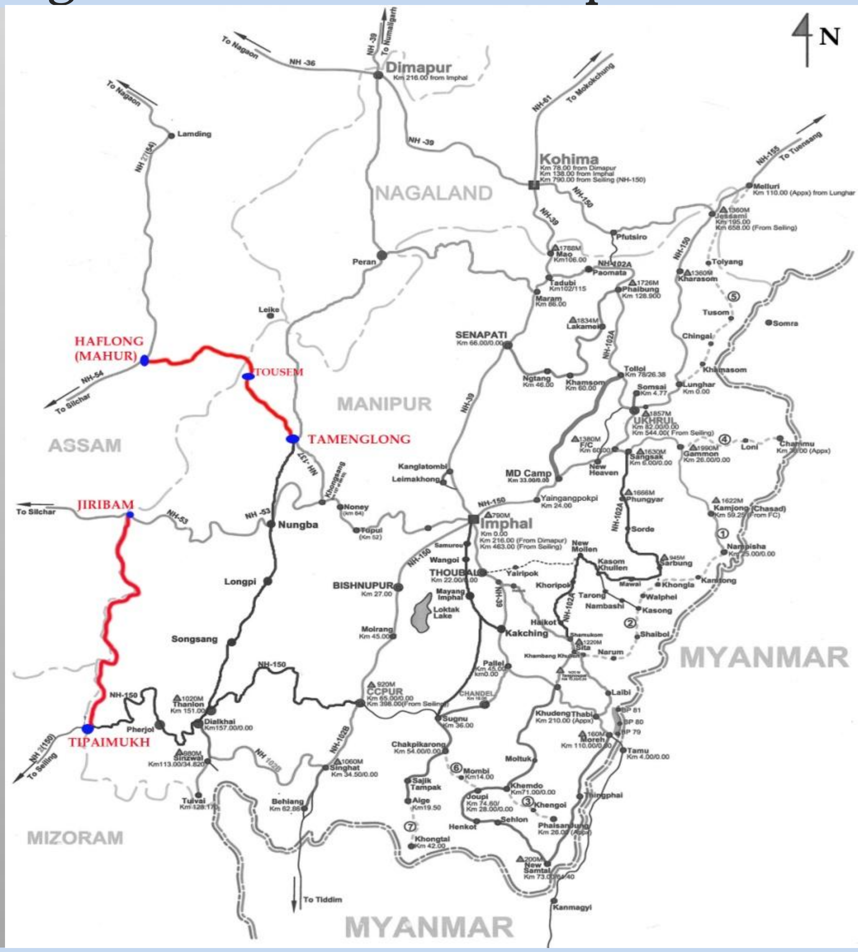
NATIONAL HIGHWAY INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

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-5

AZURAM- MAKRU RIVER SECTION

(FROM KM 54+180 TO KM 69+500) LENGTH-15.32 KM

M/s L.N Malviya Infra Projects PVT. LTD. Bhopal.
Head Office:- T-10, IIIrd Floor, City Centre, Press Complex Plot No.-1, M.P Nagar, Zone-1, Bhopal (M.P.)
Tel: +91-7771011298, +91-7771011300

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)	Plain Rolling Ruling 100 Mm: 80	Ruling : 60 Minimum : 40	Ruling : 60 Minimum : 40

1.1 Geometric Design

1.1.1 General

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

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

1.1.2 Design Speed

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

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

Table 6.2: Design Speed Standards

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

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

1.1.3 Levels of Service (LOS)

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

Table 6.3: Standards for Level of Service

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

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

1.1.4 Cross Sectional Elements

1.1.4.1 Roadway Width for Multilane Highways

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

Table 6.4: Road Cross Section

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

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

1.1.4.2 Lane Width

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

1.1.4.3 Shoulders

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

1.1.4.4 Pavement Camber (Cross-fall)

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

Table 6.5: Provision for Cross-fall

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

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

1.1.4.5 Embankment Slopes

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

1.1.5 Typical Cross-sections

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

1.1.6 Horizontal Alignment

1.1.6.1 General

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

1.1.6.2 Sight Distances

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

Table 6.6: Sight Stopping Distance Criteria

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

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

1.1.6.3 Horizontal Curve

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

Table 6.7: Horizontal Radii Criteria

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

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

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

Table 6.8: Adopted Horizontal Radii

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

1.1.6.4 Transition (Spiral) Curves

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

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

1.1.6.5 Super-elevation

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

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

1.1.7 Vertical Alignment

1.1.7.1 General

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

1.1.7.2 Gradients

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

Table 6.9 : Vertical Gradient

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

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

1.1.7.3 Vertical Curves

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

L = K x A,

Where L = Length of vertical curve in metres;

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

Summit or Crest Curves

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

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

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

Valley or Sag Curves

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

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

1.2 Bridges and Cross Drainage Structures

1.2.1 General

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

1.2.1.1 Bridges and Culvert

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

1.3 Hydrological and Hydraulic Investigations

Hydrological Data

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

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

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

1.4 Hydrological Design Methodology

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

The following assumptions have been made during peak discharge calculation:

For locations where water spreads over the banks, the cross-sections were extended up to the HFL, in order to calculate the effective cross-section of flow.
The longitudinal section to determine the bed slope have been taken at an approximate regular interval of 100 m following the channel course extending on both the upstream and the downstream sides of the structure. Caution is taken by following the curved flow line for longitudinal gradient, rather than a straight line.

1.4.1.1 Assessment of Peak Discharge

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

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

Dickens Method

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

Q = CM (0.75)

Where,

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

M Is the catchment area in sq.km and

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

14-19, in Madhya Pradesh; and

32, in Western Ghats.

Area – Velocity Method (Manning's Formula)

Q = A x V

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

Where, Q = the discharge in cumecs ;

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

V = Velocity in m/sec;

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

P = Wetted perimeter of the stream in m.;

S = Bed slope of the stream; and

n = Rugosity Co-efficient.

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

1.4.1.2 Hydraulic Analysis for Design HFL

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

1.4.1.3 Afflux Calculation

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

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

Where, h = Afflux in meters;

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

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

and

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

1.4.1.4 Scour Depth Calculation

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

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

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

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

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

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

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

1.4.1.5 Maximum Depth of Scour for Design of Foundation

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

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

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

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

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

1.4.1.6 Additional Balancing Culvert on Main Carriage Way

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

1.4.1.7 Pipe Culvert

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

1.4.1.8 Various Codes and Publication to be adopted

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

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

1.4.1.9 Design Live Load

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

1.4.1.10 Vertical Load

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

1.4.1.11 Longitudinal Forces

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

1.4.1.12 Seismic Zone

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

1.4.1.13 Condition of Exposure

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

1.4.1.14 Grade of Concrete

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

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

1.5 Miscellaneous

1.5.1 Road Signs

Road signs are proposed to be placed according to IRC: 67:2012. The signs are to be placed on embankment such that extreme edge of sign would be 2.0m away from the edge of the carriageway. The location of each sign is to be decided in accordance with the guidelines therein.

The sheeting shall be provided of Super High Intensity Micro Prismatic sheets Type IX as per ASTM D 4956 for all types of road sign boards as well as Over Head Signs.

1.5.2 Road Markings

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

1.5.3 Traffic Barriers

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

1.5.4 River Training work

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

2.0 PAVEMENT DESIGN

2.1 General

2.1.1 Objectives

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

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

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

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

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

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

2.1.2 Scope

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

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

2.2 Analysis Of Data For Pavement Design

2.2.1 General

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

2.2.2 Pavement Condition Study Data

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

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

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

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

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

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

2.2.3 Classified Traffic Volume Data

2.2.3.1 Vehicle Classes Considered for Pavement Design

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

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

2.2.3.2 Traffic Growth Rate

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

2.2.5 Design C.S.A. Values

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

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

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

2.3.2 Calculation of VDF

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

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

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

2.3.3 Computation of design traffic

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

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

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

…………………………………………..Eqn. 5.1

Where

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

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

r = Annual growth rate of commercial vehicles, %

x = Design life in years

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

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

1.6 PAVEMENT DESIGN OF PROJECT ROAD

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

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

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

1.7 Average Annual Daily Traffic and it Composition

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

Table 1.4: Annual Average Daily Traffic (AADT)

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

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

Traffic growth rate during the design life in percentage

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

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

Vehicle Damage Factor

Summary of VDF

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

Cumulative Mean Standard Axles (CMSA)

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

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

Adopted MSA is 20 as per IRC SP 73:2018

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

1.4. PAVEMENT DESIGN

As per plate No.-4 of IRC-37:2018 the Pavement Design is:-

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

Table 1.5

Homogenous Section (Km)			CBR (%)	MSA	Adopted Pavement Composition (mm)			
From	To	Length (in Km)		Adopted	BC	DBM	WWM	GSB
54+180	69+500	15.320	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%.

HYDROLOGY & 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.

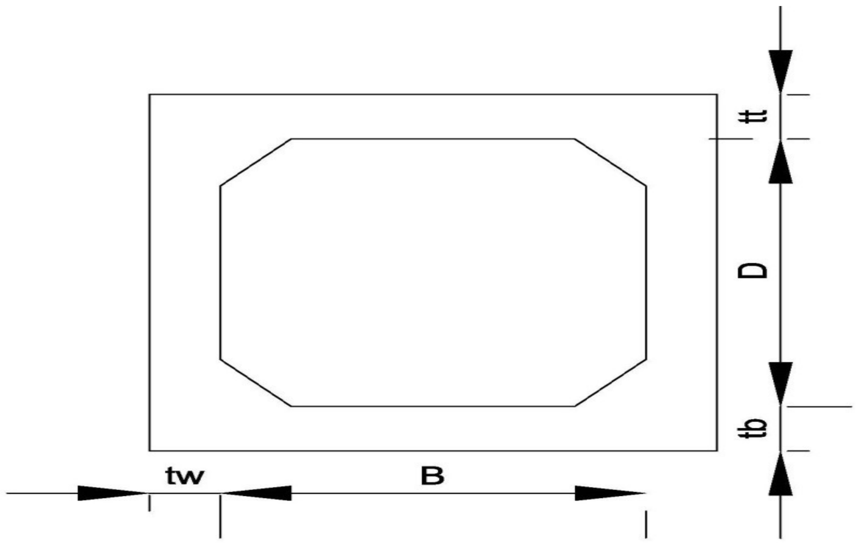
1.5 Load combinations

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.

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

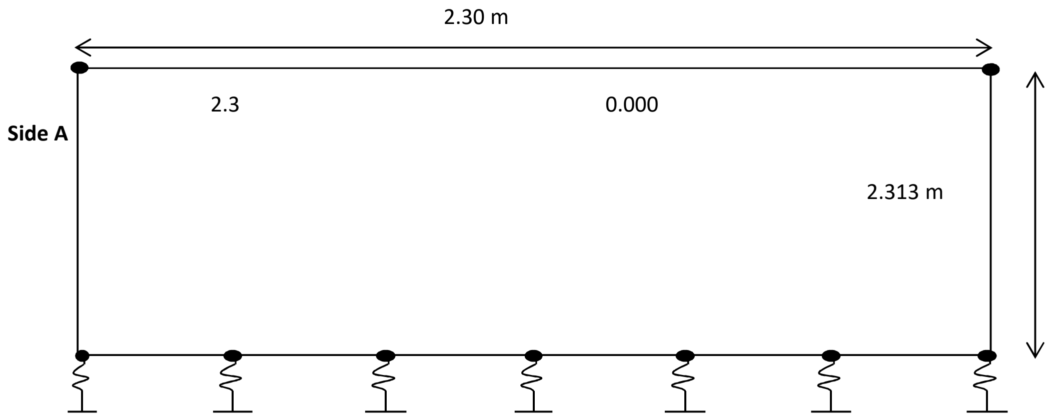
Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpres:	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge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

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

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

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



Nos. of beam for one span at bottom	=	10	
Spacing between Springs	=	0.230	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

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

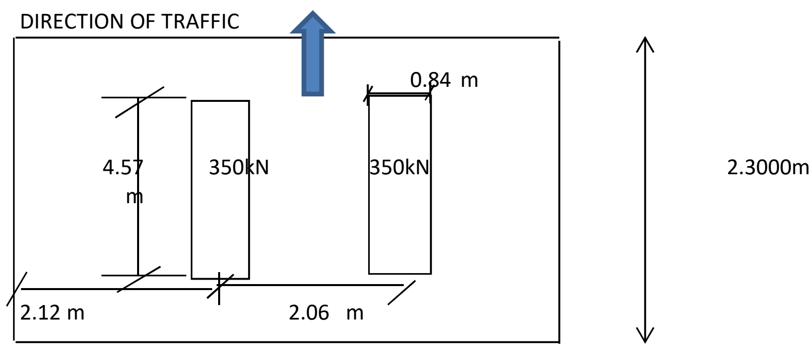
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 13.75 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



Total Load = **700kN** 4.57 2.3000m

153.17 KN/m

352.3 KN

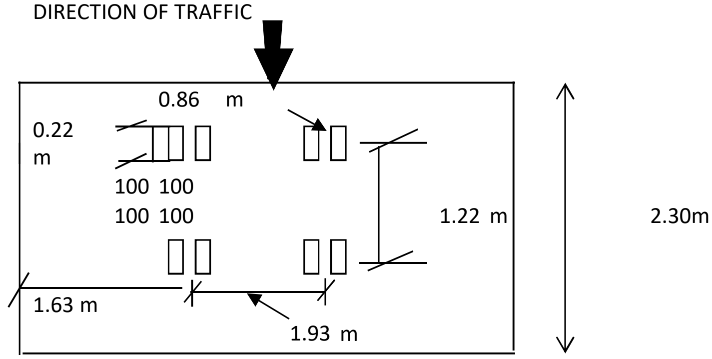
<u>Effective width of Loading</u>

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

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

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

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

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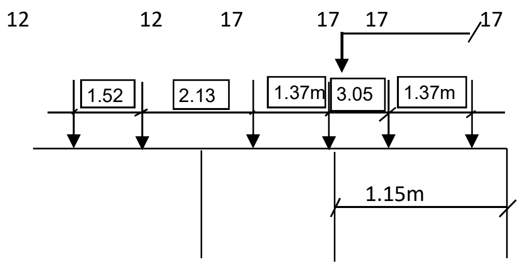
Increase due to impact = 42.08 kN/m^2

Say **42.10** kN/m^2

F) 70R Wheel Case 1

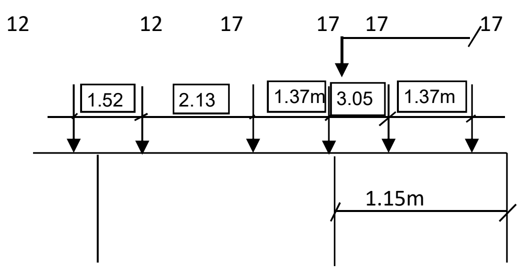


0.86m 1.93m 0.86m

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

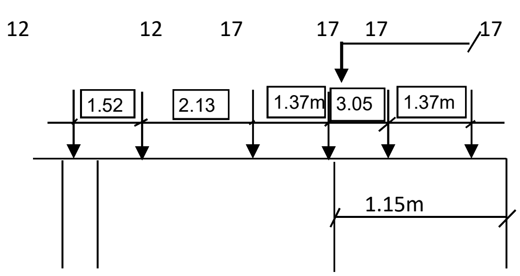
F) 70R Wheel Case 2



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

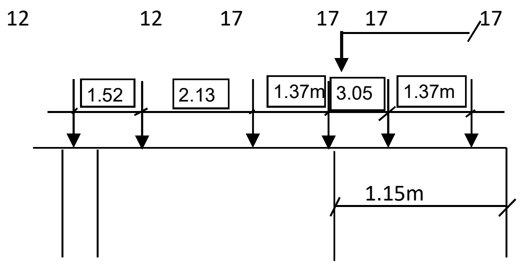


Width along span = 0.970m

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

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	/°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

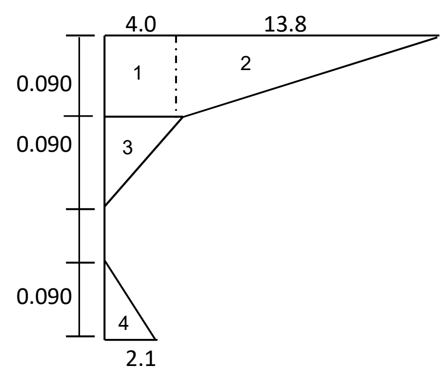
a = Coefficient of Thermal expansion = 1.20E-05 /°C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 300 mm

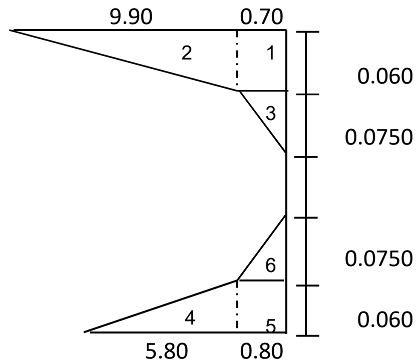
EFFECT OF TEMPERATURE RISE



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	0.030m 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

3.3 Summary of factored moments

Grade of Concrete = M30

Grade of Steel = Fe500

Summary of factored moments

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

4.0 Partial Safety Factors

Material Parameters

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

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

Partial Safety Factor for Materials

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

Partial Safety Factor for Loads

Ultimate Limit State

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

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
(1)	(2)	(3)	(4)	(5)	(4)	(3)
	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect
Permanent Loads: Dead Load, SIDL except surfacing, Backfill Weight, Settlement, Creep and shrinkage effect	1.05	0.95	1.00	1.00	1.05	0.95
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

	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 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

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

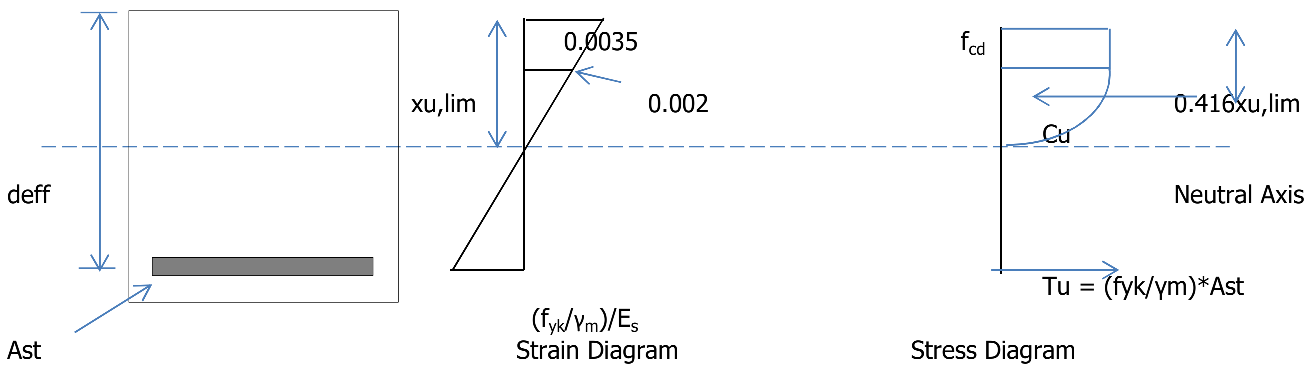
Combination for Base Pressure and Design of Foundation

Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

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

5.1.1 Verification of structural strength for top slab



ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

f_{cd}	=	13.40	N/mm^2	For Basic Combination
f_{cd}	=	16.75	N/mm^2	For Accidental Combination
f_{cd}	=	13.40	N/mm^2	For Seismic Combination
E_c	=	31000	MPa	

Grade of steel

f_Y	=	500	N/mm^2	
f_{Yd}	=	435	N/mm^2	For Basic Combination
f_{Yd}	=	500	N/mm^2	For Accidental Combination
f_{Yd}	=	435	N/mm^2	For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

E_c = 31000 MPa

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

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 300 mm

Clear cover = 50

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

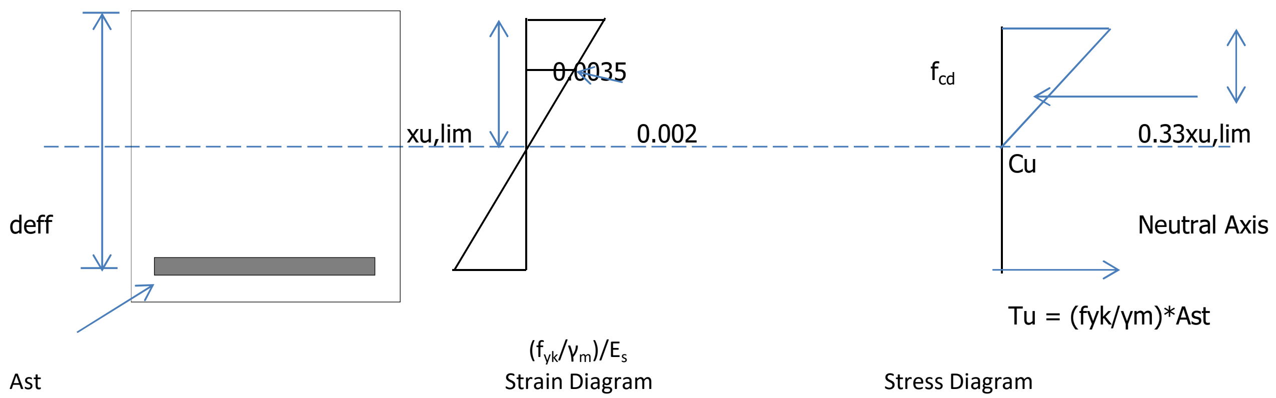
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	57.0			48.3		
b	1000			1000		
D	300			300		
c	50			50		
d	232.0			233.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$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

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

Shear on the section	**Top slab Top End support**		
Actual shear V_{Ed} (KN)	30.0		
Actual shear stress (N/mm2)	0.144		
Max shear capacity, 0.135 fck(1-fck/310)	3.7		
	OK.		
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		
$\Theta = 0.5 \times \sin^{-1}$ (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	1.928		
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

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

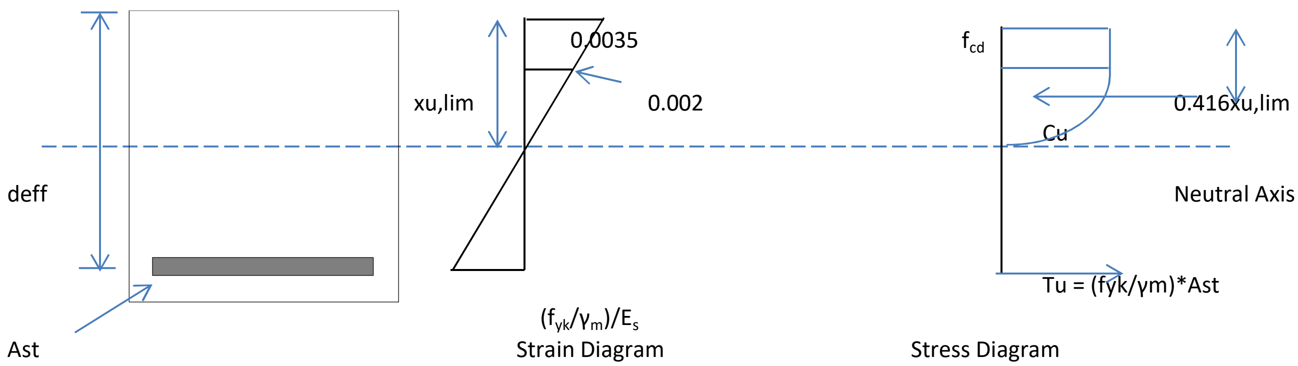
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	243.0		243.0
f_{cd}	14.40		10.80	14.40		10.80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

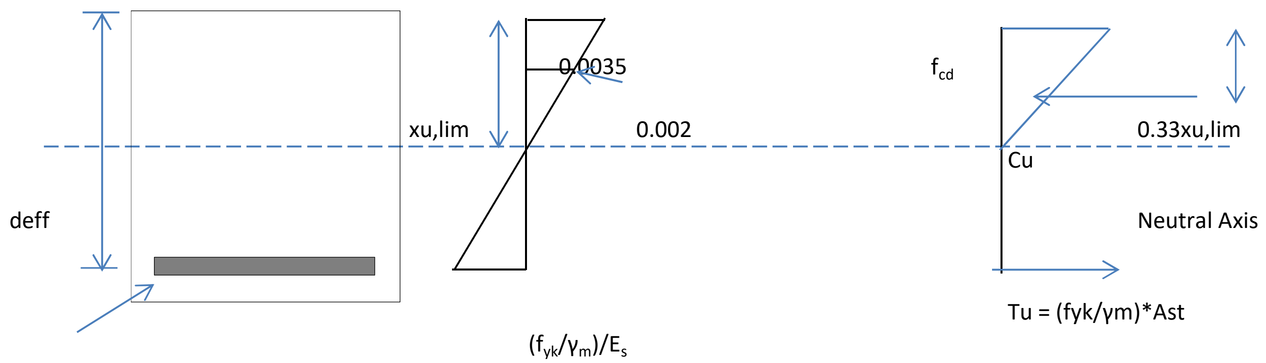
Moment on the section	Bottom End support			Top Mid Span		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	86.0		80.0	65.0		58.0
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435		435	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
Θ = 0.5 x $\sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.928		1.928
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$n_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.455		0.455
cl. 10.3.1 of IRC :112-2011			
r1 = $A_{sl}/(b_w\ d)$ <= 0.02	0.007		0.007
	OK		**OK**
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.586		0.6
Axial compressive force N_{Ed} (KN)	0		0
$s_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		0.0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (KN)	105		105
	Provide Shear Reinf.		**Provide Shear Reinf.**

	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

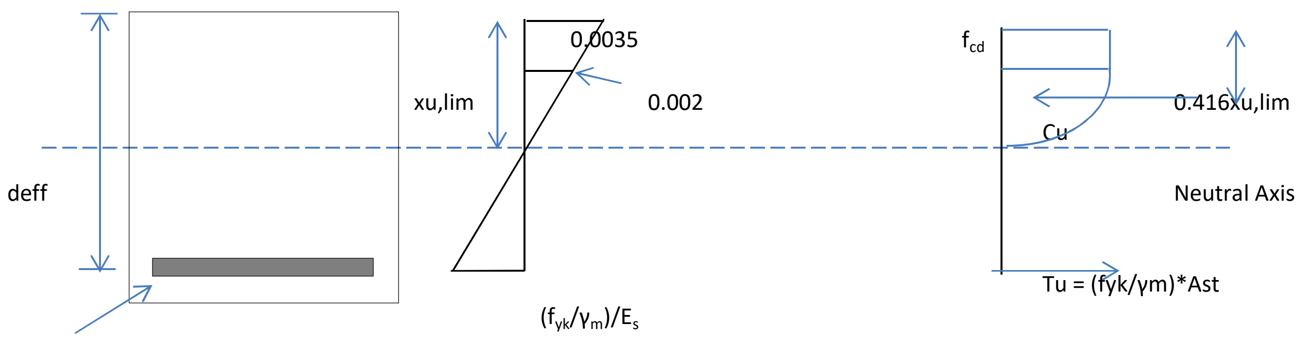
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	65.0		15.0	43		6
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}	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**

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

5.3.1 Verification of structural strength for outer wall



Ast   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*(3/7$xu_{,lim}$ + 2/3*4/7$xu_{,lim}$)

= 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

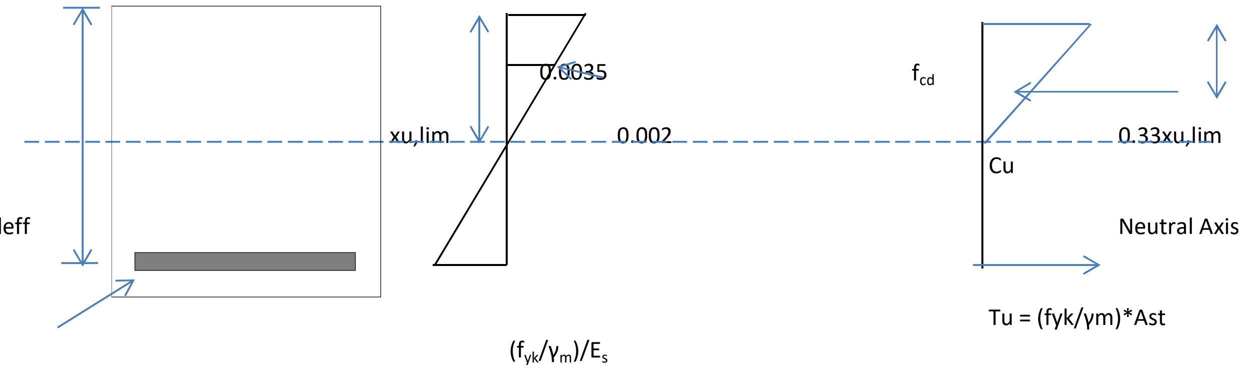
Clear cover = 75

	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



Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

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

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 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		

Outer Wall

At outer face of top end

Area of Steel Provided = 1615.7 mm^2/m

12mm dia	@	140mmc/c	Outer wall (Outer main reinforcement)	
12mm dia	@	140mmc/c	Top slab (Top main reinforcement)	OK
0mm dia	@	140mmc/c	Top corner extra reinforcement	

At inner face of top end

Area of Steel Required = 313.8 mm^2/m

Area of Steel Provided = 561.0 mm^2/m

10mm dia	@	140mmc/c	Outer wall (Inner main reinforcement)	OK

At outer face of bottom end

Area of Steel Provided = 1615.7 mm^2/m

12mm dia	@	140mmc/c	Bottom slab (Bottom main reinforcement)	
12mm dia	@	140mmc/c	Outer wall (Outer main reinforcement)	OK
0mm dia	@	140mmc/c	Bottom corner extra reinforcement	

At inner face of bottom end

Area of Steel Provided = 561.0 mm^2/m

10mm dia	@	140mmc/c	Outer wall (Inner main reinforcement)

Shear Reinforcement

Bottom Slab

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

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

Top Slab

Req. Reinforcement = 174 mm^2/m

Provided Reinforcement =

12mm dia @ 225mmc/c 502.7 mm^2/m OK

Bottom Slab

Req. Reinforcement = 200.3 mm^2/m

Provided Reinforcement =

12mm dia @ 225mmc/c 502.7 mm^2/m OK

Outer Wall

Req. Reinforcement = 192.7 mm^2/m

Provided Reinforcement =

12mm dia @ 225mmc/c 502.7 mm^2/m OK

7.0 Base Pressure

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

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

Bearing capacity = 100 KN/sqm

Design note

for

RCC BOX OF SIZE 1 x 3 x 3

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

Index

1.0 Design Report

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

1.1 Introduction:-

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

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

1.2 Reference documents :-

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

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

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

1.4 Loads:-

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

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

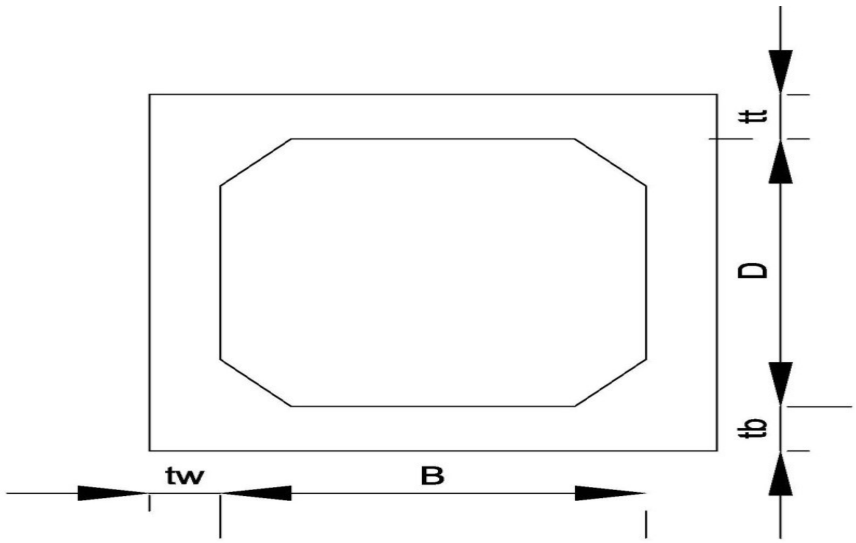
1.5 Load combinations

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

1.6 Material properties

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

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



2.1 Dimensions of Box

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

SIDL (Top Slab)

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

2.2 Basic Parameters

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

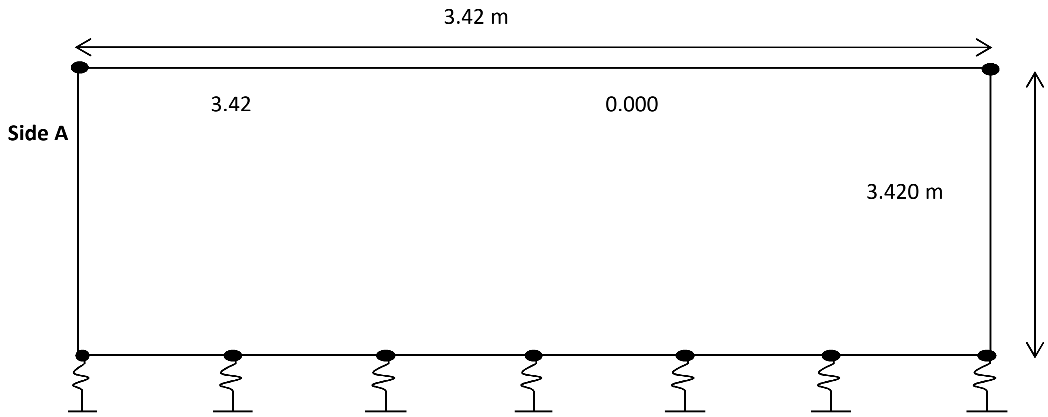
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

Safe Bearing Pressure = 100 kN/m^2

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

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



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

3.1 Earth Pressure and Live Load Calculation

1) a Earth Pressure (Normal Condition)

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

1) b Fluid Pressure

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

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

Earth Pressure	Height
2.69	0.21
46.43	3.630 m

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

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

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

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

Live Load Surcharge = 5.651 kN/m

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

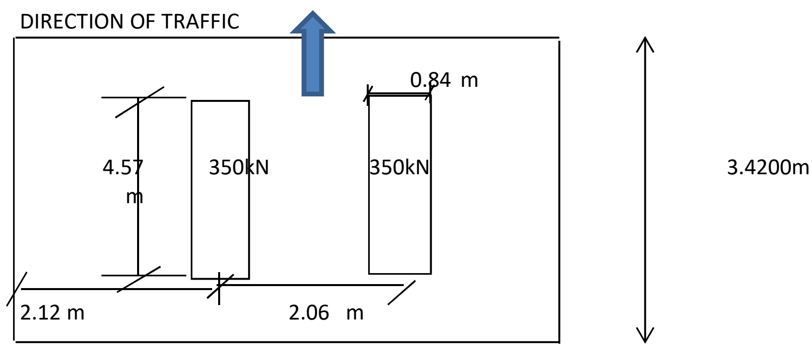
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 24.95 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



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

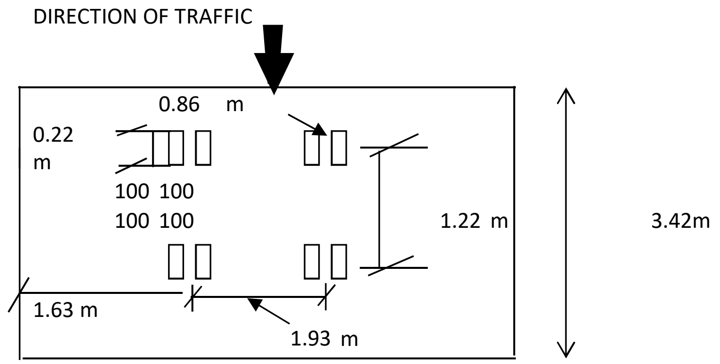
Effective width of Loading

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	=	3.42 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

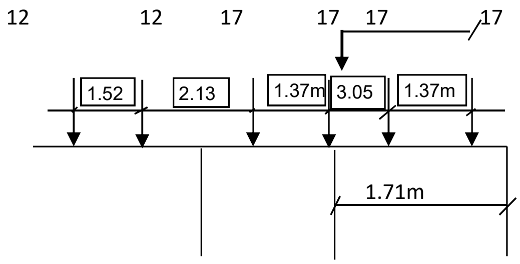
2.06<3.21 ***Therefore overlapping due to load dispersion occurs***

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

Increase due to impact = 36.34 kN/m^2

Say **36.40** kN/m^2

F) 70R Wheel Case 1

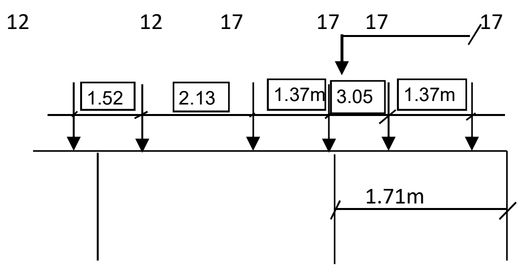


0.86m 1.93m 0.86m

Width along span = 1.210m

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

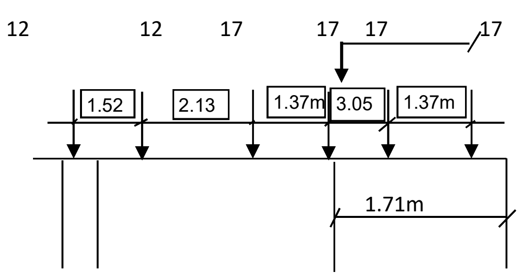
F) 70R Wheel Case 2



Width along span = 1.210m

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

G) 70R Wheel Case 3



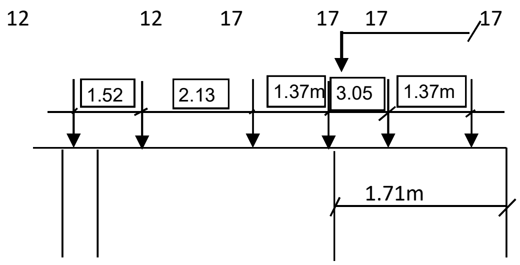
Width along span = 1.210m

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

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

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

H) 70R Wheel Case 4



Width along span = 1.210m

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

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

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

3.2 Temperature load calculation

Effective Bridge Temperature

Maximum Air Shade temperature	=	47.9	/oC (as per Annexure F of IRC:6-2014)
Minimum Air Shade temperature	=	0.2	/°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.

$F = E_c\, aDt\, A$

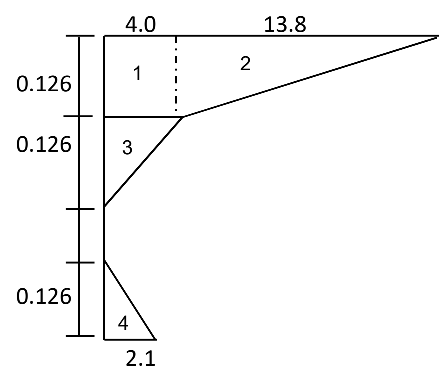
E_c = Modulus of Elasticity of Concrete	=	3.21E+06	t/m^2
a = Coefficient of Thermal expansion	=	1.20E-05	/°C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 420 mm

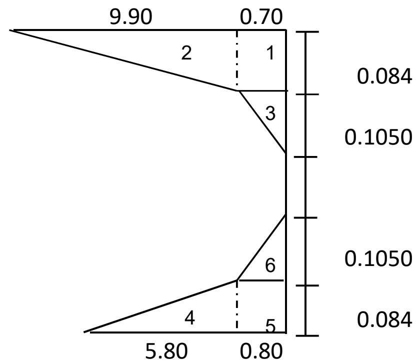
EFFECT OF TEMPERATURE RISE



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	Momen t in Mid-Span	Mome nt at End Suppor	Top slab shear at	Mome nt in Mid-Span	Mome nt at End Suppor	Botto m slab shear	Min. Axial force	Momen t at top	Mome nt at botto m	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

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

Partial Safety Factor for Loads

Ultimate Limit State

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

Also refer IRC Amendment dated 28th July, 2012

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

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

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

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

Serviceability Limit State

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

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

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

Combination for Base Pressure and Design of Foundation

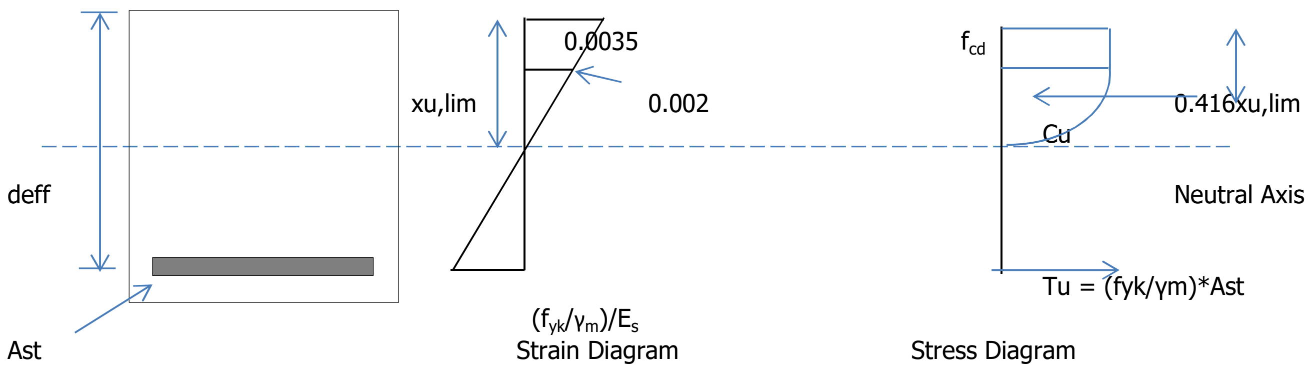
Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

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

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

5.1.1 Verification of structural strength for top slab



ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

E_c = 31000 MPa

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

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

Clear cover = 50

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

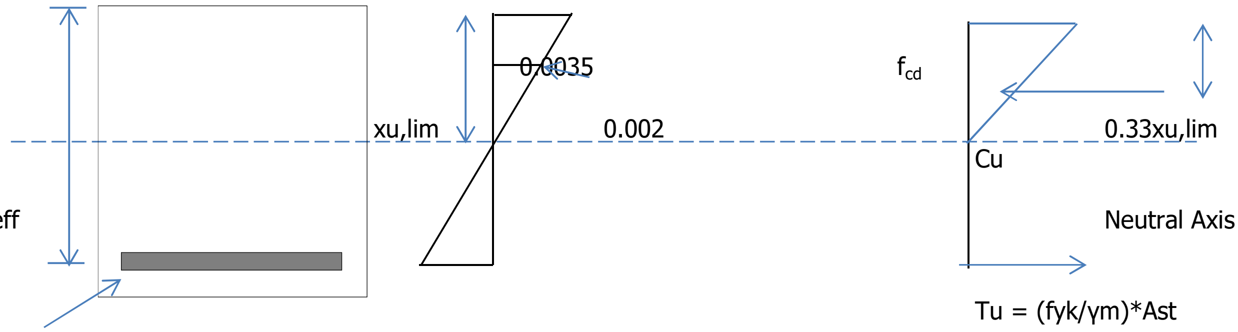
Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Basic Comb			Basic Comb		
Actual moment (KNm)	80.0			70.0		
b	1000			1000		
D	420			420		
c	50			50		
d	352.0			353.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97		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

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

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

	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

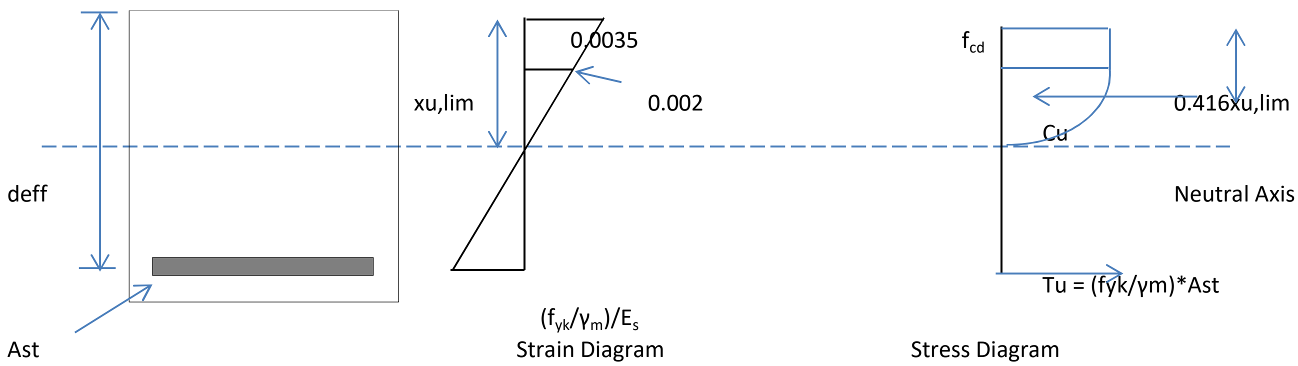
Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	68.0		26.0	53		14
b	1000		1000	1000		1000
D	420		420	420		420
c	40		40	40		40
d	362.0		362.0	363.0		363.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	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	

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

5.2.1 Verification of structural strength for bottom slab



<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 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*(3/7$xu_{,lim}$ + 2/3*4/7$xu_{,lim}$)

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

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

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

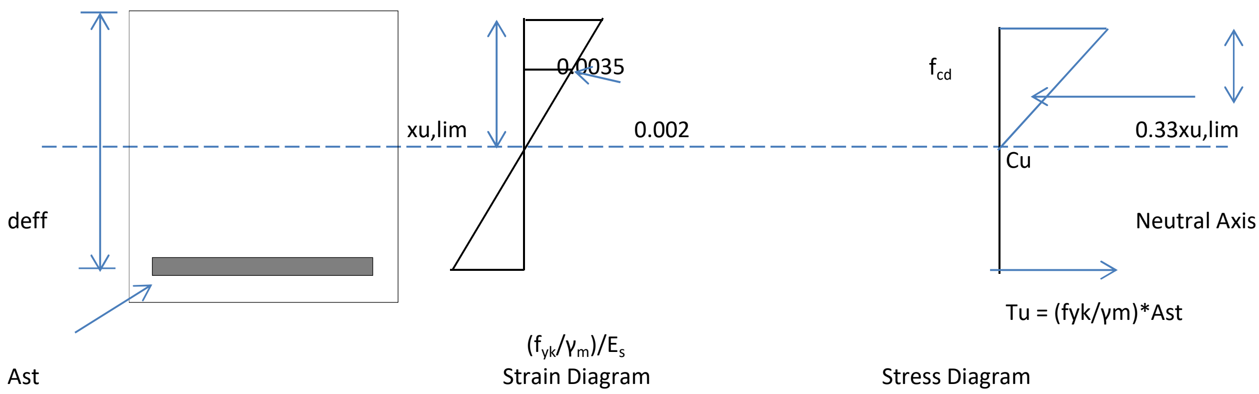
Moment on the section	Bottom End support			Top Mid Span		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	130.0		107.0	111.0		93.0
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435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

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

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

	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 Refer Chaper 5 of Reinfroced Concrete

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

Tu = fyd*Ast

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 420 mm

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

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

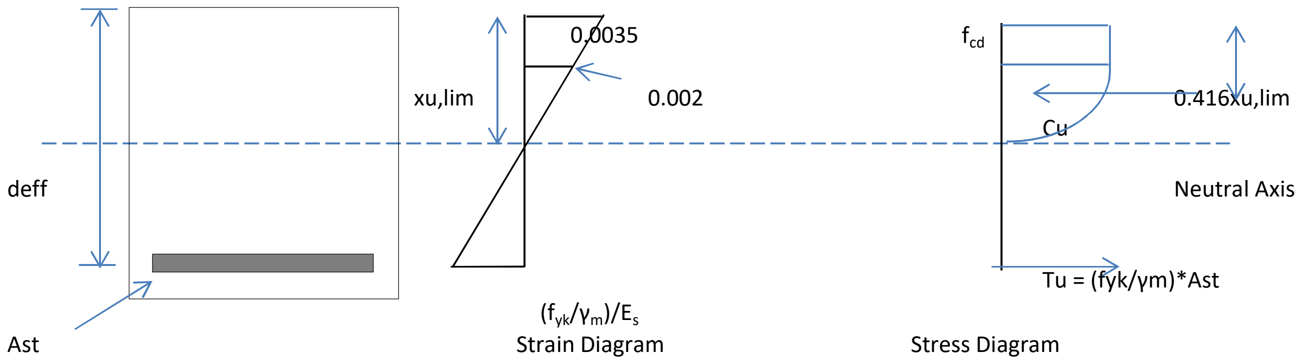
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	91.0		28.0	77		24
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}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

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

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

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

5.3.1 Verification of structural strength for outer wall



Strain Diagram

Stress Diagram

<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 $\quad$ E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

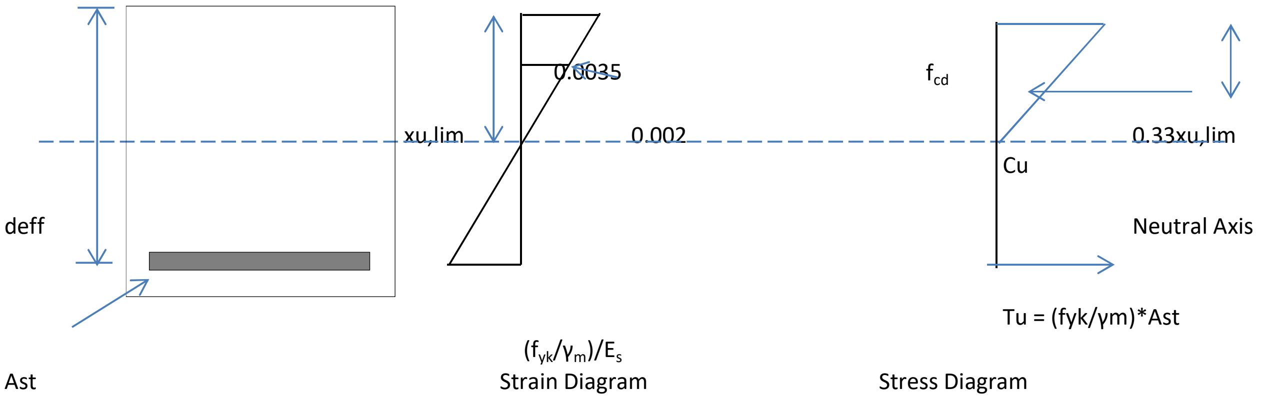
Clear cover = 75

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

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

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

5.3.2 Verification for serviceability limit state for outer wall



SERVICEABILITY LIMIT STATE

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

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 = 420 mm

Clear cover = 75

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

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

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

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

6.0 Summary of provided Reinforcement

Provided Reinforcement

Top Slab

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

Bottom Slab

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

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

Outer Wall

At outer face of top end

Area of Steel Provided = 1508.0 mm^2/m

12mm dia @ 150mmc/c Outer wall (Outer main reinforcement)

12mm dia @ 150mmc/c Top slab (Top main reinforcement) OK

0mm dia @ 150mmc/c Top corner extra reinforcement

At inner face of top end

Area of Steel Required = 488.9 mm^2/m

Area of Steel Provided = 523.6 mm^2/m

10mm dia @ 150mmc/c Outer wall (Inner main reinforcement) OK

At outer face of bottom end

Area of Steel Provided = 1508.0 mm^2/m

12mm dia @ 150mmc/c Bottom slab (Bottom main reinforcement)

12mm dia @ 150mmc/c Outer wall (Outer main reinforcement) OK

0mm dia @ 150mmc/c Bottom corner extra reinforcement

At inner face of bottom end

Area of Steel Provided = 523.6 mm^2/m

10mm dia @ 150mmc/c Outer wall (Inner main reinforcement)

Shear Reinforcement

Bottom Slab

12mm dia 225mmc/c (Long. Direc 0 185.295 kN

12mm dia 150mmc/c (Trans. Direction)

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

Top Slab

Req. Reinforcement = 264 mm^2/m

Provided Reinforcement =

12mm dia @ 225mmc/c 502.7 mm^2/m OK

Bottom Slab

Req. Reinforcement = 271.3 mm^2/m

Provided Reinforcement =

12mm dia @ 225mmc/c 502.7 mm^2/m OK

Outer Wall

Req. Reinforcement = 244.4 mm^2/m

Provided Reinforcement =

12mm dia @ 225mmc/c 502.7 mm^2/m OK

	Project	0		KB
	Client	0		0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3		0

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 2 x 2

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

Index

1.0 Design Report

The following report represents the design note of RCC BOX of clear span 2 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 50mm 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 : 2017 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

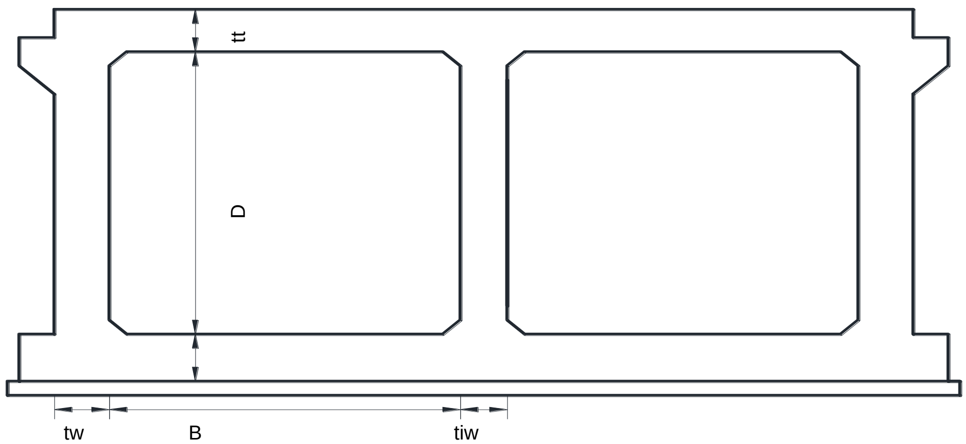
Load combinations as per IRC 6: 2017 have been considered in staad load combination.

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 2 x 2	Date & Rev.	-

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



2.1 Dimensions of Box

No. of Cell	=	2	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	=	4.600 m
Side Wall Thick. (tw)	=	0.300 m	C/C Height of structure	=	2.313 m
Int. wall Thickness (ti)	=	0.300 m	Total length of Structure at top =		4.900 m
Total Deck width	=	12.00 m	Total length of Structure at bottom =		4.900 m
Carrriageway Width	=	11.00 m	Total Height of Structure	=	2.63 m
water above bott. Slab	=	0.375 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

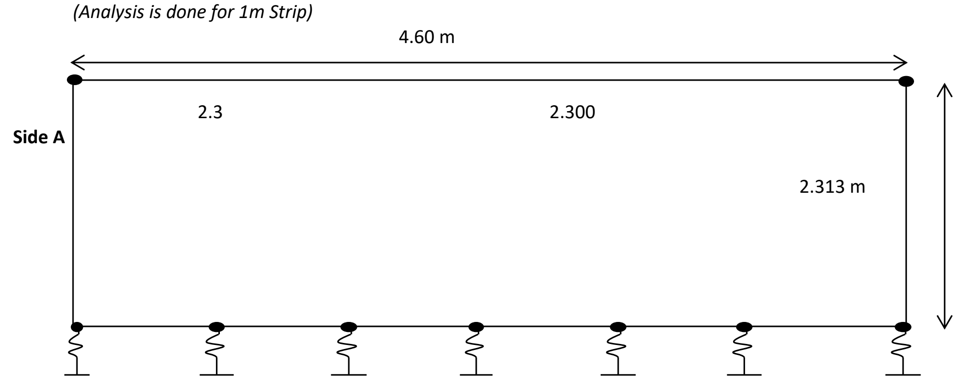
2.2 Basic Parameters

Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpressu	=	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

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

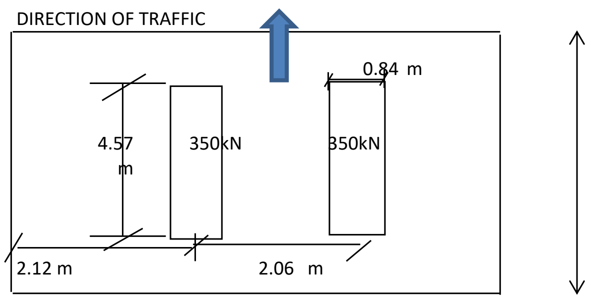
Live Load Surcharge = 12.000 kN/m

2) Load due to water on Bottom Slab

Uniform Load = 3.75 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		

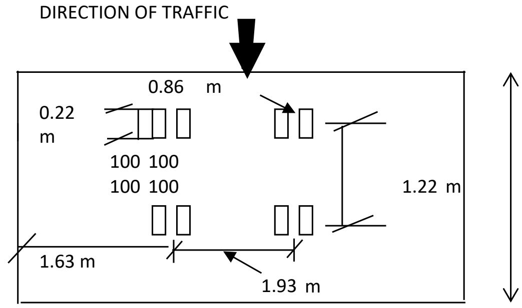
Effective width of Loading

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
Increase due to impact	=	42.08 kN/m^2
	Say	**42.10** kN/m^2

E) 70R Track at int side wall

Effective width of Loading

a	1.14 m
b1	0.99 m
b/lo	5.22
a	2.60
beff	2.48 m

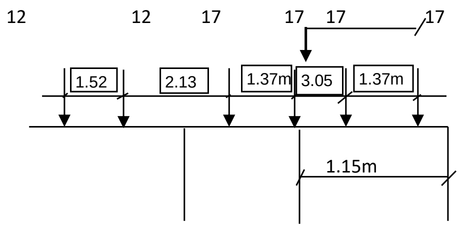
2.06<2.48 ***Therefore overlapping due to load dispersion occurs***

Effective width		4.54	m
Width along span		2.3	m
Load Intensity		33.74	kN/m^2
Increase due to impact		42.18	kN/m^2
	Say	**42.20**	kN/m^2

E) Live Load Case for Bottom Slab

Uniform Load = 42.10 kN/m^2

F) 70R Wheel Case 1 (at support)



9.44
10.66

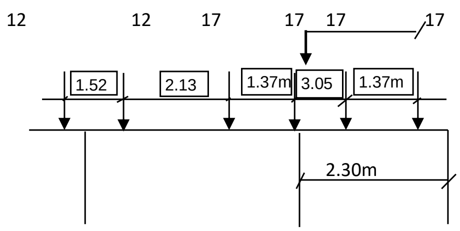
0.86m 1.93m 0.86m

5.79

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

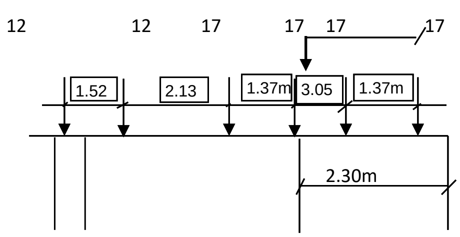
F) 70R Wheel Case 2 (at mid)



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

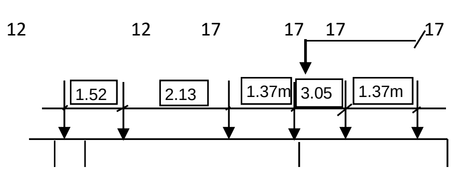
G) 70R Wheel Case 3 (outerwall)



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

H) 70R Wheel Case 4 (inner wall)



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Width along span = 0.970m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.685	2.60	2.26m	Yes	4.19m	41.0 kN/sqm	51 kN/sqm
2	166.77	0.245	2.60	1.58m	No	1.58m	54.4 kN/sqm	68 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

		20%	Av. Eff. Width	Load per meter
G) **Braking load**				
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**

A) **70R Track at Inner Wall**

a	=	1.14	m
b1	=	0.99	m
b/lo	=	5.22	
a	=	2.60	
beff	=	2.48	m
2.06<2.48 ***Therefore overlapping due to load dispersion occurs***			
Effective width	=	4.54	m
Width along span	=	2.3	m
Load Intensity	=	33.74	kN/m^2
Increase due to impact	=	42.18	kN/m^2
	Say	**42.20**	kN/m^2

4) COLLISION LOAD

Nominal Vehicle collision load as per cl. 222.3 table 9 of IRC 6 2010

Point of application above Carriageway level		Direction of load	Load	Av. Eff. Width	Load per meter
At crash barrier due to live load moving on bottom slab					
Main + Residual Load	1.0m	Normal to the carriageway	0 kN	1.00m	0 kN/m/m
Main + Residual Load	1.0m	Parallel to the carriageway	0 kN	1.00m	0 kN/m/m

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

3.2 Temperature load calculation

Effective Bridge Temperature

Maximum Air Shade temperature	=	47.9	/oC (as per Annexure F of IRC:6-2017)
Minimum Air Shade temperature	=	0.2	/^{o}C (as per Annexure F of IRC:6-2017)
Mean of max and min temperature	=	23.85	/^{o}C (as per clause 215.2 of IRC:6-2017)
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 = 3.20E+06 t/m^2

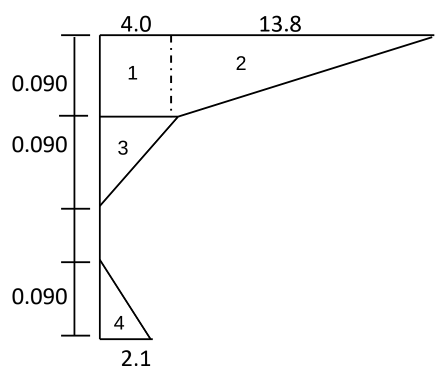
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

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	13.82	0.045 m from top	0.105
2	13.8 / 2	1.0	0.100	0.100	26.50	0.033 m from top	0.117
3	4.0 / 2	1.0	0.090	0.090	6.91	0.120 m from top	0.030
4	2.1 / 2	1.0	0.090	0.090	3.63	0.030m from bottom	-0.120
				SF =	50.86	M =	4.315

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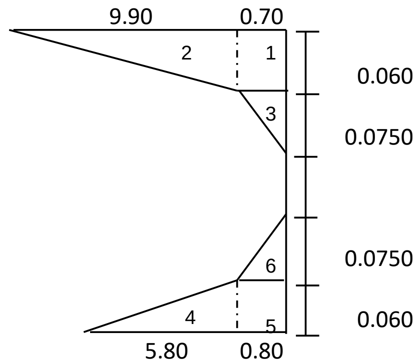
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

EFFECT OF TEMPERATURE FALL



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	0.70	1.0	0.060	0.060	1.61	0.03 m from top	0.120
2	9.90 / 2	1.0	0.060	0.060	11.40	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	6.68	0.020 m from bottom	-0.130
5	0.80	1.0	0.060	0.060	1.84	0.030 m from bottom	-0.120
6	0.80 / 2	1.0	0.0750	0.0750	1.15	0.085 m from bottom	-0.065
				SF =	23.70	M =	0.577

3.3 Summary of factored moments

Grade of Concrete = M25

Grade of Steel = Fe500

Summary of factored moments

	Top slab			Bottom slab			Outer wall				Inner 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	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
Basic Combination (35 - 72)	48.3	57	30	-	-	-	17	55	80	93	18	26	37	17
Rare Combination (73 -148)	33	42	26	43	65		14	39	62	70	16	20	31	18
Frequent Combinatio (149 - 225)	-	-	-	-	-	-	-	-	-	-		-	-	-
Quasi Static (226 - 229)	10	15		6	15			14	13			1	1	
Combination 1 (230 -301)	-	-	-	65	86	123	-	-	-	-		-	-	-
Combination 2 (302 - 373)	-	-	-	58	80	122	-	-	-	-		-	-	-
	-	-	-	58	80	122	-	-	-	-		-	-	-

4.0 Partial Safety Factors

Material Parameters

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

Grade		=	**M35**	
Cube strength of concrete at 28 days	f_{ck}	=	35	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}	=	2.8	MPa
For Basic Combination	f_{cd}	=	15.63	MPa
For Accidental Combination	f_{cd}	=	19.54	MPa
For Seismic Combination	f_{cd}	=	15.63	MPa
Modulus of Elasticity	E_c	=	32000	MPa
Mean value of axial tensile strength of concrete	f_{ctm}	=	2.8	MPa
Density		=	**2.50**	t/m^3
Grade		=	**Fe500**	
Characteristics yield strength	f_{yk}	=	500	MPa
Design yield strength	f_{yd}	=	f_{yk} / γ_m	
For Basic Combination	f_{yd}	=	434.78	MPa
For Accidental Combination	f_{yd}	=	500	MPa
For Seismic Combination	f_{yd}	=	434.78	MPa
Modulus of Elasticity	E_s	=	**2.0E+05**	MPa
Density		=	**7.85**	t/m^3

Partial Safety Factor for Materials

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

Partial Safety Factor for Loads

Ultimate Limit State

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

Also refer IRC Amendment dated 28th July, 2012

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

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

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

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

Combination for Base Pressure and Design of Foundation

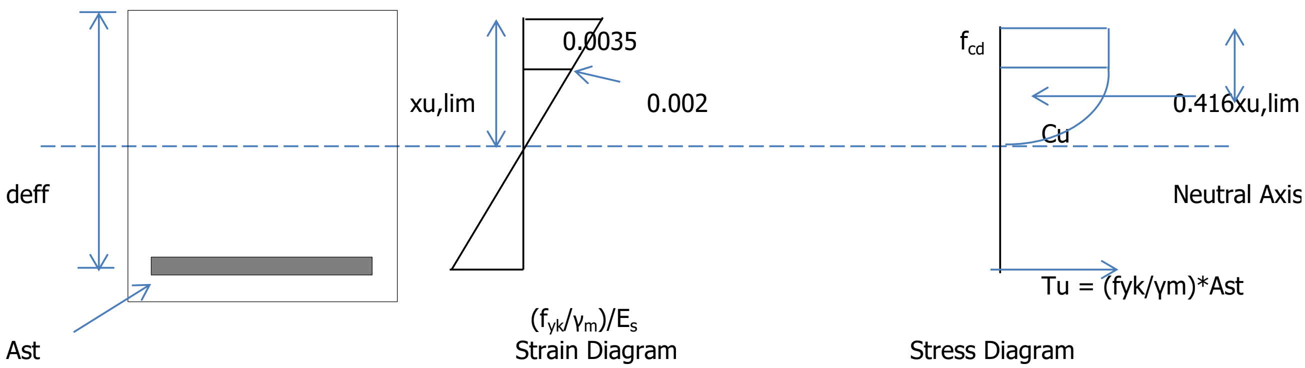
Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

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

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

5.1.1 Verification of structural strength for top slab



ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 35 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd} = 15.63 N/mm^2 For Basic Combination

f_{cd} = 19.54 N/mm^2 For Accidental Combination

f_{cd} = 15.63 N/mm^2 For Seismic Combination

E_c = 32000 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 = 32000 MPa

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashc 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
$R_{lim} = M_{u,Lim}/bd^2$	5.80	6.99	5.80

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

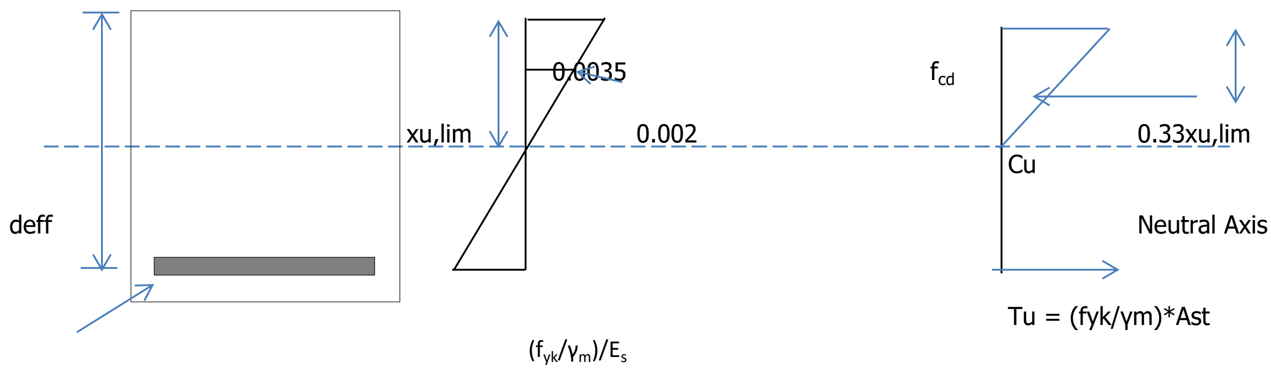
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	57.0			48.3		
b	1000			1000		
D	300			300		
c	50			50		
d	232.0			232.0		
f_{cd}	15.63			15.63		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	5.80			5.80		
$M_{u,Lim}$ (KNm)	312			312		
	OK			**OK**		
Ast Req.	586			494		
Dia of bar (main tension) (mm)	12			12		
Spacing (mm)	180			180		
+ dia of bar (main tension) (mm)	12			12		
Spacing (mm)	180			180		
Ast provided (sq mm)	1257			1257		
Dia of bar (main compresion) (mm)	12			12		
Spacing (mm)	180			180		
Area of main compresion (mm^2)	628			628		
f_{ctm}	2.8			2.8		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26 f_{ctm} b_t d / f_{yk} >= 0.0013 b_t d$	388			388		
A_{ct}	256827			256827		
$f_{ct,eff}$	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)	43			43		
x/d	0.186			0.186		
	OK			**OK**		
z (mm)	214			214		
MR (KNm)	117			117		
	OK			**OK**		

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

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)	4.2		
	OK.		
Min shear capacity, 0.0924 fck(1-fck/310)	2.9		
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			
$n_{min} = 0.031 K^{3/2} fck^{1/2}$	0.491		
cl. 10.3.1 of IRC :112-2011			
r1 = $A_{sl}/(b_w d)$ <= 0.02	0.005		
	OK		
$0.12 K (80 r1 f_{ck})^{0.33}$	0.568		
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)	114		
	OK.		
Min shear stress	0.491		
Min shear force for providing reinf., V_E (N)	102552.9		
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	1001		
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	-	Designed by	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

5.1.2 Verification for serviceability limit state for top slab



Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	35	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	16.80	N/mm^2	For Rare Combination
	f_{cd}	=	16.80	N/mm^2	For Frequent Combination
	f_{cd}	=	12.60	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 = 32000 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
$R_{sls} = M_{u,sls}/bd^2$	4.52	4.52	3.39

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 2 x 2	Date & Rev.	-

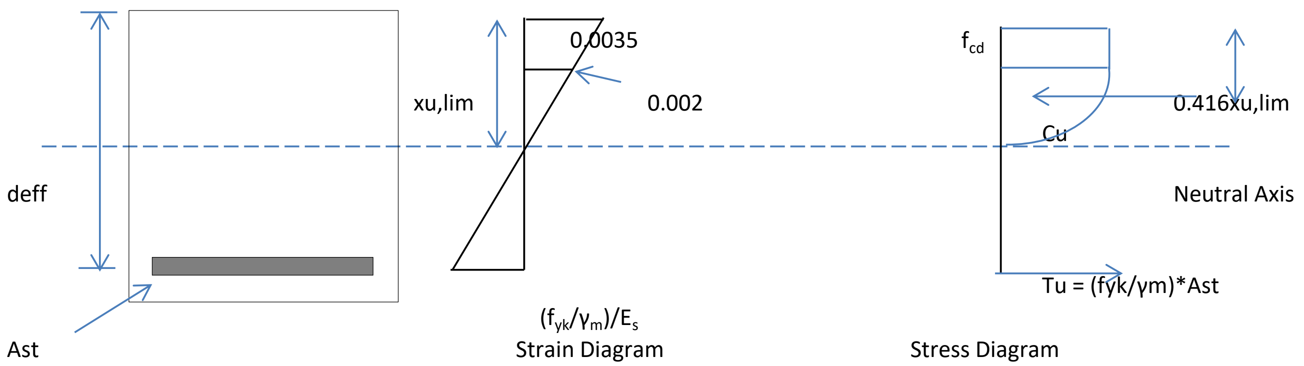
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	242.0		242.0
f_{cd}	16.80		12.60	16.80		12.60
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	4.52		3.39	4.52		3.39
$M_{u,sls}$ (KNm)	265		199	265		199
	OK		**OK**	**OK**		**OK**
Ast Req.	596		209	465		139
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
+ dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Ast provided (sq mm)	1257		1257	1257		1257
Dia of bar (main compresion) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Area of main compresion (mm^2)	628		628	628		628
f_{ctm}	2.8		2.8	2.8		2.8
x (mm)	44.9		59.8	44.9		59.8
x/d	0.185		0.247	0.185		0.247
	OK		**OK**	**OK**		**OK**
z (mm)	227		222	227		222
MR_{sls} (KNm)	86		84	86		84
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	147		54	116		36
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095 z b x_u)$	8.24		2.26	6.47		1.50
	OK		**OK**	**OK**		**OK**

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

Calculation of crack width	**Top slab Top End support**			**Top slab Bottom Mid Span**		
n_1			6			6
n_2			6			6
$f_{eq} = (n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1 + n_2 f_2)$			12			12
cl. 12.3.4 (3) of IRC :112-2011						
c			40			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$r_{p.eff} = A_s / A_{c,eff}$			0.011			0.011
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 f) / r_{p.eff} \}$			323			323
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}			32000			32000
$a_e = E_s / E_{cm}$			6.25			6.25
$(e_{sm}-e_{cm})=(s_{sc}-k_t f_{ct,eff}(1+a_e r_{p,eff})/r_{p,eff})/E_s >=0.6 s_{sc}/E_s$			0.0002			0.0001
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (e_{sm} - e_{cm})$			0.052			0.03
cl. 12.3.4 (1) of IRC :112-2011						
			OK	**OK**	**OK**	**OK**
Calculation of deflection						
Span (mm)					4600	
span/800					5.8	
cl. 12.4.1 (2) of IRC :112-2011						
Short term elastic deflection from STAAD					0.2	
					OK	

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

5.2.1 Verification of structural strength for bottom slab



ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 35 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd} = 15.63 N/mm^2 Combination (1)

f_{cd} = 19.54 N/mm^2 Accidental Combi.

f_{cd} = 15.63 N/mm^2 Combination (2)

E_c = 32000 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 = 32000 MPa

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

= 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
$R_{lim} = M_{u,Lim}/bd^2$	5.80	6.99	5.80

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

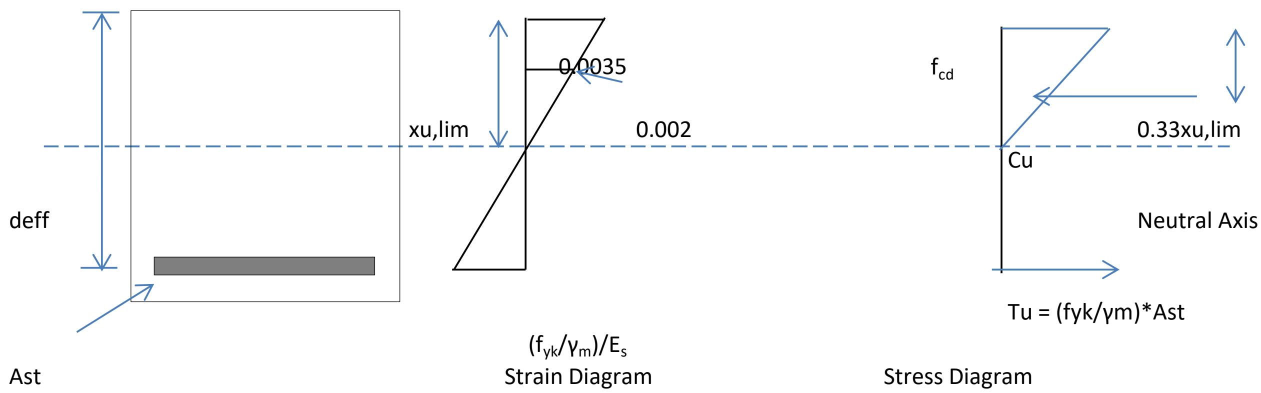
Moment on the section	**Bottom End support**			**Top Mid Span**		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	86.0		80.0	65.0		58.0
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	267.0		267.0
f_{cd}	15.63		15.63	15.63		15.63
f_{Yd}	435		435	435		435
$xu_{,lim}/d$	0.62		0.62	0.62		0.62
$R_{sls} = M_{u,sls}/bd^2$	5.80		5.80	5.80		5.80
$M_{u,Lim}$ (KNm)	312		312	414		414
	OK		**OK**	**OK**		**OK**
Ast Req.	903		836	578		514
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
+ dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Ast provided (sq mm)	1257		1257	1257		1257
Dia of bar (main compresion) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Area of main compresion (mm^2)	628		628	628		628
f_{ctm}	2.8		2.8	2.8		2.8
f_{yk}	435		435	435		435
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	388		388	447		447
A_{ct}	281827		281827	281827		281827
$f_{ct,eff}$	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)	43		43	43		43
x/d	0.186		0.186	0.162		0.162
	OK		**OK**	**OK**		**OK**
z (mm)	214		214	249		249
MR (KNm)	117		117	136		136
	OK		**OK**	**OK**		**OK**

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

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)	4.2		4.2
	OK.		**OK.**
Min shear capacity, 0.0924 fck(1-fck/310)	2.9		2.9
$\Theta = 0.5 \times \sin^{-1}$ (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			
$n_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.491		0.491
cl. 10.3.1 of IRC :112-2011			
$r1 = A_{sl}/(b_w\ d) <= 0.02$	0.005		0.005
	OK		**OK**
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.568		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)	114		114
	Provide Shear Reinf.		**Provide Shear Reinf.**

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

5.2.2 Verification for serviceability limit state for bottom slab



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	35	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	16.80	N/mm^2	For Rare Combination
	f_{cd}	=	16.80	N/mm^2	For Frequent Combination
	f_{cd}	=	12.60	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 = 32000 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
$R_{sls} = M_{u,sls}/bd^2$	4.52	4.52	3.39

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

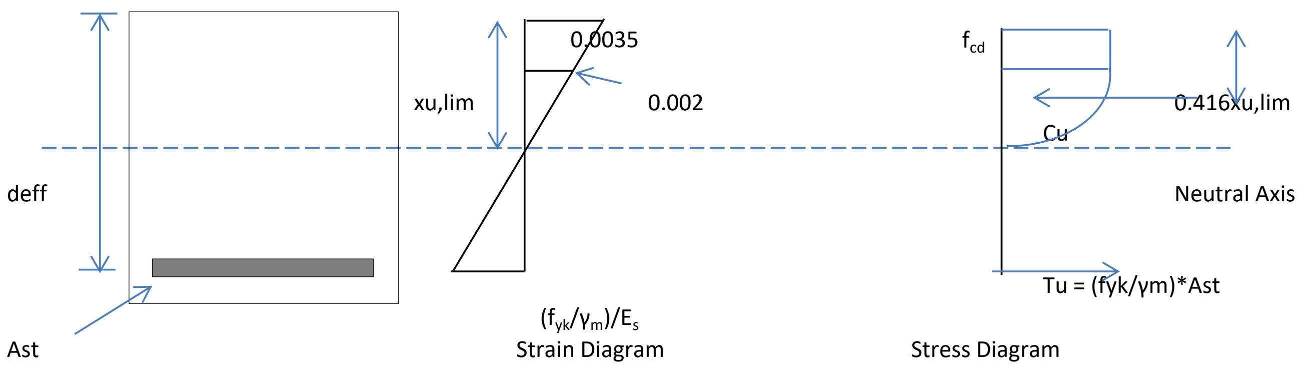
	Project	-	Designed by	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

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)	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	267.0		267.0
f_{cd}	16.80		12.60	16.80		12.60
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	4.52		3.39	4.52		3.39
$M_{u,sls}$ (KNm)	243		183	322		242
	OK		**OK**	**OK**		**OK**
Ast Req.	983		219	550		75
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
+ dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Ast provided (sq mm)	1257		1257	1257		1257
Dia of bar (main compresion) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Area of main compresion (mm^2)	628		628	628		628
f_{ctm}	2.8		2.8	2.8		2.8
x (mm)	44.9		59.8	44.9		59.8
x/d	0.193		0.258	0.168		0.224
	OK		**OK**	**OK**		**OK**
z (mm)	217		212	252		247
MR_{sls} (KNm)	82		80	95		93
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	238		56	136		19
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095\ z\ b\ x_u)$	13.34		2.36	7.60		0.81
	OK		**OK**	**OK**		**OK**

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

Calculation of crack width	**Bottom End support**			**Top Mid Span**		
n_1			6			6
n_2			6			6
$f_{eq} = (n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1 + n_2 f_2)$			12			12
cl. 12.3.4 (3) of IRC :112-2011						
c			75			40
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer						
$r_{p.eff} = A_s / A_{c,eff}$			0.008			0.011
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 f) / r_{p.eff} \}$			519			323
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}			32000			32000
$a_e = E_s / E_{cm}$			6.25			6.25
$(e_{sm}-e_{cm})=(s_{sc}-k_t f_{ct,eff}(1+a_e r_{p,eff})/r_{p,eff})/E_s$ $>=0.6 s_{sc}/E_s$			0.0002			0.0001
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (e_{sm} - e_{cm})$			0.09			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}	=	35	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	15.63	N/mm^2	For Basic Combination
	f_{cd}	=	19.54	N/mm^2	For Accidental Combination
	f_{cd}	=	15.63	N/mm^2	For Seismic Combination
	E_c	=	32000	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 = 32000 MPa

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

= 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
$R_{lim} = M_{u,Lim}/bd^2$	5.80	6.99	5.80

Here R_{lim} is in MPa

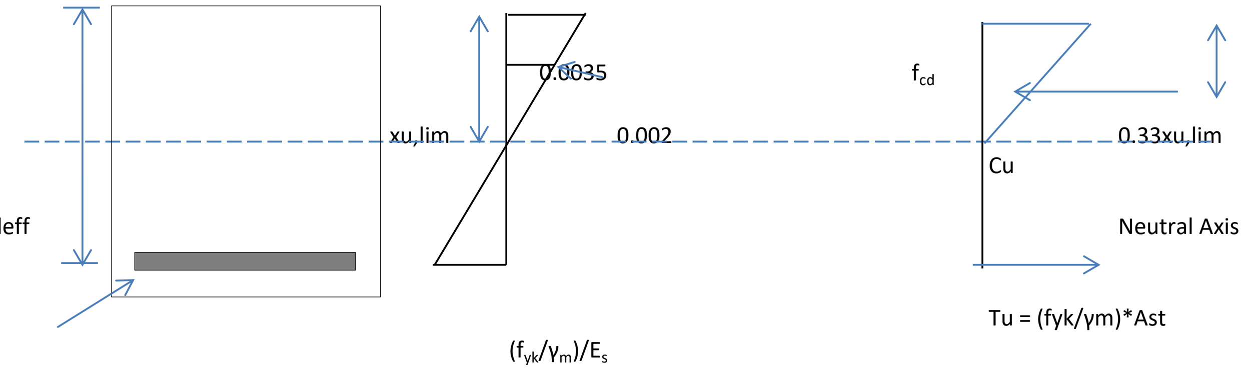
Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	300	mm
Clear cover	=	75	

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

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}	15.63			15.63		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	5.80			5.80		
$M_{u,Lim}$ (KNm)	249			249		
	OK			**OK**		
Ast Req.	951			639		
Dia of bar (main tension) (mm)	12			12		
Spacing (mm)	180			180		
+ dia of bar (main tension) (mm)	12			12		
Spacing (mm)	180			180		
Ast provided (sq mm)	1257			1257		
Dia of bar (main compresion) (mm)	12			12		
Spacing (mm)	180			180		
Area of main compresion (mm^2)	628			628		
f_{ctm}	2.8			2.8		
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			347		
A_{ct}	256827			256827		
$f_{ct,eff}$	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)	43			43		
x/d	0.209			0.209		
	OK			**OK**		
z (mm)	189			189		
MR (KNm)	103			103		
	OK			**OK**		

5.3.2 Verification for serviceability limit state for outer wall



Ast   Strain Diagram   Stress Diagram

SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	35	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	16.80	N/mm^2	For Rare Combination
	f_{cd}	=	16.80	N/mm^2	For Frequent Combination
	f_{cd}	=	12.60	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 = 32000 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
$R_{sls} = M_{u,sls}/bd^2$	4.52	4.52	3.39

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 75

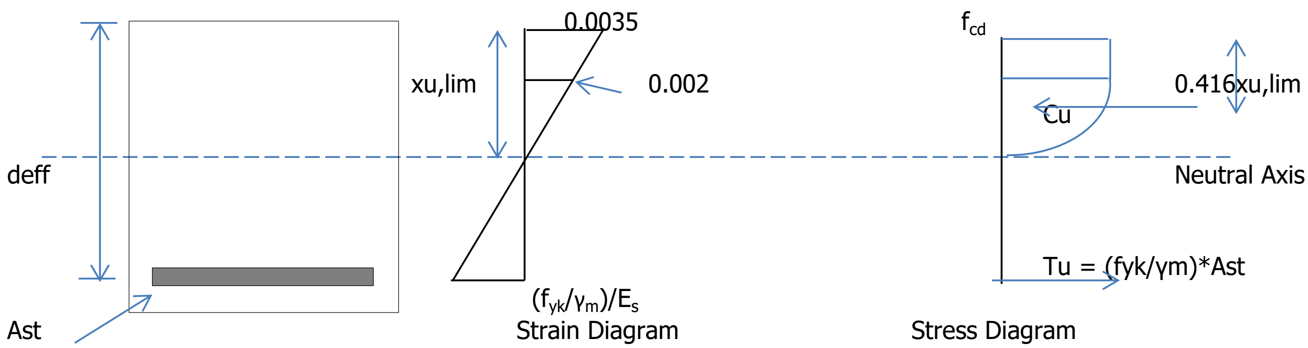
	Project	-	Designed by	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

Moment on the section	**Bottom End support**			**Top End support**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	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}	16.80		12.60	16.80		12.60
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	4.52		3.39	4.52		3.39
$M_{u,sls}$ (KNm)	194		145	194		145
	OK		**OK**	**OK**		**OK**
Ast Req.	1063		213	652		229
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
+ dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Ast provided (sq mm)	1257		1257	1257		1257
Dia of bar (main compresion) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Area of main compresion (mm^2)	628		628	628		628
f_{ctm}	2.8		2.8	2.8		2.8
x (mm)	44.9		59.8	44.9		59.8
x/d	0.217		0.289	0.217		0.289
	OK		**OK**	**OK**		**OK**
z (mm)	192		187	192		187
MR_{sls} (KNm)	72		71	72		71
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	257		55	161		59
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095\ z\ b\ x_u)$	14.38		2.32	9.04		2.50
	OK		**OK**	**OK**		**OK**

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

Calculation of crack width	**Bottom End support**			**Top End support**		
n_1			6			6
n_2			6			6
$f_{eq} = (n_1 f_1^2 + n_2 f_2^2) / (n_1 f_1 + n_2 f_2)$			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						
$r_{p.eff} = A_s / A_{c,eff}$			0.008			0.008
$S_{r,max} = \{ 3.4 c + (0.425 k_1 k_2 f) / r_{p.eff} \}$			499			499
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}			32000			32000
$a_e = E_s / E_{cm}$			6.25			6.25
$(e_{sm}-e_{cm})=(s_{sc}-k_t f_{ct,eff}(1+a_e r_{p,eff})/r_{p,eff})/E_s >=0.6 s_{sc}/E_s$			0.0002			0.0002
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max} (e_{sm} - e_{cm})$			0.08			0.09
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

5.4.1 Verification of structural strength for inner wall



<u>ULTIMATE LIMIT STATE</u>

Grade of Concrete	f_{ck}	=	35	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	15.63	N/mm^2	For Basic Combination
	f_{cd}	=	19.54	N/mm^2	For Accidental Combination
	f_{cd}	=	15.63	N/mm^2	For Seismic Combination
E_c		=	32000	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 = 32000 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
$R_{lim} = M_{u,Lim}/bd^2$	5.80	6.99	5.80

Here R_{lim} is in MPa

Calculation of Reinforcement

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

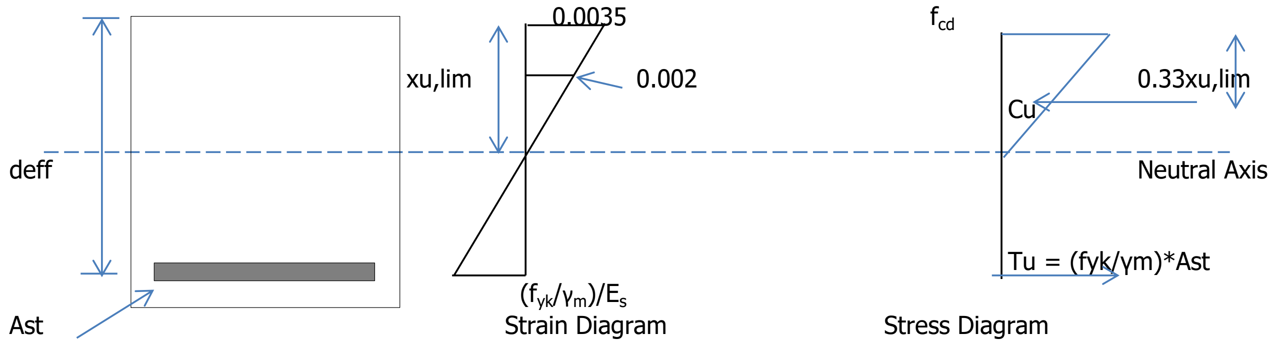
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

Moment on the section	**Bottom End support**			**Top End support**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	37.0			26.0		
b	1000			1000		
D	300			300		
c	50			50		
d	234.0			234.0		
f_{cd}	15.63			15.63		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	5.80			5.80		
$M_{u,Lim}$ (KNm)	318			318		
	OK			**OK**		
Ast Req.	372			260		
Dia of bar (main tension) (mm)	12			12		
Spacing (mm)	175			175		
+ dia of bar (main tension) (mm)	0			0		
Spacing (mm)	175			175		
Ast provided (sq mm)	646			646		
Dia of bar (main compresion) (mm)	12			12		
Spacing (mm)	175			175		
Area of main compresion (mm^2)	646			646		
f_{ctm}	2.8			2.8		
f_{yk}	435			435		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	392			392		
A_{ct}	277797			277797		
$f_{ct,eff}$	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)	22			22		
x/d	0.095			0.095		
	OK			**OK**		
z (mm)	225			225		
MR (KNm)	63			63		
	OK			**OK**		

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

Shear on the section	**Bottom End support**
Actual shear V_{Ed} (KN)	17.0
Actual shear stress (N/mm2)	0.081
Max shear capacity, 0.135 fck(1-fck/310)	4.2
	OK.
Min shear capacity, 0.0924 fck(1-fck/310)	2.9
$\Theta = 0.5 \times \sin^{-1}$ (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	1.925
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010	
$\nu_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.490
cl. 10.3.1 of IRC :112-2011	
$\rho 1 = A_{sl}/(b_w\ d) <= 0.02$	0.003
	OK
$0.12\ K\ (80\ \rho 1\ f_{ck})^{0.33}$	0.454
Axial compressive force N_{Ed} (KN)	18
$\sigma_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.1
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)	108
	OK

5.4.2 Verification for serviceability limit state for inner wall



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	35	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	16.80	N/mm^2	For Rare Combination
	f_{cd}	=	16.80	N/mm^2	For Frequent Combination
	f_{cd}	=	12.60	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 = 32000 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
$R_{sls} = M_{u,sls}/bd^2$	4.52	4.52	3.39

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 50

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	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)	31.0		1.0	20		1
b	1000		1000	1000		1000
D	300		300	300		300
c	50		50	50		50
d	234.0		234.0	234.0		234.0
f_{cd}	16.80		12.60	16.80		12.60
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	4.52		3.39	4.52		3.39
$M_{u,sls}$ (KNm)	248		186	248		186
	OK		**OK**	**OK**		**OK**
Ast Req.	452		14	289		14
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	175		175	175		175
+ dia of bar (main tension) (mm)	0		0	0		0
Spacing (mm)	175		175	175		175
Ast provided (sq mm)	646		646	646		646
Dia of bar (main compresion) (mm)	12		12	12		12
Spacing (mm)	175		175	175		175
Area of main compresion (mm^2)	646		646	646		646
f_{ctm}	2.8		2.8	2.8		2.8
x (mm)	23.1		30.8	23.1		30.8
x/d	0.099		0.132	0.099		0.132
	OK		**OK**	**OK**		**OK**
z (mm)	226		224	226		224
MR_{sls} (KNm)	44		43	44		43
	OK		**OK**	**OK**		**OK**
$\sigma_{sc} = M/(A_s z)$	212		7	137		7
	OK		**OK**	**OK**		**OK**
$\sigma_{ca} = M/(0.8095\ z\ b\ x_u)$	11.87		0.29	7.66		0.29
	OK		**OK**	**OK**		**OK**

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

Calculation of crack width	**Bottom End support**			**Top End support**		
n_1			6			6
n_2			6			6
$\phi_{eq} = (n_1\phi_1^2 + n_2\phi_2^2) / (n_1\phi_1 + n_2\phi_2)$			12			12
cl. 12.3.4 (3) of IRC :112-2011						
c			50			50
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$\rho_{p.eff} = A_s / A_{c,eff}$			0.005			0.005
$S_{r,max} = \{3.4\, c + (0.425\, k_1\, k_2\, \phi) / \rho_{p.eff}\}$			612			612
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}			32000			32000
$\alpha_e = E_s / E_{cm}$			6.25			6.25
$(\varepsilon_{sm}-\varepsilon_{cm})=(\sigma_{sc}-k_t\, f_{ct,eff}(1+\alpha_e\, \rho_{p,eff})/\rho_{p,eff})/E_s >= 0.6\sigma_{sc}/E_s$			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**

	Project	-		KB
	Client	-		-
	Job	RCC BOX OF SIZE 2 x 2 x 2		-

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	20	39	38	36	35	34	33	32	31	30	15	343	70
300	22	43	42	41	39	38	37	36	35	35	17	386	79

Max	**79**
Min.	**70**
	OK

Bearing capacity = 100 KN/sqm

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

Index

1.0 Design Report

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

1.1 Introduction:-

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

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

1.2 Reference documents :-

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

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

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

1.4 Loads:-

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

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

1.5 Load combinations

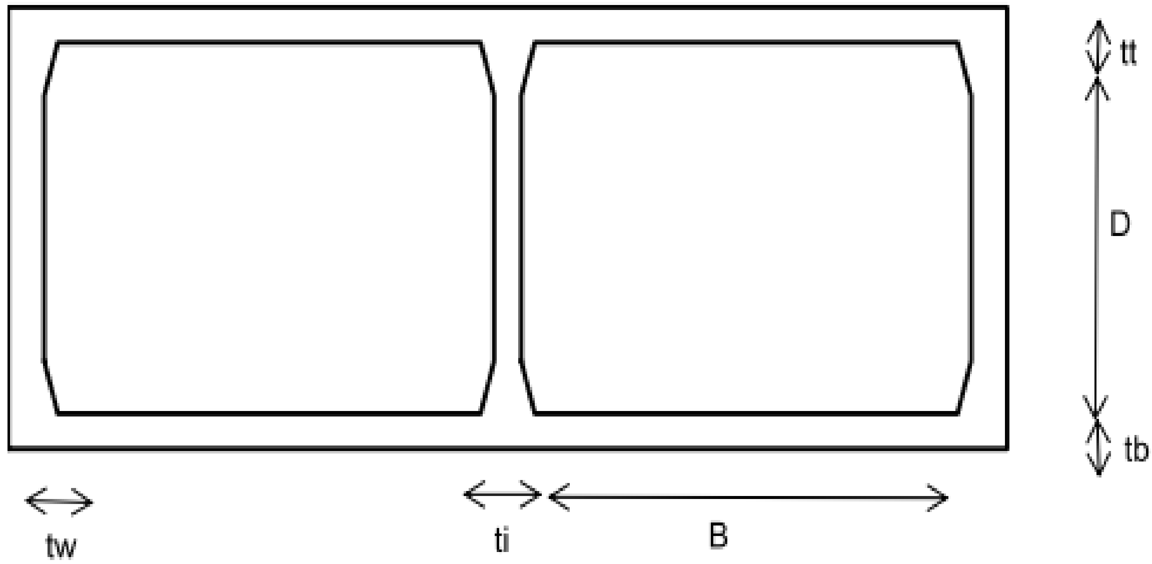
Load combinations as per IRC 6: 2014 have been considered in staad load combination.

1.6 Material properties

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

	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

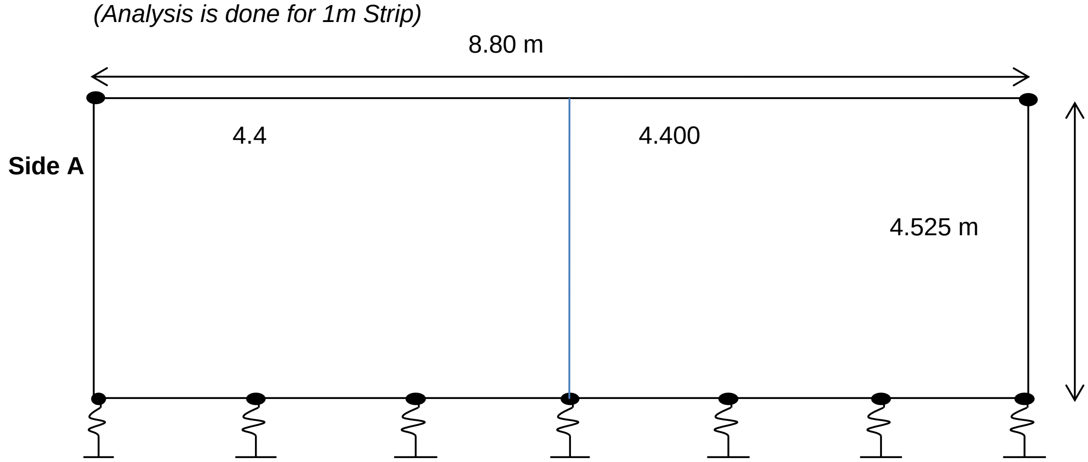
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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

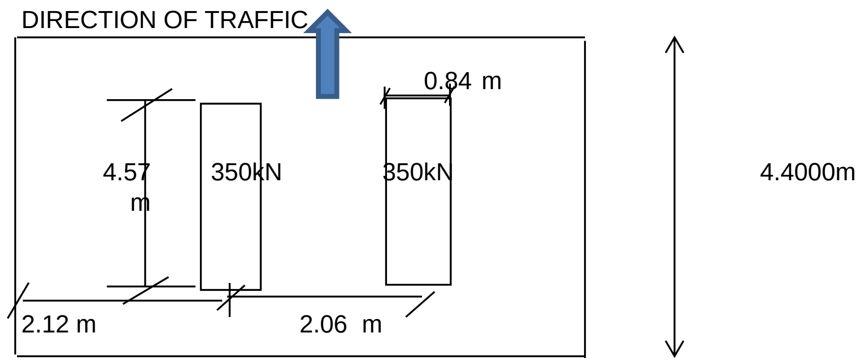
2) e Load due to water on Bottom Slab

Uniform Load = 29.00 kN/m^2

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

3) Live Load on Top Slab

A) 70R Track at Mid Span



Total Load = **700kN**

674.0 KN

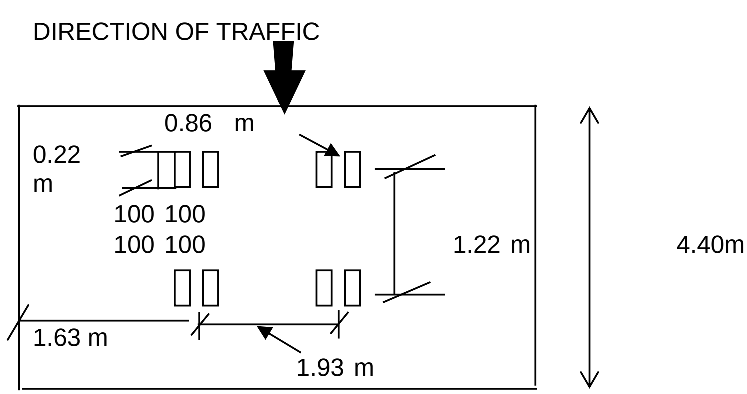
Effective width of Loading

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

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

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

B) 40T Boggie Load at Mid Span



Total Load = 400kN

Effective width of Loading

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

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

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

C) 40T Boggie Load at Support

Effective width of Loading

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

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

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

D) 70R Track at Support

Effective width of Loading

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

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

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

E) 70R Track at int side wall

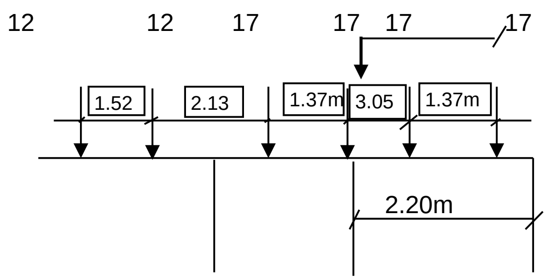
Effective width of Loading

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

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

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

F) 70R Wheel Case 1

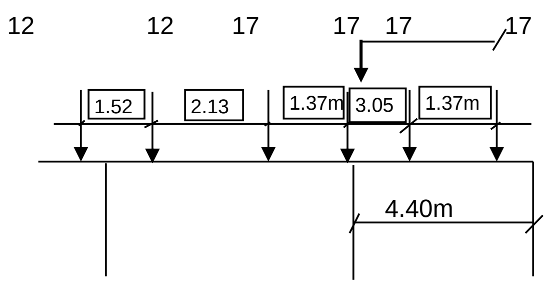


0.86m 1.93m 0.86m

Width along span = 1.370m

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

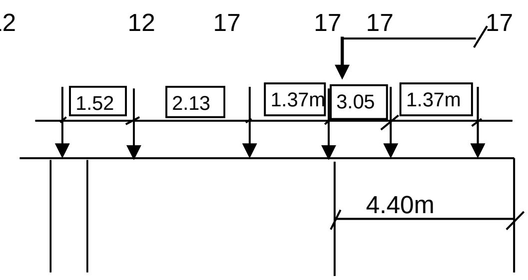
F) 70R Wheel Case 2



Width along span = 1.370m

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

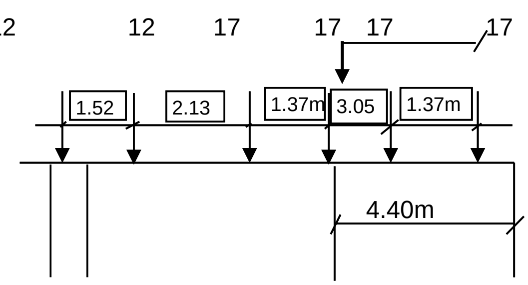
G) 70R Wheel Case 3



Width along span = 1.370m

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

H) 70R Wheel Case 4



Width along span = 1.370m

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

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

3.2 Temperature load calculation

Effective Bridge Temperature

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

Effect of temperature gradient

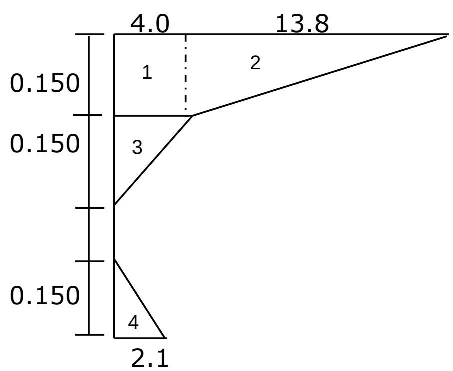
The box has been checked for temperature differential.

F = E_c aDt A

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

Average thickness of Deck slab = 500 mm

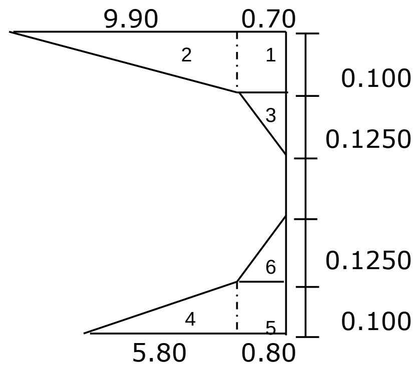
EFFECT OF TEMPERATURE RISE



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

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

EFFECT OF TEMPERATURE FALL



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	0.70	1.0	0.100	0.100	2.70	0.05m from top	0.200
2	9.90 / 2	1.0	0.100	0.100	19.09	0.033m from top	0.217
3	0.70 / 2	1.0	0.1250	0.1250	1.69	0.142m from top	0.108
4	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	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 iii) Impact due to floating bodies	0.00	1.00	0.00
Seismic Effect			
a) During Service	0.00	0.00	1.50
b) During Construction	0.00	0.00	0.75
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	1.00
Wave Pressure	1.00	1.00	1.00
Hydrodynamic Effect	0.00	0.00	1.00
Buoyancy	0.15	0.15	0.15

Serviceability Limit State

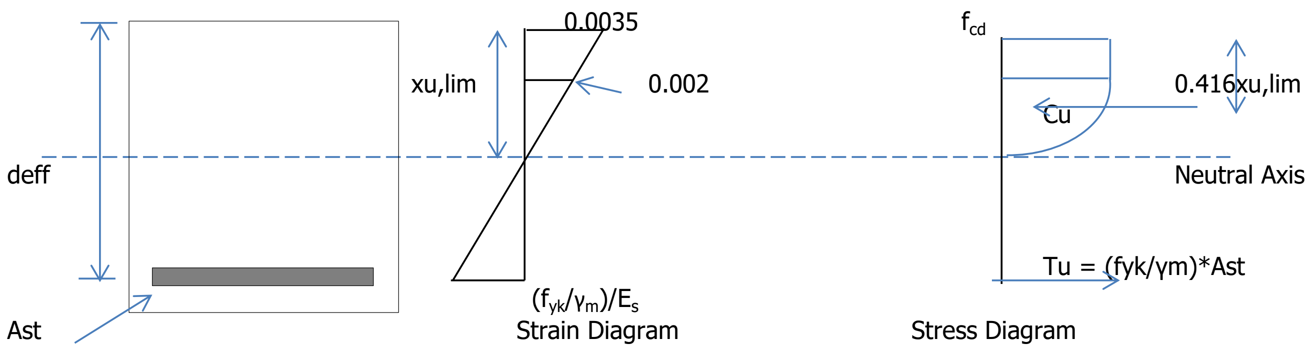
Partial Safety for Verification of Serviceability Limit St Table 3.3, Annex B, IRC:6-2014

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

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

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

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	

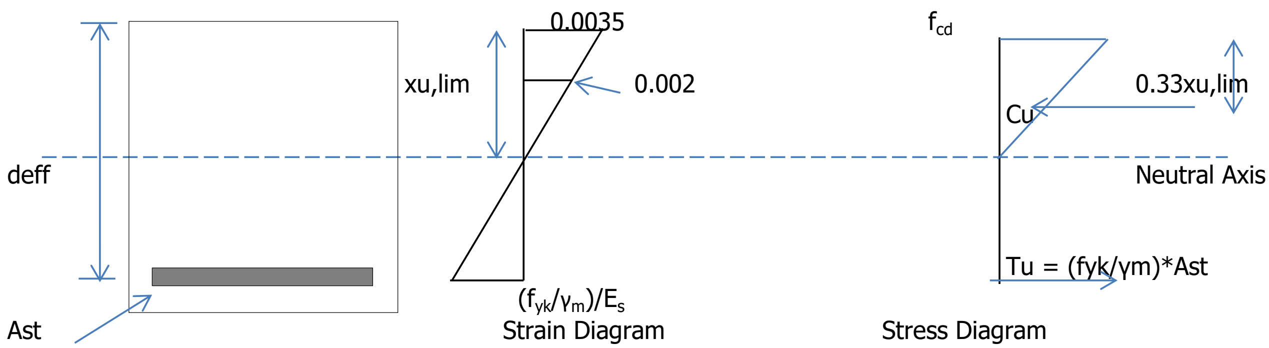
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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

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 = 500 mm

Clear cover = 40

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

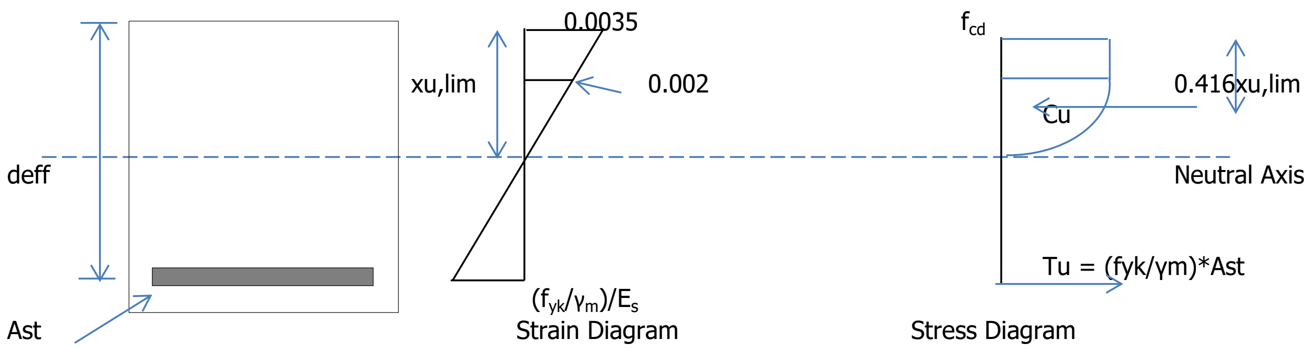
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	128.0		52.2	55.3		11
b	1000		1000	1000		1000
D	500		500	500		500
c	40		40	40		40
d	442.0		442.0	442.0		442.0
f_{cd}	14.40		10.80	14.40		10.80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

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

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

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

5.2.1 Verification of structural strength for bottom slab



Strain Diagram   Stress Diagram

<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	Combination (1)
	f_{cd}	=	16.75	N/mm^2	Accidental Combi.
	f_{cd}	=	13.40	N/mm^2	Combination (2)
E_c		=	31000	MPa	
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	435	N/mm^2	Combination (1)
	f_{Yd}	=	500	N/mm^2	Accidental Combi.
	f_{Yd}	=	435	N/mm^2	Combination (2)

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 550 mm

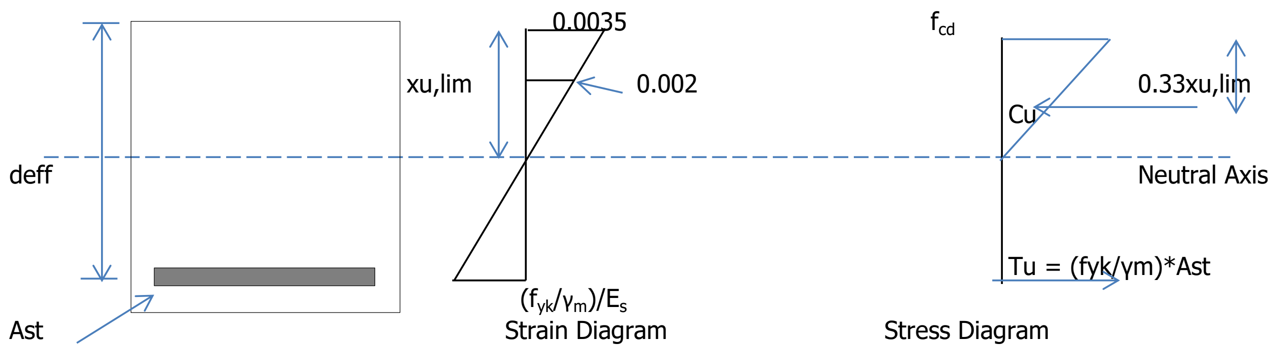
Clear cover at bott. = 75   Clear cover at top = 40

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

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

Shear on the section	**Bottom End support**		
Actual shear V_{Ed} (KN)	137.0		137.0
Actual shear stress (N/mm2)	0.333		0.333
Max shear capacity, 0.135 fck(1-fck/310)	3.7		3.7
	OK.		**OK.**
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		2.5
$\Theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.662		1.662
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$\nu_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.364		0.364
cl. 10.3.1 of IRC :112-2011			
$\rho 1 = A_{sl}/(b_w\ d) <= 0.02$	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

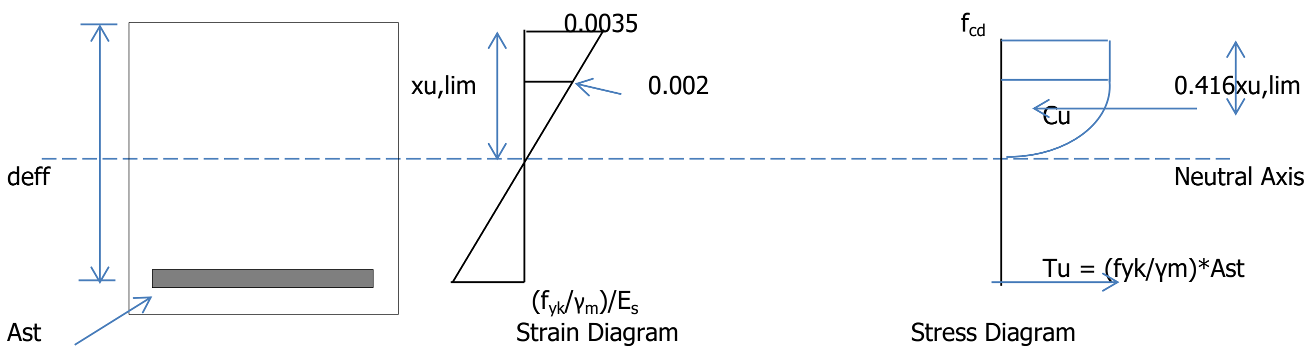
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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**

5.3.1 Verification of structural strength for outer wall



ULTIMATE LIMIT STATE

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

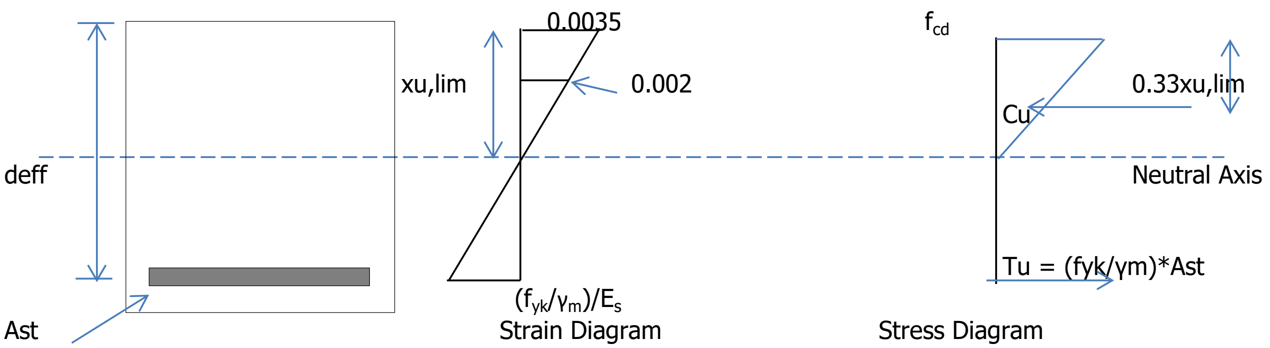
Calculation of Reinforcement

Width of section b	=	1000	mm
Depth of section D	=	500	mm
Clear cover	=	75	

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

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

5.3.2 Verification for serviceability limit state for outer wall



SERVICEABILITY LIMIT STATE

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 500 mm

Clear cover = 75

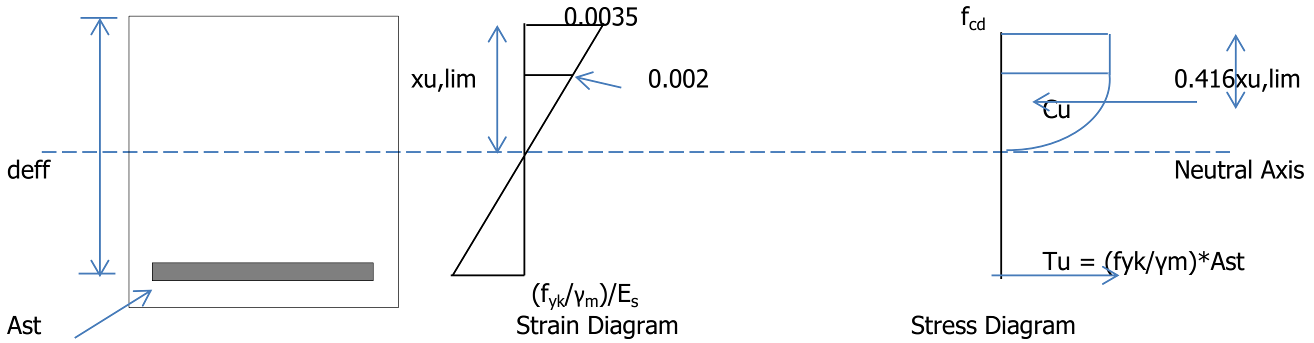
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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

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

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

5.4.1 Verification of structural strength for inner wall



<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

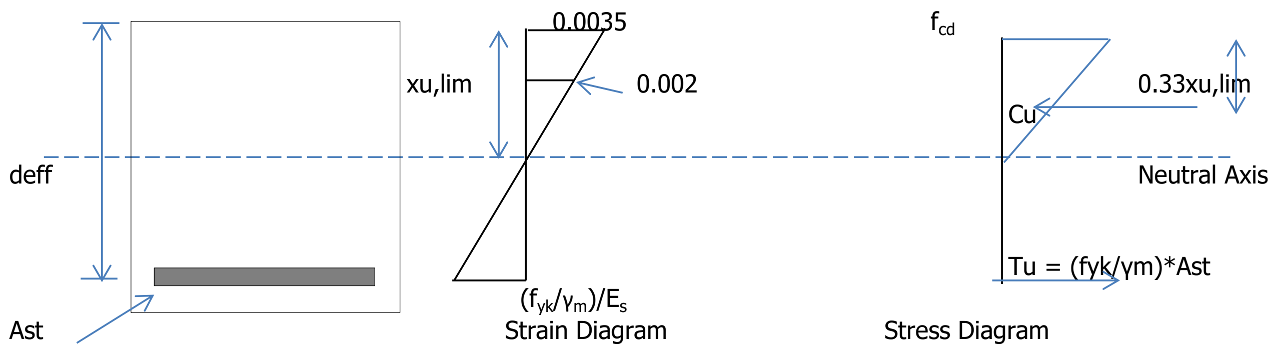
Calculation of Reinforcement

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



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	=	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

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

Outer Wall

At outer face of top end

Area of Steel Provided = 1398.0 mm^2/m

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

At inner face of top end

Area of Steel Required = 608.5 mm^2/m

Area of Steel Provided = 1570.8 mm^2/m

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

At outer face of bottom end

Area of Steel Provided = 1398.0 mm^2/m

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

At inner face of bottom end

Area of Steel Provided = 1570.8 mm^2/m

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

Inner Wall

Area of Steel Provided = 1005.3 mm^2/m

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

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

Top Slab

Req. Reinforcement = 330 mm^2/m

Provided Reinforcement =

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

Bottom Slab

Req. Reinforcement = 367.8 mm^2/m

Provided Reinforcement =

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

Outer Wall

Req. Reinforcement = 304.2 mm^2/m

Provided Reinforcement =

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

Inner Wall

Reinforcement Required = 180.9 mm^2/m

Provided Reinforcement =

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

7.0 Base Pressure

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

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

Bearing capacity = 220 KN/sqm

DESIGN OF BREAST WALL & RETAINING WALL

Project	-	Designed by:	KB
Client	-	Checked by:	-
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

<u>Levels</u>

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

<u>Wall</u>

Thickness of Wall shaft at Top = 0.300 m

Thickness of Wall shaft at Bottom = 0.550 m

<u>Foundation</u>

Total Width of Footing = 3.650 m

Width of Toe Slab = 1.100 m

Width of Heel Slab = 2.000 m

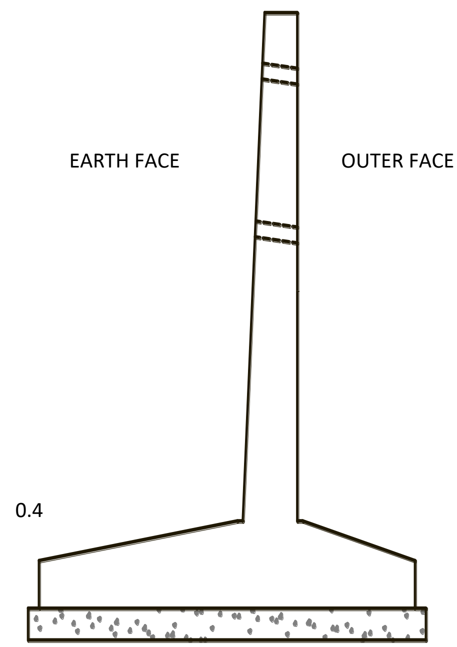
Thickness of Toe slab at tip = 0.300 m

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



<u>Material Specification</u>

Concrete Grade = 30 M

Characteristic Compressive Strength of Concrete,fck = 30.00 Mpa at 28 days

Design Compressive strength of Concrete, fcd = 13.400 Mpa at 28 (0.67/1.5 * fck)

Tensile strength of concrete , fctm = 2.50 Mpa

Strain at reaching Characteistic Strength, $\epsilon c2$ = 0.02

Ultimate Strain, $\epsilon cu2$ = 0.035

Modulus of Elasticity of Concrete (Ec) = 27386.128 N/mm2 (5000 x sqrt (fck)

Ecm = 31000 N/mm2

Steel Grade = 500 Fe (HYSD Steel) D

Yield Strength of Reinforcement, fy or fyk = 500 Mpa

Design Yield Strength of Reinforcement, fyd = 434.783 Mpa (1/1.15 * fy)

Modulus of Elasticity of Steel (Es) = 200000 Mpa

Dry weight of Concrete = 25 kN/m^3

Dry unit weight of soil = 20 kN/m^3

Permissible Crack Width = 0.3 mm - For Moderate Exposure Condition

Maximum compressive stress in concrete under rare combination = 0.48 fck

= 14.4 N/mm^2

Maximum tensile stress in steel under rare combination = 0.8 fyk

= 400 N/mm^2

σcbc = 10.00

σst = 240

m = 9.3333333

k = 0.280

j = 0.907

Q = 1.27

As per Cl. 214.1 of IRC :6 -2014 (Y fluid) = 4.8

Project	-	Designed by:	KB
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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

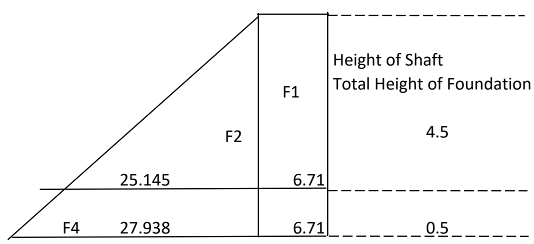
Project	-	*Designed by:*	*KB*	
Client	-	*Checked by:*	-	
Job Name	*Design of Breast Wall for height 3 m from G.L*	*Date & Rev.*	-	

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



100 (Deck Level)

Height of Shaft	4.5	m	4.5
Total Height of Foundation	5	m	5

95.5 shaft bottom level

95 Foundation Lvl.

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

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

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)	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
Shaft	1.000	25	1.913	47.8125	0.506	24.211	1.000	47.8125	-1.319	-63.047
Back filling over heel slab	1.000	20	9.200	184	-0.771	-141.936	1.000	184	-2.596	-477.736
Back filling on flared portion of shaft	1.000	20	0.563	11.25	0.258	2.906	1.000	11.25	-1.567	-17.625
Front Filling over toe slab RCC Railing or Crash Barrier or	1.000	20	1.760	35.2	1.280	45.054	1.000	35.2	-0.545	-19.186
Crash Barrier	1.000			0	0.725	0.000	1.000	0	-1.1	0.000
Heel slab	1.000	25	0.800	20	-0.727	-14.539	1.000	20	-2.552	-51.039
Toe slab	1.000	25	0.440	11	1.221	13.432	1.000	11	-0.604	-6.643
portion between heel & toe	1.000	25	0.250	6.25	0.45	2.813	1.000	6.25	-1.375	-8.594
Total				315.513		-68.059		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	

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

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

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

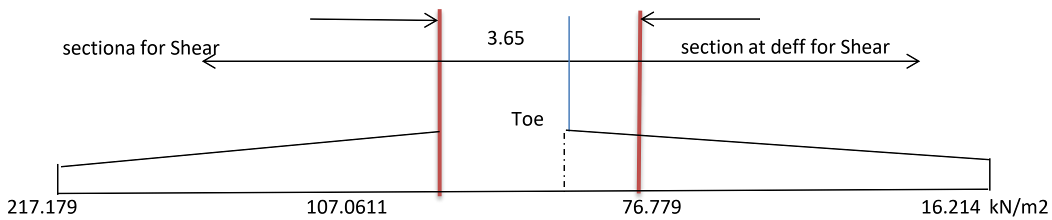
		load factor					
Moment due to active earth pressure	=	1.500	x	146.6764098	=	220.015	kNm
Moment due to Live load surcharge	=	1.200	x	83.8151	=	100.578	kNm
						320.593	

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

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	

Toe Slab - Moment Calculation

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
Client	-	Checked by:	-
Job Name	Design of Breast Wall for height 3 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	=	0.455	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)		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:	-
Job Name	Design of Breast Wall for height 3 m from G.L	Date & Rev.	-

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

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

SLS CHECK OF FOUNDATION

Foundation Lvl = 95.000 m

Properties of Footing Base:

A	=	3.650	m²
ZL	=	2.220	m³
ZT	=	0.608	m³

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

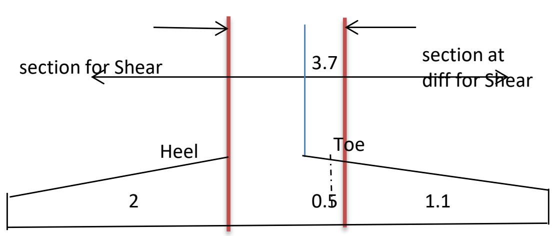
Normal Dry Case

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



Normal Dry Case 150.83 80.27 60.86 22.05 kN/m2

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

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
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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 = 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	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
$\Sigma_{r\,eff}$ = 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	=	0.010	
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		
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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

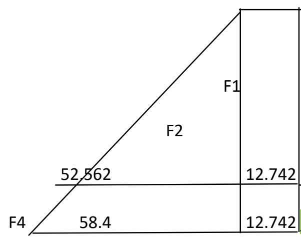
Type of reinforcement	Area of steel required	Area of steel provided						
Straight Portion of Shaft								
Vertical steel at earth face	2041	16	mm bar @	150	mm c/c (i.e.)	2094	mm2	OK
		12	mm bar @	150	mm c/c (i.e.)			
Vertical steel at non-earth face	660	12	mm bar @	150	mm c/c (i.e.)	754	mm2	OK
Distribution 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.		

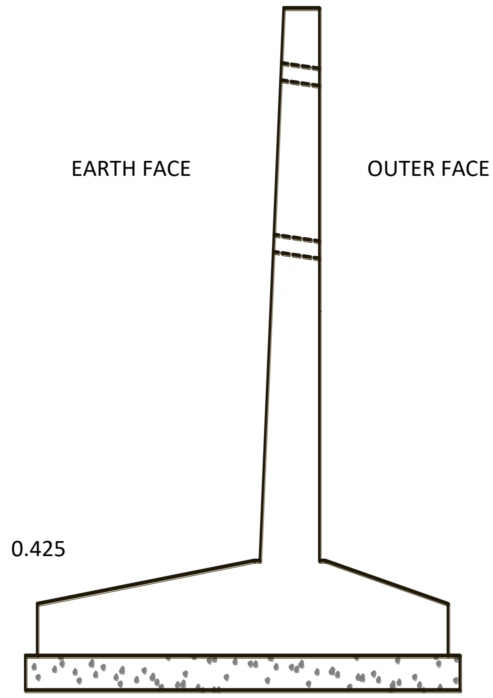
Project	-	**Designed by:**	KB
Client	-	**Checked by:**	-
Job Name	Design of Retaining Wall for height 3 m from G.L	**Date & Rev.**	-

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

INDEX

	Project	-	*Designed by:*	*KB*
	Client	-	*Checked by:*	-
	Job Name	*Design of Retaining 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	=	200.000	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	=	0.500	m	
Foundation				
Total Width of Footing	=	3.500	m	
Width of Toe Slab	=	1.200	m	
Width of Heel Slab	=	1.800	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	=	0.550	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, 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	=	9.33333333		
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 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 Retaining Wall for height 3 m from G.L*	Date & Rev.	-

VOLUME CALCULATION

C.G. Of Footing = 1.75 m

C.G. Of shaft from toe tip = 1.45 m

Distance between c.g. Of shaft and footing = 0.3 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		0.400	4.500		1.800	0.046	0.346	-1.404
Footing										
Heel Slab	1	1.00		1.800	0.425		0.765		-0.775	-2.525
Toe Slab	1	1.00		1.200	0.425		0.510		1.100	-0.650
Portion between Heel and Toe	1	1.00		0.550	0.550		0.303		0.300	-1.450
Back filling over Heel Slab	1	1.00		1.800	4.575		8.235		-0.808	-2.558
Front Filling over Toe Slab	1	1.00		1.200	1.575		1.890		1.154	-0.596
Back fill on flared portion of stem	1	1.00		0.200	4.500		0.450		0.117	-1.633
				L				eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barrier	1	0	kN/m	1.000	0	kN		0.250	0.550	-1.200

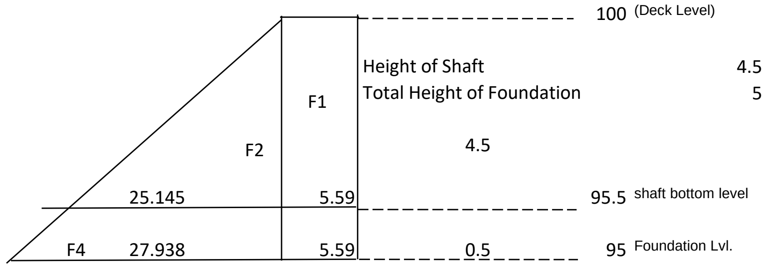
Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Retaining Wall for height 3 m from G.L*	*Date & Rev.*	-

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 =	5.5876728	x	4.5	x	1		=	25.145	kN
M1 =	25.145	x	2.25	=	56.575	**kN.m at Shaft Bottom**			
F3 =	5.5876728	x	5	x	1		=	27.938	kN
M3 =	27.938	x	2.5	=	69.846	**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**			

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

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	56.575	69.846	25.145	27.938
Due to Passive pressure	N		0.000		0.000

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

Stability Check of Foundation

Foundation Lvl = 95.000 m

Properties of Footing Base:

		B		L			
A	=	3.500	x	1.000	=	3.500	m^2
ZL	=	1.000	x	2.042	=	2.042	m^3
ZT	=	3.500	x	0.167	=	0.583	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	1.800	45	0.346	15.563
Back filling over heel slab	1.000	20	8.235	164.7	-0.808	-133.090
Back filling on flared portion of shaft	1.000	20	0.450	9	0.117	1.050
Front Filling over toe slab RCC Railing or Crash Barrier or	1.000	20	1.890	37.8	1.154	43.634
Crash Barrier	1.000			0	0.55	0.000
Heel slab	1.000	25	0.765	19.125	-0.775	-14.822
Toe slab	1.000	25	0.510	12.75	1.100	14.025
portion between heel & toe	1.000	25	0.303	7.5625	0.3	2.269
Total				295.938		-71.371

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
1.000	45	-1.404	-63.188
1.000	164.7	-2.558	-421.315
1.000	9	-1.633	-14.700
1.000	37.8	-0.596	-22.516
1.000	0	-1.2	0.000
1.000	19.125	-2.525	-48.291
1.000	12.75	-0.650	-8.288
1.000	7.5625	-1.45	-10.966
	295.938		-589.262

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	69.846	x	69.8459094	kNm
						216.522319	
Moment due to passive relief	=	1	x	**0**	=	0	
						216.522319	

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

P	295.938	KN	
ML	145.151	kNm	
MT	0	kNm	
A	3.500	m^2	
ZL	2.042	m^3	
ZT	0.583	m^3	
P/A+ML/ZL+MT/ZT (Max)	155.648	kN/m2	**SAFE**
P/A-ML/ZL-MT/ZT (Min)	13.459	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	27.938	=	27.9383638	KN				
						97.784					
Total Sliding Force	=	97.784 KN									
Total Restoring Force	=	mP + c.A + Fp =		0.5	x	295.938		+	0	=	147.9688 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	69.846	=	69.846	kNM
						216.522	
Overturning Moment	=	216.522 kNm					
Restoring Moment	=	S P.e Toe+		Mp	=	589.262	kNm
FOS against overturnng	=	2.7214837	>	2	**SAFE**		

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

Design of Foundation

Foundation Lvl = 95.000 m

Properties of Footing Base:

A = 3.500 m^2

ZL = 2.042 m^3

ZT = 0.583 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	1.800	60.750	0.300	18.225
Back filling over heel slab	1.350	20	8.235	222.345	-0.808	-179.67
Back filling on flared portion of shaft	1.350	20	0.450	12.150	0.058	0.71
Front Filling over toe slab	1.350	20	1.890	51.030	1.154	58.906
RCC Railing or Crash Barrier	1.35			0.000	0.550	0.000
Heel slab	1.35	25	0.765	25.819	-0.775	-20.01
Toe slab	1.35	25	0.510	17.213	1.100	18.93375
portion between heel & toe	1.35	25	0.303	10.209	0.300	3.063
Total				399.516		-99.844

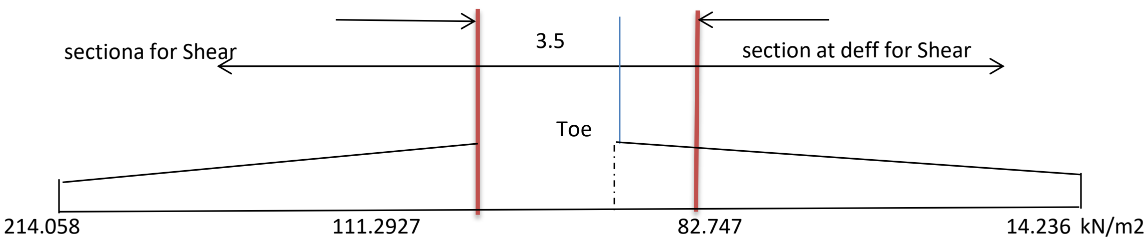
		load factor					
Moment due to active earth pressure	=	1.500	x	146.6764098	=	220.015	kNm
Moment due to Live load surcharge	=	1.200	x	69.8459	=	83.815	kNm
						303.830	

P	399.516	KN
ML	203.985	kNm
MT	0.000	kNm
A	3.500	m2
ZL	2.042	m3
ZT	0.583	m3
P/A+ML/ZL+MT/ZT (Max)	214.058	kN/m2
P/A-ML/ZL-MT/ZT (Min)	14.236	kN/m2

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

Normal Dry Case

Ultimate Base Pressure (kN/m^2)	**Max**	**214.058**
	Min	**14.236**



Normal Dry Case

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=	162.68 kN/m2											
Upward moment due to Base pressure	=	263.53 kNm/m											
	factor			VOL									
Downward moment due to backfill	=	1.350	x	8.235	/	1	x	20	x	0.9	=	200.111	kNm/m
Downward moment due to self weight of Heel	=	1.35	x	0.765	/	1	x	25	x	0.825	=	21.300	kNm/m
Net Moment at face of shaft	=	263.53	-200.11	-21.30		42.12	kNm/m	OK					

Heel Slab - Shear Calculation at Face of Wall

Shear Force due to upward pressure at Face of wall	=	162.68	x	1.8	x	1	=	292.816	KN
	factor								
Downward Force due to backfill	=	1.350	x	8.235	x	20	=	222.345	KN
Downward Force due to self weight of Heel slab	=	1.35	x	0.765	x	25	=	25.819	KN
Net Shear Force	=	292.816	-222.345	-25.819			=	**44.652**	KN
Net Shear Force / unit meter	=	44.652	/	1			=	**44.652**	KN/m

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

Average Base Pressure for Design of Toe Slab													
	=	48.49	kN/m2										
Upward moment due to Base pressure	=	34.91	kNm/m										
Downward moment due to self weight of Toe	=	1.35	x	0.51	/	1	x	25	x	0.550	=	9.467	kNm/m
Net Moment at face of shaft	=	34.91		-9.467	=	25.447	kNm/m	OK					

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 3 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	=	0.430	m											
effective depth at critical section	=	0.349	m											
Base pressure at deff from face of wall	=	58.825	kN/m2											
upward shear force due to base pressure	=	36.531	x		0.781 x		1 =		28.530 kN					
C.g. Of base pressure	=	4.144	m											
moment due to upward pressure at critical section	=	118.230	kNm											
tanb		0.167												
reduction in shear force (Vccd)		M tanb / d		=	45.81 KN									
Downward force due to self weight of toe slab	=	1.35		x	0.365083333	x	0.781	x	1	x	25	=	9.623	KN
Net Shear Force at deff	=	28.530		-9.623	-45.80784345	=	-26.901	KN						
Net Shear Force / unit meter	=	-26.901		/	1	=	-26.901	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 3 m from G.L	Date & Rev.	-

Flexural Reinforcement Calculation:

		Heel Slab	Toe Slab
Ultimate bending moment,Mu (kNm/m)	=	42.124	25.45
Effective depth required (dreq) (mm)	=	100.87	78.40
Effective depth provided (dpro) (mm)	=	469.00	469.00
Check for provided depth	=	SAFE	SAFE
R = Mu/(b d2)	=	0.19	0.12
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)	=	277.587	167.631
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	=	140.00	140.00
+ Dia (mm)	=	0.00	0.00
Spacing (mm)	=	140.00	140.00
Ast provided (mm2 / m)	=	807.74	807.74
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)	=	161.55	161.55
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 3 m from G.L	Date & Rev.	-

Shear Reinforcement Calculation:

		Heel Slab	Toe Slab	
Ultimate Shear Force (VEd)	=	44.652	-26.901	kN/m
Ast provided	=	807.737	807.74	mm2/m
Depth of slab at critical section	=	550.000	430.167	mm
Effective depth at critical section	=	469.000	349.167	mm
percentage of steel provided (r1)	=	0.0024	0.0027	
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)	=	0.106	0.086	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	1.757	
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010				
V_{min} = 0.031 K3/2 fck1/2	=	0.361	0.395	N/mm2
0.12 K (80 r1 fck)^0.33	=	0.351	0.391	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	=	164.79	136.70	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 3 m from G.L	Date & Rev.	-

SLS CHECK OF FOUNDATION

Foundation Lvl = 95.000 m

Properties of Footing Base:

A	=	3.500	m^2
ZL	=	2.042	m^3
ZT	=	0.583	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

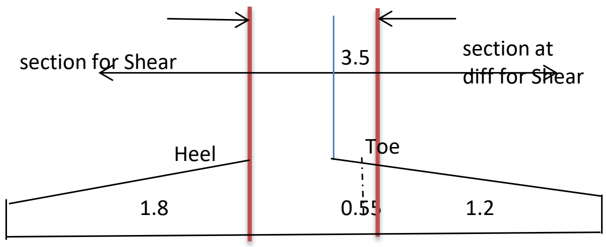
Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1	25	1.800	45.000	0.300	13.500
Back filling over heel slab	1	20	8.235	164.700	-0.808	133.090
Back filling on flared portion of shaft	1	20	0.450	9.000	0.117	1.050
Front Filling over toe slab	1	20	1.890	37.800	1.154	43.634
RCC Railing or Crash Barrier	1			0.000	0.550	0.000
Heel slab	1	25	0.765	19.125	-0.775	14.822
Toe slab	1	25	0.510	12.750	1.100	14.025
portion between heel & toe	1	25	0.303	7.563	0.300	2.269
Total				**295.938**		**-73.434**

		load factor					
Moment due to active earth pressur	=	1.0	x	146.676	=	146.676	kNm
Moment due to Live load surcharge	=	0.8	x	69.846	=	55.877	kNm
						202.553	

P	295.938	KN
ML	129.119	kNm
MT	0.000	kNm
A	3.500	m2
ZL	2.042	m3
ZT	0.583	m3
P/A+ML/ZL+MT/ZT (Max)	147.796	kN/m2
P/A-ML/ZL-MT/ZT (Min)	21.311	kN/m2

		Normal Dry Case
Base Pressure (kN/m2)	Max	147.796
	Min	21.311



Normal Dry Case 147.80 82.75 64.68 21.31 kN/m2

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

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=	115.27	kN/m2									
Upward moment due to Base pressure	=	186.74	kNm/m									
	factor											
Downward moment due to backfill	=	1.00	x	8.235	x	20	x	0.9	=	148.23	kNm/m
Downward moment due to self weight of Heel	=	1.00	x	0.765	x	25	x	0.825	=	15.78	kNm/m
Net Moment at face of shaft	=	186.74		-148.23		-15.78			=	22.73	kNm/m
				Tension at Bottom of Heel Slab							

Toe Slab - Moment Calculation

Average Base Pressure for Design of Toe Slab	=	42.99	kN/m2								
Upward moment due to Base pressure	=	30.96	kNm/m								
Downward moment due to self weight of Toe	=	1	x	0.51	x	25	x	0.550	=	7.01	kNm/m
Net Moment at face of shaft	=	30.96		-7.01					=	23.94	kNm/m
				Tension at Bottom of Heel Slab							

		Heel Slab	Toe Slab	
Working bending moment, M	=	22.73	23.94	kNm/m
Dx	=	1.00	1.00	m
Dy	=	0.50	0.50	m
Section Modulus (ZL) of uncracked sectio	=	0.04	0.04	m3
Bending Stress (M/ZL)	=	0.546	0.575	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	=	807.737	807.737	mm2/m
Percentage of steel , pt	=	0.0024	0.0027	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.227	0.242	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	106.616	113.448	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	362.384	355.552	mm
Depth of neutral axis from c.g. Of tension steel (ys)	=	281.384	274.552	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 3 m from G.L*	*Date & Rev.*	-

Icr	=	990427223.8	953533381.5	mm4
Maximum compressive stress in concrete	=	2.447	2.849	< 14.4, SAFE
Maximum tensile stress in concrete	=	8.317	8.928	
Maximum Tensile stress in steel	=	61.667	64.956	< 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	=	106.616	113.448	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	=	77.500	77.500	mm	
Ac, eff = Dx * hc,eff	=	77500.000	77500.000	mm	
r r eff = As/Ac eff	=	0.010	0.010		
Maximum crack spacing , Sr max	=	450.732	450.732	mm	
(εsm - εcm)	=	$\dfrac{\sigma sc - k_t f_{ct\,eff} (1 + \alpha_e\, p_{p\,eff})}{p_p\, eff}$	/ Es		
tensile stress in steel, ,σsc	=	61.667	64.956	N/mm2	
Kt	=	0.500	0.500		
Tensile strength of concrete = fct eff = fctm	=	2.500	2.500	N/mm2	128
αe = Es/Ecm	=	6.452	6.452		
(εsm - εcm)	=	0.000	-0.0003		
Crack width , Wk=Sr max (εsm - εcm)	=	**0.000**	**0.000**		
Check	=	**SAFE**	**SAFE**		

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining Wall for height 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	1.800	60.75	0.046	2.784
RCC Railing or Crash Barrier	1.35			0	0.25	0.000
Total				**60.750**		**2.784**

Horizontal Force :	load factor						
Due to Earth pressure		1.5	x	56.58	=	84.86	KN
Due to Live load Surcharge		1.2	x	25.14	=	30.17	KN
						115.04	

Total Horizontal Force = 115.04 KN

Moment Due to Horizontal Force:		load factor					
Moment due to active earth pressure	=	1.5	x	155.299	=	232.948	kNm
Moment due to Live load surcharge	=	1.2	x	56.575	=	67.8902	kNm
						300.839	

Total Moment due to Horizontal Force = 300.839 kNm

Summary of Forces:

P	60.750	KN
ML	303.623	kNm
FL	115.036	KN

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining 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) = 0.5 m

Depth of Wall (D) = 1 m

Area of Concrete (Ac) = 0.5 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	60.75	303.62	115.04
MAX	60.75	303.62	115.04

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = 60.75 kN

0.1 fcd Ac

= 0.1 13.4 500000

= 670000 N

= 670.0 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) = 303.62 kNm = 303.62 kNm/m

Check For Depth of Wall :

Mult = 0.167 x fck x b x d^2

= 303.62 kNm/m

b = 1000 mm

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

(dreq) 246.18 mm

Total Depth Required (Dreq) = 329.18 mm

Total Depth Provided (Dprov) = 500 mm OK

Effective depth provided(deff) = 417 mm

R= Mu/(b d^2) = 1.746

Minimum Longitudinal Reinforcement in wall on each face

=

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

Ast min = 600 mm2/m

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

Area of Steel Required:

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

= 0.0043

Ast_{req} = 2163.07 mm2/m

Ast required = max(Astmin, Astreq) = 2163.07 mm2/m

Provide	16	mm dia	@	140	mm c/c	=	1435.98	2243.71	mm²/m	OK
	12	mm dia	@	140	mm c/c	=	807.74			

Percentage of steel = 0.449 %

Check for Moment of Resistance of Section due to Steel

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

= 257.23 mm

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

= 90.33 mm

OK

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

z = d - 0.416 x X

= 379.42 mm

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

MR = fyd . Ast . Z

= 370138822.9

= 3.70E+08 Nmm /m

= 3.70E+02 kNm/m > 303.62 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 = 600 mm2/m

Provide	12	mm dia	140	mm c/c	=	807.74	mm²/m	OK

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

maximum of following = 0.25 x 3051.45 = 762.86 **As per IRC:112-2011' Clause 16.32.2**

= 0.001 x 5.00E+05 = 500.00

Minimum Horizontal Reinf. provided 762.9 mm2 per meter

Min dia of bar = 0.25 x 16 = 4 mm

or 8 mm

Maximum Spacing between bars <= 300 mm/cc

2 Legged	12	dia	@	200	c/c	=	1130.4	mm²	OK

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

SLS CHECK OF WALL

Foundation Lvl = 95.5 m

Creep Coeff (ϕ) = 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	1.800	45	0.045833333	2.0625
RCC Railing or Crash Barrier	1.000			0	0.25	0
Total				**45.000**		**2.063**

Horizontal Force :		load factor				
Due to Earth pressure	=	1.000	x	56.57518663	=	56.57519 KN
Due to Live load Surcharge	=	0.800	x	25.14452739	=	20.11562 KN
Total Horizontal Force	=	76.69080854	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	56.575	=	45.260 kNm
Total Moment due to Horizontal Force	=	152.187252032	kNm			

Summary of Forces:

P	45.000	KN
ML	154.250	kNm
FL	76.691	KN

Bending Moment, M	=	154.25	kNm
Dx	=	1.00	m
Dy	=	0.50	m
Section Modulus (ZL) of uncracked secti	=	0.04	m3
Bending Stress (M/ZL)	=	3.702	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)	=	417.000	mm
Ast provided	=	2243.714	mm2/m
Percentage of steel , pt	=	0.0069	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.355	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	147.941	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	269.059	mm

Depth of neutral axis from c.g. Of tesnion steel (ys)	=	186.059	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast	* (dy - k * dy)^2
Icr	=	1517084137	mm4
Maximum compressive stress in concrete	=	15.0	< 14.4, SAFE
Maximum tensile stress in concrete	=	27.357	
Maximum Tensile stress in steel	=	170.018	< 400, SAFE

Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	Design of Retaining 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	=	140.000	mm
Check for Applicability of Formula	=	OK	
Maximum crack spacing , $S_{r\,max}$	=	3.4 c +	0.425 k1 k2 ϕ / $\rho_{p\,eff}$
K1	=	0.700	for deformed b
K2	=	0.500	for bending
depth of neutral axis , yc	=	147.941	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	=	207.500	mm
Ac, eff = Dx * hc,eff	=	207500.000	mm
$r_{r\,eff}$ = As/Ac eff	=	0.011	
Maximum crack spacing , $S_{r\,max}$	=	475.104	mm
(ε_{sm} - ε_{cm})	=	σsc - kt fct eff (1 + αe r r eff) / r r eff	/ Es
tensile stress in steel, ,σsc	=	170.018	N/mm2
Kt	=	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.500	N/mm2
αe = Es/Ecm	=	6.452	
(εsm - εcm)	=	0.00023	
Crack width , Wk=Sr max (εsm - εcm)	=	**0.110**	
Check	=	**SAFE**	

Project	-	Designed by:	KB		
Client	-	Checked by:	-		
Job Name	Design of Retaining 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	155.65	13.46	1.51	2.72	0.106	-0.086
Permissible	200	0	1.5	2	3.658	3.658
Remarks	OK	OK	OK	OK	OK	OK

Reinforcement summary

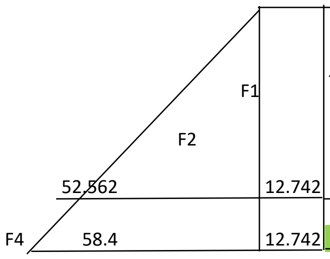
Type of reinforcement	**Area of steel required**	**Area of steel provided**						
Straight Portion of Shaft								
Vertical steel at earth face	2163	16	mm bar @	140	mm c/c (i.e.)	2244	mm2	OK
		12	mm bar @	140	mm c/c (i.e.)			
Vertical steel at non-earth face	600	12	mm bar @	140	mm c/c (i.e.)	808	mm2	OK
Distribution steel	763	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 @	140	mm c/c (i.e.)	808	mm2	OK
		0	mm bar @	140	mm c/c (i.e.)			
Steel at bottom face	250	12	mm bar @	140	mm c/c (i.e.)	808	mm2	OK
Distribution reinforcement	162	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 @	140	mm c/c (i.e.)	808	mm2	OK
		0	mm bar @	140	mm c/c (i.e.)			
Steel at top face	250	12	mm bar @	140	mm c/c (i.e.)	808	mm2	OK
Distribution reinforcement	162	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.

PCL COORDINATES

Proposed Centerline coordinates

Station	Easting	Northing	Bearing
54180	542136.597	2769082.836	335 53 52.803
54190	542132.514	2769091.964	335 53 52.803
54200	542128.43	2769101.093	335 53 52.803
54300	542087.724	2769192.431	337 41 5.671
54400	542073.938	2769290.428	6 18 58.116
54500	542086.099	2769389.349	356 20 20.202
54600	542074.098	2769488.619	352 52 13.681
54700	542061.547	2769587.827	349 59 11.331
54800	542016.206	2769563.513	179 15 34.567
54900	542017.498	2769463.521	179 15 34.567
55000	542018.347	2769363.532	182 22 32.070
55100	542008.901	2769263.988	184 37 10.419
55200	542025.676	2769166.105	164 33 41.747
55300	542051.853	2769069.6	168 27 13.122
55400	542038.952	2768972.293	206 39 2.992
55500	541975.391	2768895.626	223 22 44.774
55600	541906.709	2768822.943	223 22 44.774
55700	541838.026	2768750.261	223 22 44.774
55800	541767.611	2768679.343	229 45 6.399
55900	541685.341	2768622.67	237 34 23.332
56000	541596.582	2768577.355	251 54 41.441
56100	541498.148	2768562.412	269 7 23.194
56200	541398.16	2768560.882	269 7 23.194
56300	541298.311	2768557.586	257 1 11.532
56400	541269.253	2768478.554	144 6 55.573
56500	541339.188	2768407.145	134 55 34.911
56600	541409.989	2768336.526	134 55 34.911
56700	541379.27	2768302.235	311 37 58.600
56800	541304.529	2768368.67	311 37 58.600
56900	541229.787	2768435.106	311 37 58.600
57000	541161.317	2768506.819	337 40 13.326
57100	541186.678	2768596.04	54 3 53.068

Proposed Centerline coordinates

Station	Easting	Northing	Bearing
57200	541283.253	2768616.843	83 55 0.376
57300	541294.186	2768663.597	267 37 58.060
57400	541194.407	2768656.956	266 9 46.167
57500	541095.745	2768644.387	244 12 34.285
57600	541055.065	2768561.028	167 48 54.543
57700	541102.868	2768473.623	148 38 43.409
57800	541154.902	2768388.226	148 38 43.409
57900	541160.587	2768310.685	279 9 40.025
58000	541098.541	2768386.81	325 56 35.061
58100	541042.539	2768469.658	325 56 35.061
58200	540986.538	2768552.506	325 56 35.061
58300	540963.53	2768646.161	14 2 43.291
58400	541028.547	2768716.636	71 20 28.098
58500	541127.913	2768724.709	87 48 32.036
58600	541227.84	2768728.532	87 48 32.036
58700	541327.767	2768732.356	87 48 32.036
58800	541339.732	2768778.574	272 20 7.814
58900	541239.769	2768781.301	271 33 4.488
59000	541139.805	2768784.008	271 33 4.488
59100	541039.842	2768786.715	271 33 4.488
59200	540948.949	2768819.639	317 21 8.736
59300	540881.589	2768890.406	282 28 50.378
59400	540816.864	2768831.58	191 45 43.198
59500	540796.479	2768733.68	191 45 43.198
59600	540749.389	2768649.082	235 48 10.579
59700	540664.079	2768596.915	238 27 29.434
59800	540611.402	2768516.622	184 48 4.164
59900	540641.124	2768422.702	154 13 49.847
60000	540697.268	2768341.974	122 7 12.769
60100	540794.078	2768331.514	82 15 15.541
60200	540888.955	2768321.711	137 48 42.364
60300	540936.099	2768233.719	153 16 51.867

Proposed Centerline coordinates

Station	Easting	Northing	Bearing
60400	540981.06	2768144.397	153 16 51.867
60500	540940.814	2768121.723	329 28 56.240
60600	540890.034	2768207.87	329 28 56.193
60700	540806.232	2768239.108	255 51 51.786
60800	540708.484	2768220.218	274 45 24.525
60900	540625.474	2768270.648	316 14 52.295
61000	540547.133	2768332.071	319 51 19.713
61100	540521.109	2768426.376	352 33 52.200
61200	540489.892	2768520.838	354 51 32.712
61300	540526.967	2768609.94	42 15 18.628
61400	540594.2	2768683.965	41 52 51.600
61500	540641.069	2768771.134	13 57 45.408
61600	540640.5	2768870.107	346 17 13.463
61700	540616.411	2768967.163	346 3 24.957
61800	540592.315	2769064.216	346 3 24.957
61900	540568.219	2769161.27	346 3 24.957
62000	540573.756	2769257.943	30 24 54.592
62100	540656	2769307.237	87 42 39.398
62200	540753.171	2769285.295	105 36 13.927
62300	540849.485	2769258.396	105 36 13.927
62400	540945.8	2769231.498	105 36 13.927
62500	541042.236	2769229.726	58 43 31.791
62600	541074.763	2769316.591	342 19 52.050
62700	541011.083	2769392.41	314 44 32.117
62800	540941.534	2769464.182	321 23 52.654
62900	540893.197	2769551.196	340 29 47.589
63000	540857.377	2769644.409	332 45 46.688
63100	540802.231	2769727.653	323 27 3.793
63200	540742.68	2769807.988	323 27 3.793
63300	540677.618	2769883.734	313 44 36.643
63400	540614.373	2769958.785	351 52 51.656
63500	540678.231	2770015.406	93 26 38.268

Proposed Centerline coordinates

Station	Easting	Northing	Bearing
63600	540778.052	2770009.413	92 48 35.460
63700	540771.111	2770056.74	277 56 38.899
63800	540671.823	2770066.927	265 30 15.846
63900	540575.011	2770042.494	254 3 37.124
64000	540506.099	2769983.162	178 40 54.646
64100	540565.64	2769906.444	132 42 1.067
64200	540639.131	2769838.628	132 42 1.067
64300	540697.569	2769758.822	160 6 26.893
64400	540638.981	2769735.088	323 44 56.019
64500	540577.229	2769813.534	314 21 53.909
64600	540501.372	2769878.669	310 11 47.743
64700	540424.995	2769943.217	310 30 41.558
64800	540394.102	2770031.89	11 27 24.106
64900	540428.508	2770123.729	47 49 9.968
65000	540523.02	2770136.126	101 40 7.254
65100	540609.134	2770151.824	8 42 13.469
65200	540537.198	2770210.696	295 7 29.867
65300	540446.659	2770253.155	295 7 29.867
65400	540355.272	2770293.437	282 25 54.270
65500	540271.738	2770253.117	206 2 14.529
65600	540272.902	2770154.917	171 7 39.716
65700	540288.326	2770056.114	171 7 39.716
65800	540237.244	2770011.724	321 18 6.724
65900	540208.557	2770107.091	345 27 29.179
66000	540167.395	2770195.571	305 57 35.183
66100	540070.504	2770207.36	266 36 15.804
66200	539972.752	2770214.037	306 37 19.411
66300	539978.085	2770298.56	54 38 38.115
66400	540062.001	2770352.944	57 8 56.897
66500	540146.01	2770407.19	57 8 56.897
66600	540230.018	2770461.435	57 8 56.897
66700	540311.984	2770518.197	36 29 3.738

Proposed Centerline coordinates

Station	Easting	Northing	Bearing
66800	540268.291	2770580.286	253 27 53.100
66900	540181.484	2770530.88	239 18 28.291
67000	540095.492	2770479.838	239 18 28.291
67100	540007.599	2770432.436	248 45 21.032
67200	539910.128	2770412.26	267 51 15.968
67300	539810.368	2770418.225	276 18 45.981
67400	539714.621	2770445.431	295 24 40.917
67500	539629.605	2770497.91	301 55 49.658
67600	539533.994	2770505.593	245 59 12.709
67700	539460.632	2770438.745	222 45 29.188
67800	539392.742	2770365.323	222 45 29.188
67900	539324.851	2770291.9	222 44 2.516
68000	539285.937	2770202.504	180 50 26.707
68100	539314.679	2770107.688	158 50 23.092
68200	539312.326	2770010.357	204 17 46.215
68300	539260.636	2769924.828	206 4 34.659
68400	539263.634	2769827.123	170 56 58.936
68500	539214.791	2769835.65	345 40 38.116
68600	539190.053	2769932.542	345 40 38.116
68700	539155.249	2770025.66	326 54 16.979
68800	539082.678	2770093.111	302 24 55.895
68900	538998.26	2770146.716	302 24 55.895
69000	538920.67	2770209.393	316 4 41.022
69100	538860.918	2770289.264	329 19 27.076
69200	538809.9	2770375.271	329 19 27.076
69300	538752.007	2770456.539	317 36 36.427
69400	538676.106	2770521.246	303 17 10.225
69500	538590.115	2770572.276	300 23 40.815