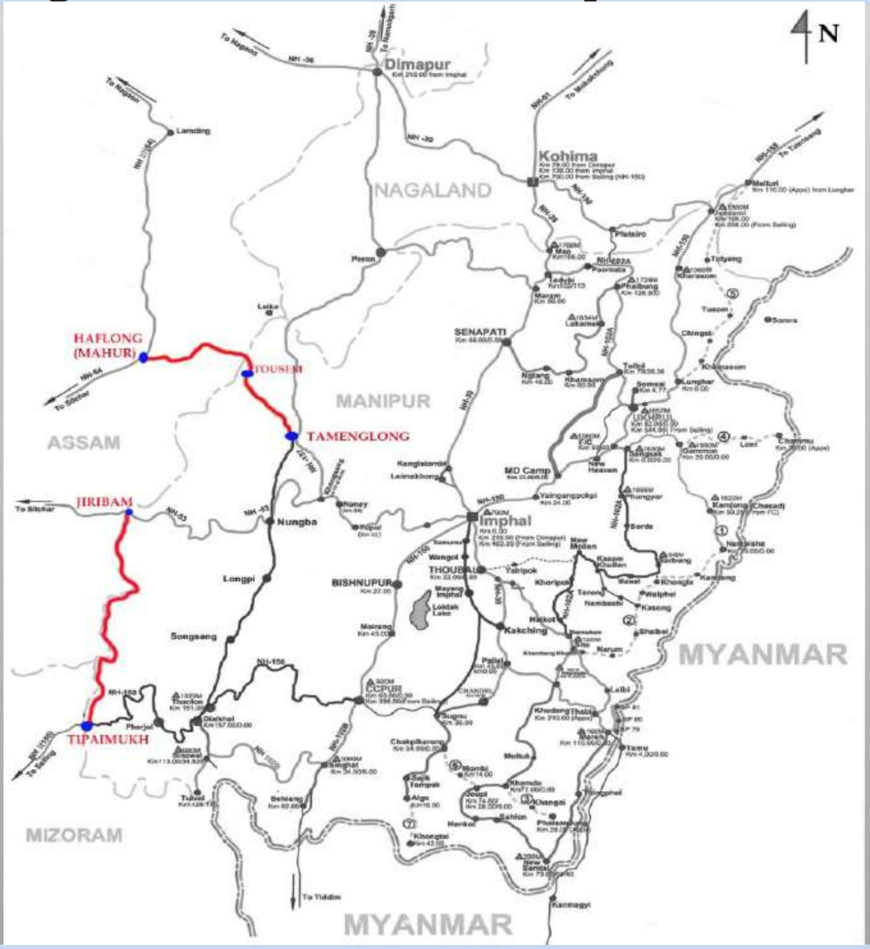
NATIONAL HIGHWAY INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

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-1
TAMENGLONG-DIALONG SECTION
(FROM KM 0+000 TO KM 10+000) LENGTH-10.0KM

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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 79-2018, 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 73-2015, 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

It is learnt that the National Highways and Infrastructure Development Corporation Limited (NHIDCL) did not carried out traffic volume count on the project road. Therefore, no previous data has been provided to Consultant.

IRC:37-2019 stated" If the data for the annual growth rate of commercial vehicles is not available or if it is less than 5 per cent, a growth rate of 5 per cent should be used".

Hence traffic growth rate is adopted 5% for projection of present traffic.

Vehicle Damage Factor

As per IRC: 37-2019 clause 4.4.6 stated" where the sufficient information on axle loads is not available the default values of vehicles of vehicle damage factor as given in table 4.2 may be used".

As per table 4.2 for CVPD more than 1500 adopted VDF should be 2.5 for Hilly terrain.

Hence, The Adopted VDF is 2.5.

Cumulative Mean Standard Axles (CMSA)

Summary of CMSA By Assumed Traffic		
Year	**Pkg-1**	**Design year**
2017 to 2020	Project Clearance	
2021	**0.21**	1
2022	**0.43**	2
2023	**0.67**	3
2024	**0.91**	4
2025	**1.17**	5
2026	**1.44**	6
2027	**1.73**	7
2028	**2.03**	8

2029	2.35	9
2030	2.68	10
2031	3.02	11
2032	3.39	12
2033	3.77	13
2034	4.17	14
2035	4.59	15
2036	5.04	16
2037	5.50	17
2038	5.99	18
2039	6.50	19
2040	7.04	20
2041	7.60	21
2042	8.20	22
2043	8.82	23
2044	9.47	24
2045	10.16	25

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.-4 of IRC-37:2019 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	GSB
0+000	10+000	10.000	8	20	30	90	250	200

As Per test results the average CBR Varies from 8-12%. So, the value of adopted CBR is 8%.

DESIGN OF CULVERTS

& BRIDGES

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

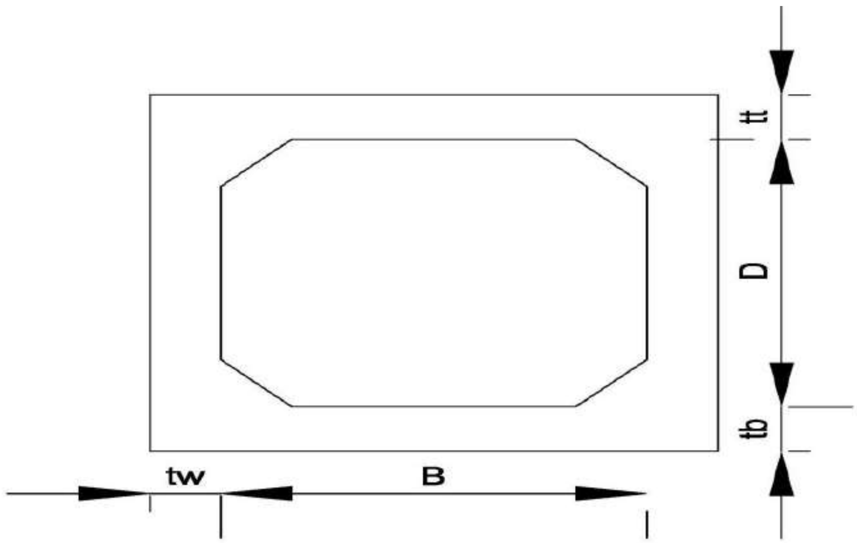
Load combinations as per IRC 6: 2014 have been considered in staad load combination.

1.6 Material properties

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

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

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

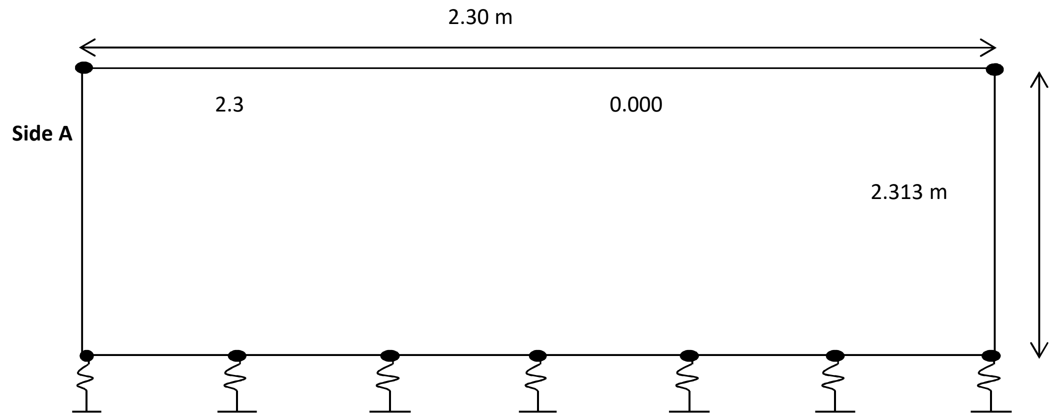
Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpres:	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge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

(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 Earth Pressure and Live Load Calculation

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

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

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

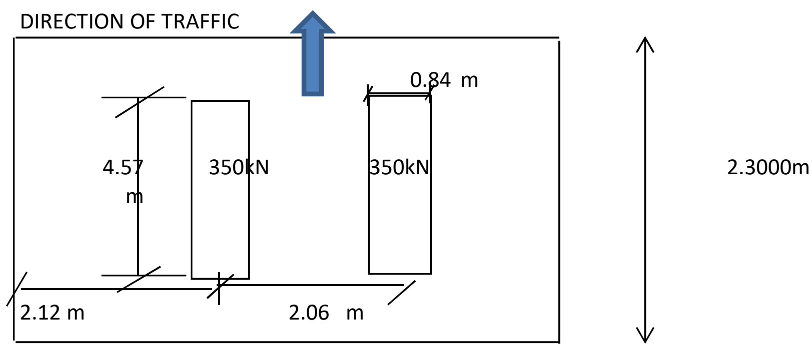
Live Load Surcharge = 12.000 kN/m

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

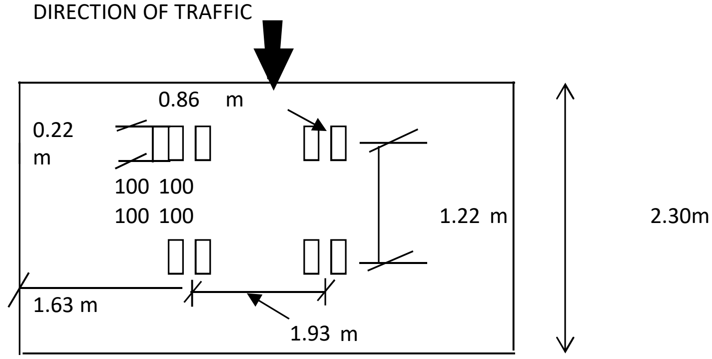
Effective width of Loading

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	=	2.3 m
Load Intensity	=	33.66 kN/m^2
Increase due to impact	=	42.08 kN/m^2
	Say	**42.10** kN/m^2

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***

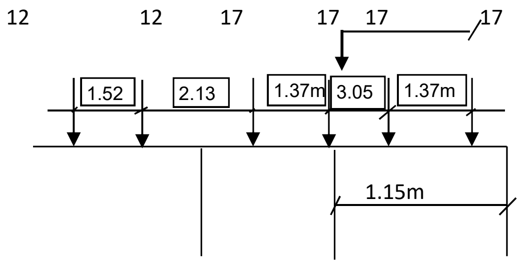
Effective width	=	4.55 m
Width along span	=	2.300 m
Load Intensity	=	33.66 kN/m^2

	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

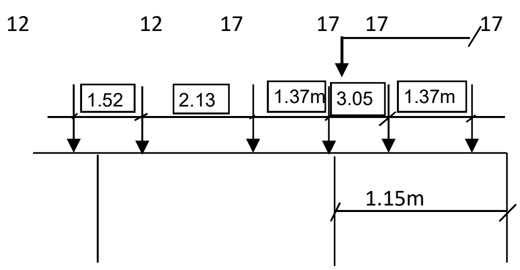


0.86m 1.93m 0.86m

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

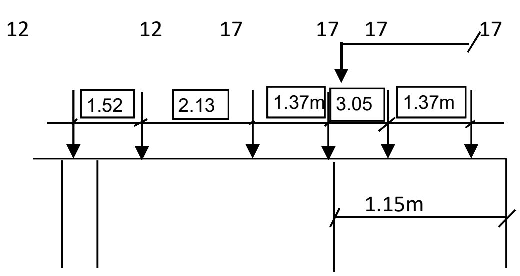
F) 70R Wheel Case 2



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



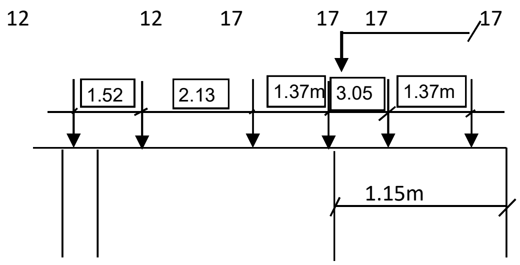
Width along span = 0.970m

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

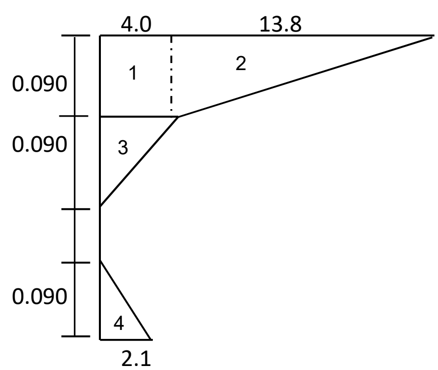
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 300 mm

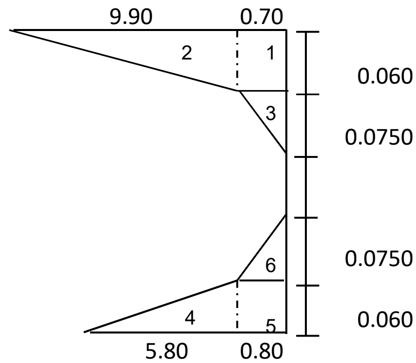
EFFECT OF TEMPERATURE RISE



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

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

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

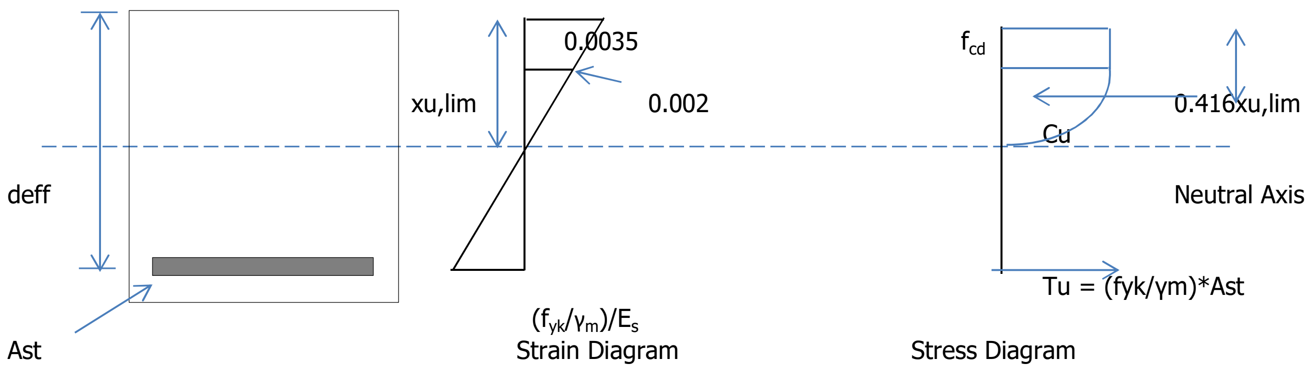
Combination for Base Pressure and Design of Foundation

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 Combinatio n
(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

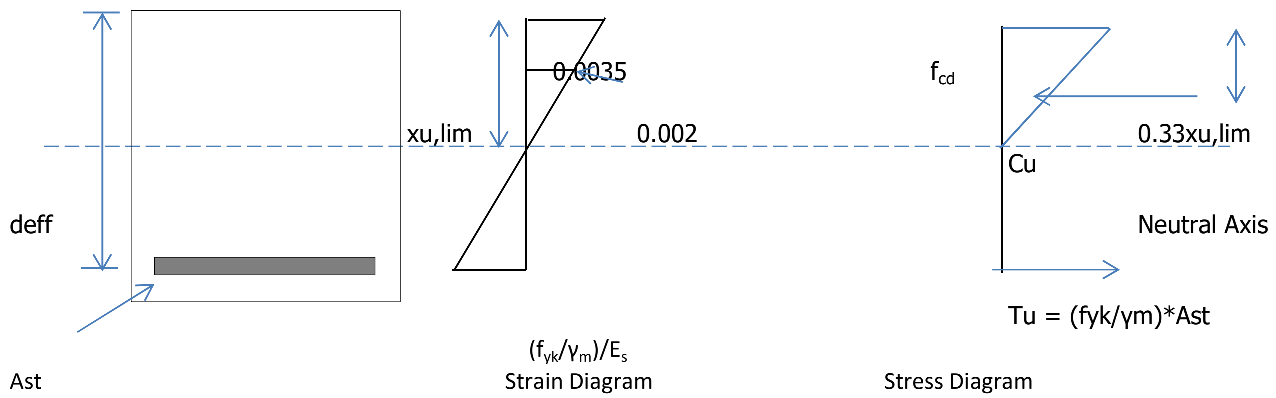
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	57.0			48.3		
b	1000			1000		
D	300			300		
c	50			50		
d	232.0			233.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	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			
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (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



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

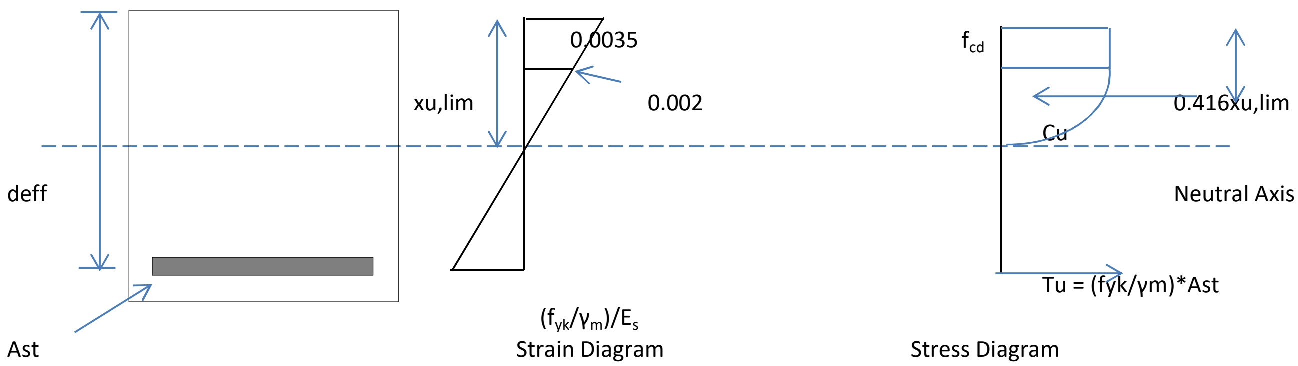
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	243.0		243.0
f_{cd}	14.40		10.80	14.40		10.80
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



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

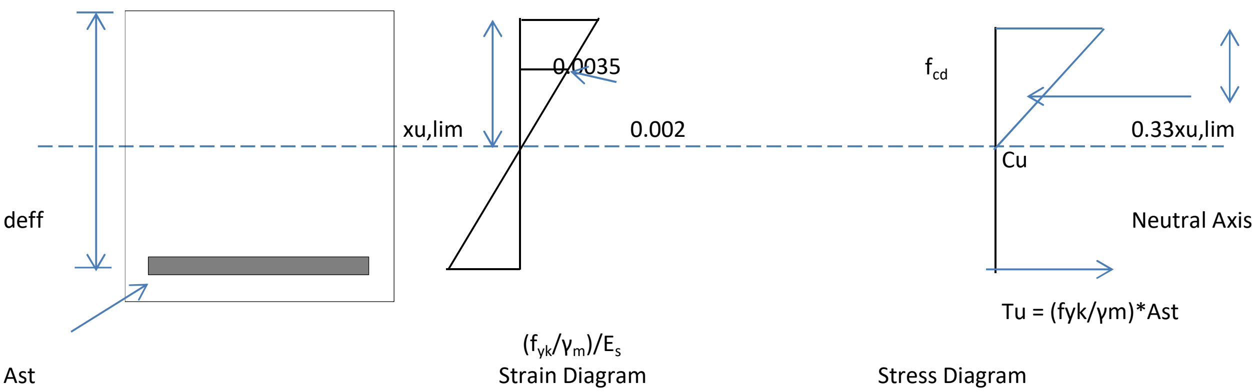
Moment on the section	**Bottom End support**			**Top Mid Span**		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	86.0		80.0	65.0		58.0
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	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			
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (KN)	105		105
	Provide Shear Reinf.		**Provide Shear Reinf.**

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

5.2.2 Verification for serviceability limit state for bottom 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

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 = 325 mm

Clear cover at bott. = 75

Clear cover at top = 40

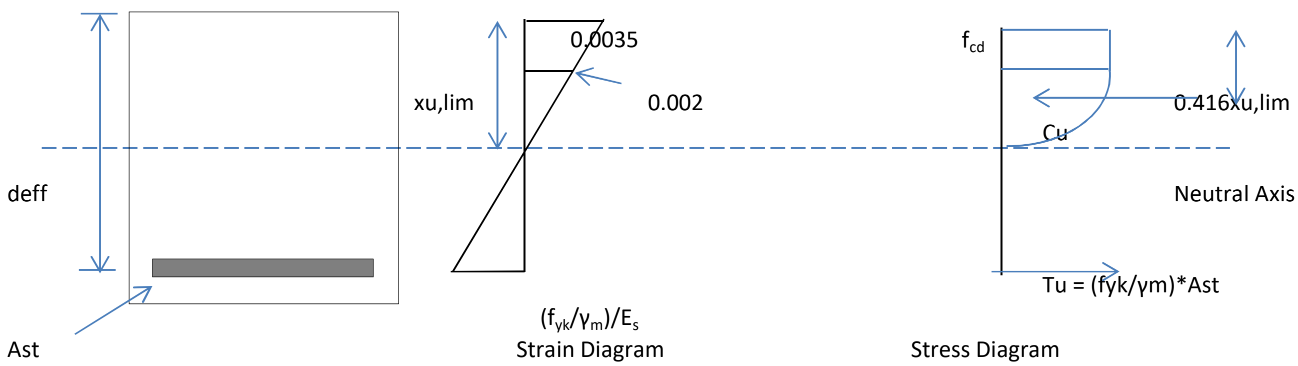
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

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**

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 = 300 mm

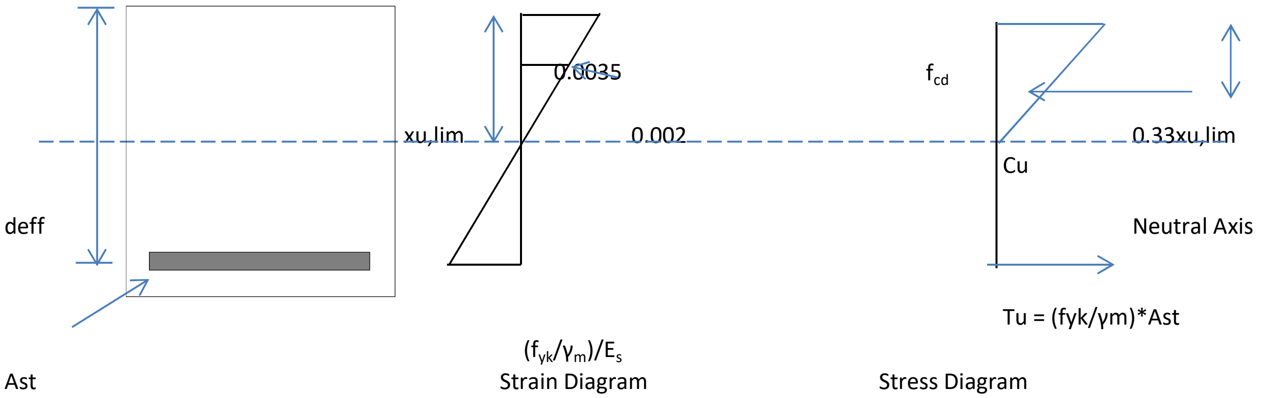
Clear cover = 75

	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**		

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

5.3.2 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

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 = 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

				Required
At top of Mid Span				
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.

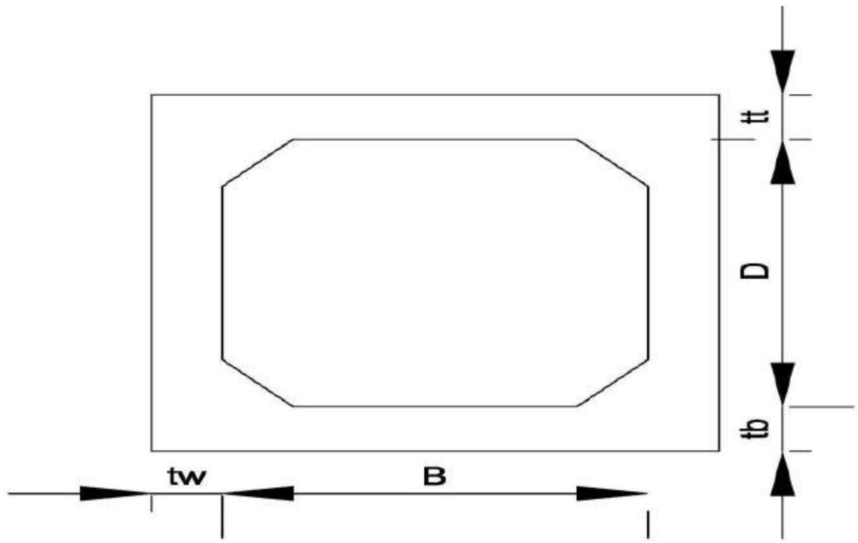
1.5 Load combinations

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

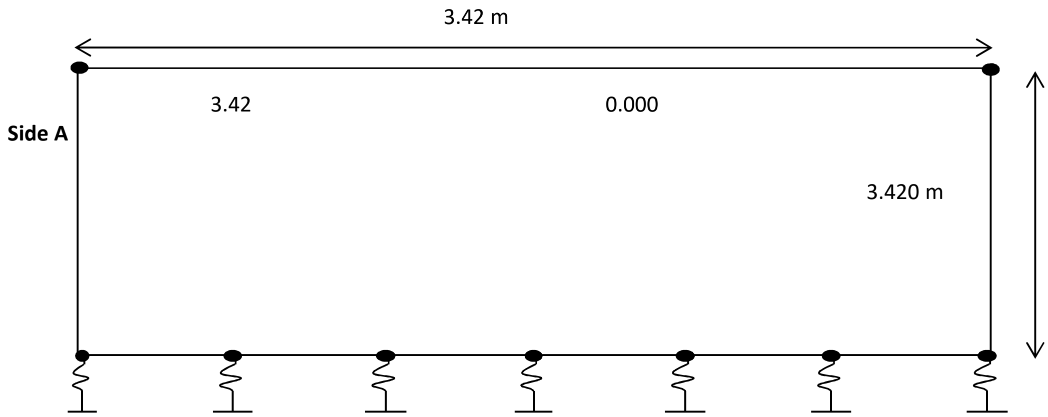
Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpres:	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge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

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

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

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

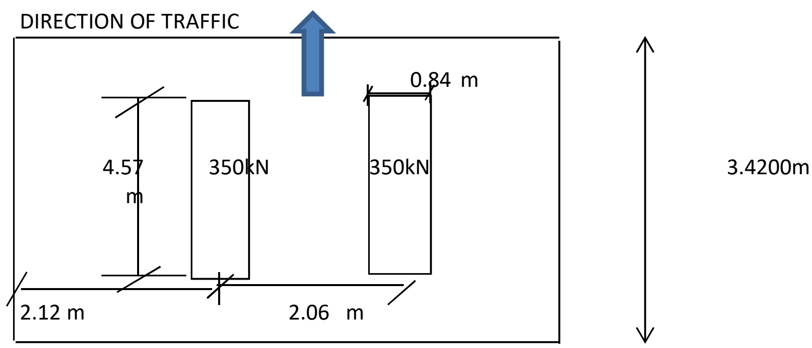
Live Load Surcharge = 12.000 kN/m

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		

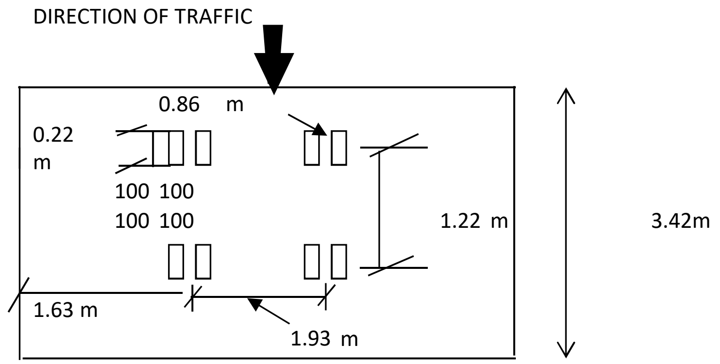
<u>Effective width of Loading</u>

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***

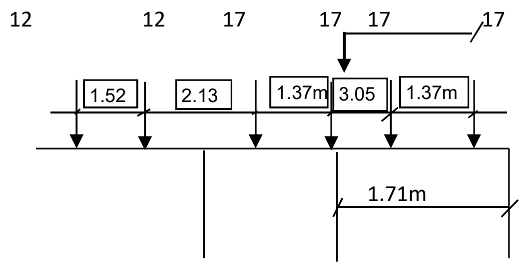
Effective width	=	5.27	m
Width along span	=	3.420	m
Load Intensity	=	29.07	kN/m^2

	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

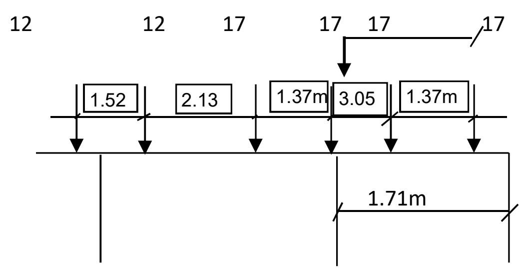


0.86m 1.93m 0.86m

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

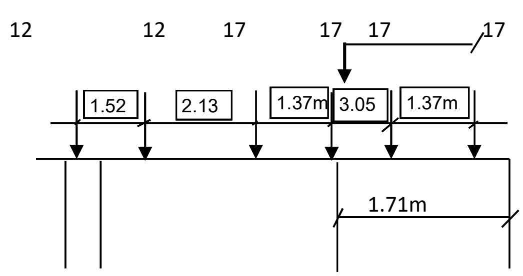
F) 70R Wheel Case 2



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



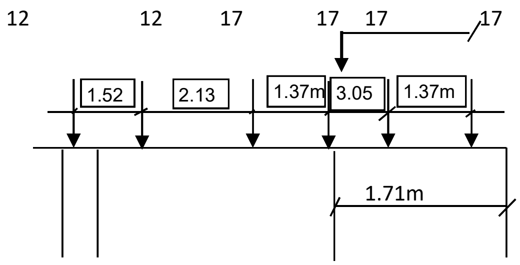
Width along span = 1.210m

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**

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	/°C (as per Annexure F of IRC:6-2014)
Mean of max and min temperature	=	23.85	/°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.

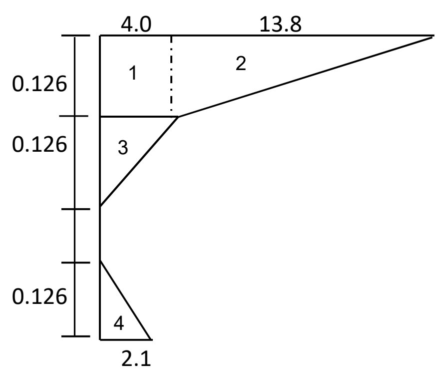
F = E_c aDt A

E_c = Modulus of Elasticity of Concrete	=	3.21E+06	t/m^2
a = Coefficient of Thermal expansion	=	1.20E-05	/°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

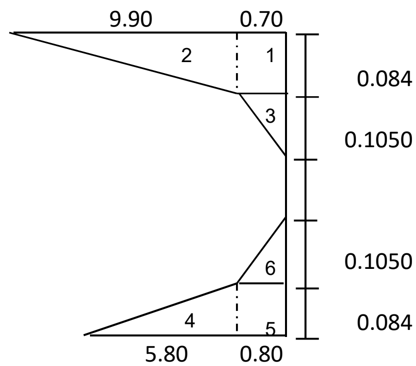
EFFECT OF TEMPERATURE RISE



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

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

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

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

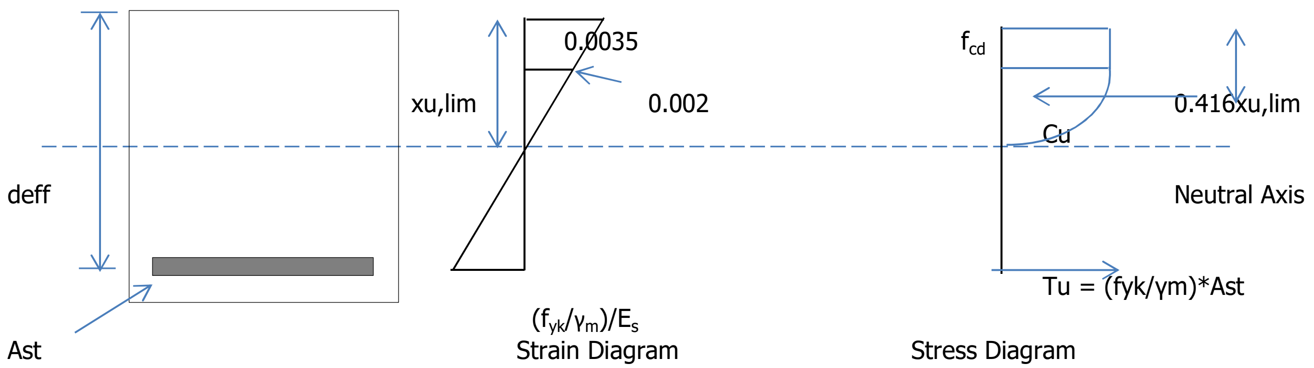
Table 3.4, Annex B, IRC:6-2014

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

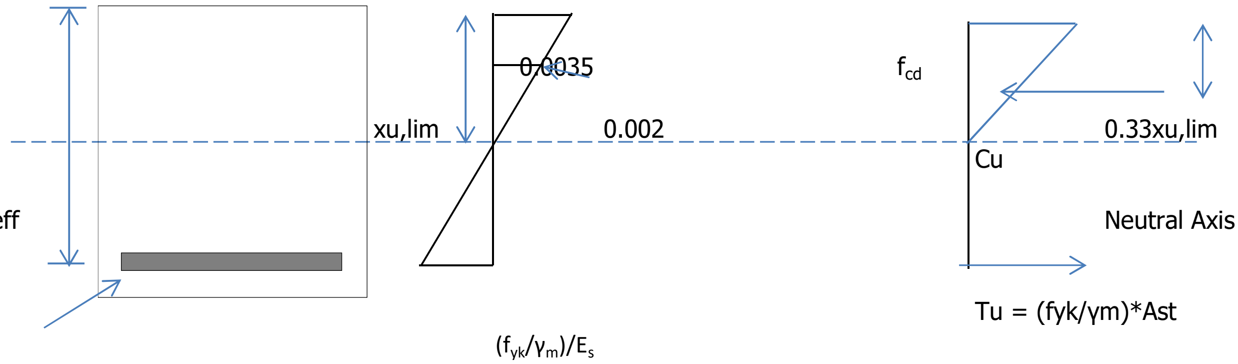
Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Basic Comb			Basic Comb		
Actual moment (KNm)	80.0			70.0		
b	1000			1000		
D	420			420		
c	50			50		
d	352.0			353.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			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		
$\Theta = 0.5 \times \sin^{-1}$ (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	1.754		
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		

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

5.1.2 Verification for serviceability limit state for top 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 = 40

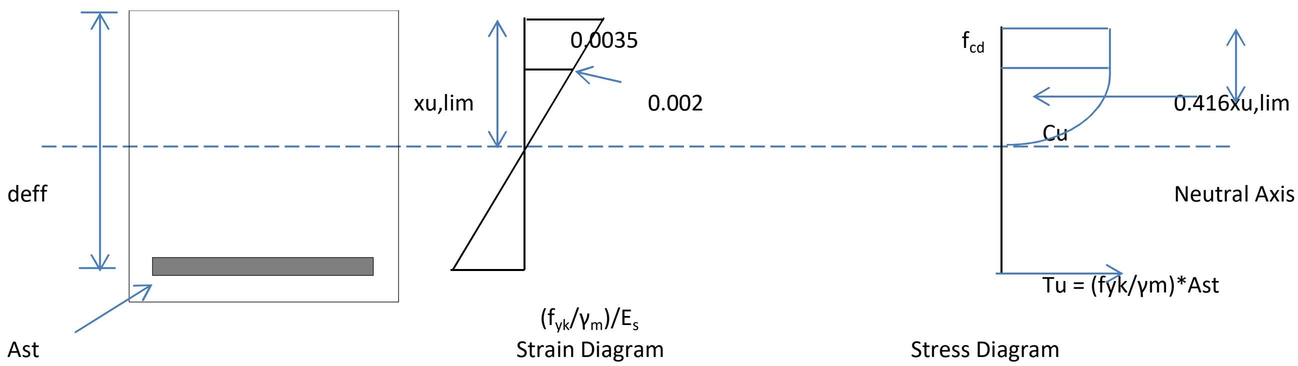
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

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	

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

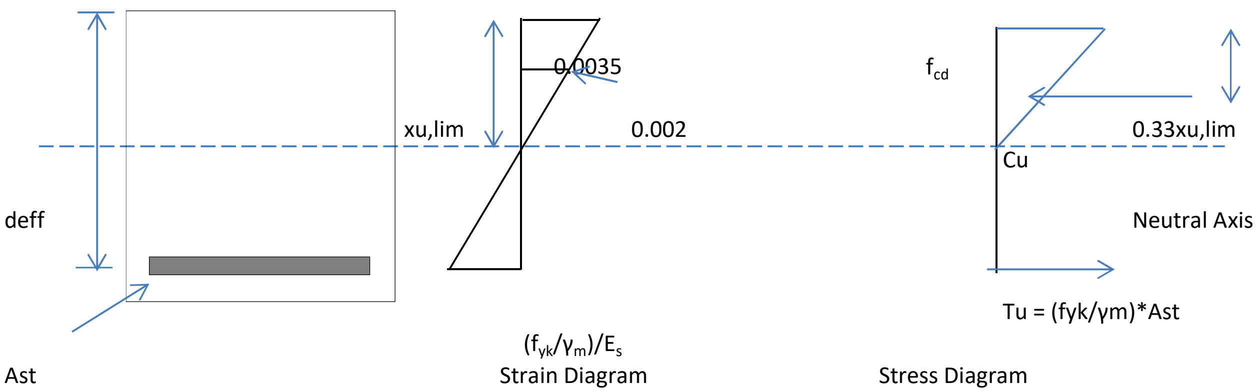
Moment on the section	Bottom End support			Top Mid Span		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	130.0		107.0	111.0		93.0
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435		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
$\Theta = 0.5 \times \sin^{-1}$ (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	1.782		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.**

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

5.2.2 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

Refer Chaper 5 of Reinfroced Concrete 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 at bott. = 75 Clear cover at top = 40

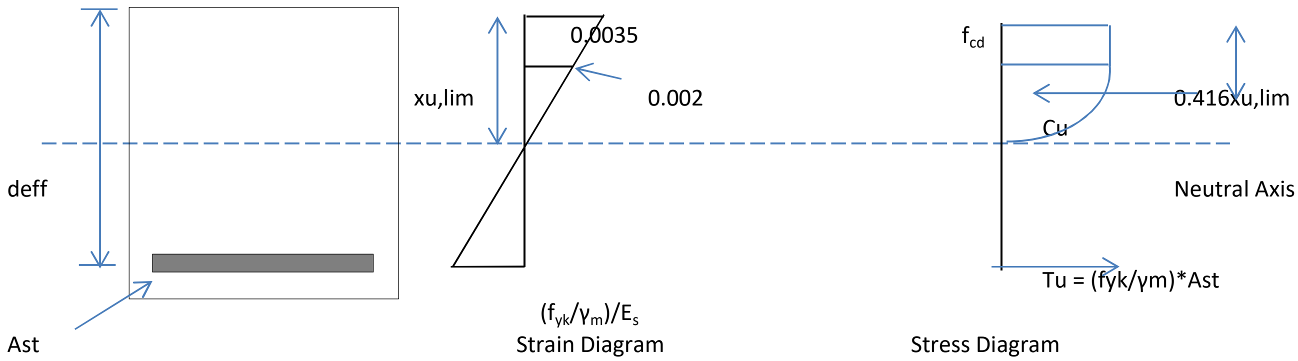
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

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**

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

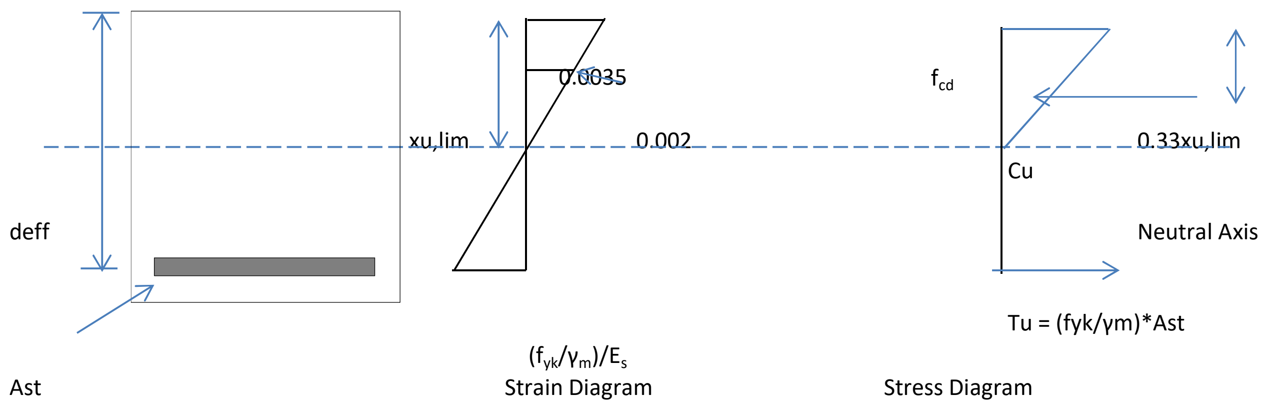
Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	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**		

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			

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 note
for
RCC BOX OF SIZE 2 x 4.0 x 4.0

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

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

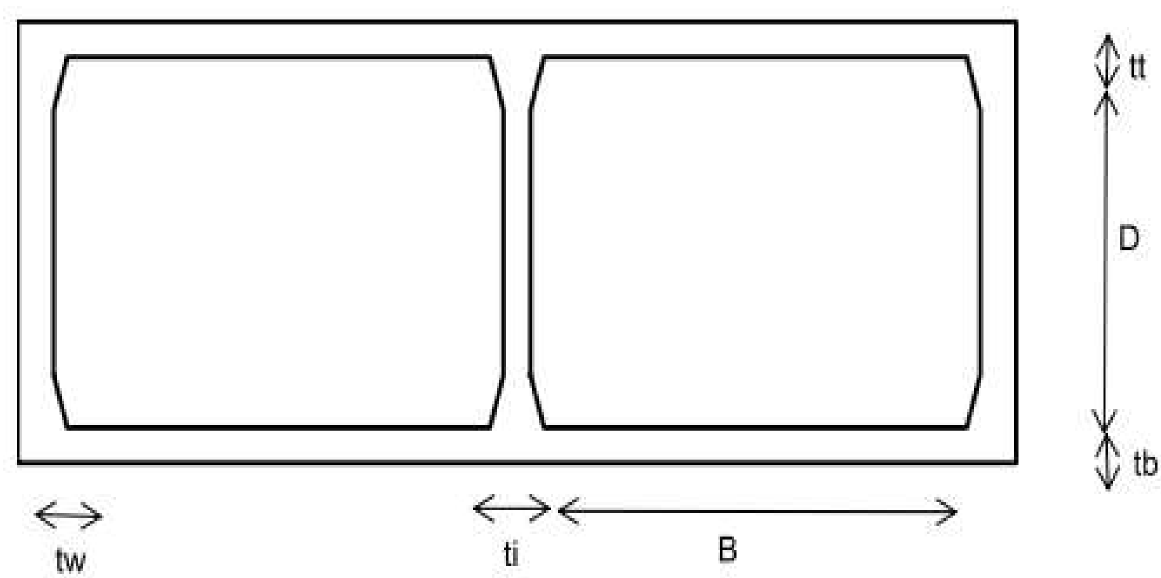
Load combinations as per IRC 6: 2014 have been considered in staad load combination.

1.6 Material properties

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

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

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)

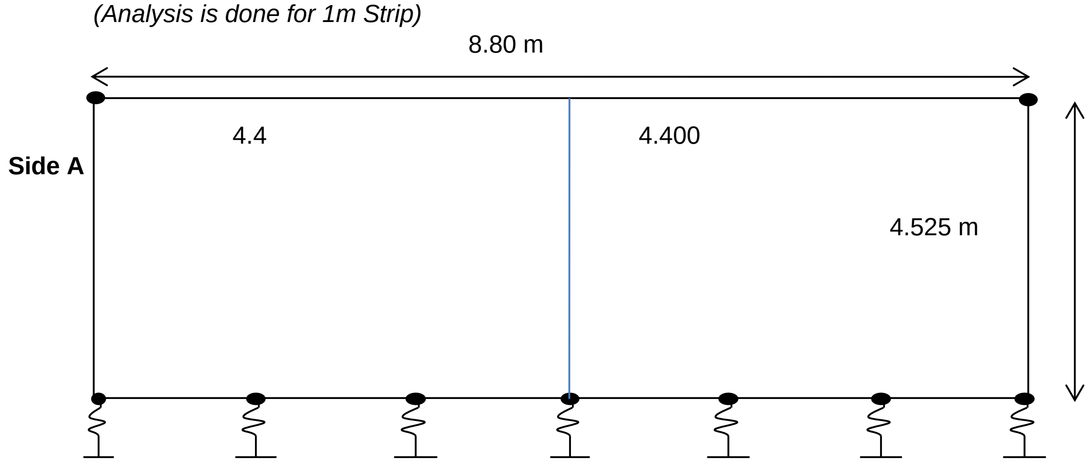
Crash barrier	=		1	kN/m^2
Due to earth fill	=	0 x20 =	0	kN/m^2
			1	kN/m^2
Due to wearing coat	=	0.075 x 22 =	1.65	kN/m^2

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

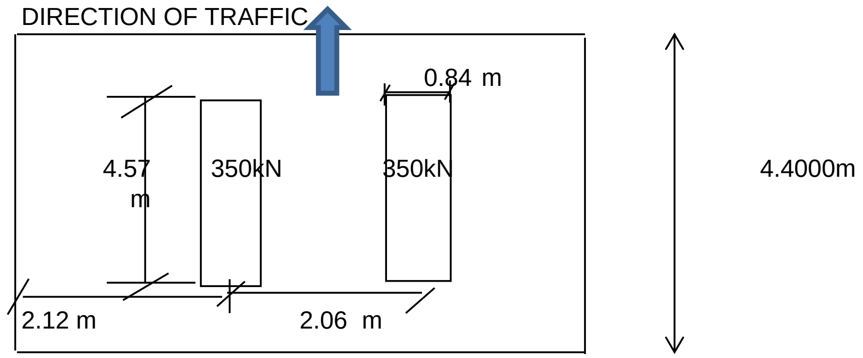
Live Load Surcharge = 12.000 kN/m

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

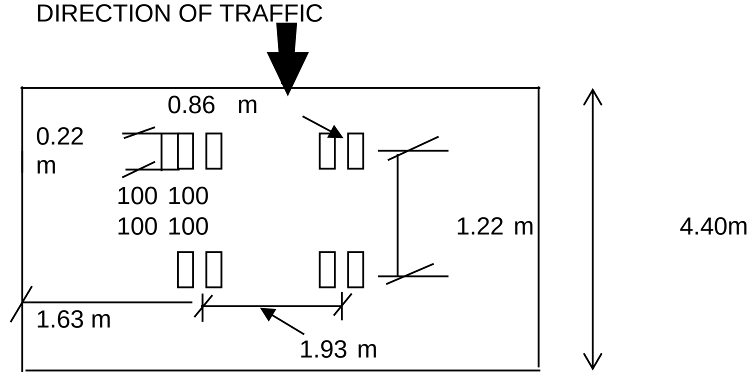
<u>Effective width of Loading</u>

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

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

E) 70R Track at int side wall

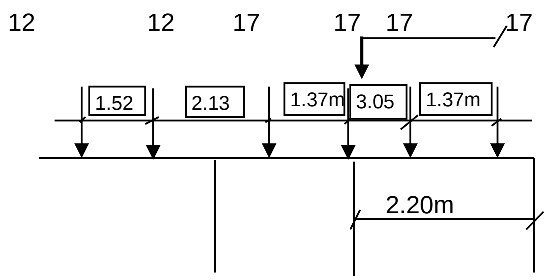
Effective width of Loading

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

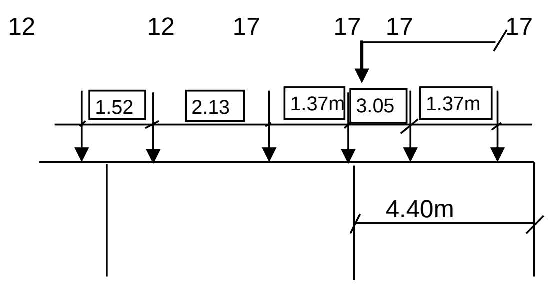


0.86m 1.93m 0.86m

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

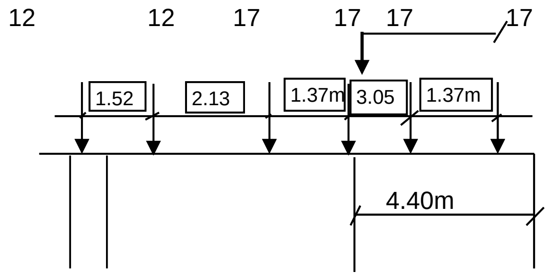


Width along span = 1.370m

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

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

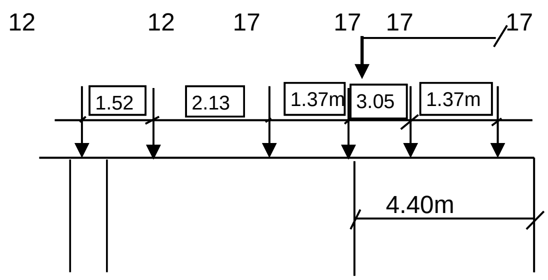
G) 70R Wheel Case 3



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

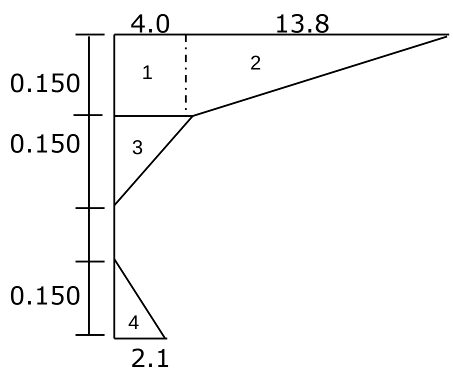
The box has been checked for temperature differential.

$F = E_c \, a Dt \, A$

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

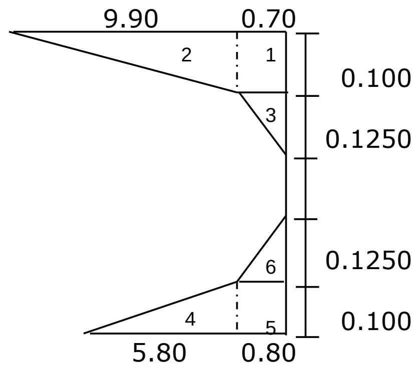
EFFECT OF TEMPERATURE RISE



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

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	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

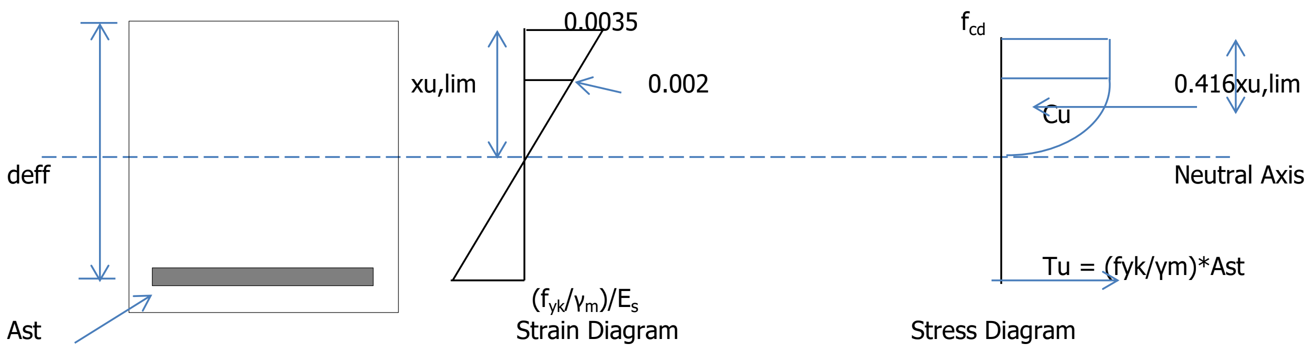
Partial Safety for Verification of Serviceability Limit St Table 3.3, Annex B, IRC:6-2014

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

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	

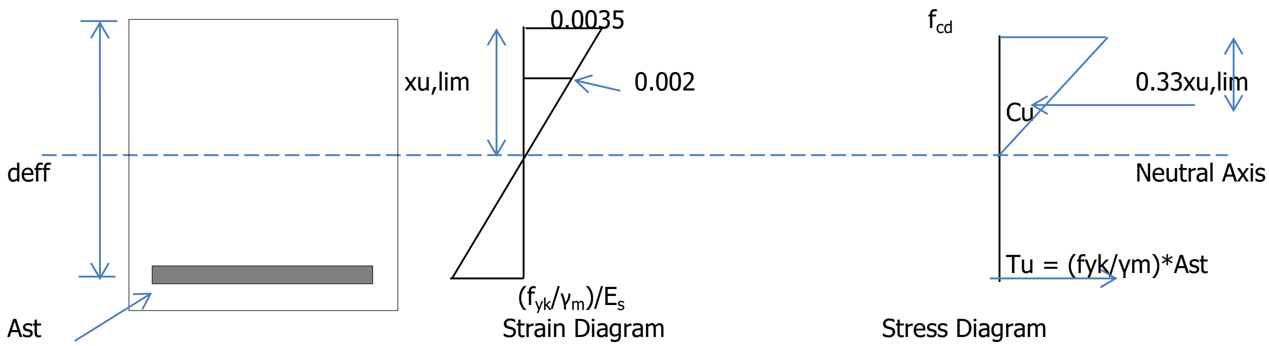
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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.

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

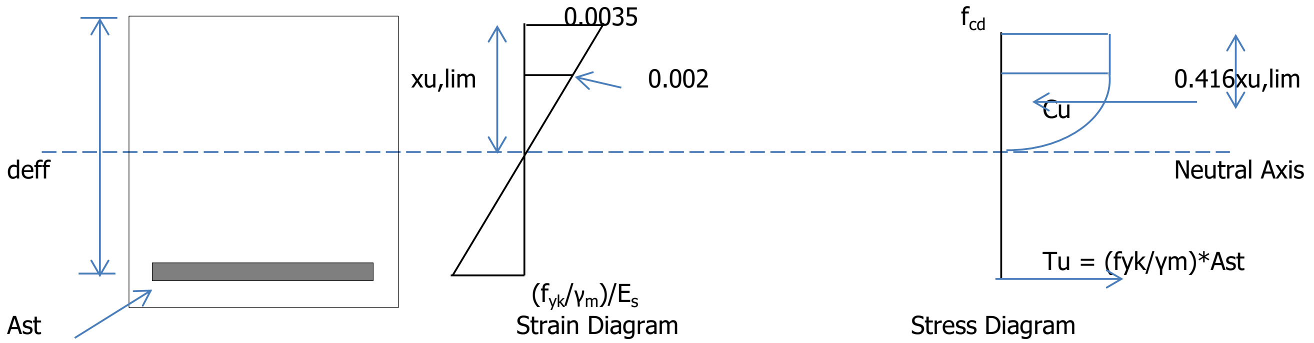
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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	

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 $\quad$ 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 = 550 mm

Clear cover at bott. = 75 $\quad$ Clear cover at top = 40

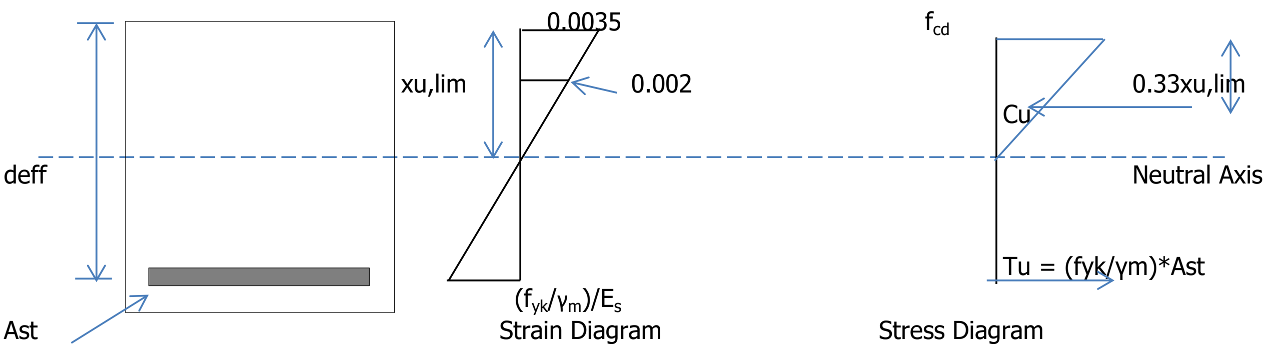
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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**

	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	**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			
$\rho 1 = A_{sl}/(b_w\ d) <= 0.02$	0.003		0.003
	OK		**OK**
$0.12\ K\ (80\ \rho 1\ f_{ck})^{0.33}$	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			
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (\nu_{min} + 0.15\ \sigma_{cp})\ b_w\ d$ (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

$R_{sls} = M_{u,sls}/bd^2$ = 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 = 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.	-

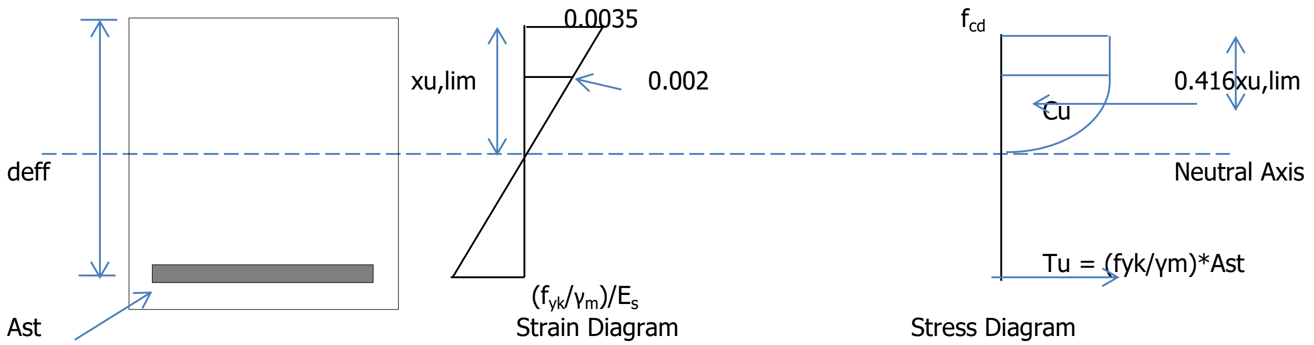
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	132.0		54.7	109.4		56.4
b	1000		1000	1000		1000
D	550		550	550		550
c	75		75	40		40
d	457.0		457.0	492.0		492.0
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**

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

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

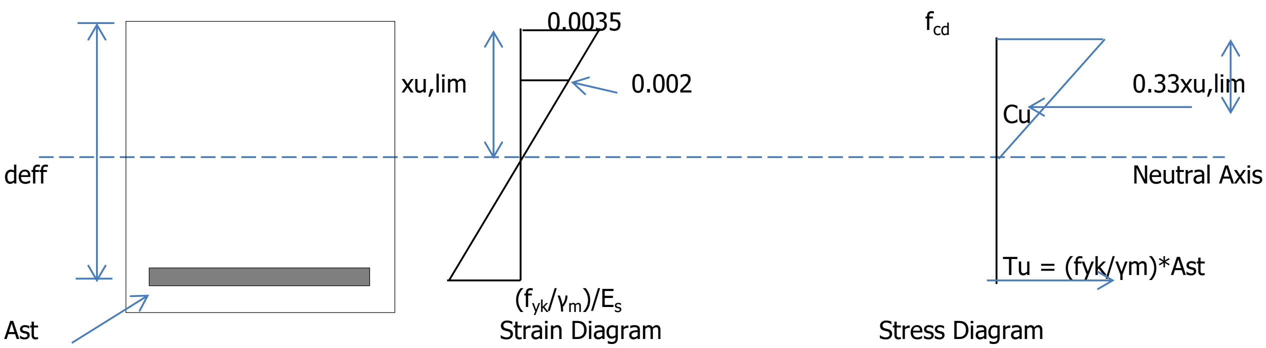
Calculation of Reinforcement

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

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 = 500 mm

Clear cover = 75

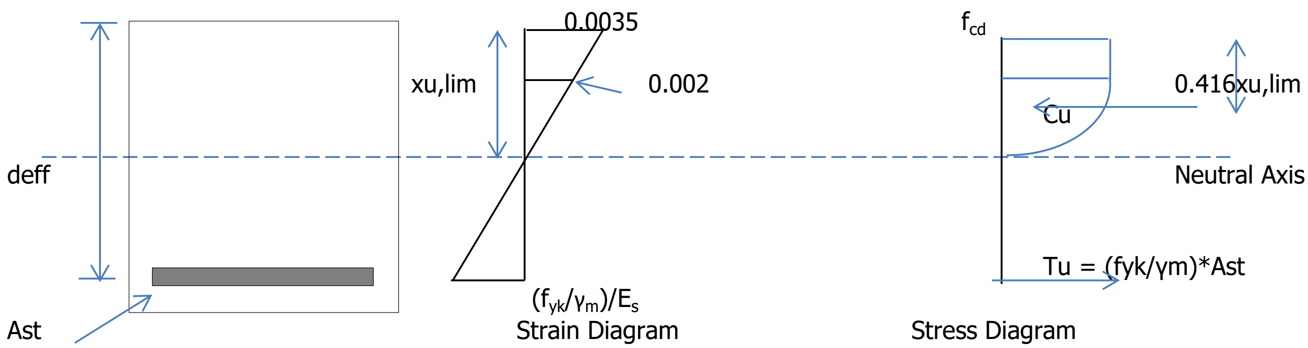
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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**

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



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

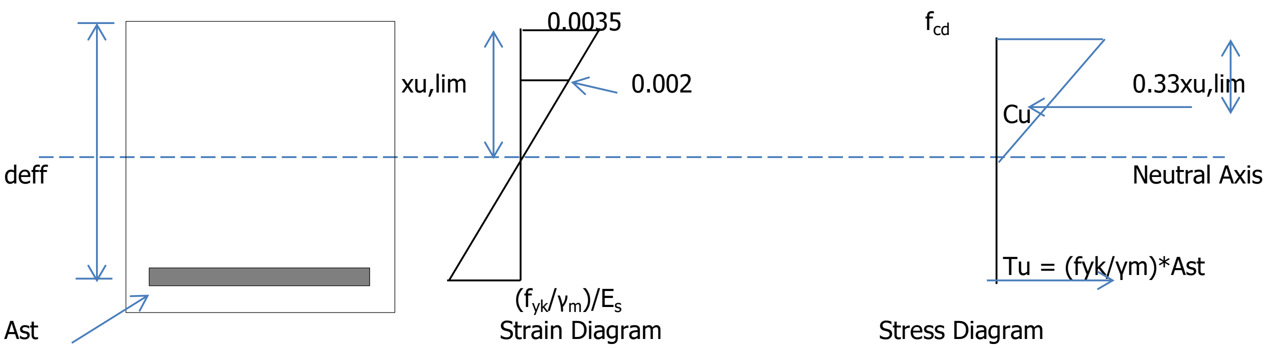
Depth of section D = 300 mm

Clear cover = 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 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

	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)	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

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

DESIGN OF BREAST WALL & RETAINING WALL

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

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

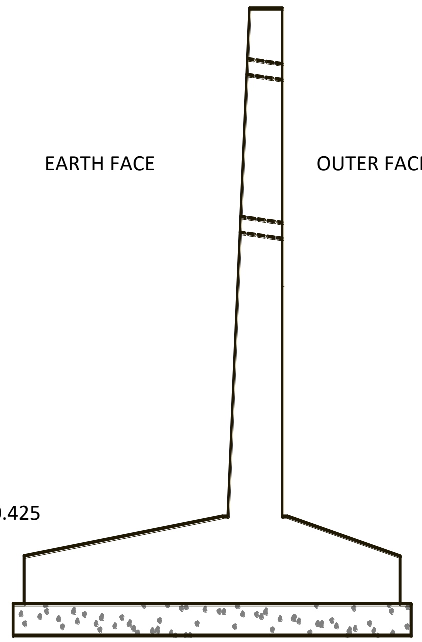
FRL		=	100.000	m (Assumed)
Wall shaft top level		=	100.000	m
Ground level/LBL/MSL		=	95.000	m (Assumed)
Foundation level		=	93.000	
Shaft bottom level		=	93.550	m
Coeff. Of Friction	μ	=	0.500	
FRL - FND LVL.	H	=	7.000	m
SBC of soil-Normal Case		=	220.000	kN/m2
Permissible FOS against Sliding		=	1.500	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, ec2	=	0.02	
Ultimate Strain, ecu2	=	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

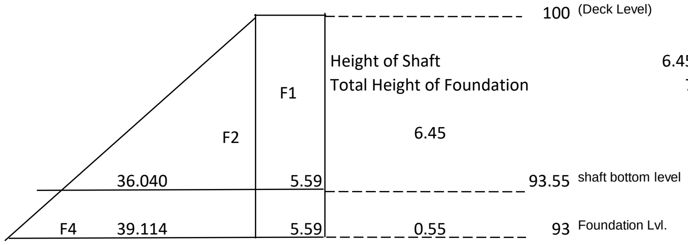
Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	-

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
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

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	

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

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

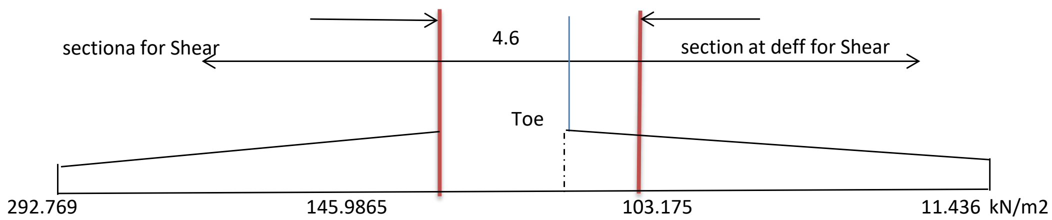
Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1.35	25	3.225	108.844	0.450	48.980
Back filling over heel slab	1.350	20	15.780	426.060	-1.004	-427.74
Back filling on flared portion of shaft	1.350	20	1.290	34.830	0.117	4.06
Front Filling 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:*	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	-

		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		

Toe Slab - Moment Calculation

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
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 5 m from G.L	Date & Rev.	-

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
Client	-	Checked by:	-
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

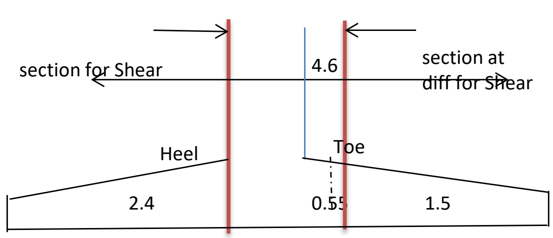
Normal Dry Case

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)	=	$\sigma sc - \frac{k_t f_{ct\,eff} (1 + \alpha_e\, p_{p\,eff})}{p_p\, eff}$	/ 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
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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
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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
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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
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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
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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

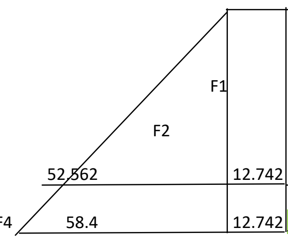
Type of reinforcement	Area of steel required	Area of steel provided						
Straight Portion of Shaft								
Vertical steel at earth face	2661	16	mm bar @	120	mm c/c (i.e.)	2618	mm2	REVISE
		12	mm bar @	120	mm c/c (i.e.)			
Vertical steel at non-earth face	840	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
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

6.45

93.55 shaft bottom level

0.55

93 Foundation Lvl.

Project	-	Designed by:	KB
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Job Name	Design of Breast Wall for height 3 m from G.L	Date & Rev.	-

DESIGN OF STRAIGHT BREAST WALL FOR HEIGHT 3 M FROM G.L

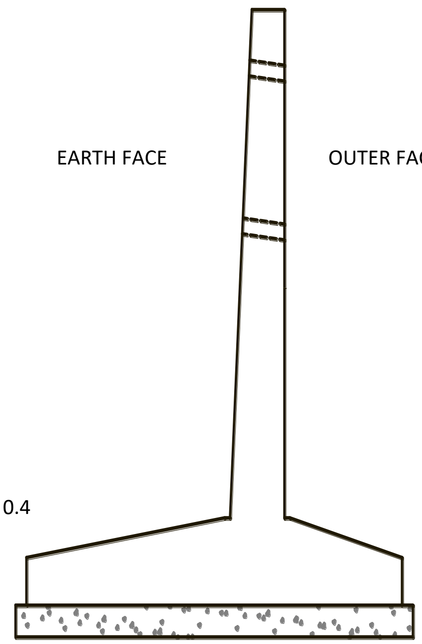
INDEX

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	Design of Breast Wall for height 3 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		=	97.000	m (Assumed)
Foundation level		=	95.000	
Shaft bottom level		=	95.500	m
Coeff. Of Friction	μ	=	0.500	
FRL - FND LVL.	H	=	5.000	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		=	0.550	m
Foundation				
Total Width of Footing		=	3.650	m
Width of Toe Slab		=	1.100	m
Width of Heel Slab		=	2.000	m
Thickness of Toe slab at tip		=	0.300	m
Thickness of Toe slab near shaft		=	0.500	m
Thickness of heel slab at tip		=	0.300	m
Thickness of heel slab near shaft		=	0.500	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, εc2	=	0.02	
Ultimate Strain, εcu2	=	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 Breast Wall for height 3 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 Breast Wall for height 3 m from G.L	Date & Rev.	-

VOLUME CALCULATION

C.G. Of Footing = 1.825 m

C.G. Of shaft from toe tip = 1.375 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		0.425	4.500		1.913	0.056	0.506	-1.319
Footing										
Heel Slab	1	1.00		2.000	0.400		0.800		-0.727	-2.552
Toe Slab	1	1.00		1.100	0.400		0.440		1.221	-0.604
Portion between Heel and Toe	1	1.00		0.500	0.500		0.250		0.450	-1.375
Back filling over Heel Slab	1	1.00		2.000	4.600		9.200		-0.771	-2.596
Front Filling over Toe Slab	1	1.00		1.100	1.600		1.760		1.280	-0.545
Back fill on flared portion of stem	1	1.00		0.250	4.500		0.563		0.258	-1.567
				L				eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barrier	1	0	kN/m	1.000	0	kN		0.275	0.725	-1.100

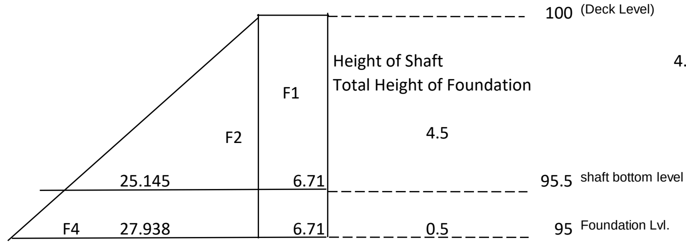
Project	-	*Designed by:*	*KB*	
Client	-	*Checked by:*	-	
Job Name	*Design of Breast Wall for height 3 m from G.L*	*Date & Rev.*	-	

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	4.5	m	4.5	
Total Height of Foundation	5	m	5	

Horizontal Forces and Moments @ RL 95.5 m (at Shaft Base)

@ RL 95 m (at Foundation Level)

Due to Live Load Surcharge

Intensity for = rectangular portion	0.279	x	20	x	1.2		=	6.71		kN/m^2
F1 =	6.7052073	x	4.5	x	1		=	30.173		kN
M1 =	30.173	x	2.25	=	67.890	**kN.m at Shaft Bottom**				
F3 =	6.7052073	x	5	x	1		=	33.526		kN
M3 =	33.526	x	2.5	=	83.815	**kN.m at Foundation**				

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

=	0.279	x	20	x	4.5	=		25.145	kN/m^2
F2 =	0.5	x	25.145	x	4.5	x	1	=	**56.575** 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 =	56.575	x	1.89	=	**106.927**	**kN.m**	**at Shaft Bottom**

Intensity for triangular portion (At Foundation level)

=	0.279	x	20	x	5	=		27.938	kN/m^2
F4 =	0.5	x	27.938	x	5	x	1	=	**69.846** KN
M4 =	69.846	x	2.1	=	**146.676**	**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	4.5	=	21.600	kN/m^2			
F =	0.5	x	21.600	x	4.5	x	1	=	**48.600** KN
M =	48.600	x	1.5	=	**72.900**	**kN.m at Shaft Bottom**			

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Intensity for triangular portion (At Foundation level)

= 4.8 x 5 = 24.000 kN/m^2

F = 0.5 x 24.000 x 5 x 1 = 60.000 KN

M = 60.000 x 1.67 = 100.000 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	106.927	146.676	56.575	69.846
Due to Minimum Fluid Pressure	Y	72.900	100.000	48.600	60.000
Governing of Two	Y	**106.927**	**146.676**	**56.575**	**69.846**
Due to Live Load Surcharge	Y	67.890	83.815	30.173	33.526
Due to Passive pressure	N		0.000		0.000

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Stability Check of Foundation

Foundation Lvl = 95.000 m

Properties of Footing Base:

		B		L			
A	=	3.650	x	1.000	=	3.650	m^2
ZL	=	1.000	x	2.220	=	2.220	m^3
ZT	=	3.650	x	0.167	=	0.608	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	1.913	47.8125	0.506	24.211
Back filling over heel slab	1.000	20	9.200	184	-0.771	-141.936
Back filling on flared portion of shaft	1.000	20	0.563	11.25	0.258	2.906
Front Filling over toe slab RCC Railing or Crash Barrier or	1.000	20	1.760	35.2	1.280	45.054
Crash Barrier	1.000			0	0.725	0.000
Heel slab	1.000	25	0.800	20	-0.727	-14.539
Toe slab	1.000	25	0.440	11	1.221	13.432
portion between heel & toe	1.000	25	0.250	6.25	0.45	2.813
Total				315.513		-68.059

Loads	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
Shaft	1.000	47.8125	-1.319	-63.047
Back filling over heel slab	1.000	184	-2.596	-477.736
Back filling on flared portion of shaft	1.000	11.25	-1.567	-17.625
Front Filling over toe slab RCC Railing or Crash Barrier or	1.000	35.2	-0.545	-19.186
Crash Barrier	1.000	0	-1.1	0.000
Heel slab	1.000	20	-2.552	-51.039
Toe slab	1.000	11	-0.604	-6.643
portion between heel & toe	1.000	6.25	-1.375	-8.594
Total		315.513		-643.869

For Safe Bearing Capacity Calculation :

load factor

Moment due to active earth pressure	=	1	x	146.676	x	146.67641	kNm
Moment due to Live load surcharge	=	1	x	83.815	x	83.8150913	kNm
						230.491501	
Moment due to passive relief	=	1	x	**0**	=	0	
						230.491501	

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P	315.513	KN	
ML	162.432	kNm	
MT	0	kNm	
A	3.650	m^2	
ZL	2.220	m^3	
ZT	0.608	m^3	
P/A+ML/ZL+MT/ZT (Max)	159.596	kN/m2	**SAFE**
P/A-ML/ZL-MT/ZT (Min)	13.288	kN/m2	**SAFE**

Check Against Sliding:

		load factor										
Due to Earth pressure	=	1.000	x	69.846	=	69.8459094	KN					
Due to Live load Surcharge	=	1.000	x	33.526	=	33.5260365	KN					
						103.372						
Total Sliding Force	=	103.372 KN										
Total Restoring Force	=	mP + c.A + Fp =		0.5	x	315.513		+	0	=	157.7563	KN
FOS against sliding	=	1.5	>	1.5	SAFE							

Check Against Overturning

		load factor							
Moment due to active earth pressure	=	1	x	146.676	=	146.676	kNM		
Moment due to Live load surcharge	=	1	x	83.815	=	83.815	kNM		
						230.492			
Overturning Moment	=	230.492 kNm							
Restoring Moment	=	S P.e Toe+		Mp		=		643.869	kNm
FOS against overturnng	=	2.7934628	>	2	**SAFE**				

Project	-	Designed by:	KB
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Design of Foundation

Foundation Lvl = 95.000 m

Properties of Footing Base:

A = 3.650 m^2

ZL = 2.220 m^3

ZT = 0.608 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	1.913	64.547	0.450	29.046
Back filling over heel slab	1.350	20	9.200	248.400	-0.771	-191.61
Back filling on flared portion of shaft	1.350	20	0.563	15.188	0.129	1.96
Front Filling over toe slab	1.350	20	1.760	47.520	1.280	60.823
RCC Railing or Crash Barrier	1.35			0.000	0.725	0.000
Heel slab	1.35	25	0.800	27.000	-0.727	-19.63
Toe slab	1.35	25	0.440	14.850	1.221	18.13301471
portion between heel & toe	1.35	25	0.250	8.438	0.450	3.797
Total				425.942		-97.480

		load factor					
Moment due to active earth pressure	=	1.500	x	146.6764098	=	220.015	kNm
Moment due to Live load surcharge	=	1.200	x	83.8151	=	100.578	kNm
						320.593	

P	425.942	KN
ML	223.113	kNm
MT	0.000	kNm
A	3.650	m2
ZL	2.220	m3
ZT	0.608	m3
P/A+ML/ZL+MT/ZT (Max)	217.179	kN/m2
P/A-ML/ZL-MT/ZT (Min)	16.214	kN/m2

Project	-	*Designed by:*	*KB*
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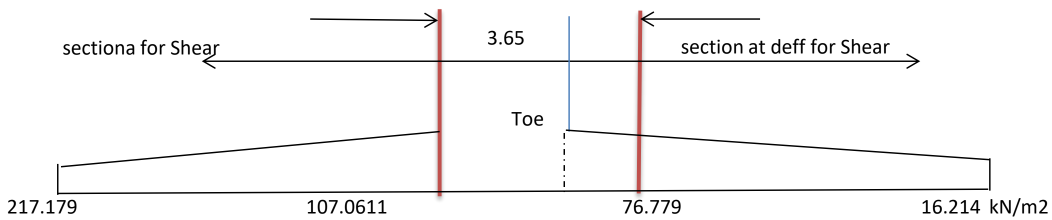
		Normal Dry Case
Ultimate Base Pressure (kN/m^2)	**Max**	**217.179**
	Min	**16.214**



Normal Dry Case

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=	162.12 kN/m2												
Upward moment due to Base pressure	=	324.24 kNm/m												
	factor			VOL										
Downward moment due to backfill	=	1.350	x	9.2	/	1	x	20	x	1	=	248.400	kNm/m	
Downward moment due to self weight of Heel	=	1.35	x	0.8	/	1	x	25	x	0.902	=	24.353	kNm/m	

Net Moment at face of shaft	=	324.24	-248.40	-24.35	51.49	kNm/m	OK

Heel Slab - Shear Calculation at Face of Wall

Shear Force due to upward pressure at Face of wall	=	162.12	x	2	x	1	=	324.240	KN	
	factor									
Downward Force due to backfill	=	1.350	x	9.2	x	20	=	248.400	KN	
Downward Force due to self weight of Heel slab	=	1.35	x	0.8	x	25	=	27.000	KN	
Net Shear Force	=	324.240	-248.400	-27.000			=	**48.840**	KN	
Net Shear Force / unit meter	=	48.840	/	1			=	**48.840**	KN/m	

<u>Toe Slab - Moment Calculation</u>

Average Base Pressure for Design of Toe Slab												
	=	46.50	kN/m2									
Upward moment due to Base pressure	=	28.13	kNm/m									
Downward moment due to self weight of Toe	=	1.35	x	0.44	/	1	x	25	x	0.496	=	7.367 kNm/m

Net Moment at face of shaft	=	28.13	-7.367	=	20.764	kNm/m	OK

Project	-	Designed by:	KB
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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	=	0.455	m											
effective depth at critical section	=	0.374	m											
Base pressure at deff from face of wall	=	50.956	kN/m2											
upward shear force due to base pressure	=	33.585	x		0.681 x		1 =		22.872 kN					
C.g. Of base pressure	=	4.144	m											
moment due to upward pressure at critical section	=	94.780	kNm											
tanb		0.182												
reduction in shear force (Vccd)		$\frac{M\ tanb}{d}$		=	37.89 KN									
Downward force due to self weight of toe slab	=	1.35		x	0.377386364	x	0.681	x	1	x	25	=	8.674	KN
Net Shear Force at deff	=	22.872		-8.674	-37.8928637	=	-23.695	KN						
Net Shear Force / unit meter	=	-23.695		/	1	=	-23.695	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*
Client	*-*	*Checked by:*	*-*
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Flexural Reinforcement Calculation:

		Heel Slab	Toe Slab
Ultimate bending moment,Mu (kNm/m)	=	51.487	20.76
Effective depth required (dreq) (mm)	=	111.52	70.82
Effective depth provided (dpro) (mm)	=	419.00	419.00
Check for provided depth	=	SAFE	SAFE
R = Mu/(b d2)	=	0.29	0.12
Total depth provided (mm)	=	500.00	500.00
Limiting depth of neutral axis (mm)	=	259.78	259.78
Actual depth of neutral axis (mm)	=	37.94	37.94
Check for Neutral axis depth	=	OK	OK
Lever arm (z) , mm	=	403.07	403.07
Moment of Resistance w.r.to steel	=	165.16	165.16
Check for Moment Capacity	=	SAFE	SAFE
Ast reqd (mm2 / m)	=	316.974	127.755
cl. 16.6.1 (2) of IRC :112-2011			
AS.min = 0.26 fctm bt d / fyk >= 0.0013 bt d	=	544.70	544.70
Governing Ast (mm2 / m)	=	544.70	544.70
Tension Reinforcement			
Dia (mm)	=	12.00	12.00
Spacing (mm)	=	207.53	207.53
Spacing provided	=	180.00	180.00
+ Dia (mm)	=	0.00	0.00
Spacing (mm)	=	180.00	180.00
Ast provided (mm2 / m)	=	628.24	628.24
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)	=	125.65	125.65
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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Shear Reinforcement Calculation:

		Heel Slab	Toe Slab	
Ultimate Shear Force (VEd)	=	48.840	-23.695	kN/m
Ast provided	=	628.240	628.24	mm2/m
Depth of slab at critical section	=	500.000	454.773	mm
Effective depth at critical section	=	419.000	373.773	mm
percentage of steel provided (r1)	=	0.0022	0.0023	
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)	=	0.130	0.070	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	=	1.691	1.731	
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010				
V_{min} = 0.031 K3/2 fck1/2	=	0.373	0.387	N/mm2
0.12 K (80 r1 fck)^0.33	=	0.351	0.366	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	=	147.26	136.76	kN
Check for Shear Reinforcement		No Shear R/f required	No Shear R/f required	

Project:	-	*Designed by:*	*KB*
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SLS CHECK OF FOUNDATION

Foundation Lvl = 95.000 m

Properties of Footing Base:

A	=	3.650	m^2
ZL	=	2.220	m^3
ZT	=	0.608	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

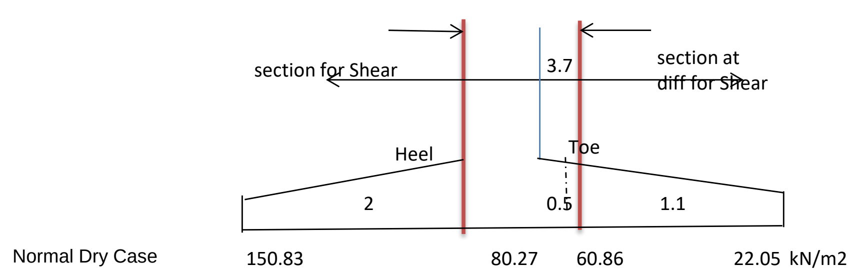
Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1	25	1.913	47.813	0.450	21.516
Back filling over heel slab	1	20	9.200	184.000	-0.771	141.936
Back filling on flared portion of shaft	1	20	0.563	11.250	0.258	2.906
Front Filling over toe slab	1	20	1.760	35.200	1.280	45.054
RCC Railing or Crash Barrier	1			0.000	0.725	0.000
Heel slab	1	25	0.800	20.000	-0.727	14.539
Toe slab	1	25	0.440	11.000	1.221	13.432
portion between heel & toe	1	25	0.250	6.250	0.450	2.813
Total				**315.513**		**-70.754**

		load factor					
Moment due to active earth pressure	=	1.0	x	146.676	=	146.676	kNm
Moment due to Live load surcharge	=	0.8	x	83.815	=	67.052	kNm
						213.728	

P	315.513	KN
ML	142.974	kNm
MT	0.000	kNm
A	3.650	m2
ZL	2.220	m3
ZT	0.608	m3
P/A+ML/ZL+MT/ZT (Max)	150.832	kN/m2
P/A-ML/ZL-MT/ZT (Min)	22.051	kN/m2

		Normal Dry Case
Base Pressure (kN/m2)	Max	150.832
	Min	22.051



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Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=	115.55	kN/m2								
Upward moment due to Base pressure	=	231.10	kNm/m								
	factor										
Downward moment due to backfill	=	1.00	x	9.2	x	20	x	1	=	184.00	kNm/m
Downward moment due to self weight of Heel	=	1.00	x	0.800	x	25	x	0.902	=	18.04	kNm/m
Net Moment at face of shaft	=	231.10		-184.00		-18.04			=	29.06	kNm/m
				Tension at Bottom of Heel Slab							

Toe Slab - Moment Calculation

Average Base Pressure for Design of Toe Slab	=	41.46	kN/m2								
Upward moment due to Base pressure	=	25.08	kNm/m								
Downward moment due to self weight of Toe	=	1	x	0.44	x	25	x	0.496	=	5.46	kNm/m
Net Moment at face of shaft	=	25.08		-5.46					=	19.62	kNm/m
				Tension at Bottom of Heel Slab							

		Heel Slab	Toe Slab	
Working bending moment, M	=	29.06	19.62	kNm/m
Dx	=	1.00	1.00	m
Dy	=	0.55	0.55	m
Section Modulus (ZL) of uncracked sectio	=	0.05	0.05	m3
Bending Stress (M/ZL)	=	0.576	0.389	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)	=	419.000	419.000	mm
Ast provided	=	628.240	628.240	mm2/m
Percentage of steel , pt	=	0.0022	0.0023	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.221	0.226	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	92.472	94.512	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	326.528	324.488	mm
Depth of neutral axis from c.g. Of tension steel (ys)	=	245.528	243.488	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2		

Icr	=	625441124.5	617669624.3	mm4
Maximum compressive stress in concrete	=	4.297	3.003	< 14.4, SAFE
Maximum tensile stress in concrete	=	15.172	10.309	
Maximum Tensile stress in steel	=	113.835	76.872	< 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	=	92.472	94.512	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	=	209.500	209.500	mm	
Ac, eff = Dx * hc,eff	=	209500.000	209500.000	mm	
r r eff = As/Ac eff	=	0.003	0.003		
Maximum crack spacing , Sr max	=	935.281	935.281	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	=	113.835	76.872	N/mm2	
Kt	=	0.500	0.500		
Tensile strength of concrete = fct eff = fctm	=	2.500	2.500	N/mm2	424.9
αe = Es/Ecm	=	6.452	6.452		
(εsm - εcm)	=	-0.002	-0.0017		
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 Breast Wall for height 3 m from G.L	Date & Rev.	-

Calculation of Forces For Design of Wall

Wall bottom level = 95.5 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	1.913	64.546875	0.056	3.639
RCC Railing or Crash Barrier	1.35			0	0.275	0.000
Total				**64.547**		**3.639**

Horizontal Force :	load factor						
Due to Earth pressure		1.5	x	56.58	=	84.86	KN
Due to Live load Surcharge		1.2	x	30.17	=	36.21	KN
						121.07	

Total Horizontal Force = 121.07 KN

Moment Due to Horizontal Force:		load factor					
Moment due to active earth pressure	=	1.5	x	163.446	=	245.169	kNm
Moment due to Live load surcharge	=	1.2	x	67.890	=	81.4683	kNm
						326.637	

Total Moment due to Horizontal Force = 326.637 kNm

Summary of Forces:

P	64.547	KN
ML	330.276	kNm
FL	121.071	KN

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Breast Wall for height 3 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) = 0.55 m

Depth of Wall (D) = 1 m

Area of Concrete (Ac) = 0.55 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	64.55	330.28	121.07
MAX	64.55	330.28	121.07

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = 64.55 kN

0.1 fcd Ac

= 0.1 13.4 550000

= 737000 N

= 737.0 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) = 330.28 kNm = 330.28 kNm/m

Check For Depth of Wall :

Mult = 0.167 x fck x b x d^2

= 330.28 kNm/m

b = 1000 mm

Effective Depth Required (dreq) = SQRT(597.03 x 1000000) / (0.167 x 30.00 x 1000)

(dreq) 256.76 mm

Total Depth Required (Dreq) = 339.76 mm

Total Depth Provided (Dprov) = 550 mm **OK**

Effective depth provided(deff) = 467 mm

R= Mu/(b d^2) = 1.514

Minimum Longitudinal Reinforcement in wall on each face

=

= 0.0012 x b x D -Refer Clause 16.9 of IRC:112-2011'

Ast min = 660 mm2/m

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Breast Wall for height 3 m from G.L	Date & Rev.	-

Area of Steel Required:

$\frac{Pt}{100} = \frac{Ast_{req}}{bD} = \frac{fck \{ 1 - sqrt(1- 4.598\ R/fck) \}}{2fy}$

= 0.0037

Ast_{req} = 2041.14 mm2/m

Ast required = max(Astmin, Astreq) = 2041.14 mm2/m

Provide	16	mm dia	@	150	mm c/c	=	1340.25	2094.13	mm²/m	OK
	12	mm dia	@	150	mm c/c	=	753.89			

Percentage of steel = 0.381 %

Check for Moment of Resistance of Section due to Steel

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

= 288.07 mm

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

= 84.30 mm

OK

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

z = d - 0.416 x X

= 431.93 mm

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

MR = fyd . Ast . Z

= 393268377.6

= 3.93E+08 Nmm /m

= **3.93E+02** kNm/m > **330.28** 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 = 660 mm2/m

Provide	12	mm dia	150	mm c/c	=	753.89	mm²/m	OK

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

maximum of following = 0.25 x 2848.02 = 712.01 **As per IRC:112-2011' Clause 16.32.2**

= 0.001 x 5.50E+05 = 550.00

Minimum Horizontal Reinf. provided 712.0 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 Breast Wall for height 3 m from G.L	Date & Rev.	-

SLS CHECK OF WALL

Foundation Lvl = 95.5 m

Creep Coeff (¢ = 1.2 For Dry atmosperic condition

Ecm = 31000

Es = 200000 N/mm2

Eceff = $\frac{Ecm}{(1+\phi)}$ = 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	1.913	47.8125	0.056372549	2.695313
RCC Railing or Crash Barrier	1.000			0	0.275	0
Total				**47.813**		**2.695**

Horizontal Force :		load factor				
Due to Earth pressure	=	1.000	x	56.57518663	=	56.57519 KN
Due to Live load Surcharge	=	0.800	x	30.17343287	=	24.13875 KN
Total Horizontal Force	=	80.71393292	KN			

Moment Due to Horizontal Force:		load factor				
Moment due to active earth pressure	=	1.000	x	106.927	=	106.927 kNm
Moment due to Live load surcharge	=	0.8	x	67.890	=	54.312 kNm
Total Moment due to Horizontal Force	=	161.239281892	kNm			

Summary of Forces:

P	47.813	KN
ML	163.935	kNm
FL	80.714	KN

Bending Moment, M	=	163.93	kNm
Dx	=	1.00	m
Dy	=	0.55	m
Section Modulus (ZL) of uncracked secti	=	0.05	m3
Bending Stress (M/ZL)	=	3.252	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)	=	467.000	mm
Ast provided	=	2094.133	mm2/m
Percentage of steel , pt	=	0.0071	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.359	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	167.664	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	299.336	mm

Depth of neutral axis from c.g. Of tesnion steel (ys)	=	216.336	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast	* (dy - k * dy)^2
Icr	=	1752863282	mm4
Maximum compressive stress in concrete	=	15.7	< 14.4, SAFE
Maximum tensile stress in concrete	=	27.995	
Maximum Tensile stress in steel	=	172.295	< 400, SAFE

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Breast Wall for height 3 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	=	160.000	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	=	167.664	mm
$\rho_{r\,eff}$ = 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
$\rho_{r\,eff}$ = As/Ac eff	=	0.010	
Maximum crack spacing , $S_{r\,max}$	=	490.825	mm
(ε_{sm} - ε_{cm})	=	σsc - kt fct eff (1 + αe r r eff) / r r eff	/ Es
tensile stress in steel, ,σsc	=	172.295	N/mm2
Kt	=	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.500	N/mm2
αe = Es/Ecm	=	6.452	
(εsm - εcm)	=	0.00020	
Crack width , Wk=Sr max (εsm - εcm)	=	**0.099**	
Check	=	**SAFE**	

Project	-	Designed by:	KB		
Client	-	Checked by:	-		
Job Name	Design of Breast Wall for height 3 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	159.60	13.29	1.53	2.79	0.130	-0.070
Permissible	220	0	1.5	2	3.658	3.658
Remarks	OK	OK	OK	OK	OK	OK

Reinforcement summary

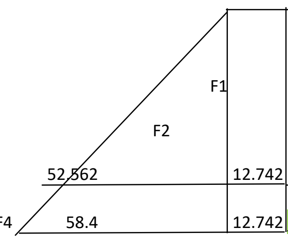
Type of reinforcement	Area of steel required	Area of steel provided						
Straight Portion of Shaft								
Vertical steel at earth face	2041	16	mm bar @	150	mm c/c (i.e.)	2094	mm2	OK
		12	mm bar @	150	mm c/c (i.e.)			
Vertical steel at non-earth face	660	12	mm bar @	150	mm c/c (i.e.)	754	mm2	OK
Distribution steel	712	12	mm 2 Legged bar @	200	mm c/c (i.e.)	1130	mm2	OK
Heel Slab								
Main steel at top face	545	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
		0	mm bar @	180	mm c/c (i.e.)			
Steel at bottom face	250	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
Distribution reinforcement	126	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	545	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
		0	mm bar @	180	mm c/c (i.e.)			
Steel at top face	250	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
Distribution reinforcement	126	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 4.5 m 4.5

Total Height of Foundation 5 m 5

4.5

95.5 shaft bottom level

0.5 95 Foundation Lvl.

HORIZONTAL ALIGNMENT REPORT

Number	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Chord length	Chord Direction	Start Direction	End Direction	Incurve
1	Line	00.000m	46.856m	46.856m			N35° 22' 45.58"W						
2	Spiral-Curve-Spiral	46.856m	71.856m	25.000m		43.301m		9.5493 (d)			N35° 22' 45.58"W	N44° 55' 43.05"W	Incurve
2	Spiral-Curve-Spiral	71.856m	107.336m	35.480m	75.000m			27.1045 (d)	35.150m	N58° 28' 51.15"W	N44° 55' 43.05"W	N72° 01' 59.26"W	
2	Spiral-Curve-Spiral	107.336m	132.336m	25.000m		43.301m		9.5493 (d)			N72° 01' 59.26"W	N81° 34' 56.72"W	Outcurve
3	Line	132.336m	316.845m	184.509m			N81° 34' 56.72"W						
4	Spiral-Curve-Spiral	316.845m	361.845m	45.000m		63.640m		14.3239 (d)			N81° 34' 56.72"W	N67° 15' 30.52"W	Incurve
4	Spiral-Curve-Spiral	361.845m	413.730m	51.885m	90.000m			33.0310 (d)	51.169m	N50° 44' 34.81"W	N67° 15' 30.52"W	N34° 13' 39.10"W	
4	Spiral-Curve-Spiral	413.730m	458.730m	45.000m		63.640m		14.3239 (d)			N34° 13' 39.10"W	N19° 54' 12.90"W	Outcurve
5	Line	458.730m	572.165m	113.435m			N19° 54' 12.90"W						
6	Spiral-Curve-Spiral	572.165m	592.165m	20.000m		100.000m		1.1459 (d)			N19° 54' 12.90"W	N18° 45' 27.60"W	Incurve
6	Spiral-Curve-Spiral	592.165m	731.449m	139.284m	500.000m			15.9608 (d)	138.834m	N10° 46' 38.21"W	N18° 45' 27.60"W	N2° 47' 48.81"W	
6	Spiral-Curve-Spiral	731.449m	751.449m	20.000m		100.000m		1.1459 (d)			N2° 47' 48.81"W	N1° 39' 03.52"W	Outcurve
7	Line	751.449m	826.114m	74.665m			N1° 39' 03.52"W						
8	Spiral-Curve-Spiral	826.114m	856.114m	30.000m		94.868m		2.8648 (d)			N1° 39' 03.52"W	N1° 12' 49.72"E	Incurve
8	Spiral-Curve-Spiral	856.114m	938.760m	82.646m	300.000m			15.7843 (d)	82.385m	N9° 06' 21.48"E	N1° 12' 49.72"E	N16° 59' 53.25"E	
8	Spiral-Curve-Spiral	938.760m	968.760m	30.000m		94.868m		2.8648 (d)			N16° 59' 53.25"E	N19° 51' 46.49"E	Outcurve
9	Line	968.760m	1009.142m	40.382m			N19° 51' 46.49"E						
10	Spiral-Curve-Spiral	1009.142m	1024.142m	15.000m		67.082m		1.4324 (d)			N19° 51' 46.49"E	N18° 25' 49.87"E	Incurve
10	Spiral-Curve-Spiral	1024.142m	1076.560m	52.418m	300.000m			10.0111 (d)	52.351m	N13° 25' 29.97"E	N18° 25' 49.87"E	N8° 25' 10.08"E	
10	Spiral-Curve-Spiral	1076.560m	1091.560m	15.000m		67.082m		1.4324 (d)			N8° 25' 10.08"E	N6° 59' 13.46"E	Outcurve
11	Line	1091.560m	1183.974m	92.414m			N6° 59' 13.46"E						
12	Spiral-Curve-Spiral	1183.974m	1198.974m	15.000m		77.460m		1.0743 (d)			N6° 59' 13.46"E	N8° 03' 40.93"E	Incurve
12	Spiral-Curve-Spiral	1198.974m	1324.117m	125.143m	400.000m			17.9254 (d)	124.633m	N17° 01' 26.57"E	N8° 03' 40.93"E	N25° 59' 12.21"E	
12	Spiral-Curve-Spiral	1324.117m	1339.117m	15.000m		77.460m		1.0743 (d)			N25° 59' 12.21"E	N27° 03' 39.68"E	Outcurve
13	Line	1339.117m	1494.752m	155.636m			N27° 03' 39.68"E						
14	Spiral-Curve-Spiral	1494.752m	1524.752m	30.000m		67.082m		5.7296 (d)			N27° 03' 39.68"E	N21° 19' 53.20"E	Incurve
14	Spiral-Curve-Spiral	1524.752m	1723.228m	198.475m	150.000m			75.8119 (d)	184.310m	N16° 34' 28.24"W	N21° 19' 53.20"E	N54° 28' 49.67"W	
14	Spiral-Curve-Spiral	1723.228m	1753.228m	30.000m		67.082m		5.7296 (d)			N54° 28' 49.67"W	N60° 12' 36.15"W	Outcurve
15	Line	1753.228m	1790.675m	37.448m			N60° 12' 36.15"W						
16	Spiral-Curve-Spiral	1790.675m	1820.675m	30.000m		77.460m		4.2972 (d)			N60° 12' 36.15"W	N55° 54' 46.29"W	Incurve
16	Spiral-Curve-Spiral	1820.675m	1879.605m	58.929m	200.000m			16.8821 (d)	58.717m	N47° 28' 18.60"W	N55° 54' 46.29"W	N39° 01' 50.90"W	
16	Spiral-Curve-Spiral	1879.605m	1909.605m	30.000m		77.460m		4.2972 (d)			N39° 01' 50.90"W	N34° 44' 01.04"W	Outcurve
17	Line	1909.605m	1965.290m	55.685m			N34° 44' 01.04"W						
18	Spiral-Curve-Spiral	1965.290m	1995.290m	30.000m		67.082m		5.7296 (d)			N34° 44' 01.04"W	N29° 00' 14.56"W	Incurve
18	Spiral-Curve-Spiral	1995.290m	2114.757m	119.467m	150.000m			45.6330 (d)	116.334m	N6° 11' 15.18"W	N29° 00' 14.56"W	N16° 37' 44.21"E	
18	Spiral-Curve-Spiral	2114.757m	2144.757m	30.000m		67.082m		5.7296 (d)			N16° 37' 44.21"E	N22° 21' 30.69"E	Outcurve
19	Line	2144.757m	2236.765m	92.008m			N22° 21' 30.69"E						
20	Spiral-Curve-Spiral	2236.765m	2266.765m	30.000m		67.082m		5.7296 (d)			N22° 21' 30.69"E	N16° 37' 44.21"E	Incurve
20	Spiral-Curve-Spiral	2266.765m	2298.082m	31.318m	150.000m			11.9625 (d)	31.261m	N10° 38' 51.69"E	N16° 37' 44.21"E	N4° 39' 59.17"E	
20	Spiral-Curve-Spiral	2298.082m	2328.082m	30.000m		67.082m		5.7296 (d)			N4° 39' 59.17"E	N1° 03' 47.31"W	Outcurve
21	Line	2328.082m	2557.450m	229.368m			N1° 03' 47.31"W						
22	Spiral-Curve-Spiral	2557.450m	2587.450m	30.000m		67.082m		5.7296 (d)			N1° 03' 47.31"W	N4° 39' 59.17"E	Incurve
22	Spiral-Curve-Spiral	2587.450m	2594.269m	6.819m	150.000m			2.6048 (d)	6.819m	N5° 58' 07.76"E	N4° 39' 59.17"E	N7° 16' 16.35"E	

Number	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Chord length	Chord Direction	Start Direction	End Direction	Incurve
22	Spiral-Curve-Spiral	2594.269m	2624.269m	30.000m		67.082m		5.7296 (d)			N7° 16' 16.35"E	N13° 00' 02.83"E	Outcurve
23	Line	2624.269m	2648.261m	23.992m			N13° 00' 02.83"E						
24	Spiral-Curve-Spiral	2648.261m	2678.261m	30.000m		45.826m		12.2777 (d)			N13° 00' 02.83"E	N0° 43' 23.23"E	Incurve
24	Spiral-Curve-Spiral	2678.261m	2724.546m	46.285m	70.000m			37.8848 (d)	45.446m	N18° 13' 09.45"W	N0° 43' 23.23"E	N37° 09' 42.13"W	
24	Spiral-Curve-Spiral	2724.546m	2754.546m	30.000m		45.826m		12.2777 (d)			N37° 09' 42.13"W	N49° 26' 21.73"W	Outcurve
25	Line	2754.546m	2756.774m	2.228m			N49° 26' 21.73"W						
26	Spiral-Curve-Spiral	2756.774m	2781.774m	25.000m		54.772m		5.9683 (d)			N49° 26' 21.73"W	N43° 28' 15.81"W	Incurve
26	Spiral-Curve-Spiral	2781.774m	2853.083m	71.309m	120.000m			34.0476 (d)	70.265m	N26° 26' 50.14"W	N43° 28' 15.81"W	N9° 25' 24.46"W	
26	Spiral-Curve-Spiral	2853.083m	2878.083m	25.000m		54.772m		5.9683 (d)			N9° 25' 24.46"W	N3° 27' 18.55"W	Outcurve
27	Line	2878.083m	3158.074m	279.991m			N3° 27' 18.55"W						
28	Spiral-Curve-Spiral	3158.074m	3168.074m	10.000m		70.711m		0.5730 (d)			N3° 27' 18.55"W	N2° 52' 55.90"W	Incurve
28	Spiral-Curve-Spiral	3168.074m	3188.623m	20.549m	500.000m			2.3547 (d)	20.547m	N1° 42' 17.44"W	N2° 52' 55.90"W	N0° 31' 38.98"W	
28	Spiral-Curve-Spiral	3188.623m	3198.623m	10.000m		70.711m		0.5730 (d)			N0° 31' 38.98"W	N0° 02' 43.67"E	Outcurve
29	Line	3198.623m	3301.291m	102.667m			N0° 02' 43.67"E						
30	Spiral-Curve-Spiral	3301.291m	3331.291m	30.000m		122.474m		1.7189 (d)			N0° 02' 43.67"E	N1° 40' 24.27"W	Incurve
30	Spiral-Curve-Spiral	3331.291m	3518.911m	187.620m	500.000m			21.4997 (d)	186.521m	N12° 25' 23.69"W	N1° 40' 24.27"W	N23° 10' 23.12"W	
30	Spiral-Curve-Spiral	3518.911m	3548.911m	30.000m		122.474m		1.7189 (d)			N23° 10' 23.12"W	N24° 53' 31.06"W	Outcurve
31	Line	3548.911m	3723.950m	175.040m			N24° 53' 31.06"W						
32	Spiral-Curve-Spiral	3723.950m	3753.950m	30.000m		67.082m		5.7296 (d)			N24° 53' 31.06"W	N30° 37' 17.54"W	Incurve
32	Spiral-Curve-Spiral	3753.950m	3829.434m	75.484m	150.000m			28.8327 (d)	74.690m	N45° 02' 16.37"W	N30° 37' 17.54"W	N59° 27' 15.20"W	
32	Spiral-Curve-Spiral	3829.434m	3859.434m	30.000m		67.082m		5.7296 (d)			N59° 27' 15.20"W	N65° 11' 01.68"W	Outcurve
33	Line	3859.434m	3900.051m	40.617m			N65° 11' 01.68"W						
34	Spiral-Curve-Spiral	3900.051m	3930.051m	30.000m		47.434m		11.4592 (d)			N65° 11' 01.68"W	N53° 43' 28.72"W	Incurve
34	Spiral-Curve-Spiral	3930.051m	4004.415m	74.365m	75.000m			56.8104 (d)	71.356m	N25° 19' 09.97"W	N53° 43' 28.72"W	N3° 05' 08.77"E	
34	Spiral-Curve-Spiral	4004.415m	4034.415m	30.000m		47.434m		11.4592 (d)			N3° 05' 08.77"E	N14° 32' 41.73"E	Outcurve
35	Line	4034.415m	4218.194m	183.778m			N14° 32' 41.73"E						
36	Spiral-Curve-Spiral	4218.194m	4248.194m	30.000m		86.603m		3.4377 (d)			N14° 32' 41.73"E	N11° 06' 25.84"E	Incurve
36	Spiral-Curve-Spiral	4248.194m	4266.652m	18.458m	250.000m			4.2303 (d)	18.454m	N8° 59' 31.36"E	N11° 06' 25.84"E	N6° 52' 36.87"E	
36	Spiral-Curve-Spiral	4266.652m	4296.652m	30.000m		86.603m		3.4377 (d)			N6° 52' 36.87"E	N3° 26' 20.98"E	Outcurve
37	Line	4296.652m	4506.969m	210.318m			N3° 26' 20.98"E						
38	Spiral-Curve-Spiral	4506.969m	4551.969m	45.000m		82.158m		8.5944 (d)			N3° 26' 20.98"E	N5° 09' 18.74"W	Incurve
38	Spiral-Curve-Spiral	4551.969m	4555.598m	3.628m	150.000m			1.3859 (d)	3.628m	N5° 50' 53.31"W	N5° 09' 18.74"W	N6° 32' 27.89"W	
38	Spiral-Curve-Spiral	4555.598m	4600.598m	45.000m		82.158m		8.5944 (d)			N6° 32' 27.89"W	N15° 08' 07.61"W	Outcurve
39	Line	4600.598m	5004.246m	403.648m			N15° 08' 07.61"W						
40	Spiral-Curve-Spiral	5004.246m	5034.246m	30.000m		67.082m		5.7296 (d)			N15° 08' 07.61"W	N20° 51' 54.09"W	Incurve
40	Spiral-Curve-Spiral	5034.246m	5077.984m	43.738m	150.000m			16.7068 (d)	43.583m	N29° 13' 06.25"W	N20° 51' 54.09"W	N37° 34' 18.41"W	
40	Spiral-Curve-Spiral	5077.984m	5107.984m	30.000m		67.082m		5.7296 (d)			N37° 34' 18.41"W	N43° 18' 04.89"W	Outcurve
41	Line	5107.984m	5199.543m	91.559m			N43° 18' 04.89"W						
42	Spiral-Curve-Spiral	5199.543m	5229.543m	30.000m		67.082m		5.7296 (d)			N43° 18' 04.89"W	N37° 34' 18.41"W	Incurve
42	Spiral-Curve-Spiral	5229.543m	5351.375m	121.832m	150.000m			46.5364 (d)	118.511m	N14° 18' 12.91"W	N37° 34' 18.41"W	N8° 57' 52.58"E	
42	Spiral-Curve-Spiral	5351.375m	5381.375m	30.000m		67.082m		5.7296 (d)			N8° 57' 52.58"E	N14° 41' 39.06"E	Outcurve
43	Line	5381.375m	5424.518m	43.143m			N14° 41' 39.06"E						
44	Spiral-Curve-Spiral	5424.518m	5454.518m	30.000m		47.434m		11.4592 (d)			N14° 41' 39.06"E	N3° 14' 06.10"E	Incurve

Number	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Chord length	Chord Direction	Start Direction	End Direction	Incurve
44	Spiral-Curve-Spiral	5454.518m	5503.097m	48.579m	75.000m			37.1115 (d)	47.734m	N15° 19' 14.55"W	N3° 14' 06.10"E	N33° 52' 35.21"W	
44	Spiral-Curve-Spiral	5503.097m	5533.097m	30.000m		47.434m		11.4592 (d)			N33° 52' 35.21"W	N45° 20' 08.17"W	Outcurve
45	Line	5533.097m	5956.373m	423.276m			N45° 20' 08.17"W						
46	Spiral-Curve-Spiral	5956.373m	5986.373m	30.000m		47.434m		11.4592 (d)			N45° 20' 08.17"W	N33° 52' 35.21"W	Incurve
46	Spiral-Curve-Spiral	5986.373m	6010.831m	24.458m	75.000m			18.6849 (d)	24.350m	N24° 32' 02.46"W	N33° 52' 35.21"W	N15° 11' 29.71"W	
46	Spiral-Curve-Spiral	6010.831m	6040.831m	30.000m		47.434m		11.4592 (d)			N15° 11' 29.71"W	N3° 43' 56.75"W	Outcurve
47	Line	6040.831m	6311.097m	270.265m			N3° 43' 56.75"W						
48	Spiral-Curve-Spiral	6311.097m	6341.097m	30.000m		67.082m		5.7296 (d)			N3° 43' 56.75"W	N9° 27' 43.23"W	Incurve
48	Spiral-Curve-Spiral	6341.097m	6361.109m	20.012m	150.000m			7.6441 (d)	19.997m	N13° 17' 02.57"W	N9° 27' 43.23"W	N17° 06' 21.90"W	
48	Spiral-Curve-Spiral	6361.109m	6391.109m	30.000m		67.082m		5.7296 (d)			N17° 06' 21.90"W	N22° 50' 08.38"W	Outcurve
49	Line	6391.109m	6577.235m	186.127m			N22° 50' 08.38"W						
50	Spiral-Curve-Spiral	6577.235m	6607.235m	30.000m		67.082m		5.7296 (d)			N22° 50' 08.38"W	N28° 33' 54.86"W	Incurve
50	Spiral-Curve-Spiral	6607.235m	6628.644m	21.409m	150.000m			8.1776 (d)	21.391m	N32° 39' 14.50"W	N28° 33' 54.86"W	N36° 44' 34.14"W	
50	Spiral-Curve-Spiral	6628.644m	6658.644m	30.000m		67.082m		5.7296 (d)			N36° 44' 34.14"W	N42° 28' 20.62"W	Outcurve
51	Line	6658.644m	6692.839m	34.195m			N42° 28' 20.62"W						
52	Spiral-Curve-Spiral	6692.839m	6722.839m	30.000m		47.434m		11.4592 (d)			N42° 28' 20.62"W	N31° 00' 47.66"W	Incurve
52	Spiral-Curve-Spiral	6722.839m	6730.039m	7.200m	75.000m			5.5008 (d)	7.198m	N28° 15' 46.27"W	N31° 00' 47.66"W	N25° 30' 44.87"W	
52	Spiral-Curve-Spiral	6730.039m	6760.039m	30.000m		47.434m		11.4592 (d)			N25° 30' 44.87"W	N14° 03' 11.91"W	Outcurve
53	Line	6760.039m	6818.498m	58.459m			N14° 03' 11.91"W						
54	Spiral-Curve-Spiral	6818.498m	6843.498m	25.000m		43.301m		9.5493 (d)			N14° 03' 11.91"W	N23° 36' 09.38"W	Incurve
54	Spiral-Curve-Spiral	6843.498m	6854.457m	10.960m	75.000m			8.3725 (d)	10.950m	N27° 47' 19.87"W	N23° 36' 09.38"W	N31° 58' 30.36"W	
54	Spiral-Curve-Spiral	6854.457m	6879.457m	25.000m		43.301m		9.5493 (d)			N31° 58' 30.36"W	N41° 31' 27.83"W	Outcurve
55	Line	6879.457m	6926.441m	46.983m			N41° 31' 27.83"W						
56	Spiral-Curve-Spiral	6926.441m	6936.441m	10.000m		17.321m		9.5493 (d)			N41° 31' 27.83"W	N51° 04' 25.30"W	Incurve
56	Spiral-Curve-Spiral	6936.441m	7014.080m	77.640m	30.000m			148.2808 (d)	57.716m	S54° 47' 09.29"W	N51° 04' 25.30"W	S19° 21' 16.13"E	
56	Spiral-Curve-Spiral	7014.080m	7024.080m	10.000m		17.321m		9.5493 (d)			S19° 21' 16.13"E	S28° 54' 13.60"E	Outcurve
57	Line	7024.080m	7074.181m	50.101m			S28° 54' 13.60"E						
58	Spiral-Curve-Spiral	7074.181m	7094.181m	20.000m		38.730m		7.6394 (d)			S28° 54' 13.60"E	S21° 15' 51.62"E	Incurve
58	Spiral-Curve-Spiral	7094.181m	7148.633m	54.452m	75.000m			41.5979 (d)	53.263m	S0° 27' 55.40"E	S21° 15' 51.62"E	S20° 20' 00.83"W	
58	Spiral-Curve-Spiral	7148.633m	7168.633m	20.000m		38.730m		7.6394 (d)			S20° 20' 00.83"W	S27° 58' 22.80"W	Outcurve
59	Line	7168.633m	7170.434m	1.801m			S27° 58' 22.80"W						
60	Spiral-Curve-Spiral	7170.434m	7200.434m	30.000m		47.434m		11.4592 (d)			S27° 58' 22.80"W	S16° 30' 49.84"W	Incurve
60	Spiral-Curve-Spiral	7200.434m	7245.491m	45.057m	75.000m			34.4210 (d)	44.382m	S0° 41' 47.89"E	S16° 30' 49.84"W	S17° 54' 25.61"E	
60	Spiral-Curve-Spiral	7245.491m	7275.491m	30.000m		47.434m		11.4592 (d)			S17° 54' 25.61"E	S29° 21' 58.58"E	Outcurve
61	Line	7275.491m	7393.058m	117.567m			S29° 21' 58.58"E						
62	Spiral-Curve-Spiral	7393.058m	7423.058m	30.000m		94.868m		2.8648 (d)			S29° 21' 58.58"E	S26° 30' 05.34"E	Incurve
62	Spiral-Curve-Spiral	7423.058m	7639.909m	216.851m	300.000m			41.4154 (d)	212.160m	S5° 47' 37.59"E	S26° 30' 05.34"E	S14° 54' 50.15"W	
62	Spiral-Curve-Spiral	7639.909m	7669.909m	30.000m		94.868m		2.8648 (d)			S14° 54' 50.15"W	S17° 46' 43.39"W	Outcurve
63	Line	7669.909m	7875.495m	205.586m			S17° 46' 43.39"W						
64	Spiral-Curve-Spiral	7875.495m	7905.495m	30.000m		47.434m		11.4592 (d)			S17° 46' 43.39"W	S6° 19' 10.43"W	Incurve
64	Spiral-Curve-Spiral	7905.495m	7925.706m	20.211m	75.000m			15.4403 (d)	20.150m	S1° 24' 02.16"E	S6° 19' 10.43"W	S9° 07' 14.75"E	
64	Spiral-Curve-Spiral	7925.706m	7955.706m	30.000m		47.434m		11.4592 (d)			S9° 07' 14.75"E	S20° 34' 47.71"E	Outcurve
65	Line	7955.706m	7982.977m	27.271m			S20° 34' 47.71"E						

Number	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Chord length	Chord Direction	Start Direction	End Direction	Incurve
66	Spiral-Curve-Spiral	7982.977m	8012.977m	30.000m		30.000m		28.6479 (d)			S20° 34' 47.71"E	S8° 04' 04.70"W	Incurve
66	Spiral-Curve-Spiral	8012.977m	8061.100m	48.123m	30.000m			91.9085 (d)	43.127m	S54° 01' 20.08"W	S8° 04' 04.70"W	N80° 01' 24.53"W	
66	Spiral-Curve-Spiral	8061.100m	8091.100m	30.000m		30.000m		28.6479 (d)			N80° 01' 24.53"W	N51° 22' 32.13"W	Outcurve
67	Line	8091.100m	8158.057m	66.956m			N51° 22' 32.13"W						
68	Spiral-Curve-Spiral	8158.057m	8188.057m	30.000m		67.082m		5.7296 (d)			N51° 22' 32.13"W	N57° 06' 18.61"W	Incurve
68	Spiral-Curve-Spiral	8188.057m	8209.247m	21.191m	150.000m			8.0942 (d)	21.173m	N61° 09' 08.14"W	N57° 06' 18.61"W	N65° 11' 57.67"W	
68	Spiral-Curve-Spiral	8209.247m	8239.247m	30.000m		67.082m		5.7296 (d)			N65° 11' 57.67"W	N70° 55' 44.16"W	Outcurve
69	Line	8239.247m	8249.635m	10.388m			N70° 55' 44.16"W						
70	Spiral-Curve-Spiral	8249.635m	8279.635m	30.000m		67.082m		5.7296 (d)			N70° 55' 44.16"W	N65° 11' 57.67"W	Incurve
70	Spiral-Curve-Spiral	8279.635m	8364.673m	85.038m	150.000m			32.4820 (d)	83.903m	N48° 57' 30.09"W	N65° 11' 57.67"W	N32° 43' 02.50"W	
70	Spiral-Curve-Spiral	8364.673m	8394.673m	30.000m		67.082m		5.7296 (d)			N32° 43' 02.50"W	N26° 59' 16.02"W	Outcurve
71	Line	8394.673m	8422.517m	27.844m			N26° 59' 16.02"W						
72	Spiral-Curve-Spiral	8422.517m	8452.517m	30.000m		47.434m		11.4592 (d)			N26° 59' 16.02"W	N15° 31' 43.06"W	Incurve
72	Spiral-Curve-Spiral	8452.517m	8512.171m	59.654m	75.000m			45.5724 (d)	58.094m	N7° 15' 27.18"E	N15° 31' 43.06"W	N30° 02' 37.42"E	
72	Spiral-Curve-Spiral	8512.171m	8542.171m	30.000m		47.434m		11.4592 (d)			N30° 02' 37.42"E	N41° 30' 10.38"E	Outcurve
73	Line	8542.171m	8624.505m	82.334m			N41° 30' 10.38"E						
74	Spiral-Curve-Spiral	8624.505m	8654.505m	30.000m		47.434m		11.4592 (d)			N41° 30' 10.38"E	N30° 02' 37.42"E	Incurve
74	Spiral-Curve-Spiral	8654.505m	8737.643m	83.138m	75.000m			63.5130 (d)	78.947m	N1° 42' 45.91"W	N30° 02' 37.42"E	N33° 28' 09.24"W	
74	Spiral-Curve-Spiral	8737.643m	8767.643m	30.000m		47.434m		11.4592 (d)			N33° 28' 09.24"W	N44° 55' 42.20"W	Outcurve
75	Line	8767.643m	8901.561m	133.918m			N44° 55' 42.20"W						
76	Spiral-Curve-Spiral	8901.561m	8931.561m	30.000m		47.434m		11.4592 (d)			N44° 55' 42.20"W	N33° 28' 09.24"W	Incurve
76	Spiral-Curve-Spiral	8931.561m	8944.265m	12.703m	75.000m			9.7046 (d)	12.688m	N28° 37' 01.03"W	N33° 28' 09.24"W	N23° 45' 52.81"W	
76	Spiral-Curve-Spiral	8944.265m	8974.265m	30.000m		47.434m		11.4592 (d)			N23° 45' 52.81"W	N12° 18' 19.85"W	Outcurve
77	Line	8974.265m	9036.550m	62.286m			N12° 18' 19.85"W						
78	Spiral-Curve-Spiral	9036.550m	9066.550m	30.000m		47.434m		11.4592 (d)			N12° 18' 19.85"W	N23° 45' 52.81"W	Incurve
78	Spiral-Curve-Spiral	9066.550m	9136.190m	69.640m	75.000m			53.2011 (d)	67.165m	N50° 21' 54.80"W	N23° 45' 52.81"W	N76° 57' 56.78"W	
78	Spiral-Curve-Spiral	9136.190m	9166.190m	30.000m		47.434m		11.4592 (d)			N76° 57' 56.78"W	N88° 25' 29.74"W	Outcurve
79	Line	9166.190m	9251.769m	85.579m			N88° 25' 29.74"W						
80	Spiral-Curve-Spiral	9251.769m	9281.769m	30.000m		47.434m		11.4592 (d)			N88° 25' 29.74"W	N76° 57' 56.78"W	Incurve
80	Spiral-Curve-Spiral	9281.769m	9310.362m	28.593m	75.000m			21.8435 (d)	28.420m	N66° 02' 38.52"W	N76° 57' 56.78"W	N55° 07' 20.25"W	
80	Spiral-Curve-Spiral	9310.362m	9340.362m	30.000m		47.434m		11.4592 (d)			N55° 07' 20.25"W	N43° 39' 47.29"W	Outcurve
81	Line	9340.362m	9444.192m	103.830m			N43° 39' 47.29"W						
82	Spiral-Curve-Spiral	9444.192m	9474.192m	30.000m		67.082m		5.7296 (d)			N43° 39' 47.29"W	N49° 23' 33.77"W	Incurve
82	Spiral-Curve-Spiral	9474.192m	9516.832m	42.640m	150.000m			16.2872 (d)	42.496m	N57° 32' 10.72"W	N49° 23' 33.77"W	N65° 40' 47.66"W	
82	Spiral-Curve-Spiral	9516.832m	9546.832m	30.000m		67.082m		5.7296 (d)			N65° 40' 47.66"W	N71° 24' 34.14"W	Outcurve
83	Line	9546.832m	9681.150m	134.319m			N71° 24' 34.14"W						
84	Spiral-Curve-Spiral	9681.150m	9711.150m	30.000m		47.434m		11.4592 (d)			N71° 24' 34.14"W	N59° 57' 01.18"W	Incurve
84	Spiral-Curve-Spiral	9711.150m	9843.651m	132.500m	75.000m			101.2229 (d)	115.929m	N9° 20' 19.93"W	N59° 57' 01.18"W	N41° 16' 21.33"E	
84	Spiral-Curve-Spiral	9843.651m	9873.651m	30.000m		47.434m		11.4592 (d)			N41° 16' 21.33"E	N52° 43' 54.29"E	Outcurve
85	Line	9873.651	10000	126.349			N52° 43' 54.29"E						

VERTICAL ALIGNMENT REPORT

Vertical Alignment Report								
No.	PVI Station	PVI Elevation	Grade In	Grade Out	A (Grade Change)	Profile Curve Type	Profile Curve Length	K Value
1	00.079m	1197.146m		-1.60%				
2	112.939m	1195.342m	-1.60%	-7.00%	5.40%	Crest	33.656m	6.232
3	1564.365m	1093.759m	-7.00%	0.00%	7.00%	Sag	50.000m	7.144
4	1661.730m	1093.759m	0.00%	-5.44%	5.44%	Crest	50.000m	9.185
5	2810.918m	1031.201m	-5.44%	-4.65%	0.80%	Sag	59.548m	74.751
6	5622.252m	900.557m	-4.65%	-4.97%	0.32%	Crest	318.301m	984.038
7	8097.122m	777.542m	-4.97%	-5.00%	0.03%	Crest	109.098m	4341.291
8	10390.703m	662.963m	-5.00%	0.00%	5.00%	Sag	50.000m	10.009

Curve Radius
623.249m
714.408m
918.497m
7475.089m
98403.772m
434129.136m
1000.869m

PCL COORDINATES

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
0	2,762,618.4361m	553,297.7926m	N35° 22' 45.58"W
25	2,762,638.8195m	553,283.3179m	N35° 22' 45.58"W
50	2,762,659.2013m	553,268.8410m	N35° 31' 49.28"W
75	2,762,678.3426m	553,252.8325m	N47° 19' 49.63"W
100	2,762,691.9394m	553,231.9912m	N66° 25' 44.57"W
125	2,762,698.4517m	553,207.9271m	N80° 45' 36.80"W
150	2,762,702.1461m	553,183.2017m	N81° 34' 56.72"W
175	2,762,705.8058m	553,158.4710m	N81° 34' 56.72"W
200	2,762,709.4654m	553,133.7403m	N81° 34' 56.72"W
225	2,762,713.1251m	553,109.0097m	N81° 34' 56.72"W
250	2,762,716.7847m	553,084.2790m	N81° 34' 56.72"W
275	2,762,720.4444m	553,059.5483m	N81° 34' 56.72"W
300	2,762,724.1041m	553,034.8176m	N81° 34' 56.72"W
325	2,762,727.7858m	553,010.0902m	N81° 06' 43.24"W
350	2,762,732.8962m	552,985.6358m	N73° 48' 24.56"W
375	2,762,742.7617m	552,962.7446m	N58° 53' 01.63"W
400	2,762,758.4692m	552,943.3986m	N42° 58' 05.85"W
425	2,762,778.8509m	552,929.0500m	N27° 57' 04.45"W
450	2,762,801.7676m	552,919.1046m	N20° 26' 33.63"W
475	2,762,825.2649m	552,910.5680m	N19° 54' 12.90"W
500	2,762,848.7716m	552,902.0570m	N19° 54' 12.90"W
525	2,762,872.2782m	552,893.5460m	N19° 54' 12.90"W
550	2,762,895.7849m	552,885.0351m	N19° 54' 12.90"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
575	2,762,919.2917m	552,876.5245m	N19° 52' 50.01"W
600	2,762,942.9142m	552,868.3449m	N17° 51' 35.47"W
625	2,762,966.8912m	552,861.2756m	N14° 59' 42.23"W
650	2,762,991.1915m	552,855.4135m	N12° 07' 48.99"W
675	2,763,015.7544m	552,850.7732m	N9° 15' 55.75"W
700	2,763,040.5186m	552,847.3664m	N6° 24' 02.51"W
725	2,763,065.4220m	552,845.2015m	N3° 32' 09.27"W
750	2,763,090.3998m	552,844.1776m	N1° 39' 25.17"W
775	2,763,115.3894m	552,843.4573m	N1° 39' 03.52"W
800	2,763,140.3790m	552,842.7370m	N1° 39' 03.52"W
825	2,763,165.3687m	552,842.0167m	N1° 39' 03.52"W
850	2,763,190.3632m	552,841.5488m	N0° 09' 54.40"E
875	2,763,215.3334m	552,842.6142m	N4° 49' 14.79"E
900	2,763,240.1286m	552,845.7501m	N9° 35' 43.52"E
925	2,763,264.5768m	552,850.9390m	N14° 22' 12.25"E
950	2,763,288.5166m	552,858.1200m	N18° 44' 33.38"E
975	2,763,312.0701m	552,866.4990m	N19° 51' 46.49"E
1000	2,763,335.5828m	552,874.9933m	N19° 51' 46.49"E
1025	2,763,359.1446m	552,883.3483m	N18° 15' 59.98"E
1050	2,763,383.1836m	552,890.1866m	N13° 29' 31.25"E
1075	2,763,407.7084m	552,895.0003m	N8° 43' 02.51"E
1100	2,763,432.5008m	552,898.2080m	N6° 59' 13.46"E
1125	2,763,457.3151m	552,901.2491m	N6° 59' 13.46"E

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
1150	2,763,482.1295m	552,904.2903m	N6° 59' 13.46"E
1175	2,763,506.9438m	552,907.3314m	N6° 59' 13.46"E
1200	2,763,531.7435m	552,910.4859m	N8° 12' 29.92"E
1225	2,763,556.3598m	552,914.8259m	N11° 47' 21.47"E
1250	2,763,580.6570m	552,920.6949m	N15° 22' 13.02"E
1275	2,763,604.5401m	552,928.0701m	N18° 57' 04.57"E
1300	2,763,627.9159m	552,936.9225m	N22° 31' 56.12"E
1325	2,763,650.6932m	552,947.2177m	N26° 06' 34.26"E
1350	2,763,672.9915m	552,958.5215m	N27° 03' 39.68"E
1375	2,763,695.2546m	552,969.8949m	N27° 03' 39.68"E
1400	2,763,717.5176m	552,981.2684m	N27° 03' 39.68"E
1425	2,763,739.7807m	552,992.6419m	N27° 03' 39.68"E
1450	2,763,762.0437m	553,004.0154m	N27° 03' 39.68"E
1475	2,763,784.3068m	553,015.3889m	N27° 03' 39.68"E
1500	2,763,806.5723m	553,026.7576m	N26° 53' 08.57"E
1525	2,763,829.2711m	553,037.2095m	N21° 14' 12.74"E
1550	2,763,853.2185m	553,044.2859m	N11° 41' 15.27"E
1575	2,763,878.0080m	553,047.2914m	N2° 08' 17.81"E
1600	2,763,902.9527m	553,046.1428m	N7° 24' 39.66"W
1625	2,763,927.3611m	553,040.8719m	N16° 57' 37.13"W
1650	2,763,950.5569m	553,031.6248m	N26° 30' 34.60"W
1675	2,763,971.8972m	553,018.6577m	N36° 03' 32.07"W
1700	2,763,990.7907m	553,002.3300m	N45° 36' 29.53"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
1725	2,764,006.7137m	552,983.0944m	N55° 08' 15.00"W
1750	2,764,019.8448m	552,961.8303m	N60° 08' 37.41"W
1775	2,764,032.2664m	552,940.1346m	N60° 12' 36.15"W
1800	2,764,044.7065m	552,918.4495m	N59° 47' 41.65"W
1825	2,764,058.0634m	552,897.3271m	N54° 40' 26.31"W
1850	2,764,073.7547m	552,877.8856m	N47° 30' 43.20"W
1875	2,764,091.7473m	552,860.5521m	N40° 21' 00.10"W
1900	2,764,111.6247m	552,845.4046m	N35° 10' 26.79"W
1925	2,764,132.1559m	552,831.1404m	N34° 44' 01.04"W
1950	2,764,152.7011m	552,816.8963m	N34° 44' 01.04"W
1975	2,764,173.2656m	552,802.6802m	N34° 08' 00.20"W
2000	2,764,194.6201m	552,789.7114m	N27° 12' 17.83"W
2025	2,764,217.7020m	552,780.1835m	N17° 39' 20.36"W
2050	2,764,242.0446m	552,774.6167m	N8° 06' 22.89"W
2075	2,764,266.9735m	552,773.1655m	N1° 26' 34.58"E
2100	2,764,291.7977m	552,775.8700m	N10° 59' 32.04"E
2125	2,764,315.8424m	552,782.6177m	N19° 52' 24.89"E
2150	2,764,339.0682m	552,791.8622m	N22° 21' 30.69"E
2175	2,764,362.1887m	552,801.3722m	N22° 21' 30.69"E
2200	2,764,385.3093m	552,810.8822m	N22° 21' 30.69"E
2225	2,764,408.4298m	552,820.3923m	N22° 21' 30.69"E
2250	2,764,431.5825m	552,829.8227m	N21° 14' 35.96"E
2275	2,764,455.3587m	552,837.4830m	N13° 28' 59.74"E

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
2300	2,764,480.0419m	552,841.2641m	N3° 57' 26.55"E
2325	2,764,505.0312m	552,841.6192m	N1° 00' 09.56"W
2350	2,764,530.0269m	552,841.1564m	N1° 03' 47.31"W
2375	2,764,555.0226m	552,840.6926m	N1° 03' 47.31"W
2400	2,764,580.0183m	552,840.2287m	N1° 03' 47.31"W
2425	2,764,605.0140m	552,839.7649m	N1° 03' 47.31"W
2450	2,764,630.0097m	552,839.3010m	N1° 03' 47.31"W
2475	2,764,655.0054m	552,838.8371m	N1° 03' 47.31"W
2500	2,764,680.0011m	552,838.3733m	N1° 03' 47.31"W
2525	2,764,704.9968m	552,837.9094m	N1° 03' 47.31"W
2550	2,764,729.9925m	552,837.4456m	N1° 03' 47.31"W
2575	2,764,754.9898m	552,837.1819m	N0° 53' 51.48"E
2600	2,764,779.8768m	552,839.2863m	N9° 15' 03.84"E
2625	2,764,804.3449m	552,844.3923m	N13° 00' 02.83"E
2650	2,764,828.7042m	552,850.0160m	N12° 57' 34.31"E
2675	2,764,853.3285m	552,854.1478m	N3° 14' 49.90"E
2700	2,764,878.0190m	552,851.1838m	N17° 04' 13.86"W
2725	2,764,900.1162m	552,839.7777m	N37° 31' 49.74"W
2750	2,764,917.8344m	552,822.2036m	N49° 09' 26.79"W
2775	2,764,934.3482m	552,803.4384m	N46° 16' 02.09"W
2800	2,764,953.2691m	552,787.1652m	N34° 46' 07.78"W
2825	2,764,975.1371m	552,775.1430m	N22° 49' 55.95"W
2850	2,764,999.0188m	552,767.9036m	N10° 53' 44.12"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
2875	2,765,023.8513m	552,765.1763m	N3° 32' 45.35"W
2900	2,765,048.8057m	552,763.6680m	N3° 27' 18.55"W
2925	2,765,073.7603m	552,762.1614m	N3° 27' 18.55"W
2950	2,765,098.7148m	552,760.6547m	N3° 27' 18.55"W
2975	2,765,123.6694m	552,759.1480m	N3° 27' 18.55"W
3000	2,765,148.6239m	552,757.6413m	N3° 27' 18.55"W
3025	2,765,173.5785m	552,756.1346m	N3° 27' 18.55"W
3050	2,765,198.5331m	552,754.6279m	N3° 27' 18.55"W
3075	2,765,223.4876m	552,753.1213m	N3° 27' 18.55"W
3100	2,765,248.4422m	552,751.6146m	N3° 27' 18.55"W
3125	2,765,273.3967m	552,750.1079m	N3° 27' 18.55"W
3150	2,765,298.3513m	552,748.6012m	N3° 27' 18.55"W
3175	2,765,323.3138m	552,747.2449m	N2° 05' 18.90"W
3200	2,765,348.3097m	552,746.9096m	N0° 02' 43.67"E
3225	2,765,373.3097m	552,746.9294m	N0° 02' 43.67"E
3250	2,765,398.3097m	552,746.9493m	N0° 02' 43.67"E
3275	2,765,423.3097m	552,746.9691m	N0° 02' 43.67"E
3300	2,765,448.3097m	552,746.9890m	N0° 02' 43.67"E
3325	2,765,473.3090m	552,746.8607m	N1° 01' 41.31"W
3350	2,765,498.2847m	552,745.8177m	N3° 49' 02.49"W
3375	2,765,523.1772m	552,743.5305m	N6° 40' 55.73"W
3400	2,765,547.9243m	552,740.0021m	N9° 32' 48.97"W
3425	2,765,572.4642m	552,735.2412m	N12° 24' 42.21"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
3450	2,765,596.7354m	552,729.2598m	N15° 16' 35.45"W
3475	2,765,620.6773m	552,722.0728m	N18° 08' 28.69"W
3500	2,765,644.2302m	552,713.6982m	N21° 00' 21.93"W
3525	2,765,667.3360m	552,704.1592m	N23° 48' 00.22"W
3550	2,765,690.0767m	552,693.7746m	N24° 53' 31.06"W
3575	2,765,712.7543m	552,683.2519m	N24° 53' 31.06"W
3600	2,765,735.4319m	552,672.7292m	N24° 53' 31.06"W
3625	2,765,758.1095m	552,662.2065m	N24° 53' 31.06"W
3650	2,765,780.7870m	552,651.6838m	N24° 53' 31.06"W
3675	2,765,803.4646m	552,641.1611m	N24° 53' 31.06"W
3700	2,765,826.1422m	552,630.6384m	N24° 53' 31.06"W
3725	2,765,848.8198m	552,620.1156m	N24° 53' 56.31"W
3750	2,765,871.2085m	552,609.0055m	N29° 12' 43.02"W
3775	2,765,891.9367m	552,595.0807m	N38° 39' 42.84"W
3800	2,765,910.0691m	552,577.9118m	N48° 12' 40.30"W
3825	2,765,925.1020m	552,557.9727m	N57° 45' 37.77"W
3850	2,765,936.9096m	552,535.9545m	N64° 37' 01.87"W
3875	2,765,947.4305m	552,513.2761m	N65° 11' 01.68"W
3900	2,765,957.9232m	552,490.5847m	N65° 11' 01.68"W
3925	2,765,969.4386m	552,468.4187m	N57° 15' 30.07"W
3950	2,765,986.0866m	552,449.9214m	N38° 29' 04.45"W
3975	2,766,007.8646m	552,437.8817m	N19° 23' 09.52"W
4000	2,766,032.3832m	552,433.6305m	N0° 17' 14.58"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
4025	2,766,057.0913m	552,437.0073m	N13° 24' 58.29"E
4050	2,766,081.3052m	552,443.2259m	N14° 32' 41.73"E
4075	2,766,105.5040m	552,449.5044m	N14° 32' 41.73"E
4100	2,766,129.7028m	552,455.7828m	N14° 32' 41.73"E
4125	2,766,153.9015m	552,462.0613m	N14° 32' 41.73"E
4150	2,766,178.1003m	552,468.3398m	N14° 32' 41.73"E
4175	2,766,202.2991m	552,474.6183m	N14° 32' 41.73"E
4200	2,766,226.4979m	552,480.8967m	N14° 32' 41.73"E
4225	2,766,250.6984m	552,487.1684m	N14° 22' 04.72"E
4250	2,766,275.0609m	552,492.7583m	N10° 41' 35.60"E
4275	2,766,299.8164m	552,496.1749m	N5° 13' 47.45"E
4300	2,766,324.7557m	552,497.8997m	N3° 26' 20.98"E
4325	2,766,349.7107m	552,499.3994m	N3° 26' 20.98"E
4350	2,766,374.6656m	552,500.8991m	N3° 26' 20.98"E
4375	2,766,399.6206m	552,502.3988m	N3° 26' 20.98"E
4400	2,766,424.5756m	552,503.8985m	N3° 26' 20.98"E
4425	2,766,449.5306m	552,505.3982m	N3° 26' 20.98"E
4450	2,766,474.4856m	552,506.8980m	N3° 26' 20.98"E
4475	2,766,499.4405m	552,508.3977m	N3° 26' 20.98"E
4500	2,766,524.3955m	552,509.8974m	N3° 26' 20.98"E
4525	2,766,549.3581m	552,511.2526m	N2° 03' 33.82"E
4550	2,766,574.3426m	552,510.9308m	N4° 25' 09.79"W
4575	2,766,599.0303m	552,507.1245m	N12° 21' 16.26"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
4600	2,766,623.2654m	552,500.9982m	N15° 08' 02.15"W
4625	2,766,647.3982m	552,494.4707m	N15° 08' 07.61"W
4650	2,766,671.5309m	552,487.9431m	N15° 08' 07.61"W
4675	2,766,695.6637m	552,481.4156m	N15° 08' 07.61"W
4700	2,766,719.7965m	552,474.8881m	N15° 08' 07.61"W
4725	2,766,743.9293m	552,468.3605m	N15° 08' 07.61"W
4750	2,766,768.0621m	552,461.8330m	N15° 08' 07.61"W
4775	2,766,792.1948m	552,455.3054m	N15° 08' 07.61"W
4800	2,766,816.3276m	552,448.7779m	N15° 08' 07.61"W
4825	2,766,840.4604m	552,442.2503m	N15° 08' 07.61"W
4850	2,766,864.5932m	552,435.7228m	N15° 08' 07.61"W
4875	2,766,888.7260m	552,429.1953m	N15° 08' 07.61"W
4900	2,766,912.8588m	552,422.6677m	N15° 08' 07.61"W
4925	2,766,936.9915m	552,416.1402m	N15° 08' 07.61"W
4950	2,766,961.1243m	552,409.6126m	N15° 08' 07.61"W
4975	2,766,985.2571m	552,403.0851m	N15° 08' 07.61"W
5000	2,767,009.3899m	552,396.5575m	N15° 08' 07.61"W
5025	2,767,033.4316m	552,389.7117m	N17° 52' 39.51"W
5050	2,767,056.5575m	552,380.2859m	N26° 52' 57.87"W
5075	2,767,077.8129m	552,367.1801m	N36° 25' 55.34"W
5100	2,767,096.8689m	552,351.0189m	N42° 53' 44.04"W
5125	2,767,115.0757m	552,333.8868m	N43° 18' 04.89"W
5150	2,767,133.2696m	552,316.7409m	N43° 18' 04.89"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
5175	2,767,151.4635m	552,299.5950m	N43° 18' 04.89"W
5200	2,767,169.6574m	552,282.4491m	N43° 18' 00.10"W
5225	2,767,188.2606m	552,265.7568m	N39° 10' 32.37"W
5250	2,767,208.8341m	552,251.6041m	N29° 45' 27.89"W
5275	2,767,231.4687m	552,241.0575m	N20° 12' 30.42"W
5300	2,767,255.5393m	552,234.4121m	N10° 39' 32.95"W
5325	2,767,280.3788m	552,231.8520m	N1° 06' 35.49"W
5350	2,767,305.2988m	552,233.4481m	N8° 26' 21.98"E
5375	2,767,329.7323m	552,238.6839m	N14° 26' 07.68"E
5400	2,767,353.9171m	552,245.0162m	N14° 41' 39.06"E
5425	2,767,378.0994m	552,251.3576m	N14° 41' 28.41"E
5450	2,767,402.5409m	552,256.5019m	N6° 25' 35.42"E
5475	2,767,427.3950m	552,255.2522m	N12° 24' 43.97"W
5500	2,767,450.4737m	552,245.9458m	N31° 30' 38.90"W
5525	2,767,469.7829m	552,230.1541m	N44° 30' 03.34"W
5550	2,767,487.3846m	552,212.4010m	N45° 20' 08.17"W
5575	2,767,504.9584m	552,194.6201m	N45° 20' 08.17"W
5600	2,767,522.5322m	552,176.8392m	N45° 20' 08.17"W
5625	2,767,540.1060m	552,159.0583m	N45° 20' 08.17"W
5650	2,767,557.6799m	552,141.2774m	N45° 20' 08.17"W
5675	2,767,575.2537m	552,123.4964m	N45° 20' 08.17"W
5700	2,767,592.8275m	552,105.7155m	N45° 20' 08.17"W
5725	2,767,610.4013m	552,087.9346m	N45° 20' 08.17"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
5750	2,767,627.9752m	552,070.1537m	N45° 20' 08.17"W
5775	2,767,645.5490m	552,052.3728m	N45° 20' 08.17"W
5800	2,767,663.1228m	552,034.5919m	N45° 20' 08.17"W
5825	2,767,680.6966m	552,016.8110m	N45° 20' 08.17"W
5850	2,767,698.2704m	551,999.0301m	N45° 20' 08.17"W
5875	2,767,715.8443m	551,981.2492m	N45° 20' 08.17"W
5900	2,767,733.4181m	551,963.4683m	N45° 20' 08.17"W
5925	2,767,750.9919m	551,945.6873m	N45° 20' 08.17"W
5950	2,767,768.5657m	551,927.9064m	N45° 20' 08.17"W
5975	2,767,786.4721m	551,910.4698m	N40° 55' 04.52"W
6000	2,767,807.4081m	551,896.9947m	N23° 27' 58.37"W
6025	2,767,831.5334m	551,890.8010m	N6° 55' 25.02"W
6050	2,767,856.4563m	551,888.8806m	N3° 43' 56.75"W
6075	2,767,881.4033m	551,887.2532m	N3° 43' 56.75"W
6100	2,767,906.3503m	551,885.6258m	N3° 43' 56.75"W
6125	2,767,931.2972m	551,883.9984m	N3° 43' 56.75"W
6150	2,767,956.2442m	551,882.3709m	N3° 43' 56.75"W
6175	2,767,981.1912m	551,880.7435m	N3° 43' 56.75"W
6200	2,768,006.1382m	551,879.1161m	N3° 43' 56.75"W
6225	2,768,031.0851m	551,877.4886m	N3° 43' 56.75"W
6250	2,768,056.0321m	551,875.8612m	N3° 43' 56.75"W
6275	2,768,080.9791m	551,874.2338m	N3° 43' 56.75"W
6300	2,768,105.9260m	551,872.6064m	N3° 43' 56.75"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
6325	2,768,130.8659m	551,870.8796m	N4° 57' 47.01"W
6350	2,768,155.5742m	551,867.2125m	N12° 51' 46.38"W
6375	2,768,179.4066m	551,859.7393m	N21° 11' 01.32"W
6400	2,768,202.5059m	551,850.1802m	N22° 50' 08.38"W
6425	2,768,225.5465m	551,840.4780m	N22° 50' 08.38"W
6450	2,768,248.5870m	551,830.7758m	N22° 50' 08.38"W
6475	2,768,271.6276m	551,821.0735m	N22° 50' 08.38"W
6500	2,768,294.6681m	551,811.3713m	N22° 50' 08.38"W
6525	2,768,317.7087m	551,801.6691m	N22° 50' 08.38"W
6550	2,768,340.7492m	551,791.9668m	N22° 50' 08.38"W
6575	2,768,363.7898m	551,782.2646m	N22° 50' 08.38"W
6600	2,768,386.6538m	551,772.1627m	N26° 08' 05.25"W
6625	2,768,408.1465m	551,759.4478m	N35° 21' 02.92"W
6650	2,768,427.4815m	551,743.6229m	N41° 59' 48.09"W
6675	2,768,445.9377m	551,726.7597m	N42° 28' 20.62"W
6700	2,768,464.3960m	551,709.8990m	N41° 49' 09.98"W
6725	2,768,484.3500m	551,694.9225m	N29° 21' 43.86"W
6750	2,768,507.6031m	551,685.9210m	N15° 20' 11.64"W
6775	2,768,531.8362m	551,679.7778m	N14° 03' 11.91"W
6800	2,768,556.0880m	551,673.7072m	N14° 03' 11.91"W
6825	2,768,580.3337m	551,667.6129m	N14° 41' 57.32"W
6850	2,768,603.7180m	551,658.9588m	N28° 34' 11.40"W
6875	2,768,623.8086m	551,644.1715m	N41° 13' 14.95"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
6900	2,768,642.5306m	551,627.6039m	N41° 31' 27.83"W
6925	2,768,661.2474m	551,611.0304m	N41° 31' 27.83"W
6950	2,768,675.3134m	551,590.9634m	N76° 58' 12.52"W
6975	2,768,670.7451m	551,567.1141m	S55° 17' 00.14"W
7000	2,768,650.0207m	551,554.4588m	S7° 32' 12.80"W
7025	2,768,626.3402m	551,560.6742m	S28° 54' 13.60"E
7050	2,768,604.4544m	551,572.7577m	S28° 54' 13.60"E
7075	2,768,582.5686m	551,584.8412m	S28° 53' 27.53"E
7100	2,768,559.8798m	551,595.2159m	S16° 49' 09.52"E
7125	2,768,535.1954m	551,598.3649m	S2° 16' 45.42"W
7150	2,768,510.8393m	551,593.2643m	S21° 20' 31.87"W
7175	2,768,488.4420m	551,582.1900m	S27° 42' 27.15"W
7200	2,768,465.5688m	551,572.1959m	S16° 50' 34.58"W
7225	2,768,440.8859m	551,569.0357m	S2° 15' 11.72"E
7250	2,768,416.5252m	551,574.1192m	S21° 05' 34.69"E
7275	2,768,394.1832m	551,585.2852m	S29° 21' 47.53"E
7300	2,768,372.3956m	551,597.5450m	S29° 21' 58.58"E
7325	2,768,350.6080m	551,609.8048m	S29° 21' 58.58"E
7350	2,768,328.8204m	551,622.0645m	S29° 21' 58.58"E
7375	2,768,307.0329m	551,634.3243m	S29° 21' 58.58"E
7400	2,768,285.2423m	551,646.5787m	S29° 12' 46.36"E
7425	2,768,263.1709m	551,658.3131m	S26° 07' 50.19"E
7450	2,768,240.2935m	551,668.3762m	S21° 21' 21.45"E

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
7475	2,768,216.6579m	551,676.5001m	S16° 34' 52.72"E
7500	2,768,192.4282m	551,682.6284m	S11° 48' 23.98"E
7525	2,768,167.7724m	551,686.7187m	S7° 01' 55.25"E
7550	2,768,142.8617m	551,688.7425m	S2° 15' 26.52"E
7575	2,768,117.8690m	551,688.6859m	S2° 31' 02.22"W
7600	2,768,092.9677m	551,686.5491m	S7° 17' 30.95"W
7625	2,768,068.3308m	551,682.3470m	S12° 03' 59.69"W
7650	2,768,044.1237m	551,676.1270m	S16° 31' 01.48"W
7675	2,768,020.2739m	551,668.6329m	S17° 46' 43.39"W
7700	2,767,996.4679m	551,660.9994m	S17° 46' 43.39"W
7725	2,767,972.6618m	551,653.3658m	S17° 46' 43.39"W
7750	2,767,948.8557m	551,645.7323m	S17° 46' 43.39"W
7775	2,767,925.0497m	551,638.0987m	S17° 46' 43.39"W
7800	2,767,901.2436m	551,630.4652m	S17° 46' 43.39"W
7825	2,767,877.4375m	551,622.8317m	S17° 46' 43.39"W
7850	2,767,853.6314m	551,615.1981m	S17° 46' 43.39"W
7875	2,767,829.8254m	551,607.5646m	S17° 46' 43.39"W
7900	2,767,805.7284m	551,600.9810m	S10° 07' 58.51"W
7925	2,767,780.8455m	551,600.5727m	S8° 34' 52.44"E
7950	2,767,756.8202m	551,607.3247m	S20° 09' 55.21"E
7975	2,767,733.4109m	551,616.0997m	S20° 34' 47.71"E
8000	2,767,709.7270m	551,624.0184m	S11° 21' 21.68"E
8025	2,767,685.5708m	551,620.5944m	S31° 01' 47.69"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
8050	2,767,671.6091m	551,600.7266m	S78° 46' 35.03"W
8075	2,767,676.4892m	551,576.8001m	N59° 37' 36.73"W
8100	2,767,691.4708m	551,556.8130m	N51° 22' 32.13"W
8125	2,767,707.0761m	551,537.2817m	N51° 22' 32.13"W
8150	2,767,722.6814m	551,517.7503m	N51° 22' 32.13"W
8175	2,767,738.1449m	551,498.1079m	N53° 12' 11.38"W
8200	2,767,751.7180m	551,477.1421m	N61° 40' 01.77"W
8225	2,767,761.8338m	551,454.3035m	N69° 38' 12.09"W
8250	2,767,770.1033m	551,430.7114m	N70° 55' 41.10"W
8275	2,767,778.8386m	551,407.2932m	N66° 49' 58.94"W
8300	2,767,790.4900m	551,385.2067m	N57° 25' 13.83"W
8325	2,767,805.6410m	551,365.3572m	N47° 52' 16.37"W
8350	2,767,823.8749m	551,348.2962m	N38° 19' 18.90"W
8375	2,767,844.6662m	551,334.4612m	N29° 27' 05.75"W
8400	2,767,866.8126m	551,322.8666m	N26° 59' 16.02"W
8425	2,767,889.0907m	551,311.5226m	N26° 54' 33.47"W
8450	2,767,911.9953m	551,301.5791m	N17° 22' 15.38"W
8475	2,767,936.6437m	551,298.1590m	N1° 38' 49.12"E
8500	2,767,961.0545m	551,302.9908m	N20° 44' 44.06"E
8525	2,767,982.6343m	551,315.4186m	N37° 44' 55.35"E
8550	2,768,001.6003m	551,331.6993m	N41° 30' 10.38"E
8575	2,768,020.3234m	551,348.2658m	N41° 30' 10.38"E
8600	2,768,039.0464m	551,364.8322m	N41° 30' 10.38"E

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
8625	2,768,057.7695m	551,381.3987m	N41° 29' 59.14"E
8650	2,768,077.2650m	551,397.0119m	N33° 13' 36.54"E
8675	2,768,100.0130m	551,407.1022m	N14° 23' 11.82"E
8700	2,768,124.8088m	551,409.2006m	N4° 42' 43.12"W
8725	2,768,148.9263m	551,403.0705m	N23° 48' 38.05"W
8750	2,768,169.8003m	551,389.4937m	N40° 57' 54.13"W
8775	2,768,187.7813m	551,372.1320m	N44° 55' 42.20"W
8800	2,768,205.4811m	551,354.4765m	N44° 55' 42.20"W
8825	2,768,223.1808m	551,336.8209m	N44° 55' 42.20"W
8850	2,768,240.8806m	551,319.1654m	N44° 55' 42.20"W
8875	2,768,258.5803m	551,301.5098m	N44° 55' 42.20"W
8900	2,768,276.2801m	551,283.8542m	N44° 55' 42.20"W
8925	2,768,294.6280m	551,266.8979m	N37° 56' 00.77"W
8950	2,768,316.4143m	551,254.8630m	N19° 48' 06.95"W
8975	2,768,340.5741m	551,248.5111m	N12° 18' 19.85"W
9000	2,768,364.9997m	551,243.1830m	N12° 18' 19.85"W
9025	2,768,389.4254m	551,237.8549m	N12° 18' 19.85"W
9050	2,768,413.8105m	551,232.3512m	N14° 36' 31.36"W
9075	2,768,437.0043m	551,223.2435m	N30° 13' 10.99"W
9100	2,768,456.1312m	551,207.3251m	N49° 19' 05.93"W
9125	2,768,468.9969m	551,186.0247m	N68° 25' 00.86"W
9150	2,768,474.3789m	551,161.7070m	N85° 05' 14.57"W
9175	2,768,475.3801m	551,136.7305m	N88° 25' 29.74"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
9200	2,768,476.0673m	551,111.7400m	N88° 25' 29.74"W
9225	2,768,476.7545m	551,086.7494m	N88° 25' 29.74"W
9250	2,768,477.4416m	551,061.7589m	N88° 25' 29.74"W
9275	2,768,479.0552m	551,036.8272m	N81° 33' 13.19"W
9300	2,768,486.5244m	551,013.0868m	N63° 02' 18.61"W
9325	2,768,501.1587m	550,992.9294m	N46° 40' 04.74"W
9350	2,768,519.0555m	550,975.4776m	N43° 39' 47.29"W
9375	2,768,537.1408m	550,958.2172m	N43° 39' 47.29"W
9400	2,768,555.2261m	550,940.9567m	N43° 39' 47.29"W
9425	2,768,573.3114m	550,923.6963m	N43° 39' 47.29"W
9450	2,768,591.3917m	550,906.4306m	N43° 52' 40.39"W
9475	2,768,608.7101m	550,888.4163m	N49° 42' 04.85"W
9500	2,768,623.2194m	550,868.0930m	N59° 15' 02.32"W
9525	2,768,634.1748m	550,845.6519m	N68° 22' 30.68"W
9550	2,768,642.5081m	550,822.0851m	N71° 24' 34.14"W
9575	2,768,650.4781m	550,798.3895m	N71° 24' 34.14"W
9600	2,768,658.4482m	550,774.6940m	N71° 24' 34.14"W
9625	2,768,666.4183m	550,750.9985m	N71° 24' 34.14"W
9650	2,768,674.3883m	550,727.3029m	N71° 24' 34.14"W
9675	2,768,682.3584m	550,703.6074m	N71° 24' 34.14"W
9700	2,768,690.7947m	550,680.0811m	N66° 53' 08.21"W
9725	2,768,703.7348m	550,658.8110m	N49° 22' 12.30"W
9750	2,768,722.8473m	550,642.8753m	N30° 16' 17.36"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
9775	2,768,746.1219m	550,634.0703m	N11° 10' 22.43"W
9800	2,768,770.9963m	550,633.3652m	N7° 55' 32.51"E
9825	2,768,794.7323m	550,640.8378m	N27° 01' 27.44"E
9850	2,768,814.7301m	550,655.6518m	N45° 36' 34.70"E
9875	2,768,830.6257m	550,674.9252m	N52° 43' 54.29"E
9900	2,768,845.7644m	550,694.8204m	N52° 43' 54.29"E
9925	2,768,860.9031m	550,714.7157m	N52° 43' 54.29"E
9950	2,768,876.0418m	550,734.6109m	N52° 43' 54.29"E
9975	2,768,891.1805m	550,754.5061m	N52° 43' 54.29"E
10000	2,768,906.3191m	550,774.4013m	N52° 43' 54.29"E