l	=	2.66	m Clear Height of Pier				
b_{eq}	=	16000	mm				
h_{eq}	=	1000	mm				
lex	=	3724	mm	ley	=	3724	mm
Ixx	=	3.4E+14	mm4	Iyy	=	1.3E+12	
A	=	1.60E+07	mm2	A	=	1.60E+07	mm2
$i_y=\sqrt{I/A}$	=	4618.8	mm	$i_x=\sqrt{I/A}$	=	288.7	mm
b_{eq}	=	16000	mm	h_{eq}	=	1000	mm
l_x	=	0.8		l_y	=	12.9	

Check for Biaxial Bending

1.0	**l_x / l_y**	**=**	**0.06**	**<=2**	Condition Satisfied	from eq 8.1 IRC 112
	l_y / l_x	**=**	**16.00**	**>2**	Condition not Satisfied	

2.0	Design Cases		Case-1	Case-2	Case-3	from eq 8.2 IRC 112
	e_x	=	832.44	832.44	888.72	
	e_y	=	1019.31	1019.31	1102.21	
	$(e_x/h_{eq}) / (e_y/b_{eq})$	=	13.07	13.07	12.90	
	$(e_y/b_{eq}) / (e_x/h_{eq})$	=	0.08	0.08	0.08	

Hence Check for Biaxial Bending is required

3.0 Check for Second Order Effect

Second order effect may be ignored og the slenderness ratio is less than

l_{lim}	=	20ABC / √n	Concrete Grade		M25	
A	=	$1/(1+0.2\Phi_{eff})$	0.7			
Φ_{eff}	=	$\Phi(\infty,t_0)$	1.68	M_{0Eqp} =	First Order BM in Quasi Permanent Combinations	
				M_{0Ed} =	First Order BM in Design Load Combinations	
B	=	$\sqrt{(1+2\omega)}$	1.1	ω =	A_sf_{yd} / A_cf_{cd}	Reinforcement Ratio
C	=	$1.7-r_m$	0.7	r_m =	M_{01}/M_{02}	Moment Ratio
n	=	N_{Ed} / (A_cf_{cd})		M_{01}, M_{02} =	First Order End Moments at two ends of Member	

As per Cl. 11.2.1 IRC-112-2011 initial dimensioning A, B C can be taken as 0.7, 1.1 and 0.7 respectively

	N_{Ed}	=	1164.90	1164.90	1082.38
	A_c	=	1.60E+07	1.60E+07	1.60E+07
	f_{cd}	=	11.17	11.17	11.17
	n	=	0.0652	0.0652	0.0606
Long	M_{0Eqp}	=	204.19	204.19	204.19
Long	M_{0Ed}	=	969.71	969.71	961.93
	Φ_{eff}	=	0.35	0.35	0.36
	A	=	0.93	0.93	0.93
	l_{lim}	=	56.33	56.33	58.44
	l_x	=	0.8	0.8	0.8
	Check	=	**Second Order Effects shall be Ignored in x Direction**		
Trans	M_{0Eqp}	=	90.91	90.91	90.91
Trans	M_{0Ed}	=	1187.40	1187.40	1193.01
	Φ_{eff}	=	0.13	0.13	0.13
	A	=	0.97	0.97	0.98
	l_{lim}	=	58.80	58.80	61.00
	l_y	=	12.9	12.9	12.9
	Check	=	**Second Order Effects shall be Ignored in y Direction**		

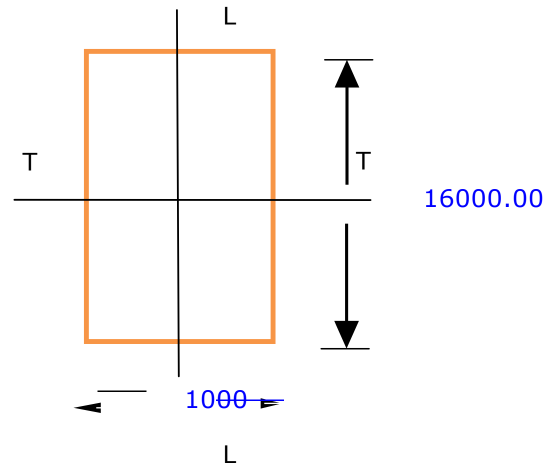
Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
Client	NHIDCL	Checked by:	RJ
Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

CHECKING OF STRESS IN WALL TYPE ABUTMENT SHAFTY

Given Data :

Abutment Size:

Width (B)	=	1000	mm	
Depth (D)	=	16000.00	mm	
Area (Ac)	=	1.60E+07	mm2	
Length (Lo)	=	**2.660**	m	



Section Reinforcement:

Dia. Of Bars	=	25	mm	
Nos. of Bars Along Width (B)	=	6	Nos.	
Nos. of Bars Along Depth (D)	=	130	Nos.	
Total Nos. of Bars	=	272	Nos.	
Total Ast	=	133518	mm^2	
% of Reinforcement (Pt)	=	0.83	%	
Clear Cover	=	50	mm	
Dia of Tie bar	=	12	mm	
D/B	=	16.00	Wall Type Abutment	

Vertical Reinforcement For Wall Type Abutment as per IRC: 112-2019 , Clause 16.3.1

Minimum Vertical Reinforcement	=	0.0012	Ac	on each Face	
	=	19200	mm^2		
Provided Vertical Reinforcement	=	66759	mm^2		**OK**
Maximum Vertical Reinforcement	=	0.02	Ac	on each face	
	=	320000	mm^2		**OK**
Spacing between Vertical Reinf.	=	123	mm		**<200 mm OK**

Horizontal Reinforcement for Wall Type Abutment as per IRC: 112-2019 , Clause 16.3.2

Horizontal r/f should be	=	0.2500	x	133517.7	=	33379.42
maximum of following	=	0.001	x	1.60E+07	=	16000.00
Minimum Horizontal Reinf. =		33379	mm^2			
Dia of bar	=	20	mm			**OK**
Min dia of bar	=	0.25Ø	mm		=	6.25 mm
	or	8	mm			
Maximum Spacing between bars	<=	300	mm c/c			
Provide 2 L	25 dia@	130	c/c		=	40176 mm^2
						OK
						35582

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
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Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

Ductile Detailing as per IRC:112-2019, Clause 17.2.1

Confinement Reinforcement

nk = $\frac{N_{ED}}{Acfck}$ = $\frac{11427689}{4.00E+08}$ = 0.03 < 0.064

IF nk > 0.064 , Confinement R/f shall be provided as per Clause 17.2.1.4 of IRC:112-2019

IF nk < 0.064 , Confinement R/f shall be provided as per Clause 17.2.2 of IRC:112-2019

Specing of Transverse Ties

	SL	<=	5	x	25	=	125	mm
		<=	0.2	x	876	=	175.2	mm
Provide	SL	=	125	mm	**OK**			

	ω_{wd}	=	ρw fyd/fcd					
where	ρw	=	Asw / SL*b					
	Asw	=	25	dia	2L	=	981.748	mm^2
	SL	=	150	mm c/c				
	b	=	1000	mm				
	ρw	=	0.00654					
	ω_{wd}	=	0.2548	**OK**				

Minimum Confining Reinforcement: as per Clause 17.2.1.2 of IRC:112-2019

ω_{wd} = max (ωw.req, 0.12)

$\omega_{w,req}$ = $\frac{0.37Ac*nk}{Acc}$ + $\frac{0.13*fyd(\rho L-0.01)}{fcd}$

Ac	=	1.60E+07	
Acc	=	13907376	mm^2
nk	=	0.03	
ρL	=	0.00834	
$\omega_{w,req}$	=	0.00378	
ω_{wd}	=	0.12000	

Project	Preparation of DPR for Tamenglong- Mahur section of NH-137 instate of Assam on EPC mode	Designed by:	
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Job Name	DESIGN OF SUBSTRUCTURE & PILE FOUNDATION OF ABUTMENTS A1 & A2	Date & Rev.	

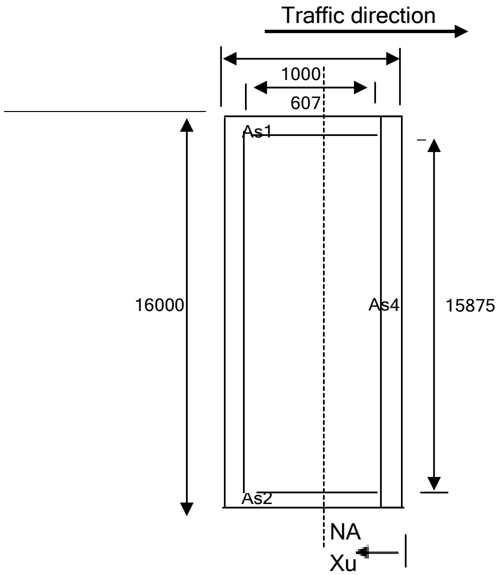
Material Property

Concrete Grade	=	**M25**	
Steel Grade	=	**Fe500**	
Characteristic Compressive Strength of Concrete at 28 days,fck	=	25.00	N/mm^2
Design strength of concrete, fcd=0.446fck	=	11.17	N/mm^2
Yield Strength of Reinforcement Steel ,fy	=	500	N/mm^2
Design Yield Strength of Reinforcement Steel ,fyd	=	434.78	N/mm^2
Modulus of Elasticity of Concrete (Ec)	=	25000.0	N/mm^2
Modulus of Elasticity of Steel (Es)	=	200000	N/mm^2
Factor of Safety For Concrete	=	1.5	
Factor of Safety For Steel	=	1.15	
Maximum Strain in Concrete,εcu	=	0.0035	
Yield Strain in Concrete, ε_{cd}	=	0.002	
Yield Strain in Steel,$\varepsilon_{st}(\varepsilon_{yd})$	=	0.002174	
Max. Strain in steel, ε_{stu}	=	0.004174	

Summary of Design Forces at Abutment Shaft Bottom :

Load Cases	Axial Load (kN)	Initial Moment (kNm)		Final Design Moment (kNm)	
	Pu or N_{Ed}	Mx(MT)	My(ML)	Mux	Muy
Normal Case 1	**11427.7**	**11648.4**	**9512.8**	11648.37	9512.81
Normal Case 2	**11427.7**	**11648.4**	**9512.8**	11648.37	9512.81
Normal Case 3	**10618.2**	**11703.4**	**9436.5**	11703.43	9436.53
Seismic Case 4	**9144.2**	**4200.4**	**7141.2**	4200.36	7141.19
Seismic Case 5	**9144.2**	**4200.4**	**7141.2**	4200.36	7141.19
Seismic Case 6	**9036.3**	**6559.7**	**4779.1**	6559.66	4779.06

DESIGN OF RECTANGULAR SECTION FOR ABUTMENT SHAFT - ULTIMATE LIMIT STATE



Section dimensions of pier shaft

Length, B = 16000 mm (equivalent length of pier shaft)
Thickness,D = 1000 mm

Material properties

fck = 25.00 Mpa
fyk = 500 Mpa
Es = 200000 Mpa

Design axial resistance of section

N_{Rd} = Ac * fcd + As * fyd

fcd = α_{cc} xf_{ck} /γ_m — α_{cc} = 0.67
= 11.167 Mpa — γ_m = 1.5
fyd = fyk/γ_s — γ_s = 1.15
= 434.7826 Mpa
N_{Rd} = 236717.8 KN

Reinforcement Details

Reinf.	Dia.(mm)	Spacing (mm)	Cover (mm)	From (mm)	To (mm)	Y_{CG} (mm)	Nos.
As1	25	134	50	196.5	803.5	401.75	6.00
As2	25	134	50	197	804	401.75	6.00
As3	25	134	50	62.5	15938	7968.75	130.00
As4	25	134	50	62.5	15938	7968.75	130.00

Total reinforcement

As3 (Along length Tension face) = 63813.60 mm^2
As4 (Along length Compression face) = 63813.60 mm^2
As2 (Along width Tension face) = 2945.24 mm^2
As1 (Along width Compression face) = 2945.24 mm^2
Total As = 133517.7 mm^2

= 0.83 %

Formula used for interaction diagram

Pu = Cc +Cs
Mu = Mc + Ms

Cc = 0.361*fck*Xu*b — for Xu ≤ D
= 0.447*fck*(1-4*g/21)*b*D — for Xu ≥ D

g = 16 / (7Xu / D-3)^2

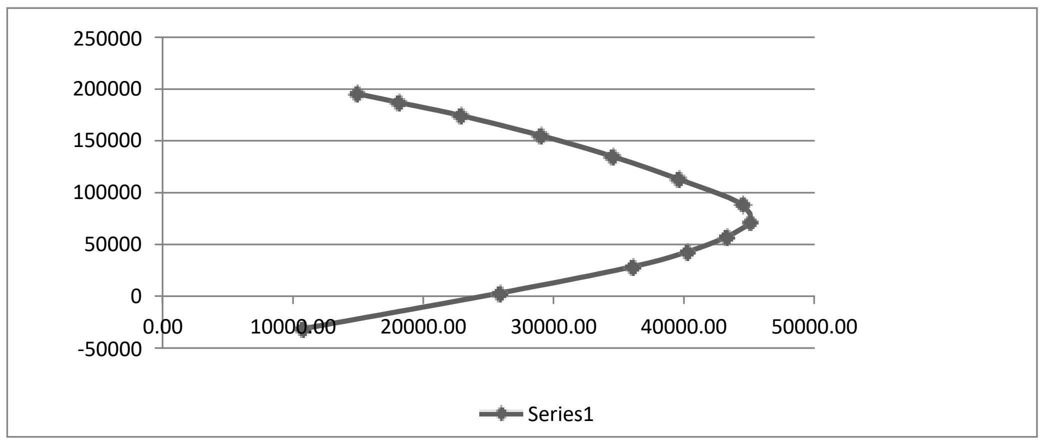
Cs	=	$\sum$ (fsi - fci) Asi	
fci	=	0.00	for ε_{si} <_0
		0.447 fck	for ε_{si} >_0.002
		0.447fck 2* (ε_{si}/0.002)-(ε_{si}/0.002)^2	otherwise
fsi	=	-0.87 fy	for ε_{si} <_-0.00217
		ε_{si} * Es	for 0.00217 $\geq \varepsilon_{si}$ > -0.00217
		0.87fy	for ε_{si} > 0.00217
Mc	=	Cc * (0.5D -x)	
Ms	=	$\sum$ Csi * yi	
x	=	0.416 Xu	for Xu $\leq$ D
	=	(0.5 - 8*g /49)* D/(1-4*g/21)	for Xu $\geq$ D
Where x	=	Centroid of stress block area from most compressed edge.	
ε_{si}	=	$\frac{0.0035 * Xu- D/2 +y_i}{Xu}$	for Xu $\leq$ D
	=	0.002* 1+ y_i - D/14 Xu - 3D/7	for Xu > D
Where y_i	=	Distance of ith row of steel from the centroidal axis measured positive in the direction towards the highly compressed edge.	

Along traffic direction

Xu/D	=	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
D(mm)	=	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Xu (mm)	=	50	100	200	300	400	500	600	700	800	900	1000	1100	1200
	<	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
g (Mpa)	=	2.278391	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.3668639	1.469238	1	0.72431	0.548697
Cc (KN)	=	7220.0	14440.0	28880.0	43320.0	57760.0	72200.0	86640.0	101080.0	115520.0	129960.0	144742.9	154132.1	160113.0
yi (compr. face in mm)	=	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5	437.5
yi (tension face in mm)	=	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5	-437.5
ε_{si}(compr. face in mm)	=	-0.000875	0.001313	0.002406	0.002771	0.002953	0.003063	0.003135	0.003188	0.0032266	0.003257	0.003281	0.00309	0.002949
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.062125	-0.02931	-0.012906	-0.00744	-0.0047	-0.00306	-0.001969	-0.001188	-0.000602	-0.000146	0.000219	0.000484	0.000681
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	0	9.854517	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175
fsi(comp.face in Mpa)	=	-175	262.5	435	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	2.310846	4.754608	6.311267
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-393.75	-237.5	-120.3125	-29.17	43.75	96.80851	136.1111
Cs (KN)	=	-38926.3	-11636.7	-713.1	-713.1	-713.1	-713.1	1919.2	11890.1	19368.2	25184.6	29690.2	32920.1	35328.8
Mc (KN-m)	=	3459.8	6619.3	12037.2	16253.7	19268.7	21082.4	21694.7	21105.5	19314.9	16323.0	12163.3	8810.0	6673.9
Ms (KN-m)	=	7258.8	19198.0	23977.1	23977.1	23977.1	23977.1	22825.4	18463.2	15191.5	12646.8	10675.6	9262.5	8208.7
Pu (KN)	**=**	**-31706.3**	**2803.3**	**28166.9**	**42606.9**	**57046.9**	**71486.9**	**88559.2**	**112970.1**	**134888.2**	**155144.6**	**174433.0**	**187052.2**	**195441.7**
Mu (KN-m)	**=**	**10718.6**	**25817.3**	**36014.2**	**40230.7**	**43245.8**	**45059.5**	**44520.1**	**39568.7**	**34506.4**	**28969.8**	**22838.9**	**18072.5**	**14882.7**

Mu (KN-m)	Pu (KN)
10718.6	-31706.3
25817.29	2803.30
36014.25	28166.88
40230.73	42606.88
43245.80	57046.88
45059.46	71486.88
44520.08	88559.19
39568.67	112970.07
34506.42	134888.23
28969.80	155144.57
22838.89	174433.04
18072.51	187052.17
14882.67	195441.75

Pu(t)

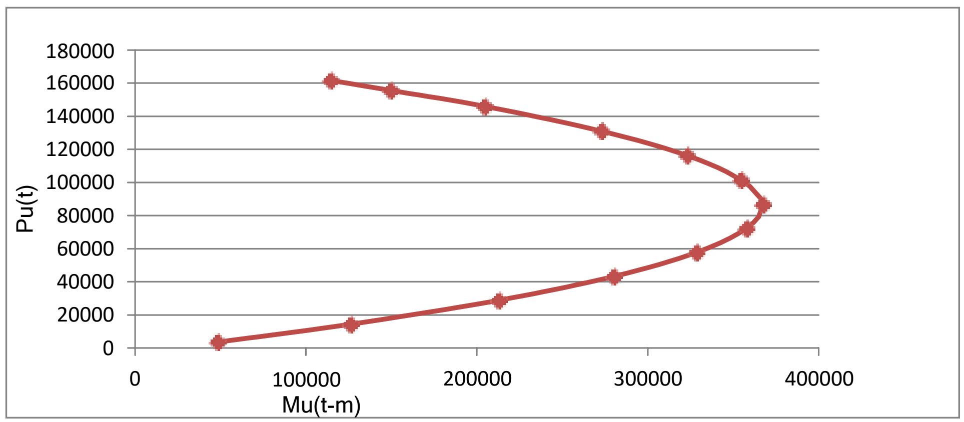


Interaction diagram Mu(t-m)

Along transverse direction

Xu/D	=	0.025	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2
B (mm)	=	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
D(mm)	=	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Xu (mm)	=	400	1600	3200	4800	6400	8000	9600	11200	12800	14400	16000	17600	19200
	<	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
g (Mpa)		2.004856	3.024575	6.25	19.75309	400	64	11.11111	4.432133	2.3668639	1.469238	1	0.72431	0.548697
Cc (KN)	=	3610.0	14440.0	28880.0	43320.0	57760.0	72200.0	86640.0	101080.0	115520.0	129960.0	144742.9	154132.1	160113.0
yi (compr. face in mm)	=	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5	7937.5
yi (tension face in mm)	=	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5	-7937.5
ε_{si}(compr. face in mm)	=	0.002953	0.003363	0.003432	0.003454	0.003466	0.003473	0.003477	0.00348	0.0034829	0.003485	0.003486	0.003265	0.003101
	>	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
ε_{si} (tension face in mm)	=	-0.135953	-0.03136	-0.013932	-0.00812	-0.00522	-0.00347	-0.002311	-0.00148	-0.000858	-0.000374	0.000014	0.00031	0.000529
	<	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
fci (comp.face in Mpa)	=	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175	11.175
fsi(comp.face in Mpa)	=	435	435	435	435	435	435	435	435	435	435	435	435	435
fci (tension face in Mpa)	=	0	0	0	0	0	0	0	0	0	0	0.152261	3.191124	5.126858
fsi (tension face in Mpa)	=	-435	-435	-435	-435	-435	-435	-435	-296.0938	-171.582	-74.73958	2.734375	61.9016	105.7292
Cs (KN)	=	-32.9	-32.9	-32.9	-32.9	-32.9	-32.9	-32.9	376.2	742.9	1028.1	1255.9	1421.2	1544.6
Mc KN-m)	=	28279.3	105908.7	192594.9	260058.6	308299.8	337318.4	347114.5	337688.1	309039.1	261167.6	194612.2	140959.5	106783.1
Ms (KN-m)	=	20077.5	20077.5	20077.5	20077.5	20077.5	20077.5	20077.5	16830.2	13919.3	11655.4	9847.8	8535.6	7556.3
Pu (KN)	**=**	**3577.1**	**14407.1**	**28847.1**	**43287.1**	**57727.1**	**72167.1**	**86607.1**	**101456.2**	**116262.9**	**130988.1**	**145998.7**	**155553.3**	**161657.5**
Mu (KN-m)	**=**	**48356.8**	**125986.2**	**212672.4**	**280136.1**	**328377.3**	**357395.9**	**367192.0**	**354518.2**	**322958.5**	**272823.0**	**204460.0**	**149495.1**	**114339.4**

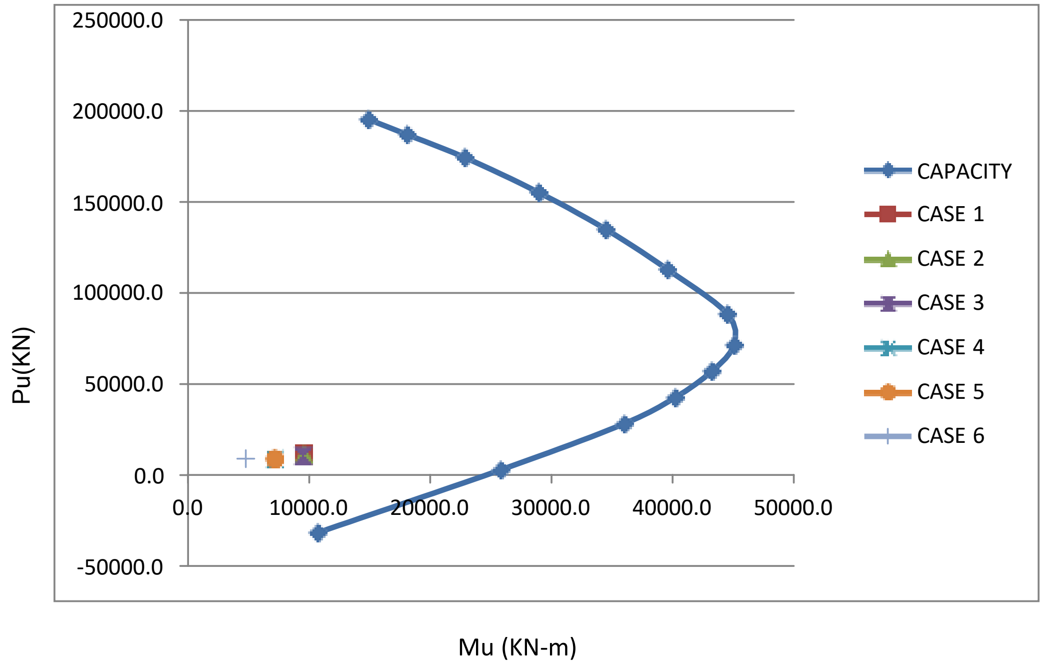
Mu (KN-M)	**Pu (KN)**
48356.79	3577.09
125986.23	14407.09
212672.44	28847.09
280136.12	43287.09
328377.27	57727.09
357395.90	72167.09
367191.99	86607.09
354518.23	101456.20
322958.45	116262.92
272822.99	130988.14
204460.01	145998.73
149495.12	155553.27
114339.38	161657.52



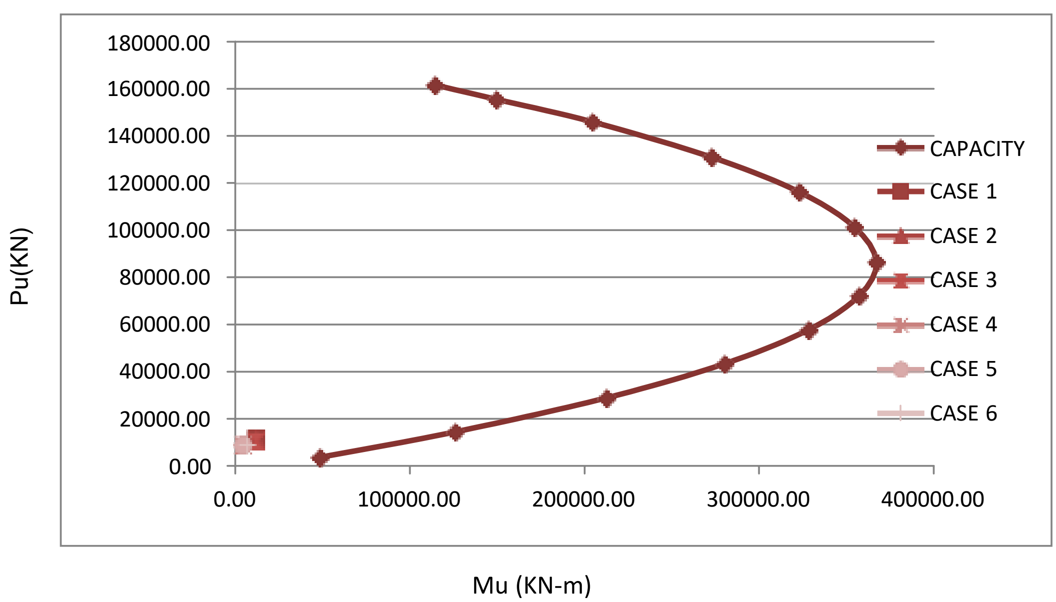
Interaction diagram

Load Cases	Axial Load (kN)	Final Design Moment (kNm)		Permissible Moment (kNm)		Max. Tensile Stress in Steel (N/mm^2)		N_{ED}/N_{RD}	a	$\left(\frac{Mux}{Mux1}\right)^{a} + \left(Muy1\right)^{a}$	**Section Status**
	Pu or N_{Ed}	Mux	Muy	Mux1	Muy1	Fsx	Fsy				
Normal Case 1	11427.7	11648.4	9512.8	104629.91	29284.57	434.8	434.8	0.05	1.00	0.44	**SAFE**
Normal Case 2	11427.7	11648.4	9512.8	104629.91	28959.11	434.8	434.8	0.05	1.00	0.44	**SAFE**
Normal Case 3	10618.2	11703.4	9436.5	98827.21	28959.11	434.8	434.8	0.04	1.00	0.44	**SAFE**
Seismic Case 4	9144.2	4200.4	7141.2	88262.21	28366.55	434.8	434.8	0.04	1.00	0.30	**SAFE**
Seismic Case 5	9144.2	4200.4	7141.2	88262.21	28366.55	434.8	434.8	0.04	1.00	0.30	**SAFE**
Seismic Case 6	9036.3	6559.7	4779.1	87488.51	28323.16	434.8	434.8	0.04	1.00	0.24	**SAFE**

Pu-Mu Interaction Curve
Along the Traffic Direction



Pu-Mu Interaction Curve
Across the Traffic Direction



Calculation of Creep Coeffiecient *(As per Annexure A2, A2.5, IRC:112-2011)*

$\Phi(t,t_0)$	=	$\beta_c(t,t_0).\Phi_0$		=	**1.68**	
Where,						
Φ_0	=	$\Phi_{RH}\ \beta(f_{cm})\ \beta(t_0).$		=	1.71	
t	=	Age of concrete in days at time the time considered =		=	25550	days
t_0	=	is the age of Concrete in days at time of loading		=	90	days
Φ_{RH}	=	$1+(1-RH/100)/(0.1*h_0^{1/3})$	for fcm <= 45	=	1.38	
RH	=	Relative Humidity		=	63	%
fck	=	Characteristic Compressive Strength		=	25	MPa
fcm	=	Mean Compressive Strength		=	35	MPa
$\beta(f_{cm})$	=	$18.78/\sqrt{f_{cm}}$		=	3.17	
$\beta(t_0).$	=	$1/(0.1+t_0^{0.2})$		=	0.39	
h_0	=	Notional side of Member	2Ac/u	=	941.2	mm
w	=	Width of Section		=	16000	mm
h	=	Depth of Section		=	1000	mm
Ac	=	Cross Sectional Area, mm2		=	1.6E+07	mm2
u	=	Perimeter in Contact with atmosphere		=	34000	mm
$\beta_c(t,t_0)$	=	$[(t-t_0) / (\beta H + t - t_0)]^{0.3}$		=	0.983	
$(t-t_0)$	=	Actual duration of loading		=	25460	days
βH	=	$1.5(1+(1.2\ RH/RH_0)^{18})h_0 + 250$	<= 1500 fcm = 45	=	1500.0	
RH_0	=			=	100	%

DESIGN OF BREAST WALL & RETAINING WALL

DESIGN OF STRAIGHT RETAINING WALL FOR HEIGHT 5 M FROM G.L

INDEX

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

Design Input:

Skew Angle of Bridge		0	Degree	0 Radians
			COS θ = 1	
			SIN θ = 0	

Design Length of Wall = 1.000 m

Levels

FRL = 100.000 m (Assumed)

Wall shaft top level = 100.000 m

Ground level/LBL/MSL = 95.000 m (Assumed)

Foundation level = 93.000

Shaft bottom level = 93.550 m

Coeff. Of Friction μ = 0.500

FRL - FND LVL. H = 7.000 m

SBC of soil-Normal Case = 220.000 kN/m2

Permissible FOS against Sliding = 1.500 Normal Case

Permissible FOS against Overturning = 2.000 Normal Case

Wall

Thickness of Wall shaft at Top = 0.300 m

Thickness of Wall shaft at Bottom = 0.700 m

Foundation

Total Width of Footing = 4.600 m

Width of Toe Slab = 1.500 m

Width of Heel Slab = 2.400 m

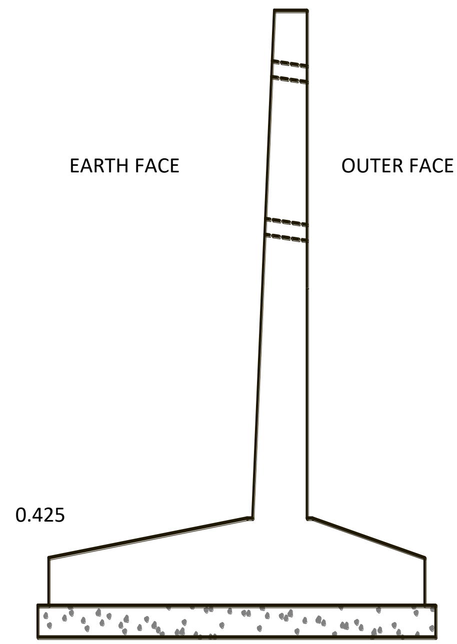
Thickness of Toe slab at tip = 0.300 m

Thickness of Toe slab near shaft = 0.550 m

Thickness of heel slab at tip = 0.300 m

Thickness of heel slab near shaft = 0.550 m

Depth of Footing below GL = 2.000 m



Material Specification

Concrete Grade = 30 M

Characteristic Compressive Strength of Concrete,fck = 30.00 Mpa at 28 days

Design Compressive strength of Concrete, fcd = 13.400 Mpa at 28 (0.67/1.5 * fck)

Tensile strength of concrete , fctm = 2.50 Mpa

Strain at reaching Characteistic Strength, $\epsilon c2$ = 0.02

Ultimate Strain, $\epsilon cu2$ = 0.035

Modulus of Elasticity of Concrete (Ec) = 27386.128 N/mm2 (5000 x sqrt (fck)

Ecm = 31000 N/mm2

Steel Grade = 500 Fe (HYSD Steel) D

Yield Strength of Reinforcement, fy or fyk = 500 Mpa

Design Yield Strength of Reinforcement, fyd = 434.783 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

= 14.4 N/mm^2

Maximum tensile stress in steel under rare combination = 0.8 fyk

= 400 N/mm^2

σcbc = 10.00

σst = 240

m = 9.3333333

k = 0.280

j = 0.907

Q = 1.27

As per Cl. 214.1 of IRC :6 -2014 (Y fluid) = 4.8

Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	-

Load Factors (As per IRC:6-2014)

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
Dead Laod+SIDL except wearing course	1.350
Wearing Course only	1.750
Back Filling Weight	1.500
Earth Pressure due to back filling	1.500
Live Load Surcharge	1.200

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
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
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
Dead Laod+SIDL except wearing course	1.35
Wearing Course only	1.750
Back Filling Weight	1.350
Earth Pressure due to back filling	1.500
Live Load Surcharge	1.200

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

VOLUME CALCULATION

C.G. Of Footing	=	2.3	m
C.G. Of shaft from toe tip	=	1.85	m
Distance between c.g. Of shaft and footing =		0.45	m

Description	No.	LENGTH		WIDTH	HEIGHT		VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe
		m		m	m		m^3	m	m	m
Shaft	1	1.00		0.500	6.450		3.225	0.087	0.537	-1.763
Footing										
Heel Slab	1	1.00		2.400	0.425		1.020		-0.940	-3.240
Toe Slab	1	1.00		1.500	0.425		0.638		1.450	-0.850
Portion between Heel and Toe	1	1.00		0.550	0.550		0.303		0.450	-1.850
Back filling over Heel Slab	1	1.00		2.400	6.575		15.780		-1.004	-3.304
Front Filling over Toe Slab	1	1.00		1.500	1.575		2.363		1.558	-0.742
Back fill on flared portion of stem	1	1.00		0.400	6.450		1.290		0.233	-2.067
				L				eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barrier	1	0	kN/m	1.000	0	kN		0.350	0.800	-1.500

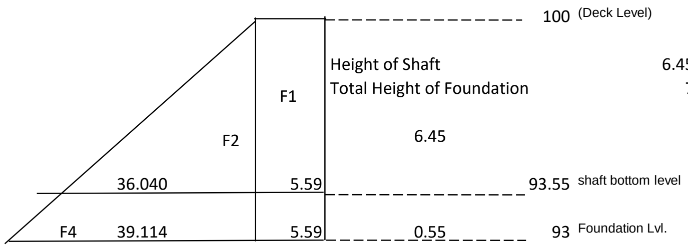
Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	-

Earth Pressure : Normal Dry Case

Properties of backfill material :

c	=	0						
ϕ	=	**30**	degree	0.524	radians	0.866	0.5	0.333333
θ	=	86.37	degree	1.507	radians	0.063		
α	=	90	degree	1.571	radians	0.000		
β	=	0	degree	0.000000000	radians	1.000		
δ	=	**20**	degree	0.349	radians	0.940		
Kah	=	0.279	active component					0.279384
Kph	=	5.737	Passive component					
γ	=	20	kN/m3					
Equivalent Live Load Surcharge height	=	1.2	m					

Assuming



Height of Shaft	6.45	m	6.45
Total Height of Foundation	7	m	7

Horizontal Forces and Moments @ RL 93.55 m (at Shaft Base)

@ RL 93 m (at Foundation Level)

Due to Live Load Surcharge

Intensity for = rectangular portion	0.279	x	20	x	1.2	=	5.59	kN/m^2
F1 =	5.5876728	x	6.45	x	1	=	36.040	kN
M1 =	36.040	x	3.225	=	116.231	kN.m at Shaft Bottom		
F3 =	5.5876728	x	7	x	1	=	39.114	kN
M3 =	39.114	x	3.5	=	136.898	kN.m at Foundation		

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

=	0.279	x	20	x	6.45	=		36.040	kN/m^2
F2 =	0.5	x	36.040	x	6.45	x	1	=	**116.231** KN

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC 6-2000

M2 =	116.231	x	2.71	=	**314.869**	**kN.m**	**at Shaft Bottom**

Intensity for triangular portion (At Foundation level)

=	0.279	x	20	x	7	=		39.114	kN/m^2
F4 =	0.5	x	39.114	x	7	x	1	=	**136.898** KN
M4 =	136.898	x	2.94	=	**402.480**	**kN.m at Foundation**			

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 Y fluid = 4.8 kN/m3

Intensity for triangular portion (At Shaft bottom level)

=	4.8	x	6.45	=	30.960	kN/m^2			
F =	0.5	x	30.960	x	6.45	x	1	=	**99.846** KN
M =	99.846	x	2.15	=	**214.669**	**kN.m at Shaft Bottom**			

Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	-

Intensity for triangular portion (At Foundation level)

= 4.8 x 7 = 33.600 kN/m^2

F = 0.5 x 33.600 x 7 x 1 = 117.600 KN

M = 117.600 x 2.33 = 274.400 kN.m at Foundation

Intensity of Passive pressure (Considered half depth of embedment of footing)

= 5.7371596 x 20 x 2 = **229.486** **kN/m^2**

Force due to passive @ Foundation, F

= 0.5 x 229.486 x 2 x 1 = 229.486 KN

Moment due to passive @ Foundation, M

= 229.486 x 0.667 = **152.991** **kN.m at Foundation**

Summary of Moment and Horizontal Force

		MOMENTS		HORIZONTAL FORCE	
	Consider (Y or N)	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl Kn	At Foundation Lvl kN
Due to active Earth Pressure	Y	314.869	402.480	116.231	136.898
Due to Minimum Fluid Pressure	Y	214.669	274.400	99.846	117.600
Governing of Two	Y	**314.869**	**402.480**	**116.231**	**136.898**
Due to Live Load Surcharge	Y	116.231	136.898	36.040	39.114
Due to Passive pressure	N		0.000		0.000

Project	-	Designed by:	KB
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Stability Check of Foundation

Foundation Lvl = 93.000 m

Properties of Footing Base:

		B		L			
A	=	4.600	x	1.000	=	4.600	m^2
ZL	=	1.000	x	3.527	=	3.527	m^3
ZT	=	4.600	x	0.167	=	0.767	m^3

Normal Dry Case

For SBC Calculation_ For Equilibrium Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1.000	25	3.225	80.625	0.537	43.269
Back filling over heel slab	1.000	20	15.780	315.6	-1.004	-316.844
Back filling on flared portion of shaft	1.000	20	1.290	25.8	0.233	6.020
Front Filling over toe slab RCC Railing or Crash Barrier or	1.000	20	2.363	47.25	1.558	73.593
Crash Barrier	1.000			0	0.8	0.000
Heel slab	1.000	25	1.020	25.5	-0.940	-23.970
Toe slab	1.000	25	0.638	15.9375	1.450	23.109
portion between heel & toe	1.000	25	0.303	7.5625	0.45	3.403
Total				518.275		-191.420

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
1.000	80.625	-1.763	-142.169
1.000	315.6	-3.304	-1042.724
1.000	25.8	-2.067	-53.320
1.000	47.25	-0.742	-35.082
1.000	0	-1.5	0.000
1.000	25.5	-3.240	-82.620
1.000	15.9375	-0.850	-13.547
1.000	7.5625	-1.85	-13.991
	518.275		-1383.453

For Safe Bearing Capacity Calculation :

load factor

Moment due to active earth pressure	=	1	x	402.480	x	402.480068	kNm
Moment due to Live load surcharge	=	1	x	136.898	x	136.897982	kNm
						539.378051	
Moment due to passive relief	=	1	x	**0**	=	0	
						539.378051	

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P	518.275	KN	
ML	347.958	kNm	
MT	0	kNm	
A	4.600	m^2	
ZL	3.527	m^3	
ZT	0.767	m^3	
P/A+ML/ZL+MT/ZT (Max)	211.333	kN/m2	SAFE
P/A-ML/ZL-MT/ZT (Min)	14.004	kN/m2	SAFE

Check Against Sliding:

		load factor									
Due to Earth pressure	=	1.000	x	136.898	=	136.897982	KN				
Due to Live load Surcharge	=	1.000	x	39.114	=	39.1137093	KN				
						176.012					
Total Sliding Force	=	176.012 KN									
Total Restoring Force	=	mP + c.A + Fp =		0.5	x	518.275	+	0	=	259.1375	KN
FOS against sliding	=	1.5	>	1.5	SAFE						

Check Against Overturning

		load factor					
Moment due to active earth pressure	=	1	x	402.480	=	402.480	kNM
Moment due to Live load surcharge	=	1	x	136.898	=	136.898	kNM
						539.378	
Overturning Moment	=	539.378 kNm					
Restoring Moment	=	S P.e Toe+		Mp	=	1383.453	kNm
FOS against overturnng	=	2.5649034	>	2	SAFE		

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

Design of Foundation

Foundation Lvl = 93.000 m

Properties of Footing Base:

A = 4.600 m^2

ZL = 3.527 m^3

ZT = 0.767 m^3

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1.35	25	3.225	108.844	0.450	48.980
Back filling over heel slab	1.350	20	15.780	426.060	-1.004	-427.74
Back filling on flared portion of shaft	1.350	20	1.290	34.830	0.117	4.06
Front Filling over toe slab	1.350	20	2.363	63.788	1.558	99.350
RCC Railing or Crash Barrier	1.35			0.000	0.800	0.000
Heel slab	1.35	25	1.020	34.425	-0.940	-32.36
Toe slab	1.35	25	0.638	21.516	1.450	31.19765625
portion between heel & toe	1.35	25	0.303	10.209	0.450	4.594
Total				699.671		-271.914

		load factor					
Moment due to active earth pressure	=	1.500	x	402.4800684	=	603.720	kNm
Moment due to Live load surcharge	=	1.200	x	136.8980	=	164.278	kNm
						767.998	

P	699.671	KN
ML	496.084	kNm
MT	0.000	kNm
A	4.600	m2
ZL	3.527	m3
ZT	0.767	m3
P/A+ML/ZL+MT/ZT (Max)	292.769	kN/m2
P/A-ML/ZL-MT/ZT (Min)	11.436	kN/m2

Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
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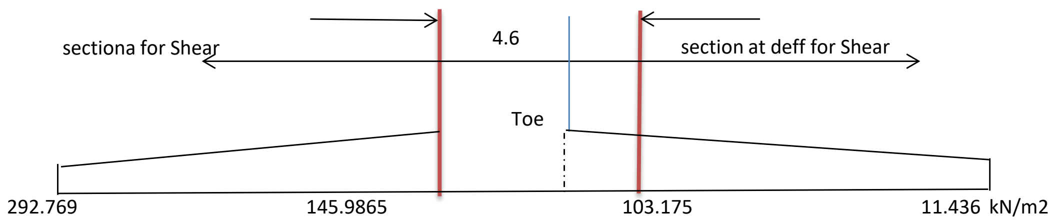
Normal Dry Case

Ultimate Base Pressure (kN/m^2)	**Max**	**292.769**
	Min	**11.436**



Normal Dry Case

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=		219.38 kN/m2											
Upward moment due to Base pressure	=		631.81 kNm/m											
	factor				VOL									
Downward moment due to backfill	=	1.350		x	15.78	/	1	x	20	x	1.2	=	511.272	kNm/m
Downward moment due to self weight of Heel	=	1.35		x	1.02	/	1	x	25	x	1.040	=	35.802	kNm/m
Net Moment at face of shaft	=		631.81	-511.27	-35.80		84.73	kNm/m	OK					

Heel Slab - Shear Calculation at Face of Wall

Shear Force due to upward pressure at Face of wall	=		219.38	x	2.4	x	1	=	526.507	KN
		factor								
Downward Force due to backfill	=		1.350	x	15.78	x	20	=	426.060	KN
Downward Force due to self weight of Heel slab	=		1.35	x	1.02	x	25	=	34.425	KN
Net Shear Force	=		526.507	-426.060	-34.425			=	**66.022**	KN
Net Shear Force / unit meter	=		66.022	/	1			=	**66.022**	KN/m

<u>Toe Slab - Moment Calculation</u>

Average Base Pressure for Design of Toe Slab													
	=	57.31	kN/m2										
Upward moment due to Base pressure	=	64.47	kNm/m										
Downward moment due to self weight of Toe	=	1.35	x	0.6375	/	1	x	25	x	0.650	=	13.985	kNm/m
Net Moment at face of shaft	=	64.47		-13.985	=	50.483	kNm/m	OK					

Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	-

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	=	0.575	m												
effective depth at critical section	=	0.494	m												
Base pressure at deff from face of wall	=	65.317	kN/m2												
upward shear force due to base pressure	=	38.377	x		1.031	x	1	=	39.566	kN					
C.g. Of base pressure	=	4.144	m												
moment due to upward pressure at critical section	=	163.963	kNm												
tanb		0.167													
reduction in shear force (Vccd)		M tanb / d		=	47.53	KN									
Downward force due to self weight of toe slab	=	1.35		x	0.437466667	x	1.031	x	1	x	25	=	15.222	KN	
Net Shear Force at deff	=	39.566		-15.222	-47.53094	=	-23.187	KN							
Net Shear Force / unit meter	=	-23.187		/	1	=	-23.187	KN/m							

Design Input :

Design length	=	1000	mm		
Clear Cover	=	75	mm		
Grade of Concrete for Footing	=	M 30			
fck	=	30	N/mm²		30
fctm	=	2.5	N/mm²		
Ec	=	27386.13	N/mm²		
Grade of Reinforcement Steel	=	500.00	Fe D	(HYSD Bars)	
fy or fyk	=	500.00	N/mm²		
fyd	=	434.78	N/mm²	(fy/1.15)	
Es	=	200000.00	N/mm²		

Project	-		Designed by:	KB
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Flexural Reinforcement Calculation:

		Heel Slab	Toe Slab
Ultimate bending moment,Mu (kNm/m)	=	84.734	50.48
Effective depth required (dreq) (mm)	=	143.06	110.43
Effective depth provided (dpro) (mm)	=	469.00	469.00
Check for provided depth	=	SAFE	SAFE
R = Mu/(b d2)	=	0.39	0.23
Total depth provided (mm)	=	550.00	550.00
Limiting depth of neutral axis (mm)	=	290.78	290.78
Actual depth of neutral axis (mm)	=	37.94	37.94
Check for Neutral axis depth	=	OK	OK
Lever arm (z) , mm	=	453.07	453.07
Moment of Resistance w.r.to steel	=	185.64	185.64
Check for Moment Capacity	=	SAFE	SAFE
Ast reqd (mm2 / m)	=	394.729	235.087
cl. 16.6.1 (2) of IRC :112-2011			
AS.min = 0.26 fctm bt d / fyk >= 0.0013 bt d	=	609.70	609.70
Governing Ast (mm2 / m)	=	609.70	609.70
Tension Reinforcement			
Dia (mm)	=	12.00	12.00
Spacing (mm)	=	185.40	185.40
Spacing provided	=	120.00	120.00
+ Dia (mm)	=	0.00	0.00
Spacing (mm)	=	120.00	120.00
Ast provided (mm2 / m)	=	942.36	942.36
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)	=	188.47	188.47
Dia (mm)	=	10.00	10.00
Spacing (mm)	=	200.00	200.00
Ast provided (mm2 /m)	=	392.65	392.65
Check for Ast provided	=	OK	OK

Project	-		Designed by:	KB
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Job Name	Design of Retaining Wall for height 5 m from G.L		Date & Rev.	-

Shear Reinforcement Calculation:

		Heel Slab	Toe Slab	
Ultimate Shear Force (VEd)	=	66.022	-23.187	kN/m
Ast provided	=	942.360	942.36	mm2/m
Depth of slab at critical section	=	550.000	574.933	mm
Effective depth at critical section	=	469.000	493.933	mm
percentage of steel provided (r1)	=	0.0019	0.0019	
cl. 10.3.1 of IRC :112-2011				
r1 = $A_{sl}/(b_w d)$ <= 0.02	=	OK	OK	
Actual shear stress=vED = (VEd/b*0.9d)	=	0.156	0.052	N/mm2
Max shear capacity, 0.135 fck(1-fck/310)	=	3.658	3.658	N/mm2
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	=	1.653	1.636	
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010				
V_{min} = 0.031 K3/2 fck1/2	=	0.361	0.355	N/mm2
0.12 K (80 r1 fck)^0.33	=	0.330	0.324	N/mm2
scp = NEd / Ac <= 0.2 fcd	=	0.000	0.000	
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010				
$V_{Rd.c}$ = [0.12K(80ρ1 fck)^0.33 + 0.15σcp]b_wd subjected to minimum (v min + 0.15 σcp) b_w d	=	154.79	159.92	kN
Check for Shear Reinforcement		No Shear R/f required	No Shear R/f required	

Project:	*-*	*Designed by:*	*KB*
Client	*-*	*Checked by:*	*-*
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	*-*

SLS CHECK OF FOUNDATION

Foundation Lvl = 93.000 m

Properties of Footing Base:

A	=	4.600	m^2
ZL	=	3.527	m^3
ZT	=	0.767	m^3

Creep Coeff = 1.2 For Dry atmosperic condition

Ecm = 31000 N/mm2

Es = 200000 N/mm2

Eceff = $\frac{Ecm}{(1+\phi)}$ = 14090.91

Modular Ratio (m) = Es/ Eceff = 14.19

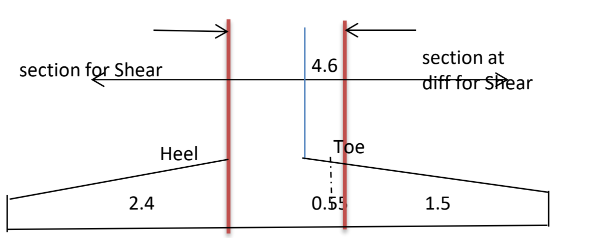
Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1	25	3.225	80.625	0.450	36.281
Back filling over heel slab	1	20	15.780	315.600	-1.004	316.844
Back filling on flared portion of shaft	1	20	1.290	25.800	0.233	6.020
Front Filling over toe slab	1	20	2.363	47.250	1.558	73.593
RCC Railing or Crash Barrier	1			0.000	0.800	0.000
Heel slab	1	25	1.020	25.500	-0.940	23.970
Toe slab	1	25	0.638	15.938	1.450	23.109
portion between heel & toe	1	25	0.303	7.563	0.450	3.403
Total				**518.275**		**-198.408**

		load factor					
Moment due to active earth pressure	=	1.0	x	402.480	=	402.480	kNm
Moment due to Live load surcharge	=	0.8	x	136.898	=	109.518	kNm
						511.998	

P	518.275	KN
ML	313.591	kNm
MT	0.000	kNm
A	4.600	m2
ZL	3.527	m3
ZT	0.767	m3
P/A+ML/ZL+MT/ZT (Max)	201.588	kN/m2
P/A-ML/ZL-MT/ZT (Min)	23.749	kN/m2

		Normal Dry Case
Base Pressure (kN/m2)	Max	201.588
	Min	23.749



Normal Dry Case 201.59 108.80 81.74 23.75 kN/m2

Project:	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=	155.20	kN/m2									
Upward moment due to Base pressure	=	446.96	kNm/m									
	factor											
Downward moment due to backfill	=	1.00	x	15.78	x	20	x	1.2	=	378.72	kNm/m	
Downward moment due to self weight of Heel	=	1.00	x	1.020	x	25	x	1.040	=	26.52	kNm/m	
Net Moment at face of shaft	=	446.96		-378.72		-26.52			=	41.72	kNm/m	
				Tension at Bottom of Heel Slab								

Toe Slab - Moment Calculation

Average Base Pressure for Design of Toe Slab	=	52.74	kN/m2								
Upward moment due to Base pressure	=	59.34	kNm/m								
Downward moment due to self weight of Toe	=	1	x	0.6375	x	25	x	0.650	=	10.36	kNm/m
Net Moment at face of shaft	=	59.34		-10.36					=	48.98	kNm/m
				Tension at Bottom of Heel Slab							

		Heel Slab	Toe Slab	
Working bending moment, M	=	41.72	48.98	kNm/m
Dx	=	1.00	1.00	m
Dy	=	0.70	0.70	m
Section Modulus (ZL) of uncracked sectio	=	0.08	0.08	m3
Bending Stress (M/ZL)	=	0.511	0.600	N/mm2
Tensile stress of concrete , fctm	=	2.500	2.500	N/mm2
Cracked or Uncracked Section	=	Uncracked	Uncracked	
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	
Maximum dia used, f	=	12.000	12.000	
Effective Depth deff (dy)	=	469.000	469.000	mm
Ast provided	=	942.360	942.360	mm2/m
Percentage of steel , pt	=	0.0019	0.0019	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.209	0.207	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	98.100	96.922	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	370.900	372.078	mm
Depth of neutral axis from c.g. Of tension steel (ys)	=	289.900	291.078	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2		

Project:	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	-

Icr	=	1210265626	1217947941	mm4	
Maximum compressive stress in concrete	=	3.382	3.898	< 14.4, SAFE	
Maximum tensile stress in concrete	=	12.786	14.963		
Maximum Tensile stress in steel	=	97.018	113.889	< 400, SAFE	

Check For Crack Width					
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)	=	405.000	405.000	mm	
Provided Spacing	=	65.000	65.000	mm	
Check for Applicability of Formula	=	OK	OK		
Maximum crack spacing , Sr max	=	3.4 c +	0.425 k1 k2 ϕ / r r eff		
K1	=	0.800	0.800	for deformed bars	
K2	=	0.500	0.500	for bending	
depth of neutral axis , yc	=	98.100	96.922	mm	
r r 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	=	234.500	234.500	mm	
Ac, eff = Dx * hc,eff	=	234500.000	234500.000	mm	
r r eff = As/Ac eff	=	0.004	0.004		
Maximum crack spacing , Sr max	=	762.640	762.640	mm	
(εsm - εcm)	=	$\sigma sc - \frac{k_t f_{ct\,eff} (1 + \alpha_e \rho_{p\,eff})}{\rho_p\,eff}$	/ Es		
tensile stress in steel, ,σsc	=	97.018	113.889	N/mm2	
Kt	=	0.500	0.500		
Tensile strength of concrete = fct eff = fctm	=	2.500	2.500	N/mm2	319.12
αe = Es/Ecm	=	6.452	6.452		
(εsm - εcm)	=	-0.001	-0.0010		
Crack width , Wk=Sr max (εsm - εcm)	=	**0.000**	**0.000**		
Check	=	**SAFE**	**SAFE**		

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

Calculation of Forces For Design of Wall

Wall bottom level = 93.55 m

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL) (m)	ML = PxeL (kNm)
Shaft	1.35	25	3.225	108.84375	0.087	9.433
RCC Railing or Crash Barrier	1.35			0	0.35	0.000
Total				**108.844**		**9.433**

Horizontal Force :	load factor						
Due to Earth pressure		1.5	x	116.23	=	174.35	KN
Due to Live load Surcharge		1.2	x	36.04	=	43.25	KN
						217.59	

Total Horizontal Force = 217.59 KN

Moment Due to Horizontal Force:		load factor					
Moment due to active earth pressure	=	1.5	x	293.753	=	440.629	kNm
Moment due to Live load surcharge	=	1.2	x	116.231	=	139.4767	kNm
						580.105	

Total Moment due to Horizontal Force = 580.105 kNm

Summary of Forces:

P	108.844	KN
ML	589.539	kNm
FL	217.594	KN

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

Design of Wall:

Grade of Concrete = 30.00 M 30

fck = 30.00 N/mm2

fcd = 13.40 N/mm2

Grade of steel 500.00 Fe

fy = 500.00 N/mm2

fyd = 434.78 N/mm2

Es = 200000.00 N/mm2

Cross section of Wall:

Thickness of Wall (B) = 0.7 m

Depth of Wall (D) = 1 m

Area of Concrete (Ac) = 0.7 m2

Clear Cover to earth faces = 75 mm

Clear Cover to non earth faces = 40 mm

Maximum Dia of Vertical Reinf. = 16 mm

Dia of Horizontal Reinf. = 12 mm

Summary of Design Forces:

	P(kN)	ML (kNm)	FL (kN)
Case 1 : Normal Dry Case	108.84	589.54	217.59
MAX	108.84	589.54	217.59

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = 108.84 kN

0.1 fcd Ac

= 0.1 13.4 700000

= 938000 N

= 938.0 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) = 589.54 kNm = 589.54 kNm/m

Check For Depth of Wall :

Mult = 0.167 x fck x b x d^2

= 589.54 kNm/m

b = 1000 mm

Effective Depth Required (dreq) = SQRT(597.03 x 1000000) / (0.167 x 30.00 x 1000)

(dreq) 343.03 mm

Total Depth Required (Dreq) = 426.03 mm

Total Depth Provided (Dprov) = 700 mm **OK**

Effective depth provided(deff) = 617 mm

R= Mu/(b d^2) = 1.549

Minimum Longitudinal Reinforcement in wall on each face

=

= 0.0012 x b x D -Refer Clause 16.9 of IRC:112-2011'

Ast min = 840 mm2/m

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

Area of Steel Required:

$\frac{Pt}{100} = \frac{Ast_{req}}{bD} = \frac{fck \{ 1 - sqrt(1- 4.598\ R/fck) \}}{2fy}$

= 0.0038

Ast_{req} = 2660.74 mm2/m

Ast required = max(Astmin, Astreq) = 2660.74 mm2/m

Provide	16	mm dia	@	120	mm c/c	=	1675.31	2617.67	mm²/m	REVISE
	12	mm dia	@	120	mm c/c	=	942.36			

Percentage of steel = 0.374 %

Check for Moment of Resistance of Section due to Steel

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

= 380.60 mm

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

= 105.38 mm

OK

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

z = d - 0.416 x X

= 573.16 mm

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

MR = fyd . Ast . Z

= 652324195.0

= 6.52E+08 Nmm /m

= **6.52E+02** kNm/m > **589.54** 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 **Refer Clause 16.9 of IRC:112-2011'**

Ast min = 840 mm2/m

Provide	12 mm dia	120 mm c/c	=	942.36 mm²/m	OK

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

maximum of following = 0.25 x 3560.03 = 890.01 **As per IRC:112-2011' Clause 16.32.2**

= 0.001 x 7.00E+05 = 700.00

Minimum Horizontal Reinf. provided 890.0 mm2 per meter

Min dia of bar = 0.25 x 16 = 4 mm

or 8 mm

Maximum Spacing between bars <= 300 mm/cc

2 Legged	12 dia	@	200 c/c	=	1130.4 mm²	OK

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

SLS CHECK OF WALL

Foundation Lvl = 93.55 m

Creep Coeff (¢ = 1.2 For Dry atmosperic condition

Ecm = 31000

Es = 200000 N/mm2

Eceff = Ecm / (1 + ø) = 14090.90909

Modular Ratio (m) = Es/ Eceff = 14.19

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL) (m)	ML = PxeL (kNm)
Shaft	1.000	25	3.225	80.625	0.086666667	6.9875
RCC Railing or Crash Barrier	1.000			0	0.35	0
Total				**80.625**		**6.988**

Horizontal Force :		load factor				
Due to Earth pressure	=	1.000	x	116.2305779	=	116.2306 KN
Due to Live load Surcharge	=	0.800	x	36.04048926	=	28.83239 KN
Total Horizontal Force	=	145.0629693	KN			

Moment Due to Horizontal Force:		load factor				
Moment due to active earth pressure	=	1.000	x	314.869	=	314.869 kNm
Moment due to Live load surcharge	=	0.8	x	116.231	=	92.984 kNm
Total Moment due to Horizontal Force	=	407.853097721	kNm			

Summary of Forces:

P	80.625	KN
ML	414.841	kNm
FL	145.063	KN

Bending Moment, M	=	414.84	kNm
Dx	=	1.00	m
Dy	=	0.70	m
Section Modulus (ZL) of uncracked secti	=	0.08	m3
Bending Stress (M/ZL)	=	5.080	N/mm2
Tensile stress of concrete , fctm	=	2.500	N/mm2
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	=	75.000	mm
Maximum dia used (Vertical), f	=	16.000	mm
Horizontal Reinf. Dia used	=	12.000	mm
Effective Depth deff (dy)	=	617.000	mm
Ast provided	=	2617.667	mm2/m
Percentage of steel , pt	=	0.0048	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.307	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	189.642	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	427.358	mm

Depth of neutral axis from c.g. Of tesnion steel (ys)	=	344.358	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast	* (dy - k * dy)^2
Icr	=	4464336844	mm4
Maximum compressive stress in concrete	=	17.6	< 14.4, SAFE
Maximum tensile stress in concrete	=	39.712	
Maximum Tensile stress in steel	=	262.226	< 400, SAFE

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

Check For Crack Width			
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)	=	415.000	mm
Provided Spacing	=	120.000	mm
Check for Applicability of Formula	=	OK	
Maximum crack spacing , $S_{r\ max}$	=	3.4 c +	0.425 k1 k2 ϕ / $p_{p\ eff}$
K1	=	0.700	for deformed b
K2	=	0.500	for bending
depth of neutral axis , yc	=	189.642	mm
$\Sigma_{r\ eff}$ = 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	=	207.500	mm
Ac, eff = Dx * hc,eff	=	207500.000	mm
$\Sigma_{r\ eff}$ = As/Ac eff	=	0.013	
Maximum crack spacing , $S_{r\ max}$	=	443.660	mm
(ε_{sm} - ε_{cm})	=	σsc - kt fct eff (1 + αe r r eff) / r r eff	/ Es
tensile stress in steel, ,σsc	=	262.226	N/mm2
Kt	=	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.500	N/mm2
αe = Es/Ecm	=	6.452	
(εsm - εcm)	=	0.00078	
Crack width , Wk=Sr max (εsm - εcm)	=	**0.344**	
Check	=	**UNSAFE**	

Project	-	Designed by:	KB	
Client	-	Checked by:	-	
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-	

Stability Check Summary

Description	P (kN/m2 max)	P (kN/m2 min)	Sliding	Overturning	Shear (Heel slab)	Shear (Toe slab)
Normal Dry case	211.33	14.00	1.47	2.56	0.156	-0.052
Permissible	220	0	1.5	2	3.658	3.658
Remarks	OK	OK	REVISE	OK	OK	OK

Reinforcement summary

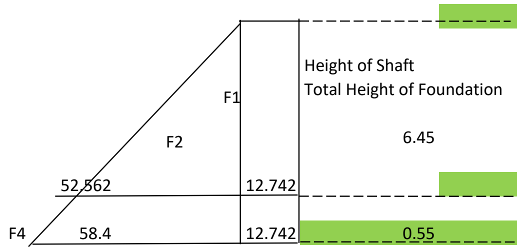
Type of reinforcement	Area of steel required	Area of steel provided						
Straight Portion of Shaft								
Vertical steel at earth face	2661	16	mm bar @	120	mm c/c (i.e.)	2618	mm2	REVISE
		12	mm bar @	120	mm c/c (i.e.)			
Vertical steel at non-earth face	840	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
Distribution steel	890	12	mm 2 Legged bar @	200	mm c/c (i.e.)	1130	mm2	OK
Heel Slab								
Main steel at top face	610	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
		0	mm bar @	120	mm c/c (i.e.)			
Steel at bottom face	250	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
Distribution reinforcement	188	10	mm bar @	200	mm c/c (i.e.)	393	mm2	OK
Shear Reinforcement	No Shear R/f required							
Toe Slab								
Main steel at bottom face	610	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
		0	mm bar @	120	mm c/c (i.e.)			
Steel at top face	250	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
Distribution reinforcement	188	10	mm bar @	200	mm c/c (i.e.)	393	mm2	OK
Shear Reinforcement	No Shear R/f required							

Earth Pressure : Normal Dry Case

Properties of backfill material :

c	=	0				
ϕ	=	**30**	degree	0.524	radians	0.866
θ	=	87.11	degree	1.520	radians	0.050
θ1	=	90	degree	1.571	radians	0.000
β	=	26.5	degree	0.462512252	radians	0.895
δ	=	**20**	degree	0.349	radians	0.940
Kah	=	0.279	active component			
Kph	=	5.737	Passive component			
γ	=	20	kN/m3			
Equivalent Live Load Surcharge height	=	1.2	m			

Assuming



100 (Deck Level)

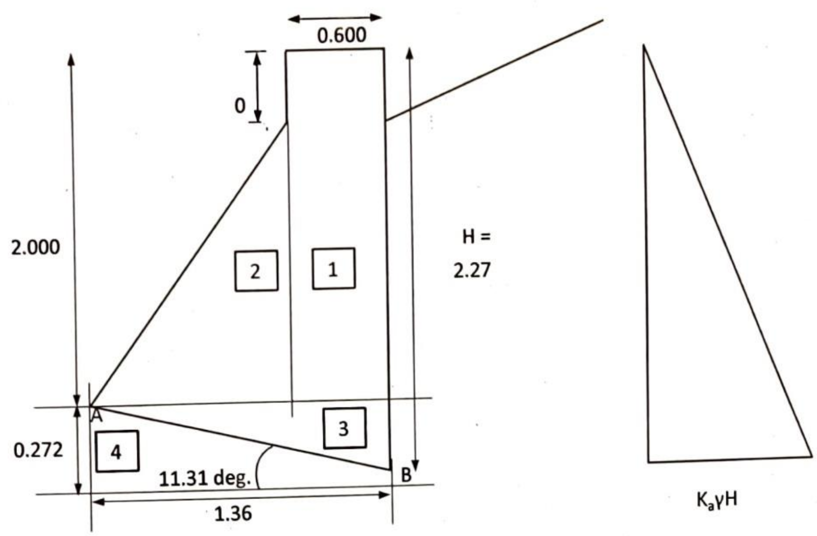
Height of Shaft	6.45	m	6.45
Total Height of Foundation	7	m	7

93.55 shaft bottom level

93 Foundation Lvl.

for 2m height from Ground

Overall Height = **2.00** m



Design Data

Width of Footing	=	1.36 m
Width of Stem at top	=	0.60 m
Height of Stem above GL	=	2.00 m
Height of Stem Below GL	=	0.27 m
Height of Straight Portion	=	0.00 m
SBC at founding level	=	15 t/m^2
Coefficient of friction at founding level, μ	=	0.50
Bottom Slope = 1.00V : 5.00H	=	11.310 Deg. = 0.197 Radians

Breast Wall Material Properties

Material	=	Crushed Rubble Masonry (CRM)	
Permissible Crushing Strength	=	1.60 MPa	*Table 2, IRC:40-2002*
Permissible Tension	=	-0.10 MPa	*Table 3, IRC:40-2002*
Density of Material, γ_{sub}	=	2.40 t/m^3	*Cl. 203, IRC:6-2017*

Backfill Parameters

Unit weight of backfill, γ	=	2.00 t/m^3
Submerged weight of backfill	=	1.00 t/m^3

				Degrees	**Radians**
α	=	Angle of wall w.r.t. horizontal	=	90.0	1.571
β	=	Slope of filling	=	42.3	0.738
δ	=	Angle of wall friction	=	50.0	0.873
ϕ	=	Angle of internal friction	=	50.0	0.873

for 2m height from Ground

Coeffiecient of Active Earth Pressure

$$K_a = \frac{\sin^2(\alpha+\phi)}{\sin^2\alpha\,\sin(\alpha-\delta)[\,1 + \{\sin(\phi+\delta)\sin(\phi-\beta)/(\sin(\alpha-\delta)\sin(\alpha+\beta))\}^{0.5}]^2}$$

K_a					=	**0.275**
K_{ah}	=	0.275	x	cos(50)	=	0.177
K_{av}	=	0.275	x	sin(50)	=	0.211

Coeffiecient of Passive Earth Pressure

$$K_p = \frac{\sin^2(\alpha-\phi)}{\sin^2\alpha\,\sin(\alpha+\delta)[\,1 - \{\sin(\phi+\delta)\sin(\phi+\beta)/(\sin(\alpha+\delta)\sin(\alpha+\beta))\}^{0.5}]^2}$$

K_p					=	**3.345**
K_{ph}	=	3.345	x	cos(50)	=	2.150
K_{pv}	=	3.345	x	sin(50)	=	2.562

Any passive pressure is however not cosnidered to be on conservtive side.

Force and Moments due to Backfill

Total Force in Horz. Dir. Pah = 0.914 t/m

Total Force in Vert. Dir. Pav = 1.089 t/m

Moment due to Earth Pressure, Ma = 0.914x 0.42 x 2.272 = 1 t-m/m

Force and Moments due to Self Weight

S.No.	Factor	γ_{sub}	B (m)	H (m)	L (m)	Wt (t/m)	Ecc. abt Toe (m)	Mom. abt toe (t-m/m)
1	1.0	2.40	0.600	2.00	1.000	2.880	1.058	3.047
2	0.5	2.40	0.758	2.00	1.000	1.819	0.505	0.919
3	0.5	2.40	1.358	0.27	1.000	0.443	0.905	0.401
4	0	2.40	1.358	0.27	1.000	0.000	0.453	0.000
					Total	**5.142**		**4**

Stability Check

Overturning

Destabilising Moment = 0.872 tm

Stabilising Moment = 4.367 tm

Factor of Safety = 4.367 / 0.872

= 5.010 > 2.0 **OK**

Sliding

Destabilising Force = 0.914 t/m

Stabilising Force = 0.50 x 5.142 + 5.142 sin (11.31)= 3.58 t/m

Factor of Safety = 3.579 / 0.914

= 3.918 > 1.5 **OK**

for 2m height from Ground

Base Pressure Check

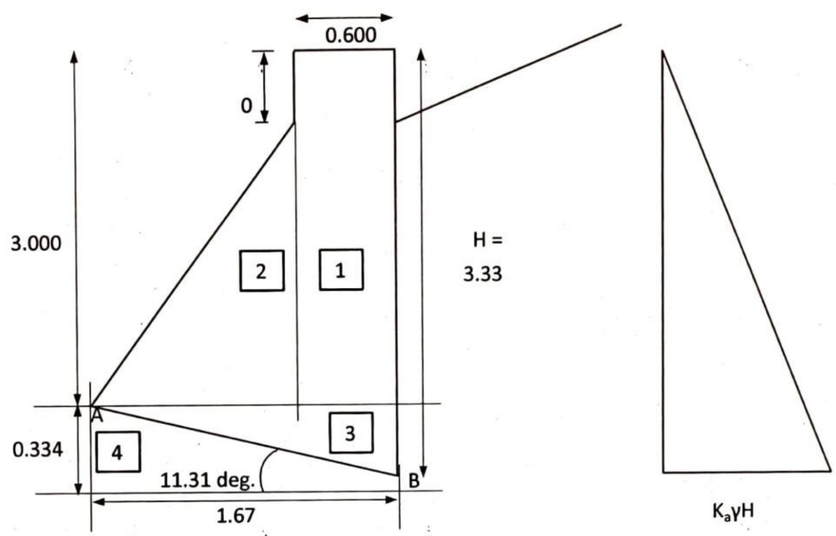
CG of Vertical force from Toe =	(4.367-0.872)/5.142	=		0.68 m		
Eccentricity wrt center =	-0.0008 m	<		0.226 m		**OK**
Pmax/min =	W/B x (1 ± 6e/B)					
Pmax =	3.77 t/m^2	<	15.0	**OK**		
Pmin =	3.80 t/m^2	>	0.0	**OK**		

Section Check

Area of foundation, A =	1.358 m^2					
Z = I/y =	0.307 m^3					
P =	5.142 t/m					
M (moment abt cg) =	-0.00407 t-m					
Max. Stress at A = P/A + M/Z =	3.77 t/m^2	=	0.0377MPa	<	1.60	**OK**
Min. Stress at B = P/A - M/Z =	3.80 t/m^2	=	0.0380MPa	>	-0.10	**OK**

for 3m height from Ground

Overall Height = **3.00** **m**



Design Data

Width of Footing		=	1.67 m		
Width of Stem at top		=	0.60 m		
Height of Stem above GL		=	3.00 m		
Height of Stem Below GL		=	0.33 m		
Height of Straight Portion		=	0.00 m		
SBC at founding level		=	15 t/m^2		
Coefficient of friction at founding level, μ		=	0.50		
Bottom Slope =	1.00V : 5.00H	=	11.310 Deg.	=	0.197 Radians

Breast Wall Material Properties

Material	=	Crushed Rubble Masonry (CRM)	
Permissible Crushing Strength	=	1.60 MPa	*Table 2, IRC:40-2002*
Permissible Tension	=	-0.10 MPa	*Table 3, IRC:40-2002*
Density of Material, γ_{sub}	=	2.40 t/m^3	*Cl. 203, IRC:6-2017*

Backfill Parameters

Unit weight of backfill, γ	=	2.00 t/m^3
Submerged weight of backfill	=	1.00 t/m^3

				Degrees	Radians
α	=	Angle of wall w.r.t. horizontal	=	90.0	1.571
β	=	Slope of filling	=	42.3	0.738
δ	=	Angle of wall friction	=	50.0	0.873
ϕ	=	Angle of internal friction	=	50.0	0.873

for 3m height from Ground

Coeffiecient of Active Earth Pressure

$$K_a = \frac{\sin^2(\alpha+\phi)}{\sin^2\alpha \sin(\alpha-\delta)[1 + \{\sin(\phi+\delta)\sin(\phi-\beta)/(\sin(\alpha-\delta)\sin(\alpha+\beta))\}^{0.5}]^2}$$

K_a					=	**0.275**
K_{ah}	=	0.275	x	cos(50)	=	0.177
K_{av}	=	0.275	x	sin(50)	=	0.211

Coeffiecient of Passive Earth Pressure

$$K_p = \frac{\sin^2(\alpha-\phi)}{\sin^2\alpha \sin(\alpha+\delta)[1 - \{\sin(\phi+\delta)\sin(\phi+\beta)/(\sin(\alpha+\delta)\sin(\alpha+\beta))\}^{0.5}]^2}$$

K_p					=	**3.345**
K_{ph}	=	3.345	x	cos(50)	=	2.150
K_{pv}	=	3.345	x	sin(50)	=	2.562

Any passive pressure is however not cosnidered to be on conservtive side.

Force and Moments due to Backfill

Total Force in Horz. Dir. Pah = 1.968 t/m

Total Force in Vert. Dir. Pav = 2.345 t/m

Moment due to Earth Pressure, Ma = 1.968x 0.42 x 3.334 = 2.756 t-m/m

Force and Moments due to Self Weight

S.No.	Factor	γ_{sub}	B (m)	H (m)	L (m)	Wt (t/m)	Ecc. abt Toe (m)	Mom. abt toe (t-m/m)
1	1.0	2.40	0.600	3.00	1.000	4.320	1.370	5.918
2	0.5	2.40	1.070	3.00	1.000	3.852	0.713	2.748
3	0.5	2.40	1.670	0.33	1.000	0.669	1.113	0.745
4	0	2.40	1.670	0.33	1.000	0.000	0.557	0.000
					Total	**8.841**		**9.411**

Stability Check

Overturning

Destabilising Moment	=	2.756 tm				
Stabilising Moment	=	9.411 tm				
Factor of Safety	=	9.411	/	2.756		
	=	3.415	>	2.0	**OK**	

Sliding

Destabilising Force	=	1.968 t/m				
Stabilising Force	=	0.50 x 8.841	+	8.841 sin (11.31)=		6.15 t/m
Factor of Safety	=	6.155	/	1.968		
	=	3.127	>	1.5	**OK**	

for 3m height from Ground

Base Pressure Check

CG of Vertical force from Toe =	(9.411-2.756)/8.841	=	0.75 m		
Eccentricity wrt center =	0.0822 m	<	0.278 m		**OK**
Pmax/min =	W/B x (1 ± 6e/B)				
Pmax =	6.86 t/m^2	<	15.0	**OK**	
Pmin =	3.73 t/m^2	>	0.0	**OK**	

Section Check

Area of foundation, A	=	1.67 m^2					
Z = I/y	=	0.465 m^3					
P	=	8.841 t/m					
M (moment abt cg)	=	0.72706 t-m					
Max. Stress at A = P/A + M/Z	=	6.86 t/m^2	=	0.0686MPa	<	1.60	**OK**
Min. Stress at B = P/A - M/Z	=	3.73 t/m^2	=	0.0373MPa	>	-0.10	**OK**

PCL COORDINATES

S.N.	CHAINAGE	NORTHING	EASTING
1	156+489	2786669.474	521924.636
2	156+500	2786668.636	521913.93
3	156+525	2786666.686	521889.007
4	156+550	2786664.735	521864.083
5	156+575	2786661.797	521839.275
6	156+600	2786652.695	521816.127
7	156+625	2786637.77	521796.098
8	156+650	2786621.931	521776.756
9	156+675	2786606.163	521757.357
10	156+700	2786593.288	521736.027
11	156+725	2786590.087	521711.492
12	156+750	2786597.219	521687.628
13	156+775	2786607.84	521664.997
14	156+800	2786618.566	521642.415
15	156+825	2786629.715	521620.046
16	156+850	2786643.935	521599.507
17	156+875	2786658.945	521579.515
18	156+900	2786671.297	521557.868
19	156+925	2786674.631	521533.283
20	156+950	2786671.041	521508.56
21	156+975	2786665.645	521484.176
22	157+000	2786650.335	521465.176
23	157+025	2786626.059	521463.063
24	157+050	2786603.157	521472.992
25	157+075	2786580.706	521483.988
26	157+100	2786557.83	521494.024
27	157+125	2786533.25	521497.901
28	157+150	2786508.306	521496.353
29	157+175	2786483.395	521494.252
30	157+200	2786458.51	521491.883
31	157+225	2786434.539	521485.152
32	157+250	2786414.285	521470.718
33	157+275	2786398.261	521451.552
34	157+300	2786382.979	521431.766
35	157+325	2786367.697	521411.981
36	157+350	2786352.411	521392.199
37	157+375	2786335.68	521373.676
38	157+400	2786315.423	521359.074
39	157+425	2786294.361	521345.606
40	157+450	2786273.298	521332.139
41	157+475	2786252.24	521318.665
42	157+500	2786232.311	521303.634
43	157+525	2786216.808	521284.125
44	157+550	2786207.248	521261.111
45	157+575	2786204.366	521236.359

S.N.	CHAINAGE	NORTHING	EASTING
46	157+600	2786207.303	521211.555
47	157+625	2786211.447	521186.901
48	157+650	2786215.591	521162.247
49	157+675	2786219.707	521137.588
50	157+700	2786221.258	521112.695
51	157+725	2786214.256	521088.883
52	157+750	2786199.096	521069.101
53	157+775	2786181.425	521051.418
54	157+800	2786163.694	521033.793
55	157+825	2786145.964	521016.168
56	157+850	2786128.234	520998.542
57	157+875	2786110.504	520980.917
58	157+900	2786092.774	520963.292
59	157+925	2786075.044	520945.667
60	157+950	2786057.314	520928.042
61	157+975	2786038.54	520911.584
62	158+000	2786016.473	520899.92
63	158+025	2785993.591	520889.851
64	158+050	2785970.707	520879.784
65	158+075	2785948.218	520868.902
66	158+100	2785929.219	520852.85
67	158+125	2785917.004	520831.189
68	158+150	2785911.537	520806.831
69	158+175	2785907.717	520782.124
70	158+200	2785903.898	520757.418
71	158+225	2785900.08	520732.711
72	158+250	2785895.711	520708.104
73	158+275	2785885.982	520685.227
74	158+300	2785868.56	520667.438
75	158+325	2785848.359	520652.713
76	158+350	2785828.04	520638.147
77	158+375	2785807.697	520623.618
78	158+400	2785784.292	520615.597
79	158+425	2785759.596	520618.685
80	158+450	2785734.926	520622.567
81	158+475	2785710.414	520618.871
82	158+500	2785690.525	520604.151
83	158+525	2785677.918	520582.653
84	158+550	2785668.114	520559.655
85	158+575	2785658.368	520536.633
86	158+600	2785649.762	520513.185
87	158+625	2785646.367	520488.463
88	158+650	2785645.224	520463.49
89	158+675	2785643.618	520438.548
90	158+700	2785636.723	520414.657

S.N.	CHAINAGE	NORTHING	EASTING
91	158+725	2785621.173	520395.282
92	158+750	2785601.055	520380.467
93	158+775	2785580.489	520366.255
94	158+800	2785562.292	520349.241
95	158+825	2785550.387	520327.337
96	158+850	2785541.172	520304.098
97	158+875	2785532.012	520280.837
98	158+900	2785522.84	520257.58
99	158+925	2785511.801	520235.197
100	158+950	2785495.224	520216.577
101	158+975	2785476.321	520200.217
102	159+000	2785457.353	520183.932
103	159+025	2785438.385	520167.647
104	159+050	2785419.416	520151.362
105	159+075	2785400.448	520135.076
106	159+100	2785381.492	520118.777
107	159+125	2785365.134	520100.031
108	159+150	2785357.328	520076.471
109	159+175	2785358.441	520051.558
110	159+200	2785361.466	520026.742
111	159+225	2785364.491	520001.925
112	159+250	2785367.932	519977.184
113	159+275	2785383.685	519958.704
114	159+300	2785406.888	519949.973
115	159+325	2785412.369	519927.22
116	159+350	2785393.298	519912.155
117	159+375	2785377.247	519894.622
118	159+400	2785385.735	519871.802
119	159+425	2785397.029	519849.618
120	159+450	2785397.498	519824.882
121	159+475	2785386.351	519802.721
122	159+500	2785372.07	519782.201
123	159+525	2785353.951	519765.343
124	159+550	2785329.993	519759.04
125	159+575	2785305.879	519753.653
126	159+600	2785297.81	519731.673
127	159+625	2785310.203	519710.098
128	159+650	2785324.217	519689.394
129	159+675	2785338.23	519668.691
130	159+700	2785352.244	519647.988
131	159+725	2785366.257	519627.285
132	159+750	2785380.173	519606.517
133	159+775	2785390.946	519584.052
134	159+800	2785393.989	519559.314
135	159+825	2785393.825	519534.315

S.N.	CHAINAGE	NORTHING	EASTING
136	159+850	2785393.817	519509.317
137	159+875	2785398.121	519484.798
138	159+900	2785410.085	519462.92
139	159+925	2785424.445	519442.456
140	159+950	2785438.839	519422.015
141	159+975	2785453.233	519401.575
142	160+000	2785467.627	519381.134
143	160+025	2785482.021	519360.694
144	160+050	2785496.405	519340.246
145	160+075	2785508.833	519318.616
146	160+100	2785512.829	519294.155
147	160+125	2785508.628	519269.547
148	160+150	2785502.78	519245.241
149	160+175	2785496.982	519220.923
150	160+200	2785494.197	519196.153
151	160+225	2785501.19	519172.417
152	160+250	2785518.674	519154.906
153	160+275	2785541.726	519145.416
154	160+300	2785565.81	519138.712
155	160+325	2785589.577	519131.021
156	160+350	2785610.538	519117.643
157	160+375	2785625.233	519097.597
158	160+400	2785631.61	519073.574
159	160+425	2785628.79	519048.879
160	160+450	2785617.208	519026.878
161	160+475	2785600.223	519008.564
162	160+500	2785583.132	518990.347
163	160+525	2785571.386	518968.423
164	160+550	2785565.933	518944.05
165	160+575	2785561.692	518919.413
166	160+600	2785555.763	518895.155
167	160+625	2785547.71	518871.487
168	160+650	2785539.633	518847.828
169	160+675	2785531.582	518824.16
170	160+700	2785525.984	518799.853
171	160+725	2785527.775	518775.001
172	160+750	2785533.126	518750.581
173	160+775	2785538.423	518726.151
174	160+800	2785540.259	518701.265
175	160+825	2785539.598	518676.274
176	160+850	2785538.909	518651.284
177	160+875	2785538.219	518626.293
178	160+900	2785537.529	518601.303
179	160+925	2785536.84	518576.312
180	160+950	2785535.868	518551.334

S.N.	CHAINAGE	NORTHING	EASTING
181	160+975	2785531.31	518526.786
182	161+000	2785525.215	518502.54
183	161+025	2785521.494	518477.873
184	161+050	2785525.648	518453.333
185	161+075	2785534.197	518429.844
186	161+100	2785542.973	518406.435
187	161+125	2785540.547	518382.274
188	161+150	2785526.121	518361.862
189	161+175	2785511.768	518341.396
190	161+200	2785500.9	518318.953
191	161+225	2785495.909	518294.523
192	161+250	2785497.118	518269.617
193	161+275	2785504.451	518245.785
194	161+300	2785516.567	518223.934
195	161+325	2785529.424	518202.494
196	161+350	2785542.281	518181.053
197	161+375	2785555.138	518159.613
198	161+400	2785567.993	518138.171
199	161+425	2785579.43	518115.976
200	161+450	2785585.108	518091.712
201	161+475	2785583.915	518066.821
202	161+500	2785575.942	518043.211
203	161+525	2785561.801	518022.692
204	161+550	2785542.575	518006.838
205	161+575	2785519.738	517996.864
206	161+600	2785495.044	517993.468
207	161+625	2785470.055	517994.116
208	161+650	2785445.072	517995.032
209	161+675	2785420.089	517995.949
210	161+700	2785395.105	517996.865
211	161+725	2785370.122	517997.781
212	161+750	2785345.138	517998.666
213	161+775	2785320.236	517997.102
214	161+800	2785296.617	517989.156
215	161+825	2785275.103	517976.446
216	161+850	2785253.959	517963.107
217	161+875	2785232.814	517949.769
218	161+900	2785211.67	517936.43
219	161+925	2785190.525	517923.092
220	161+950	2785169.381	517909.753
221	161+975	2785147.854	517897.066
222	162+000	2785124.212	517889.188
223	162+025	2785099.316	517888.092
224	162+050	2785074.912	517893.325
225	162+075	2785050.975	517900.537

S.N.	CHAINAGE	NORTHING	EASTING
226	162+100	2785026.893	517907.218
227	162+125	2785002.044	517908.477
228	162+150	2784978.281	517901.122
229	162+175	2784956.81	517888.34
230	162+200	2784935.711	517874.93
231	162+225	2784914.658	517861.448
232	162+250	2784895.45	517845.54
233	162+275	2784881.162	517825.123
234	162+300	2784871.326	517802.151
235	162+325	2784862.066	517778.929
236	162+350	2784848.26	517758.377
237	162+375	2784825.537	517748.964
238	162+400	2784801.181	517753.539
239	162+425	2784777.941	517762.752
240	162+450	2784754.251	517770.652
241	162+475	2784729.414	517772.956
242	162+500	2784704.419	517772.448
243	162+525	2784679.426	517771.879
244	162+550	2784655.88	517766.075
245	162+575	2784651.682	517743.051
246	162+600	2784657.851	517719.386
247	162+625	2784645.054	517698.749
248	162+650	2784621.174	517694.344
249	162+675	2784600.945	517708.303
250	162+700	2784583.286	517726
251	162+725	2784563.99	517741.571
252	162+750	2784541.436	517735.32
253	162+775	2784538.633	517711.481
254	162+800	2784545.351	517687.401
255	162+825	2784546.372	517662.726
256	162+850	2784530.748	517644.137
257	162+875	2784506.327	517639.965
258	162+900	2784481.328	517640.203
259	162+925	2784456.33	517640.437
260	162+950	2784431.835	517636.497
261	162+975	2784413.459	517620.149
262	163+000	2784405.187	517596.653
263	163+025	2784397.795	517572.818
264	163+050	2784380.101	517556.082
265	163+075	2784355.827	517557.589
266	163+100	2784335.601	517572.16
267	163+125	2784316.432	517588.207
268	163+150	2784297.217	517604.2
269	163+175	2784276.144	517617.502
270	163+200	2784251.704	517621.36

S.N.	CHAINAGE	NORTHING	EASTING
271	163+225	2784228.122	517613.601
272	163+250	2784207.122	517600.059
273	163+275	2784186.504	517585.921
274	163+300	2784165.886	517571.783
275	163+325	2784145.268	517557.644
276	163+350	2784124.65	517543.506
277	163+375	2784104.032	517529.367
278	163+400	2784086.669	517511.987
279	163+425	2784091.399	517488.404
280	163+450	2784104.847	517467.329
281	163+475	2784118.142	517446.159
282	163+500	2784128.417	517423.414
283	163+525	2784133.968	517399.081
284	163+550	2784134.575	517374.13
285	163+575	2784130.274	517349.54
286	163+600	2784123.766	517325.402
287	163+625	2784117.24	517301.269
288	163+650	2784110.713	517277.136
289	163+675	2784104.187	517253.003
290	163+700	2784097.66	517228.87
291	163+725	2784090.546	517204.914
292	163+750	2784079.535	517182.516
293	163+775	2784065.182	517162.052
294	163+800	2784050.517	517141.805
295	163+825	2784035.852	517121.558
296	163+850	2784020.222	517102.077
297	163+875	2784000.212	517087.282
298	163+900	2783976.466	517079.843
299	163+925	2783951.508	517079.067
300	163+950	2783926.52	517079.847
301	163+975	2783901.53	517080.038
302	164+000	2783877.284	517074.557
303	164+025	2783857.188	517059.99
304	164+050	2783843.372	517039.233
305	164+075	2783831.968	517016.986
306	164+100	2783820.603	516994.718
307	164+125	2783809.239	516972.451
308	164+150	2783797.88	516950.18
309	164+175	2783788.34	516927.119
310	164+200	2783786.697	516902.351
311	164+225	2783793.62	516878.389
312	164+250	2783802.99	516855.211
313	164+275	2783812.553	516832.115
314	164+300	2783828.253	516813.181
315	164+325	2783852.485	516810.141
316	164+350	2783876.286	516817.731
317	164+375	2783900.372	516815.619
318	164+400	2783912.021	516794.668
319	164+425	2783905.418	516770.714
320	164+450	2783896.503	516747.358
321	164+475	2783888.887	516723.575
322	164+500	2783888.517	516698.749
323	164+525	2783897.108	516675.355
324	164+550	2783908.77	516653.242
325	164+575	2783920.511	516631.171
326	164+600	2783932.304	516609.127
327	164+625	2783946.496	516588.621
328	164+650	2783966.036	516573.168
329	164+675	2783987.907	516561.062
330	164+700	2784009.893	516549.161
331	164+725	2784031.878	516537.259
332	164+750	2784053.863	516525.357
333	164+775	2784074.929	516511.967
334	164+800	2784090.237	516492.495
335	164+825	2784094.485	516468.122
336	164+850	2784086.901	516444.507
337	164+875	2784072.903	516423.816
338	164+900	2784058.08	516403.684
339	164+925	2784043.258	516383.552
340	164+950	2784028.435	516363.42
341	164+975	2784014.233	516342.871
342	165+000	2784010.178	516318.787
343	165+025	2784023.358	516297.935
344	165+050	2784041.478	516280.712
345	165+075	2784054.598	516259.827
346	165+100	2784049.981	516235.987
347	165+125	2784029.543	516222.45
348	165+150	2784005.18	516216.874
349	165+175	2783983.767	516205.421
350	165+200	2783982.565	516181.237
351	165+225	2783988.914	516157.057
352	165+250	2783998.016	516133.908
353	165+275	2784015.936	516116.63
354	165+300	2784035.631	516101.233
355	165+325	2784055.552	516086.133
356	165+350	2784076.567	516072.605
357	165+375	2784098.632	516060.867
358	165+400	2784121.104	516049.913
359	165+425	2784143.577	516038.959
360	165+450	2784166.046	516027.999

S.N.	CHAINAGE	NORTHING	EASTING
361	165+475	2784187.696	516015.547
362	165+500	2784207.027	515999.739
363	165+525	2784223.469	515980.945
364	165+550	2784237.754	515960.429
365	165+575	2784251.922	515939.831
366	165+600	2784266.09	515919.234
367	165+625	2784280.258	515898.636
368	165+650	2784294.609	515878.168
369	165+675	2784310.839	515859.173
370	165+700	2784329.31	515842.351
371	165+725	2784349.734	515827.962
372	165+750	2784371.773	515816.188
373	165+775	2784394.425	515805.612
374	165+800	2784417.082	515795.044
375	165+825	2784439.717	515784.432
376	165+850	2784460.854	515771.219
377	165+875	2784475.138	515751.012
378	165+900	2784478.008	515726.438
379	165+925	2784468.843	515703.434
380	165+950	2784452.193	515684.846
381	165+975	2784434.089	515667.606
382	166+000	2784415.981	515650.368
383	166+025	2784397.874	515633.131
384	166+050	2784379.767	515615.894
385	166+075	2784361.659	515598.656
386	166+100	2784343.552	515581.419
387	166+125	2784325.445	515564.182
388	166+150	2784307.337	515546.944
389	166+175	2784289.23	515529.707
390	166+200	2784271.123	515512.47
391	166+225	2784253.161	515495.084
392	166+250	2784238.554	515474.933
393	166+275	2784233.891	515450.631
394	166+300	2784239.066	515426.249
395	166+325	2784247.203	515402.61
396	166+350	2784255.39	515378.989
397	166+375	2784263.578	515355.367
398	166+400	2784271.549	515331.675
399	166+425	2784275.367	515307.067
400	166+450	2784271.708	515282.389
401	166+475	2784265.744	515258.111
402	166+500	2784262.922	515233.533
403	166+525	2784280.374	515217.22
404	166+550	2784303.927	515208.929
405	166+575	2784315.725	515188.531
406	166+600	2784310.349	515164.16
407	166+625	2784304.049	515139.967
408	166+650	2784297.928	515115.733
409	166+675	2784299.924	515091.073
410	166+700	2784313.499	515070.389
411	166+725	2784333.95	515056.151
412	166+750	2784345.799	515034.598
413	166+775	2784342.797	515010.187
414	166+800	2784330.083	514988.67
415	166+825	2784320.006	514965.844
416	166+850	2784312.5	514941.997
417	166+875	2784305.044	514918.135
418	166+900	2784297.587	514894.273
419	166+925	2784290.131	514870.411
420	166+950	2784282.748	514846.526
421	166+975	2784278.626	514821.952
422	167+000	2784284.567	514797.933
423	167+025	2784301.286	514779.696
424	167+050	2784324.635	514771.35
425	167+075	2784349.582	514770.106
426	167+100	2784374.582	514769.963
427	167+125	2784399.582	514769.82
428	167+150	2784424.568	514770.424
429	167+175	2784449.419	514773.081
430	167+200	2784473.978	514777.731
431	167+225	2784498.43	514782.934
432	167+250	2784522.823	514779.792
433	167+275	2784540.768	514762.972
434	167+300	2784545.478	514738.832
435	167+325	2784537.796	514715.11
436	167+350	2784530.587	514691.219
437	167+375	2784527.697	514666.391
438	167+400	2784522.274	514642.089
439	167+425	2784510.4	514620.118
440	167+450	2784497.816	514598.516
441	167+475	2784485.231	514576.915
442	167+500	2784472.646	514555.313
443	167+525	2784460.061	514533.712
444	167+550	2784448.571	514511.577
445	167+575	2784447.168	514486.876
446	167+600	2784454.178	514462.886
447	167+625	2784459.873	514438.571
448	167+650	2784461.485	514413.652
449	167+675	2784458.941	514388.811
450	167+700	2784452.366	514364.717

S.N.	CHAINAGE	NORTHING	EASTING
451	167+725	2784444.404	514341.019
452	167+750	2784436.442	514317.321
453	167+775	2784429.283	514293.382
454	167+800	2784427.869	514268.534
455	167+825	2784433.912	514244.333
456	167+850	2784442.489	514220.851
457	167+875	2784450.817	514197.281
458	167+900	2784457.365	514173.162
459	167+925	2784462.261	514148.647
460	167+950	2784466.998	514124.1
461	167+975	2784471.815	514099.569
462	168+000	2784479.931	514075.989
463	168+025	2784493.607	514055.139
464	168+050	2784510.658	514036.86
465	168+075	2784527.888	514018.746
466	168+100	2784545.118	514000.631
467	168+125	2784562.347	513982.517
468	168+150	2784579.577	513964.402
469	168+175	2784596.807	513946.288
470	168+200	2784614.032	513928.169
471	168+225	2784630.358	513909.245
472	168+250	2784645.052	513889.028
473	168+275	2784658.012	513867.658
474	168+300	2784669.148	513845.284
475	168+325	2784678.384	513822.06
476	168+350	2784686.612	513798.453
477	168+375	2784694.84	513774.846
478	168+400	2784703.068	513751.238
479	168+425	2784711.296	513727.631
480	168+450	2784719.524	513704.024
481	168+475	2784726.626	513680.073
482	168+500	2784729.865	513655.313
483	168+525	2784728.952	513630.358
484	168+550	2784723.985	513605.882
485	168+575	2784717.336	513581.782
486	168+600	2784710.679	513557.685
487	168+625	2784704.021	513533.587
488	168+650	2784697.364	513509.49
489	168+675	2784690.707	513485.393
490	168+700	2784684.351	513461.216
491	168+725	2784679.099	513436.776
492	168+750	2784675.005	513412.116
493	168+775	2784672.078	513387.29
494	168+800	2784670.326	513362.354
495	168+825	2784669.751	513337.363

S.N.	CHAINAGE	NORTHING	EASTING
496	168+850	2784670.355	513312.373
497	168+875	2784672.137	513287.439
498	168+900	2784675.092	513262.616
499	168+925	2784679.215	513237.961
500	168+950	2784684.496	513213.527
501	168+975	2784690.923	513189.37
502	169+000	2784698.395	513165.514
503	169+025	2784706.074	513141.723
504	169+050	2784713.796	513117.945
505	169+075	2784721.995	513094.328
506	169+100	2784730.781	513070.924
507	169+125	2784740.117	513047.733
508	169+150	2784749.581	513024.593
509	169+175	2784759.044	513001.454
510	169+200	2784768.459	512978.295
511	169+225	2784776.51	512954.634
512	169+250	2784782.562	512930.385
513	169+275	2784786.7	512905.734
514	169+300	2784790.401	512881.01
515	169+325	2784794.101	512856.285
516	169+350	2784796.344	512831.416
517	169+375	2784792.934	512806.714
518	169+400	2784785.575	512782.825
519	169+425	2784777.964	512759.011
520	169+450	2784770.352	512735.198
521	169+475	2784762.741	512711.385
522	169+500	2784755.129	512687.572
523	169+525	2784747.518	512663.759
524	169+550	2784736.591	512641.449
525	169+575	2784717.674	512625.381
526	169+600	2784693.985	512617.717
527	169+625	2784669.848	512611.27
528	169+650	2784647.631	512599.949
529	169+675	2784628.905	512583.484
530	169+700	2784613.993	512563.439
531	169+725	2784599.8	512542.859
532	169+750	2784585.606	512522.279
533	169+775	2784571.413	512501.698
534	169+800	2784557.22	512481.118
535	169+825	2784543.027	512460.537
536	169+850	2784529.348	512439.62
537	169+875	2784518.124	512417.3
538	169+900	2784509.77	512393.754
539	169+925	2784503.912	512369.454
540	169+950	2784498.409	512345.067

S.N.	CHAINAGE	NORTHING	EASTING
541	169+975	2784492.906	512320.68
542	170+000	2784487.403	512296.293
543	170+025	2784480.966	512272.148
544	170+050	2784471.693	512248.949
545	170+075	2784460.291	512226.702
546	170+100	2784448.714	512204.544
547	170+125	2784437.136	512182.386
548	170+150	2784425.559	512160.228
549	170+175	2784413.982	512138.071
550	170+200	2784402.405	512115.913
551	170+225	2784390.83	512093.754
552	170+250	2784380.894	512070.853
553	170+275	2784376.543	512046.301
554	170+300	2784378.402	512021.435
555	170+325	2784385.792	511997.583
556	170+350	2784394.507	511974.151
557	170+375	2784403.222	511950.719
558	170+400	2784411.938	511927.287
559	170+425	2784420.653	511903.856
560	170+450	2784429.368	511880.424
561	170+475	2784438.059	511856.983
562	170+500	2784446.063	511833.301
563	170+525	2784453.257	511809.359
564	170+550	2784460.372	511785.393
565	170+575	2784467.488	511761.427
566	170+600	2784474.603	511737.461
567	170+625	2784481.718	511713.495
568	170+650	2784488.833	511689.529
569	170+675	2784495.949	511665.563
570	170+700	2784503.917	511641.884
571	170+725	2784516.624	511620.43
572	170+750	2784534.244	511602.787
573	170+775	2784555.661	511590.008
574	170+800	2784578.651	511580.189
575	170+825	2784600.319	511567.802
576	170+850	2784619.099	511551.362
577	170+875	2784634.238	511531.52
578	170+900	2784645.48	511509.214
579	170+925	2784655.703	511486.4
580	170+950	2784665.926	511463.586
581	170+975	2784676.149	511440.771
582	171+000	2784686.066	511417.827
583	171+025	2784692.917	511393.814
584	171+050	2784696.879	511369.132
585	171+075	2784700.64	511344.416

S.N.	CHAINAGE	NORTHING	EASTING
586	171+100	2784704.401	511319.701
587	171+125	2784708.161	511294.985
588	171+150	2784711.922	511270.269
589	171+175	2784715.683	511245.554
590	171+200	2784719.444	511220.838
591	171+225	2784723.08	511196.105
592	171+250	2784723.075	511171.193
593	171+275	2784713.951	511148.111
594	171+300	2784696.336	511130.6
595	171+325	2784674.538	511118.399
596	171+350	2784652.237	511107.1
597	171+375	2784629.936	511095.802
598	171+400	2784607.635	511084.503
599	171+425	2784585.334	511073.204
600	171+450	2784563.427	511061.253
601	171+475	2784552.652	511039.492
602	171+500	2784561.514	511016.884
603	171+525	2784583.557	511005.531
604	171+550	2784606.596	510995.843
605	171+575	2784626.801	510981.376
606	171+600	2784638.391	510959.51
607	171+625	2784640.873	510934.7
608	171+650	2784640.594	510909.702
609	171+675	2784640.529	510884.705
610	171+700	2784645.016	510860.232
611	171+725	2784659.502	510840.176
612	171+750	2784681.442	510828.478
613	171+775	2784705.434	510821.466
614	171+800	2784728.813	510812.837
615	171+825	2784744.509	510794.046
616	171+850	2784744.099	510769.577
617	171+875	2784727.76	510751.358
618	171+900	2784703.665	510745.286
619	171+925	2784678.913	510741.88
620	171+950	2784656.08	510732.157
621	171+975	2784638.977	510714.067
622	172+000	2784625.02	510693.327
623	172+025	2784611.205	510672.491
624	172+050	2784597.391	510651.655
625	172+075	2784584.177	510630.446
626	172+100	2784576.782	510606.748
627	172+125	2784580.329	510582.168
628	172+150	2784589.73	510559.013
629	172+175	2784599.693	510536.084
630	172+200	2784609.656	510513.155

S.N.	CHAINAGE	NORTHING	EASTING
631	172+225	2784619.619	510490.226
632	172+250	2784630.265	510467.621
633	172+275	2784646.264	510448.644
634	172+300	2784669.112	510439.154
635	172+325	2784693.713	510441.779
636	172+350	2784715.101	510454.521
637	172+375	2784734.218	510470.63
638	172+400	2784753.229	510486.864
639	172+425	2784772.241	510503.099
640	172+450	2784791.411	510519.142
641	172+475	2784813.089	510531.353
642	172+500	2784837.771	510533.056
643	172+525	2784860.247	510522.717
644	172+550	2784875.07	510502.894
645	172+575	2784881.675	510478.841
646	172+600	2784885.904	510454.202
647	172+625	2784890.115	510429.559
648	172+650	2784894.325	510404.916
649	172+675	2784898.536	510380.273
650	172+700	2784901.476	510355.474
651	172+725	2784896.807	510331.13
652	172+750	2784882.536	510310.732
653	172+775	2784865.032	510292.884
654	172+800	2784847.405	510275.156
655	172+825	2784829.781	510257.424
656	172+850	2784813.627	510238.403
657	172+875	2784804.986	510215.185
658	172+900	2784805.37	510190.247
659	172+925	2784808.259	510165.414
660	172+950	2784813.059	510140.92
661	172+975	2784822.424	510117.755
662	173+000	2784832.517	510094.883
663	173+025	2784842.61	510072.011
664	173+050	2784852.16	510048.917
665	173+075	2784855.923	510024.367
666	173+100	2784848.191	510000.866
667	173+125	2784830.139	509983.949
668	173+150	2784806.185	509977.757
669	173+175	2784782.196	509983.808
670	173+200	2784763.877	510000.489
671	173+225	2784751.738	510022.307
672	173+250	2784740.921	510044.845
673	173+275	2784727.98	510066.168
674	173+300	2784708.431	510081.425
675	173+325	2784685.03	510090.146
676	173+350	2784661.184	510097.655
677	173+375	2784637.633	510105.995
678	173+400	2784617.119	510120.012
679	173+425	2784601.968	510139.844
680	173+450	2784588.402	510160.843
681	173+475	2784574.841	510181.846
682	173+500	2784559.44	510201.168
683	173+525	2784536.229	510198.171
684	173+550	2784530.284	510174.94
685	173+575	2784533.497	510150.191
686	173+600	2784542.456	510126.921
687	173+625	2784556.801	510106.513
688	173+650	2784573.428	510087.843
689	173+675	2784590.096	510069.211
690	173+700	2784606.764	510050.578
691	173+725	2784623.415	510031.93
692	173+750	2784638.055	510011.737
693	173+775	2784646.261	509988.229
694	173+800	2784646.842	509963.338
695	173+825	2784639.742	509939.473
696	173+850	2784625.649	509918.947
697	173+875	2784606.217	509903.309
698	173+900	2784585.252	509889.692
699	173+925	2784564.273	509876.094
700	173+950	2784543.295	509862.496
701	173+975	2784522.316	509848.899
702	174+000	2784501.338	509835.301
703	174+025	2784480.359	509821.703
704	174+050	2784459.381	509808.105
705	174+075	2784438.402	509794.507
706	174+100	2784417.424	509780.909
707	174+125	2784396.966	509766.57
708	174+150	2784379.986	509748.309
709	174+175	2784367.914	509726.476
710	174+200	2784358.236	509703.426
711	174+225	2784348.595	509680.36
712	174+250	2784338.954	509657.293
713	174+275	2784329.312	509634.227
714	174+300	2784319.671	509611.161
715	174+325	2784310.03	509588.095
716	174+350	2784299.226	509565.58
717	174+375	2784282.234	509547.534
718	174+400	2784259.169	509538.197
719	174+425	2784234.689	509533.133
720	174+450	2784210.391	509527.333

S.N.	CHAINAGE	NORTHING	EASTING
721	174+475	2784188.843	509515.05
722	174+500	2784175.502	509494.215
723	174+525	2784173.784	509469.534
724	174+550	2784183.707	509446.795
725	174+575	2784199.542	509427.472
726	174+600	2784216.074	509408.718
727	174+625	2784232.606	509389.964
728	174+650	2784248.978	509371.073
729	174+675	2784262.111	509349.901
730	174+700	2784267.871	509325.692
731	174+725	2784265.393	509300.932
732	174+750	2784255.395	509278.094
733	174+775	2784242.498	509256.678
734	174+800	2784229.518	509235.312
735	174+825	2784217.829	509213.248
736	174+850	2784213.726	509188.812
737	174+875	2784221.618	509165.363
738	174+900	2784239.704	509148.443
739	174+925	2784262.584	509138.467
740	174+950	2784285.85	509129.361
741	174+975	2784305.718	509114.496
742	175+000	2784316.486	509092.215
743	175+025	2784317.875	509067.325
744	175+050	2784316.328	509042.373
745	175+075	2784314.735	509017.424
746	175+100	2784313.142	508992.474
747	175+125	2784311.55	508967.525
748	175+150	2784309.957	508942.576
749	175+175	2784309.175	508917.602
750	175+200	2784312.692	508892.887
751	175+225	2784318.268	508868.516
752	175+250	2784323.856	508844.149
753	175+275	2784329.977	508819.918
754	175+300	2784340.934	508797.564
755	175+325	2784358.435	508779.848
756	175+350	2784378.989	508765.624
757	175+375	2784399.34	508751.125
758	175+400	2784416.881	508733.37
759	175+425	2784430.544	508712.483
760	175+450	2784439.785	508689.299
761	175+475	2784444.25	508664.742
762	175+500	2784445.905	508639.797
763	175+525	2784447.484	508614.847
764	175+550	2784449.113	508589.9

S.N.	CHAINAGE	NORTHING	EASTING
765	175+575	2784453.349	508565.301
766	175+600	2784460.576	508541.37
767	175+625	2784467.917	508517.472
768	175+650	2784475.258	508493.574
769	175+675	2784482.6	508469.676
770	175+700	2784489.931	508445.775
771	175+725	2784495.286	508421.398
772	175+750	2784494.314	508396.497
773	175+775	2784486.552	508372.817
774	175+800	2784473.046	508351.828
775	175+825	2784460.255	508330.527
776	175+850	2784458.562	508305.845
777	175+875	2784468.909	508283.372
778	175+900	2784488.721	508268.519
779	175+925	2784511.198	508257.574
780	175+950	2784533.675	508246.629
781	175+975	2784554.764	508233.476
782	176+000	2784567.574	508212.31
783	176+025	2784568.667	508187.594
784	176+050	2784560.287	508164.069
785	176+075	2784555.922	508139.696
786	176+100	2784563.679	508116.203
787	176+125	2784578.673	508096.204
788	176+150	2784593.787	508076.289
789	176+175	2784606.877	508055.057
790	176+200	2784611.504	508030.706
791	176+225	2784608.085	508005.975
792	176+250	2784603.111	507981.475
793	176+275	2784598.136	507956.975
794	176+300	2784593.161	507932.475
795	176+325	2784587.735	507908.077
796	176+350	2784577.645	507885.315
797	176+375	2784560.993	507866.776
798	176+400	2784541.705	507850.873
799	176+425	2784522.309	507835.1
800	176+450	2784502.914	507819.326
801	176+475	2784483.677	507803.363
802	176+500	2784467.401	507784.504
803	176+525	2784457.969	507761.476
804	176+550	2784456.59	507736.63
805	176+575	2784462.193	507712.304
806	176+575	2784462.193	507712.304
807	176+581	2784464.251	507705.612