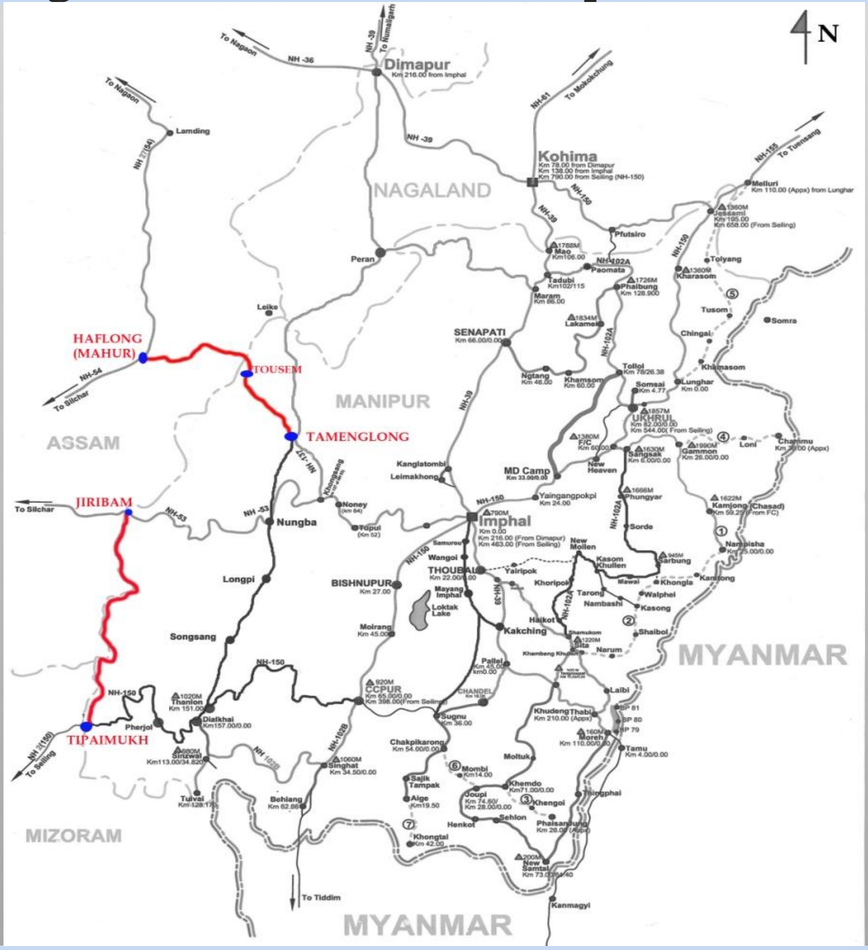
NATIONAL HIGHWAY INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

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



DRAFT DETAILED PROJECT REPORT
VOL-II DESIGN REPORT
PKG-1
TAMENGLONG-DIALONG SECTION
(FROM KM 0+000 TO KM 10+000) LENGTH-10.0KM

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FINAL DESIGN REPORT

1.0 HIGHWAY & STRUCTURE DESIGN

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

Table 6.1: Draft Design Standards

Sr. No.	Element	Terrain		
		Rural (Non Urban)	**Urban Area**	**Hilly**
1	Width of Carriageway (m)	Intermediate Lane : 5.5 2-Lane : 7.0	2-Lane : 7 2-Lane+ Paved Shoulder : 10	2-Lane : 7 2-Lane+ Paved Shoulder : 10
2	Shoulders (Earthen)	2-Lane : 2.50		2-Lane : Valley Side 1.0
		2-Lane+Paved Shoulders 12.0		2-Lane+ Paved Shoulders : Valley Side 1.0
3	Formation Width (m)	Intermediate Lane : 10.0 2-Lane : 14.0	2-Lane+Paved Shoulder : 13.0 (inclusive 2X1.5m of Drain/Foot path)	Intermediate Lane: : 10 2-Lane+ Paved Shoulders : 11
4	Camber/ Cross Fall	Bituminous : 2.5% Concrete Pavement : 2.5% Earthen Shoulder : 3.5% (min)	Bituminous :2.5% Concrete Pavement :2.5%	Bituminous: : 2.5% Concrete Pavement : 2.5% Earthen : 3.5% Shoulder : Min
5	Design Speed (km/h)	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 79-2018, are as follows:

Table 6.2: Design Speed Standards

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

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

1.1.3 Levels of Service (LOS)

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

Table 6.3: Standards for Level of Service

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

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

1.1.4 Cross Sectional Elements

1.1.4.1 Roadway Width for Multilane Highways

Adequate roadway width will be provided for the requisite number of traffic lanes besides the shoulders and a central median dividing the traffic flow directions. As specified in the IRC 73-2015, in general, for multilane highways, the shoulder width should be 2.5 m and lane width 3.5 m per lane. Based on a comparative review of international standards and safety, the values proposed to be adopted for the roadway elements by the Consultants for the project highway are as follows:

Table 6.4: Road Cross Section

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

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

1.1.4.2 Lane Width

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

1.1.4.3 Shoulders

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

1.1.4.4 Pavement Camber (Cross-fall)

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

Table 6.5: Provision for Cross-fall

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

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

1.1.4.5 Embankment Slopes

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

1.1.5 Typical Cross-sections

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

1.1.6 Horizontal Alignment

1.1.6.1 General

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

1.1.6.2 Sight Distances

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

Table 6.6: Sight Stopping Distance Criteria

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

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

1.1.6.3 Horizontal Curve

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

Table 6.7: Horizontal Radii Criteria

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

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

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

Table 6.8: Adopted Horizontal Radii

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

1.1.6.4 Transition (Spiral) Curves

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

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

1.1.6.5 Super-elevation

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

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

1.1.7 Vertical Alignment

1.1.7.1 General

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

1.1.7.2 Gradients

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

Table 6.9 : Vertical Gradient

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

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

1.1.7.3 Vertical Curves

As per IRC: SP 73-2018 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
0+000	10+000	10.000	8	20	30	90	250	200

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

HYDROLOGY & DESIGN OF CULVERTS

& BRIDGES

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

Index

1.0 Design Report

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

1.1 Introduction:-

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

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

1.2 Reference documents :-

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

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

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

1.4 Loads:-

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

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

1.5 Load combinations

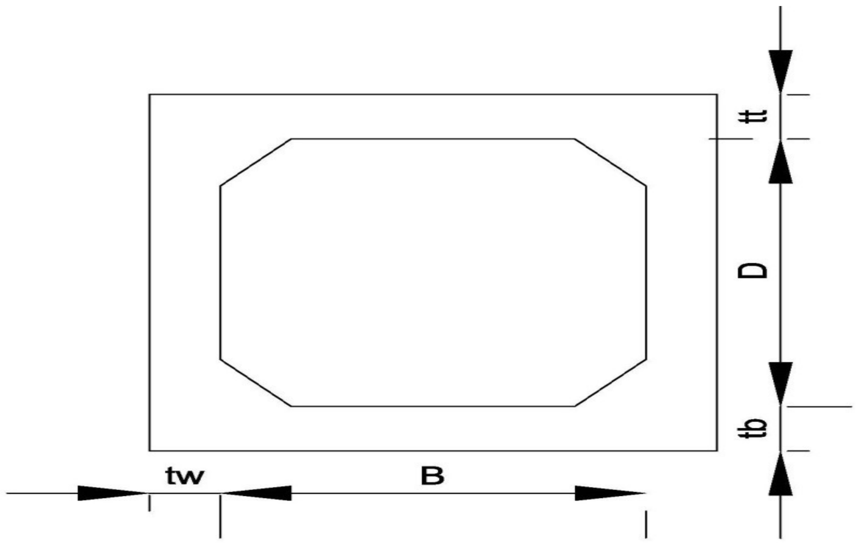
Load combinations as per IRC 6: 2014 have been considered in staad load combination.

1.6 Material properties

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

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

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



2.1 Dimensions of Box

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

SIDL (Top Slab)

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

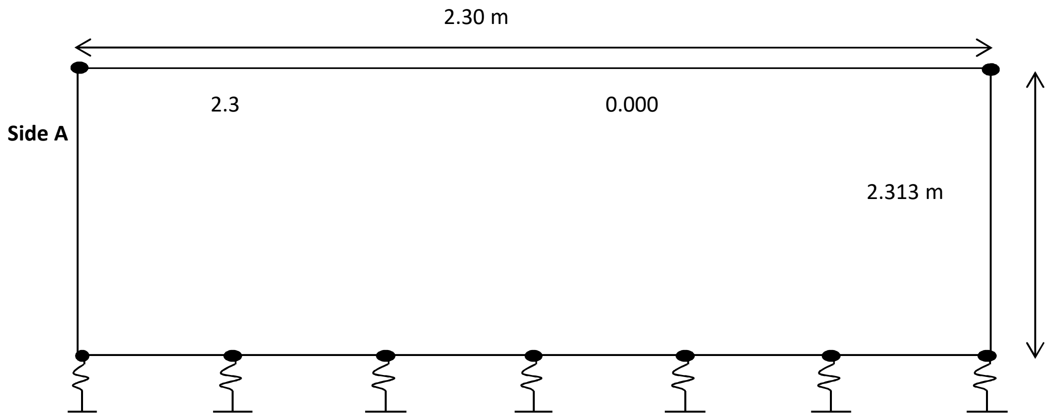
2.2 Basic Parameters

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

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

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



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

3.1 Earth Pressure and Live Load Calculation

1) a Earth Pressure (Normal Condition)

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

1) b Fluid Pressure

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

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

Earth Pressure	**Height**
1.92	0.15
31.50	2.463 m

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

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

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

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

Live Load Surcharge = 5.651 kN/m

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

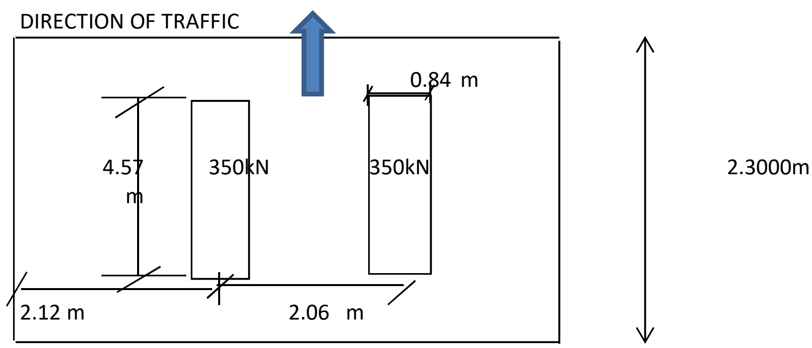
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 13.75 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



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

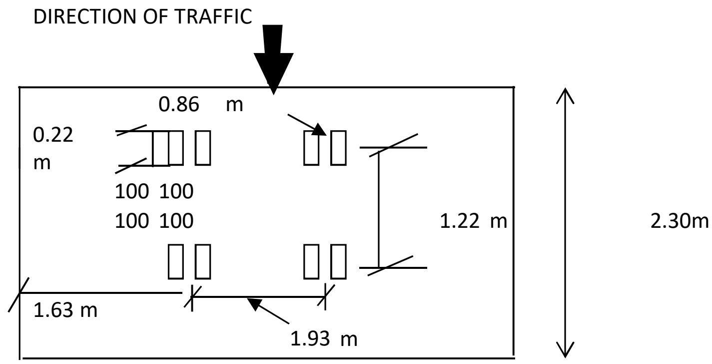
Effective width of Loading

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

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

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

B) 40T Boggie Load at Mid Span



Total Load = 400kN

Effective width of Loading

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

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

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

C) 40T Boggie Load at Support

Effective width of Loading

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

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

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

D) 70R Track at Support

Effective width of Loading

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

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

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

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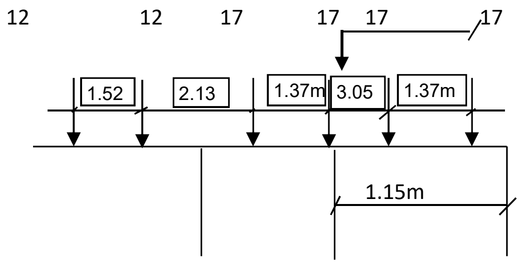
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

Increase due to impact = 42.08 kN/m^2

Say **42.10** kN/m^2

F) 70R Wheel Case 1

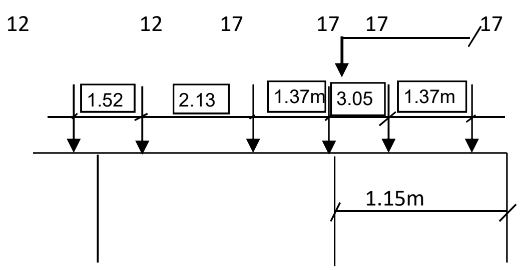


0.86m 1.93m 0.86m

Width along span = 0.970m

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

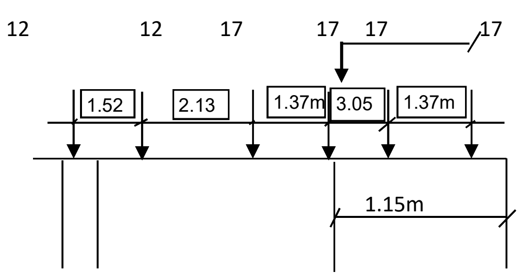
F) 70R Wheel Case 2



Width along span = 0.970m

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

G) 70R Wheel Case 3

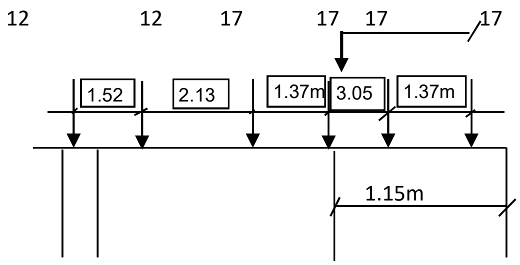


Width along span = 0.970m

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

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**

3.2 Temperature load calculation

Effective Bridge Temperature

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

Effect of temperature gradient

The box has been checked for temperature differential.

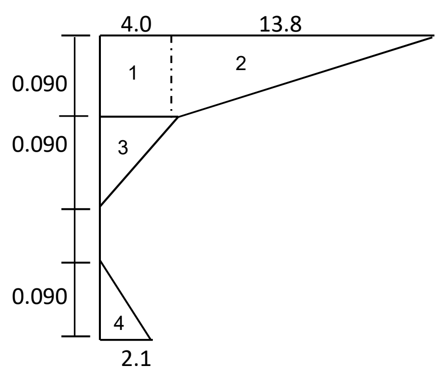
$F = E_c\, aDt\, A$

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

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

Average thickness of Deck slab = 300 mm

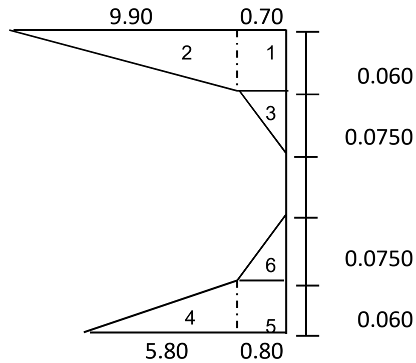
EFFECT OF TEMPERATURE RISE



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	4.0	1.0	0.090	0.090	13.88	0.045 m from top	0.105
2	$\frac{13.8}{2}$	1.0	0.100	0.100	26.60	0.033 m from top	0.117
3	$\frac{4.0}{2}$	1.0	0.090	0.090	6.94	0.120 m from top	0.030
4	$\frac{2.1}{2}$	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	$\frac{9.90}{2}$	1.0	0.060	0.060	11.45	0.020 m from top	0.130
3	$\frac{0.70}{2}$	1.0	0.0750	0.0750	1.01	0.085 m from top	0.065
4	$\frac{5.80}{2}$	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	$\frac{0.80}{2}$	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

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

Partial Safety Factor for Loads

Ultimate Limit State

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

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
(1)	(2)	(3)	(4)	(5)	(4)	(3)
	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect
Permanent Loads:	1.05	0.95	1.00	1.00	1.05	0.95
Dead Load, SIDL except surfacing, Backfill Weight, Settlement, Creep and shrinkage effect						
Surfacing	1.35	1.00	1.00	1.00	1.35	1.00
Earth Pressure due to Backfill	1.50	0.00	1.00	0.00	1.00	0.00
Variable Loads:						
Carriageway Live Load and associated loads (braking, tractive and centrifugal forces) and pedestrian live load:						
a) Leading Load	1.50	0.00	0.75	0.00	0.00	0.00
b) Accompanying Load	1.15	0.00	0.20	0.00	0.20	0.00
c) Construction Live Load	1.35	0.00	1.00	0.00	1.00	0.00
Thermal Loads						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	0.90	0.00	0.50	0.00	0.50	0.00
Wind						
a) As Leading Load	1.50	0.00	0.00	0.00	0.00	0.00
b) As Accompanying Load	0.90	0.00	0.00	0.00	0.00	0.00
Live Load Surcharge (as accompanying load)	1.20	0.00	0.00	0.00	0.00	0.00
Accidental Effects:						
i) Vehicle Collision						
ii) Barge Impact	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 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

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

Serviceability Limit State

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

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

Combination for Base Pressure and Design of Foundation

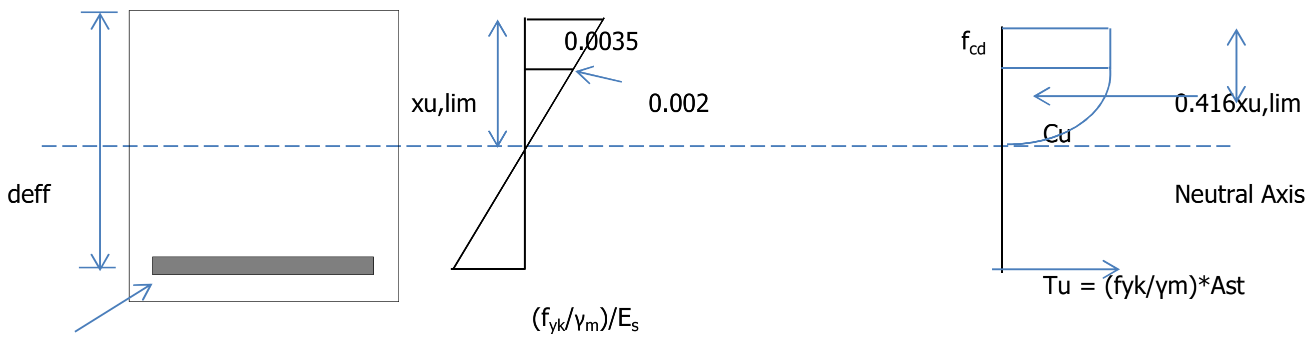
Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

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

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

5.1.1 Verification of structural strength for top slab



Strain Diagram

Stress Diagram

ULTIMATE LIMIT STATE

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

E_c = 31000 MPa

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

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 300 mm

Clear cover = 50

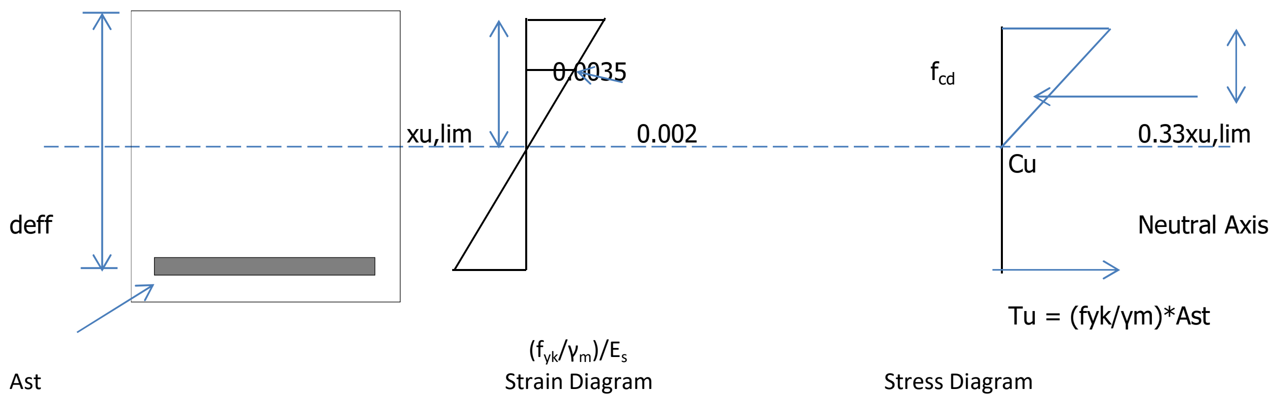
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

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

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

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

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

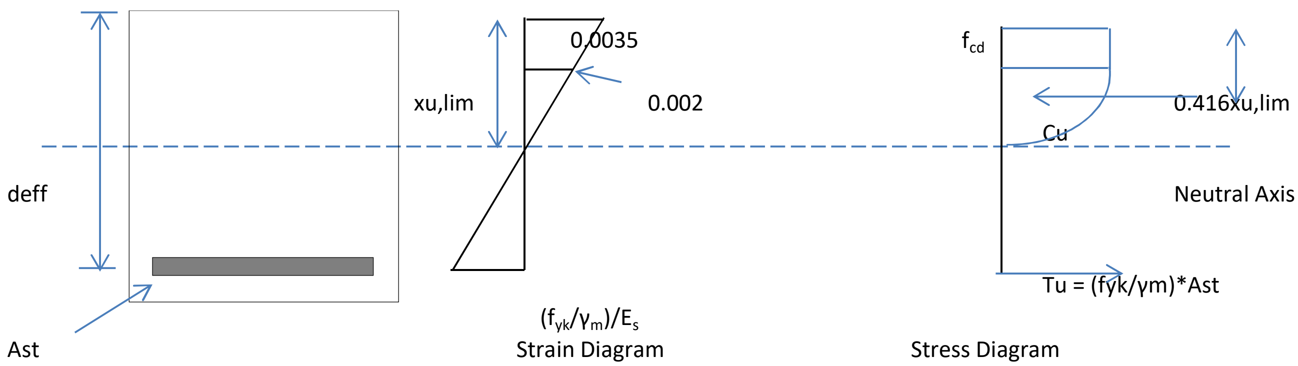
Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	243.0		243.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}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

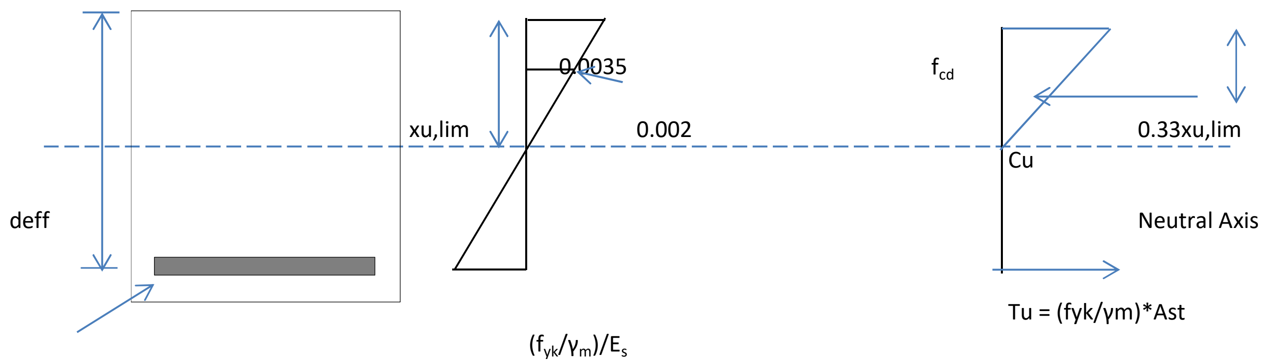
Clear cover at bott. = 75 Clear cover at top = 40

	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**

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

5.2.2 Verification for serviceability limit state for bottom slab



Ast
Strain Diagram
Stress Diagram

<u>SERVICEABILITY LIMIT STATE</u>

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

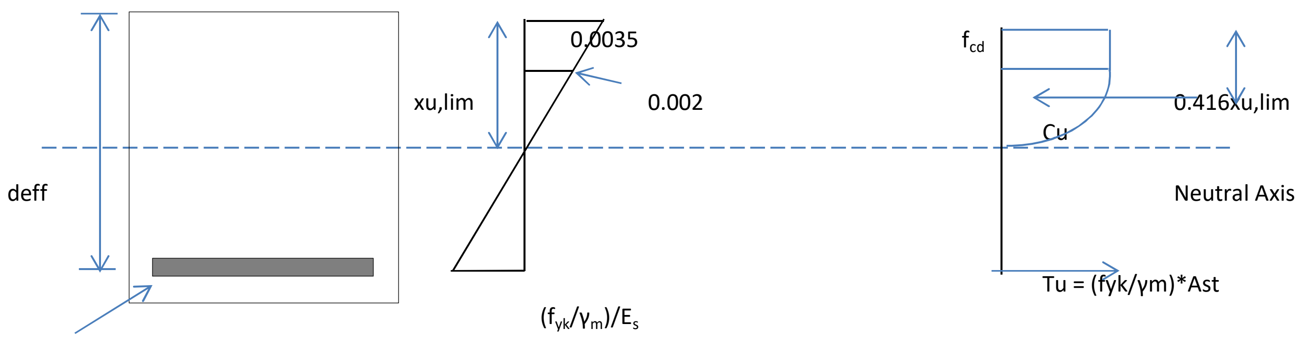
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	65.0		15.0	43		6
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}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



Strain Diagram

Stress Diagram

ULTIMATE LIMIT STATE

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

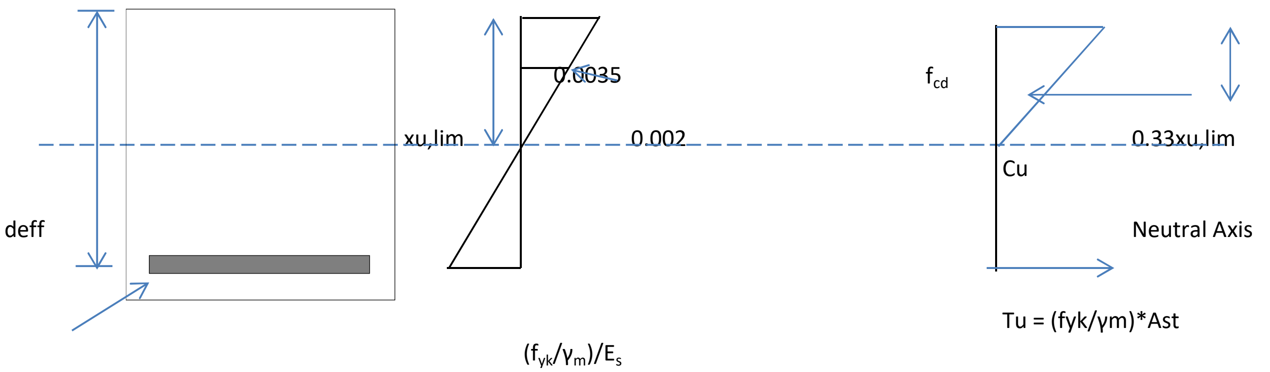
Calculation of Reinforcement

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

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

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

5.3.2 Verification for serviceability limit state for outer wall



Ast — Strain Diagram — Stress Diagram

SERVICEABILITY LIMIT STATE

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

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 = 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

	Project	0		KB
	Client	0		0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2		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	10	11	21	21	21	21	21	21	21	21	14	203	78
300	12	12	24	24	24	24	24	25	25	25	13	232	89

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

Bearing capacity = 100 KN/sqm

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

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

Index

1.0 Design Report

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

1.1 Introduction:-

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

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

1.2 Reference documents :-

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

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

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

1.4 Loads:-

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

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

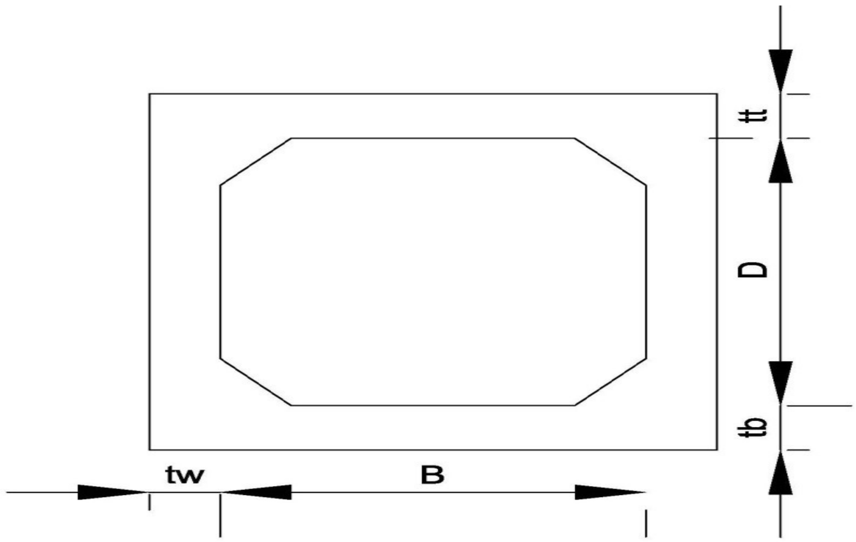
1.5 Load combinations

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

1.6 Material properties

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

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



2.1 Dimensions of Box

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

SIDL (Top Slab)

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

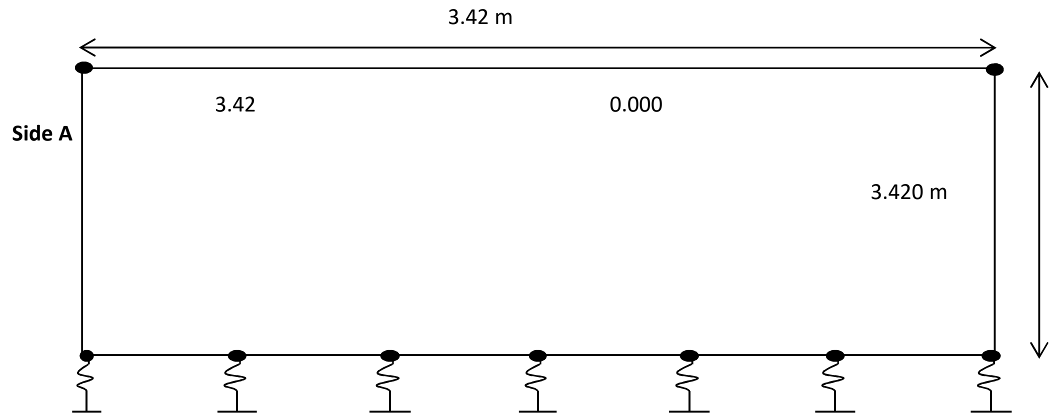
2.2 Basic Parameters

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

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

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



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

3.1 Earth Pressure and Live Load Calculation

1) a Earth Pressure (Normal Condition)

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

1) b Fluid Pressure

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

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

Earth Pressure	Height
2.69	0.21
46.43	3.630 m

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

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

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

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

Live Load Surcharge = 5.651 kN/m

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

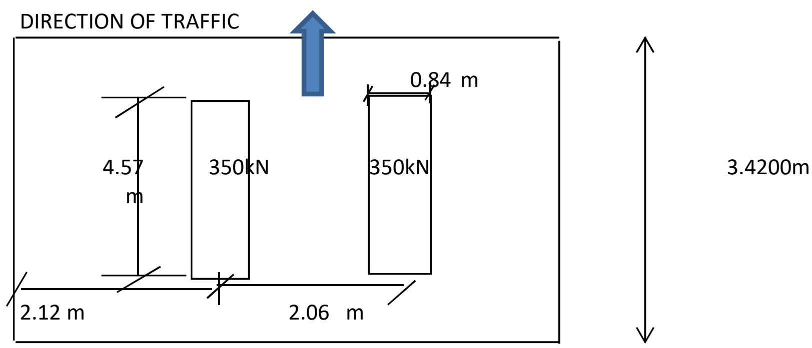
Live Load Surcharge = 12.000 kN/m

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

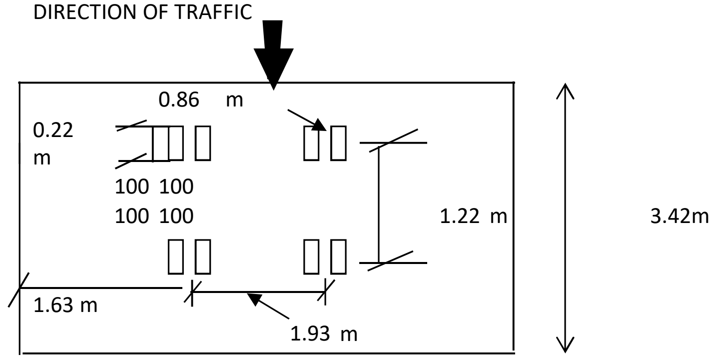
a	=	1.71	m
b1	=	0.99	m
b/lo	=	3.51	
a	=	2.60	
beff	=	3.21	m

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

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

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

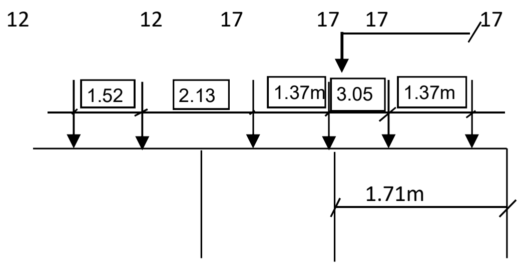
2.06<3.21 ***Therefore overlapping due to load dispersion occurs***

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

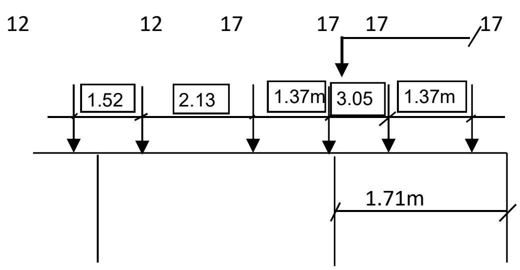


0.86m 1.93m 0.86m

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

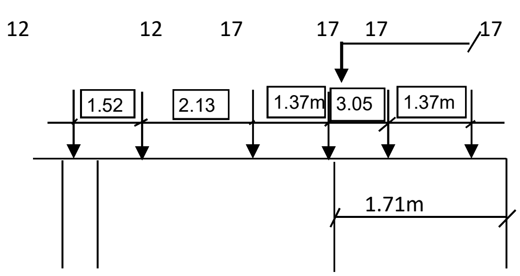
F) 70R Wheel Case 2



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

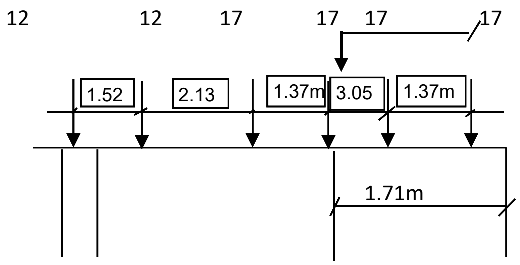


Width along span = 1.210m

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

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

H) 70R Wheel Case 4



Width along span = 1.210m

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

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

3.2 Temperature load calculation

Effective Bridge Temperature

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

Effect of temperature gradient

The box has been checked for temperature differential.

F = E_c aDt A

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

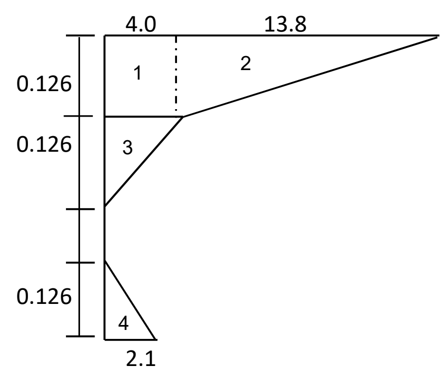
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 420 mm

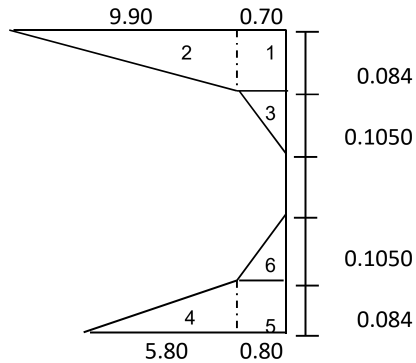
EFFECT OF TEMPERATURE RISE



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	4.0	1.0	0.126	0.126	19.43	0.063 m from top	0.147
2	$\frac{13.8}{2}$	1.0	0.126	0.126	33.52	0.042 m from top	0.168
3	$\frac{4.0}{2}$	1.0	0.126	0.126	9.72	0.168 m from top	0.042
4	$\frac{2.1}{2}$	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	$\frac{9.90}{2}$	1.0	0.084	0.084	16.03	0.028 m from top	0.182
3	$\frac{0.70}{2}$	1.0	0.1050	0.1050	1.42	0.119 m from top	0.091
4	$\frac{5.80}{2}$	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	$\frac{0.80}{2}$	1.0	0.1050	0.1050	1.62	0.119 m from bottom	-0.091
				SF =	33.32	M =	1.136

3.3 Summary of factored moments

Grade of Concrete = M30

Grade of Steel = Fe500

Summary of factored moments

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

4.0 Partial Safety Factors

Material Parameters

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

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

Partial Safety Factor for Materials

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

	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

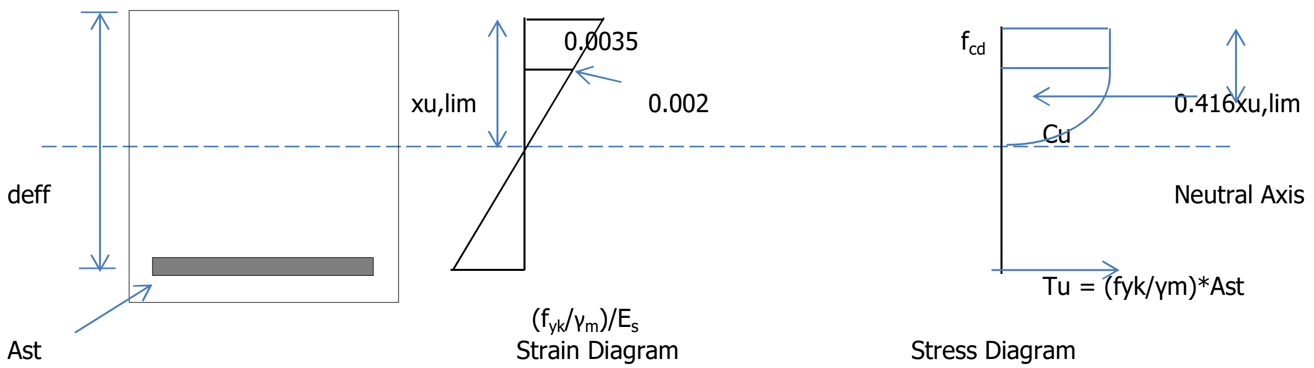
Table 3.4, Annex B, IRC:6-2014

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



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

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

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

Clear cover = 50

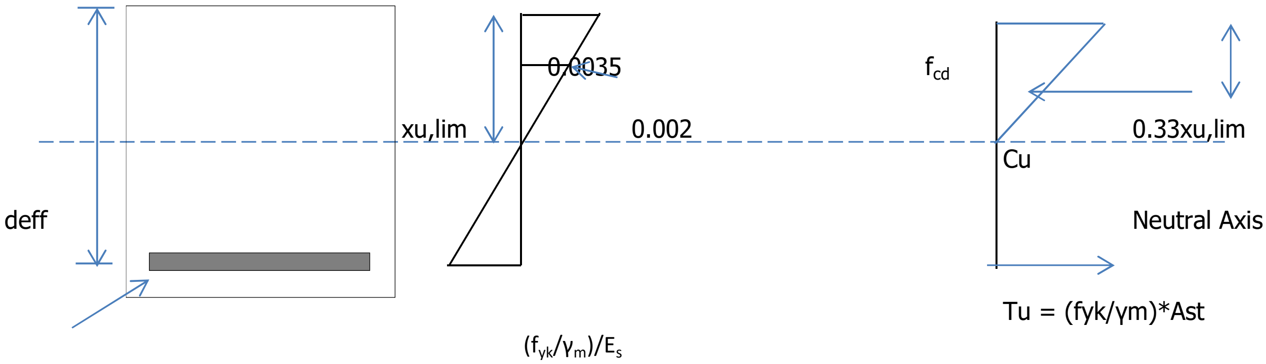
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

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

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

Shear on the section	**Top slab Top End support**		
Actual shear V_{Ed} (KN)	44.0		
Actual shear stress (N/mm2)	0.139		
Max shear capacity, 0.135 fck(1-fck/310)	3.7		
	OK.		
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		
$\Theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.754		
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$n_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.394		
cl. 10.3.1 of IRC :112-2011			
$r1 = A_{sl}/(b_w\ d) <= 0.02$	0.004		
	OK		
$0.12\ K\ (80\ r1\ f_{ck})^{0.33}$	0.454		
Axial compressive force N_{Ed} (KN)	0		
$s_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.0		
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (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		
$S = Asw \times 0.9 \times d \times \cot\Theta \times fy / V_E$	1247		
A_{SW}	452		
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011			
$S_{l.max} = 0.75\ d$	264		
Spacing provided in Long. Direction (mm)	**264.0**		
cl. 16.5.2(9) Eq. 16.8 of IRC :112-2011			
$S_{t.max} = 0.75\ d <= 600mm$	264		
Spacing provided in Trans. Direction,$S_{t.}$ mm	**150**		
	OK		

5.1.2 Verification for serviceability limit state for top slab



Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

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

As per clause 12.2.1, IRC:112-2011

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

As per clause 12.2.2, IRC:112-2011

Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	300	N/mm^2	For Rare Combination
	f_{Yd}	=	300	N/mm^2	For Frequent Combination
	f_{Yd}	=	300	N/mm^2	For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

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

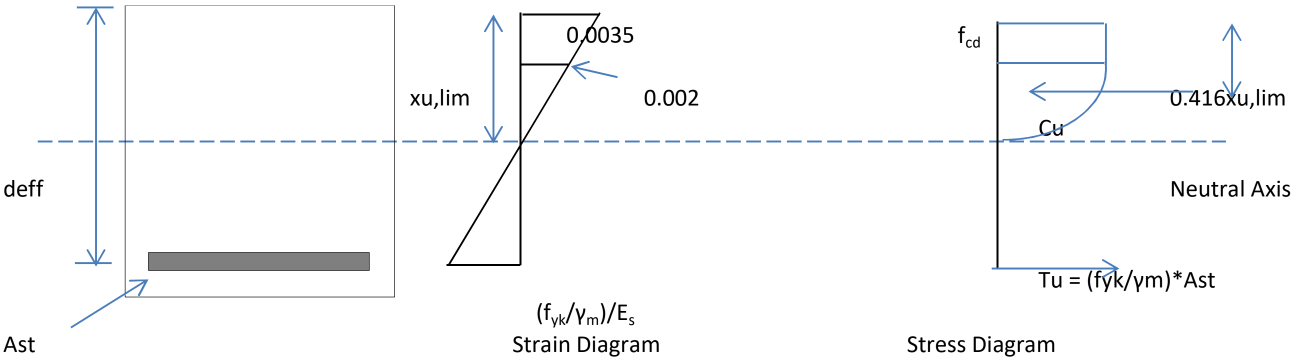
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

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

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

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

5.2.1 Verification of structural strength for bottom slab



ULTIMATE LIMIT STATE

Grade of Concrete	f_{ck}	=	30	N/mm^2	
As per clause 6.4.2.8, IRC:112-2011					
	f_{cd}	=	13.40	N/mm^2	Combination (1)
	f_{cd}	=	16.75	N/mm^2	Accidental Combi.
	f_{cd}	=	13.40	N/mm^2	Combination (2)
E_c		=	31000	MPa	
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	435	N/mm^2	Combination (1)
	f_{Yd}	=	500	N/mm^2	Accidental Combi.
	f_{Yd}	=	435	N/mm^2	Combination (2)

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

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

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

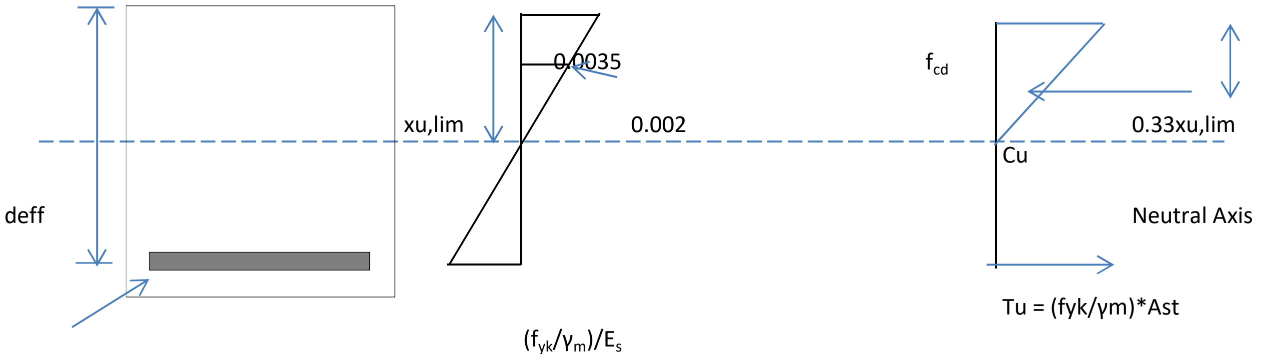
Moment on the section	Bottom End support			Top Mid Span		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	130.0		107.0	111.0		93.0
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435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

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

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

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

5.2.2 Verification for serviceability limit state for bottom slab



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 = 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

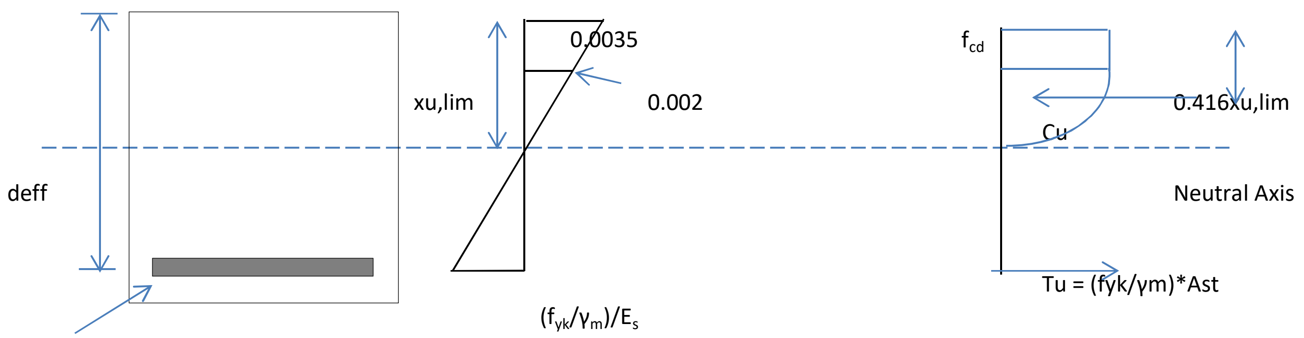
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	91.0		28.0	77		24
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}	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



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*(3/7xu$_{,lim}$ + 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

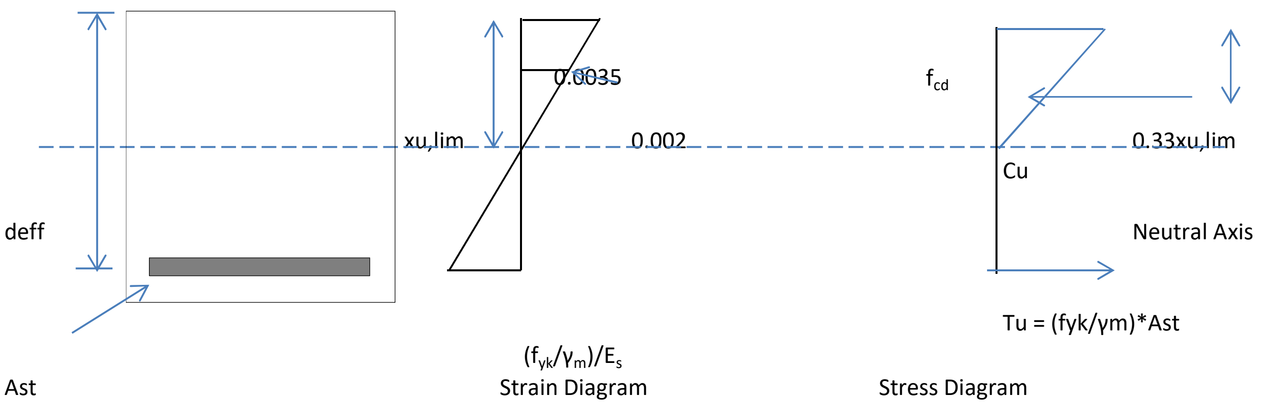
Clear cover = 75

	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

				Required
At top of Mid Span				
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

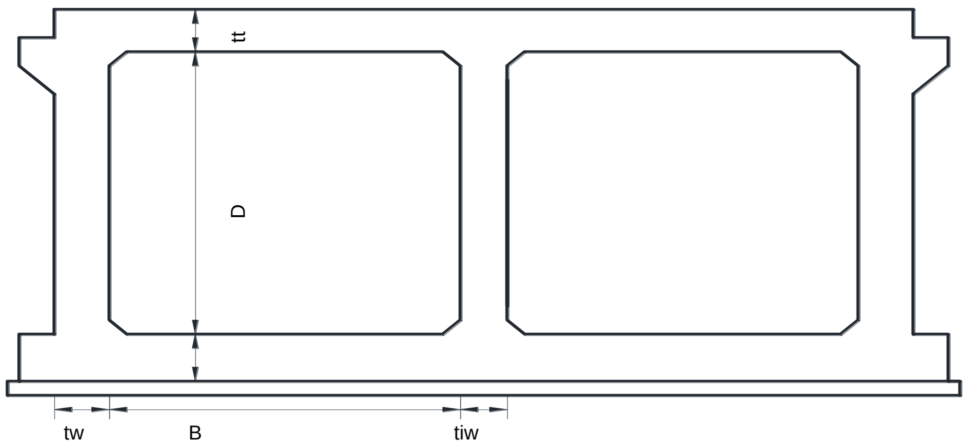
Load combinations as per IRC 6: 2017 have been considered in staad load combination.

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

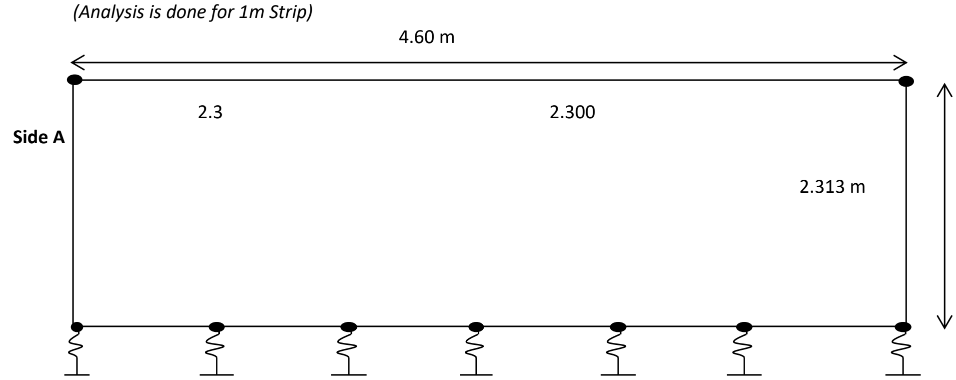
2.2 Basic Parameters

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

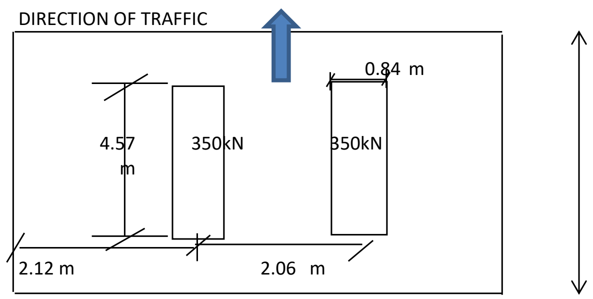
Live Load Surcharge = 12.000 kN/m

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		

<u>**Effective width of Loading**</u>

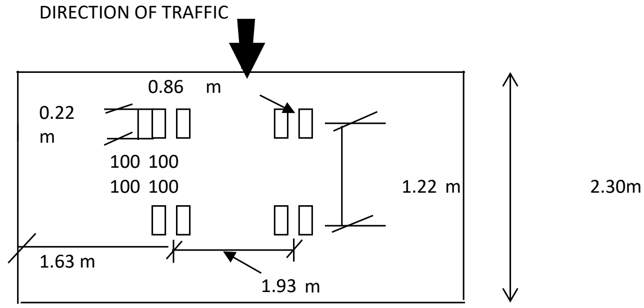
a	=	1.15 m
b1	=	0.99 m
b/lo	=	5.22
a	=	2.60
beff	=	2.49 m

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

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

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

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

	Project	-	Designed by:	KB
	Client	-	Checked by:	-
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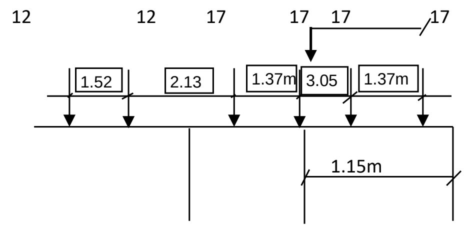
F) 70R Wheel Case 1 (at support)



9.44
10.66

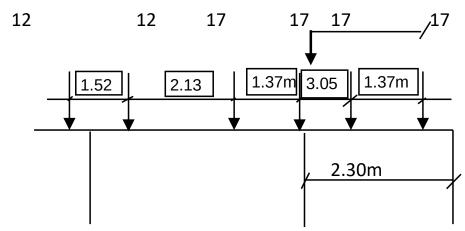
0.86m 1.93m 0.86m

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

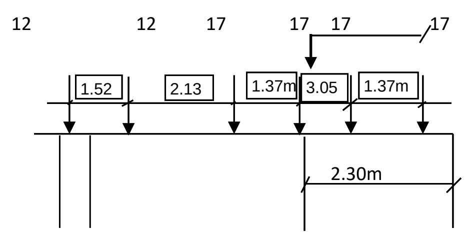
F) 70R Wheel Case 2 (at mid)



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

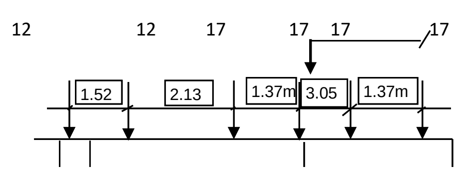
G) 70R Wheel Case 3 (outerwall)



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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2.30m

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

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**

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	/°C (as per Annexure F of IRC:6-2017)
Mean of max and min temperature	=	23.85	/°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

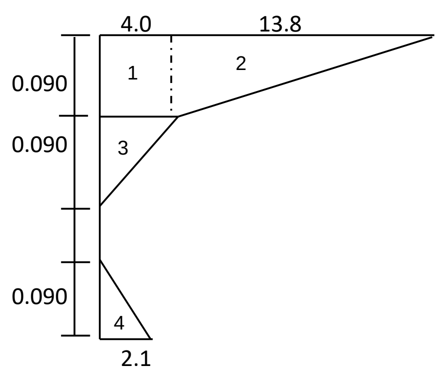
a = Coefficient of Thermal expansion = 1.20E-05 /°C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 300 mm

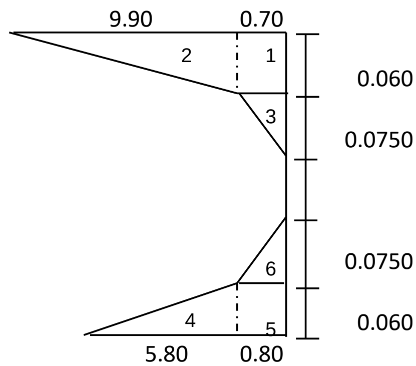
EFFECT OF TEMPERATURE RISE



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

	Project	-	Designed by:	KB
	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	0.030m 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

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

Partial Safety Factor for Loads

Ultimate Limit State

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

Also refer IRC Amendment dated 28th July, 2012

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

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

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

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

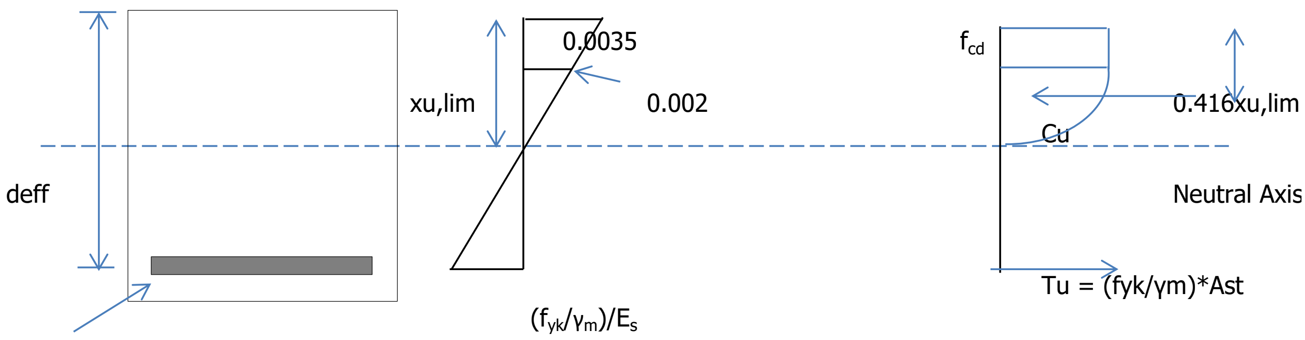
Table 3.4, Annex B, IRC:6-2014

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



Strain Diagram

Stress Diagram

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.	-

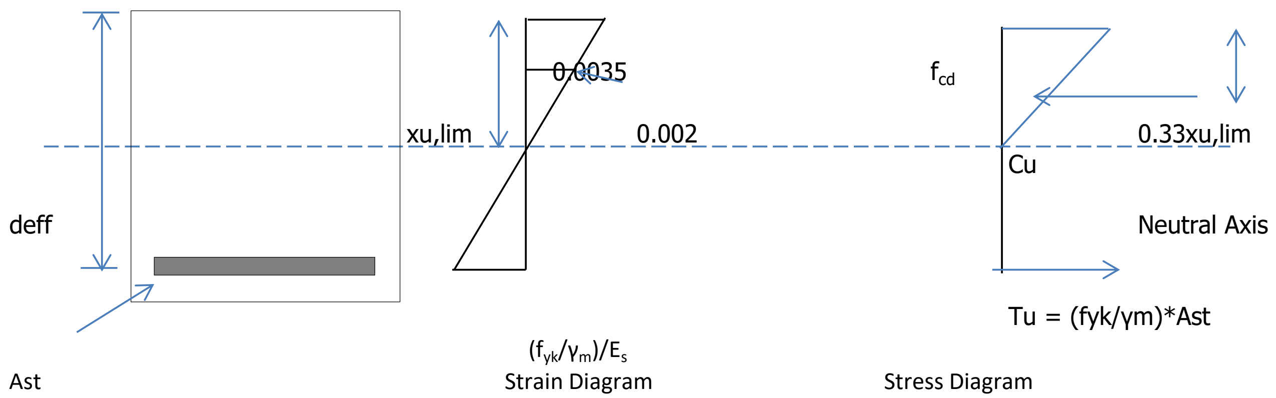
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	57.0			48.3		
b	1000			1000		
D	300			300		
c	50			50		
d	232.0			232.0		
f_{cd}	15.63			15.63		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	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		
$\Theta = 0.5 \times \sin^{-1}$ (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			
$n_{min} = 0.031 K^{3/2} fck^{1/2}$	0.491		
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			
$V_{Rd.c} = [0.12K(80\rho1 f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15 s_{cp}) b_w d$ (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



<u>SERVICEABILITY LIMIT STATE</u>

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.	-

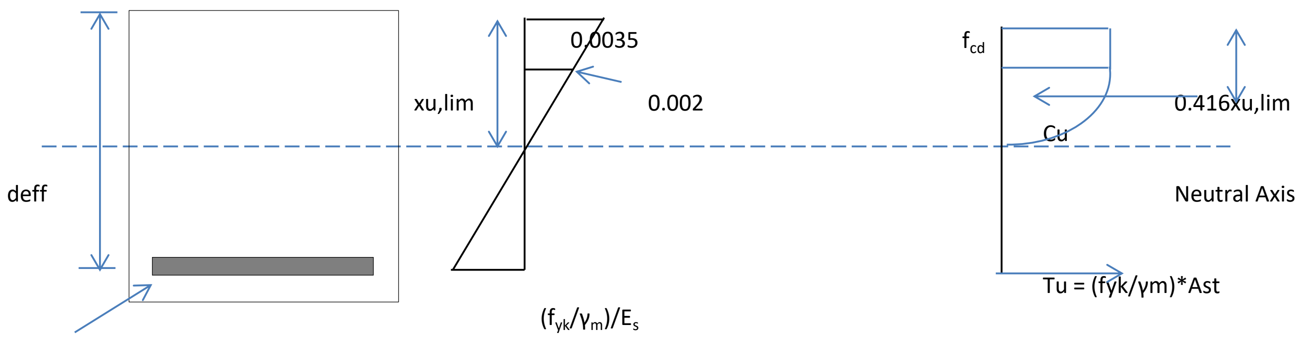
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	242.0		242.0
f_{cd}	16.80		12.60	16.80		12.60
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



Strain Diagram

Stress Diagram

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 $\quad E_c =$ 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 = 325 mm

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

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

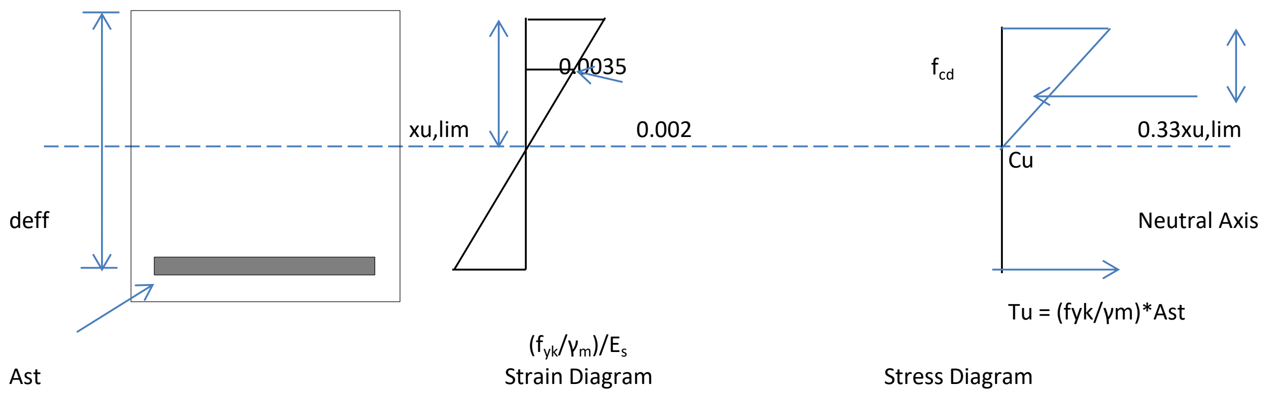
Moment on the section	**Bottom End support**			**Top Mid Span**		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	86.0		80.0	65.0		58.0
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	267.0		267.0
f_{cd}	15.63		15.63	15.63		15.63
f_{Yd}	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			
$V_{Rd.c} = [0.12K(80\rho1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (n_{min} + 0.15\ s_{cp})\ b_w\ d$ (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.	-

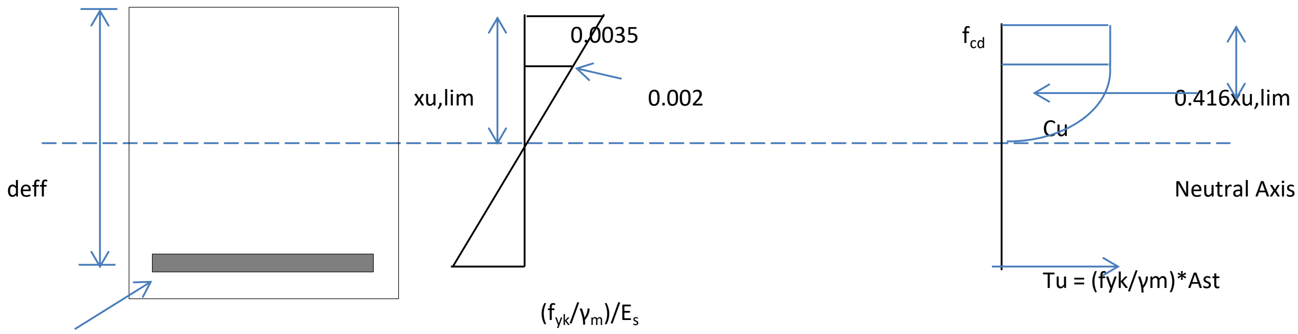
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	65.0		15.0	43		6
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	267.0		267.0
f_{cd}	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**

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

5.3.1 Verification of structural strength for outer wall



Strain Diagram

Stress Diagram

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

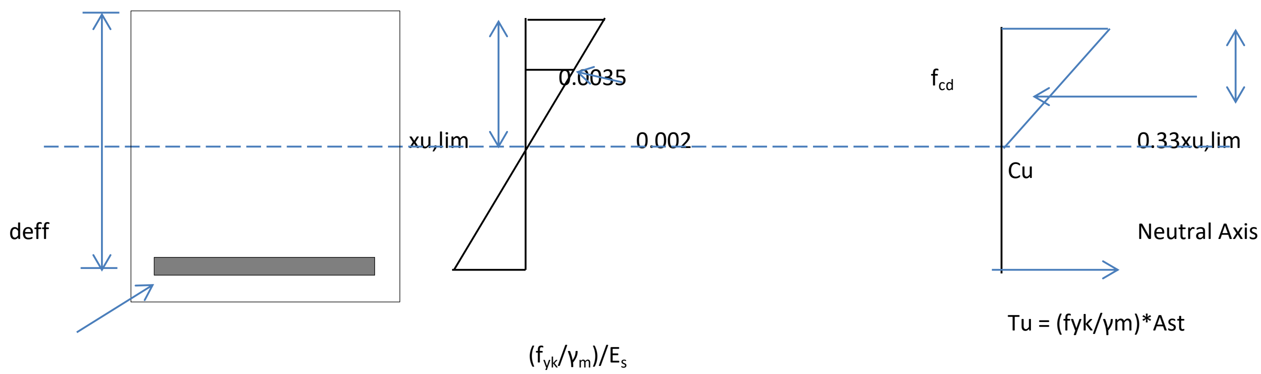
Clear cover = 75

	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**		

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

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

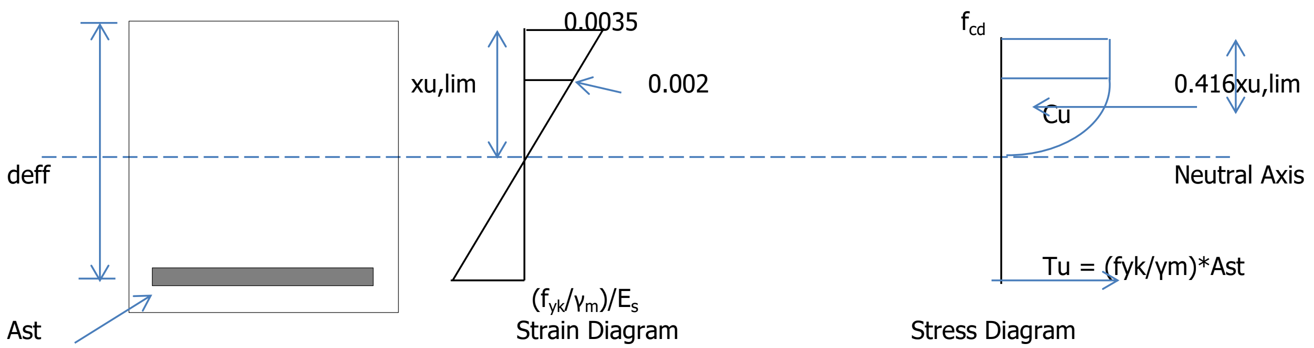
	Project	-	Designed by	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

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



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*(3/7xu,$_{lim}$ + 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

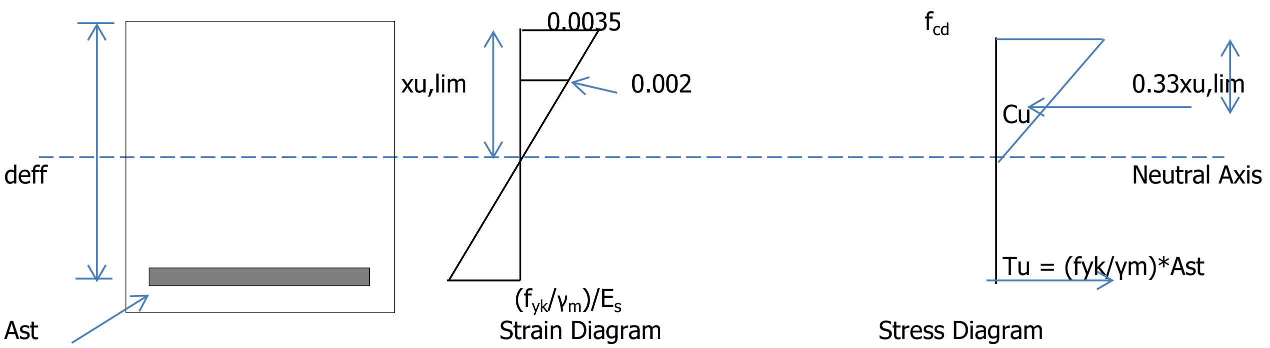
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

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
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	1.925
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

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**

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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**

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

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

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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
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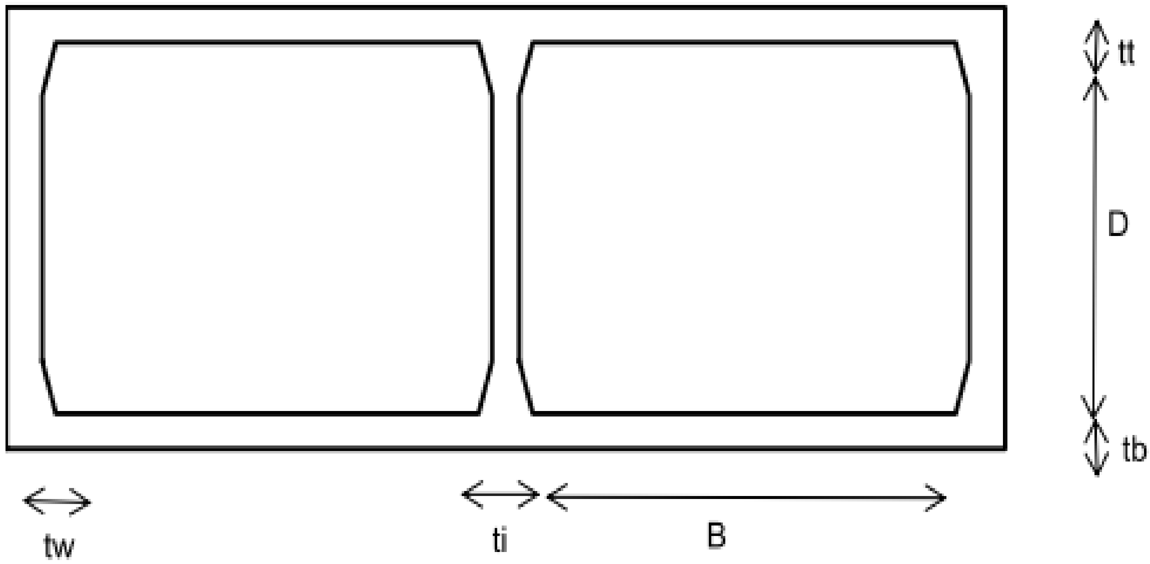
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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



2.1 Dimensions of Box

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

SIDL (Top Slab)

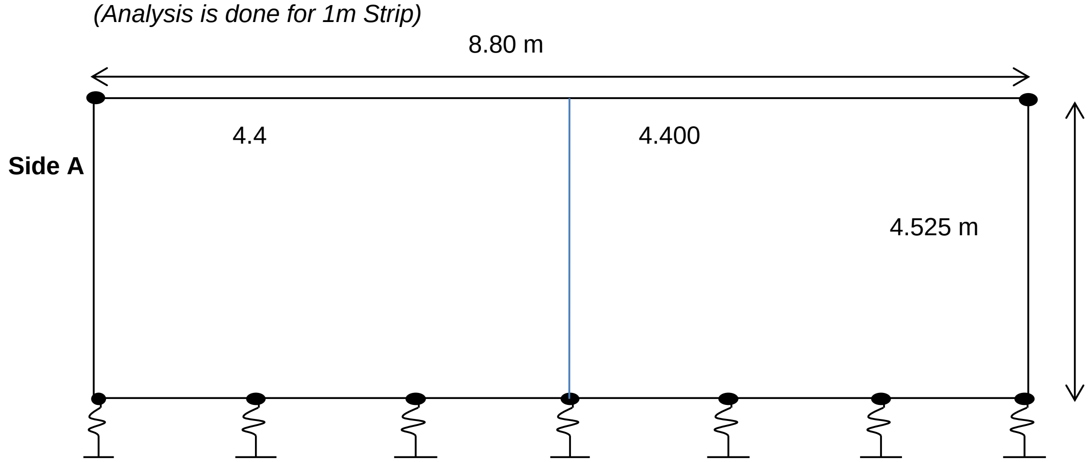
Crash barrier	=		1	kN/m^2
Due to earth fill	=	0 x20 =	0	kN/m^2
			1	kN/m^2
Due to wearing coat	=	0.075 x 22 =	1.65	kN/m^2

2.2 Basic Parameters

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

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



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

3.1 Earth Pressure and Live Load Calculation

1) a Earth Pressure (Normal Condition)

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

1) b Fluid Pressure

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

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

Earth Pressure	**Height**
3.20	0.25
61.07	4.775 m

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

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

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

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

Live Load Surcharge = 5.651 kN/m

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 29.00 kN/m^2

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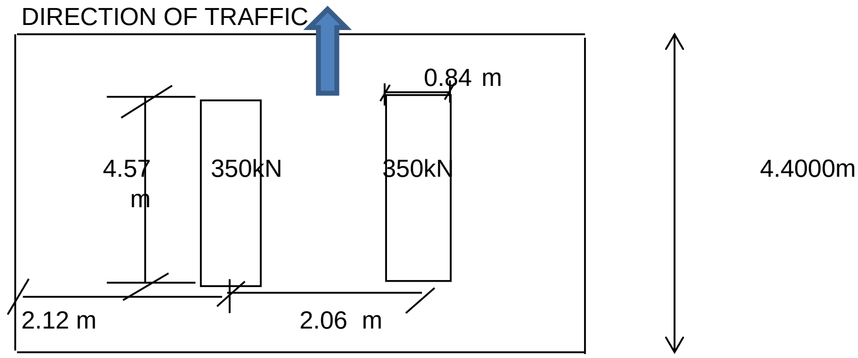
3) Live Load on Top Slab

A) 70R Track at Mid Span



Total Load = **700kN**

674.0 KN

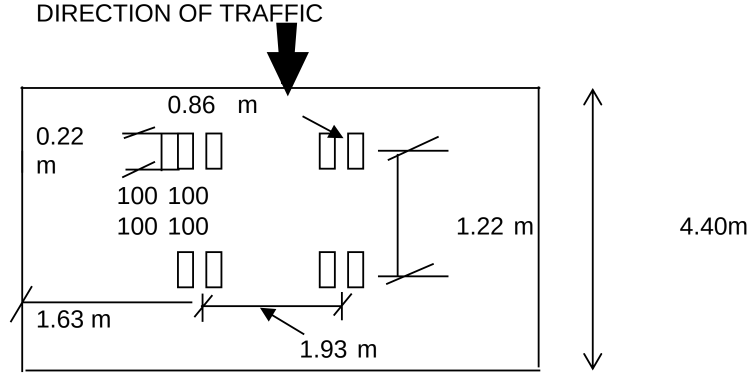
Effective width of Loading

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

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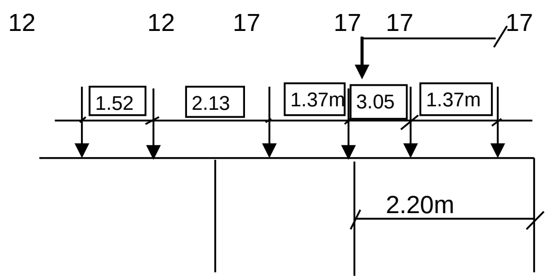
E) 70R Track at int side wall

<u>Effective width of Loading</u>

a		1.14	m
b1		0.99	m
b/lo		3.64	
a		2.60	
beff		3.19	m
2.06<3.19	***Therefore overlapping due to load dispersion occurs***		

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

F) 70R Wheel Case 1

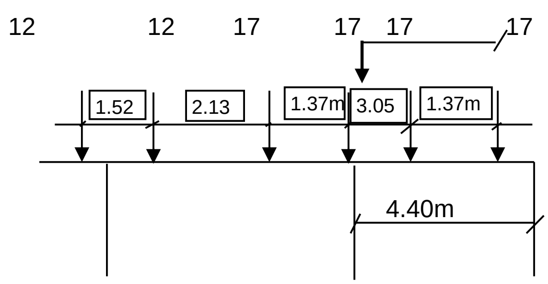


0.86m 1.93m 0.86m

Width along span = 1.370m

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

F) 70R Wheel Case 2



Width along span = 1.370m

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

	Project	-	Designed by:	KB
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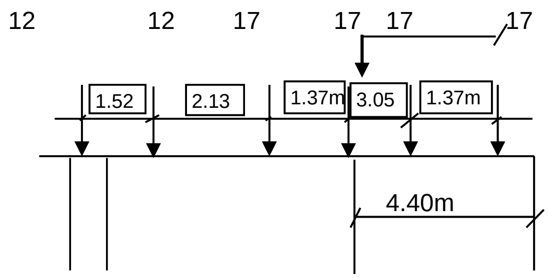
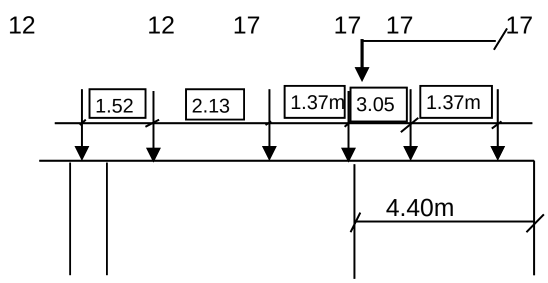
G) 70R Wheel Case 3



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

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

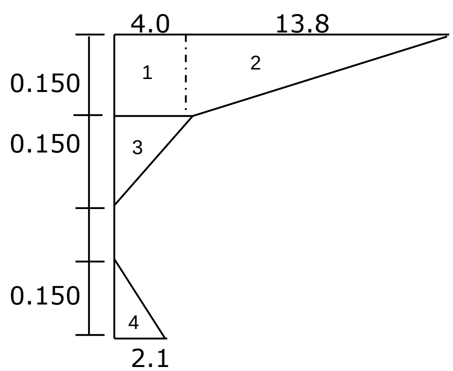
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

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	$\frac{13.8}{2}$	1.0	0.150	0.150	39.91	0.050 m from top	0.200
3	$\frac{4.0}{2}$	1.0	0.150	0.150	11.57	0.200 m from top	0.050
4	$\frac{2.1}{2}$	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
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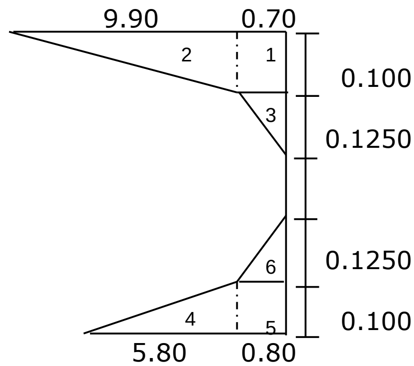
EFFECT OF TEMPERATURE FALL



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

3.3 Staad input file (Without Fluid Pressure)

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

6 4.4 0 0
7 8.8 0 0

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

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

```
*************************************
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)**

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

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
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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

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

LOAD COMBINATION 214 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 21 1.15 25 0.9 27 0.9
LOAD COMBINATION 215 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 22 1.15 25 0.9 27 0.9
LOAD COMBINATION 216 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 23 1.15 25 0.9 27 0.9
LOAD COMBINATION 217 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 24 1.15 25 0.9 27 0.9
LOAD COMBINATION 218 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 18 1.15 26 0.9 28 0.9
LOAD COMBINATION 219 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 19 1.15 26 0.9 28 0.9
LOAD COMBINATION 220 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 20 1.15 26 0.9 28 0.9
LOAD COMBINATION 221 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 21 1.15 26 0.9 28 0.9
LOAD COMBINATION 222 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 22 1.15 26 0.9 28 0.9
LOAD COMBINATION 223 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 23 1.15 26 0.9 28 0.9
LOAD COMBINATION 224 EARTH PRESSURE AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1.5 10 1.5 11 1.2 12 1.2 17 1 24 1.15 26 0.9 28 0.9
LOAD COMBINATION 225 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 18 1.5 25 0.9 27 0.9
LOAD COMBINATION 226 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 19 1.5 25 0.9 27 0.9
LOAD COMBINATION 227 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 20 1.5 25 0.9 27 0.9
LOAD COMBINATION 228 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 21 1.5 25 0.9 27 0.9
LOAD COMBINATION 229 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 22 1.5 25 0.9 27 0.9
LOAD COMBINATION 230 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 23 1.5 25 0.9 27 0.9
LOAD COMBINATION 231 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 24 1.5 25 0.9 27 0.9
LOAD COMBINATION 232 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 18 1.5 26 0.9 28 0.9
LOAD COMBINATION 233 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 19 1.5 26 0.9 28 0.9
LOAD COMBINATION 234 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 20 1.5 26 0.9 28 0.9
LOAD COMBINATION 235 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 21 1.5 26 0.9 28 0.9
LOAD COMBINATION 236 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 22 1.5 26 0.9 28 0.9
LOAD COMBINATION 237 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 23 1.5 26 0.9 28 0.9
LOAD COMBINATION 238 LIVE LOAD AS LEADING LOAD
2 1.35 3 1.35 4 1.75 9 1 10 1 11 1.2 12 1.2 17 1 24 1.5 26 0.9 28 0.9
***Combination for Base Pressure and Design of Foundation (Combination 2)**
LOAD COMBINATION 239 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 18 1 25 0.8 27 0.8
LOAD COMBINATION 240 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 19 1 25 0.8 27 0.8
LOAD COMBINATION 241 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 20 1 25 0.8 27 0.8
LOAD COMBINATION 242 EARTH PRESSURE AS LEADING LOAD

1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 21 1 25 0.8 27 0.8
LOAD COMBINATION 243 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 22 1 25 0.8 27 0.8
LOAD COMBINATION 244 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 23 1 25 0.8 27 0.8
LOAD COMBINATION 245 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 24 1 25 0.8 27 0.8
LOAD COMBINATION 246 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 18 1 26 0.8 28 0.8
LOAD COMBINATION 247 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 19 1 26 0.8 28 0.8
LOAD COMBINATION 248 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 20 1 26 0.8 28 0.8
LOAD COMBINATION 249 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 21 1 26 0.8 28 0.8
LOAD COMBINATION 250 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 22 1 26 0.8 28 0.8
LOAD COMBINATION 251 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 23 1 26 0.8 28 0.8
LOAD COMBINATION 252 EARTH PRESSURE AS LEADING LOAD
1 1 3 1 4 1 5 1.3 6 1.3 7 1 8 1 24 1 26 0.8 28 0.8
LOAD COMBINATION 253 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 18 1.3 25 0.8 27 0.8
LOAD COMBINATION 254 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 19 1.3 25 0.8 27 0.8
LOAD COMBINATION 255 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 20 1.3 25 0.8 27 0.8
LOAD COMBINATION 256 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 21 1.3 25 0.8 27 0.8
LOAD COMBINATION 257 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 22 1.3 25 0.8 27 0.8
LOAD COMBINATION 258 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 23 1.3 25 0.8 27 0.8
LOAD COMBINATION 259 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 24 1.3 25 0.8 27 0.8
LOAD COMBINATION 260 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 18 1.3 26 0.8 28 0.8
LOAD COMBINATION 261 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 19 1.3 26 0.8 28 0.8
LOAD COMBINATION 262 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 20 1.3 26 0.8 28 0.8
LOAD COMBINATION 263 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 21 1.3 26 0.8 28 0.8
LOAD COMBINATION 264 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 22 1.3 26 0.8 28 0.8
LOAD COMBINATION 265 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 23 1.3 26 0.8 28 0.8
LOAD COMBINATION 266 LIVE LOAD AS LEADING LOAD
1 1 3 1 4 1 5 0.8 6 0.8 7 1 8 1 24 1.3 26 0.8 28 0.8

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

LOAD COMBINATION 267 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 18 1 25 0.8 27 0.8
LOAD COMBINATION 268 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 19 1 25 0.8 27 0.8
LOAD COMBINATION 269 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 20 1 25 0.8 27 0.8
LOAD COMBINATION 270 EARTH PRESSURE AS LEADING LOAD
2 1 3 1 4 1 9 1.3 10 1.3 11 1 12 1 17 1 21 1 25 0.8 27 0.8

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

3.4 Summary of factored moments

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

4.0 Partial Safety Factors

Material Parameters

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

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

Partial Safety Factor for Materials

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

Partial Safety Factor for Loads

Ultimate Limit State

Partial Safety for Verification of Structural Strength   Table 3.1, Annex B, IRC:6-2014
Also refer IRC Amendment dated 28th July, 2012

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

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

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

Serviceability Limit State

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

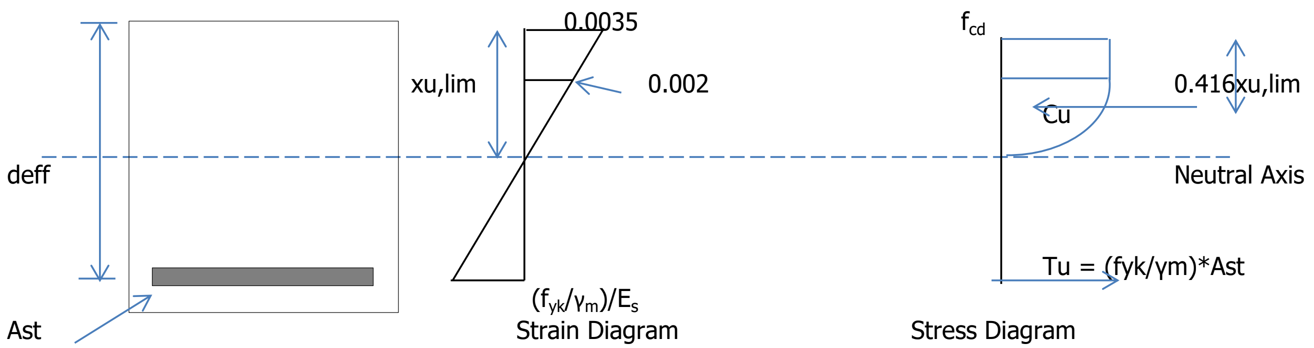
Loads	Partial Safety Factor		
	Rare Combination	Frequent Combination	Quasi-permanent
(1)	(2)	(3)	(4)
Permanent Loads:			
Dead Load	1.00	1.00	1.00
SIDL including surfacing	1.00	1.00	1.00
Backfill Weight	1.00	1.00	1.00
Shrinkage and Creep Effects	1.00	1.00	1.00
Earth Pressure due to Backfill	1.00	1.00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

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

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

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

5.1.1 Verification of structural strength for top slab



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	=	40	

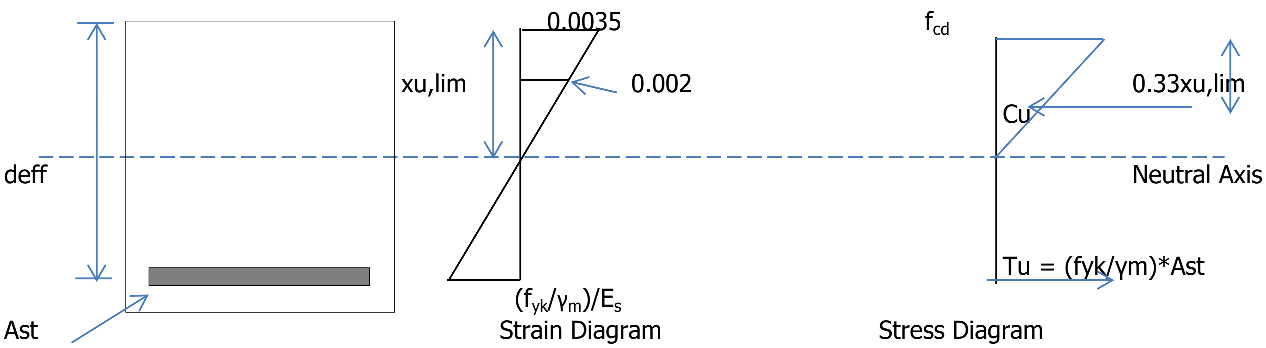
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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.	-

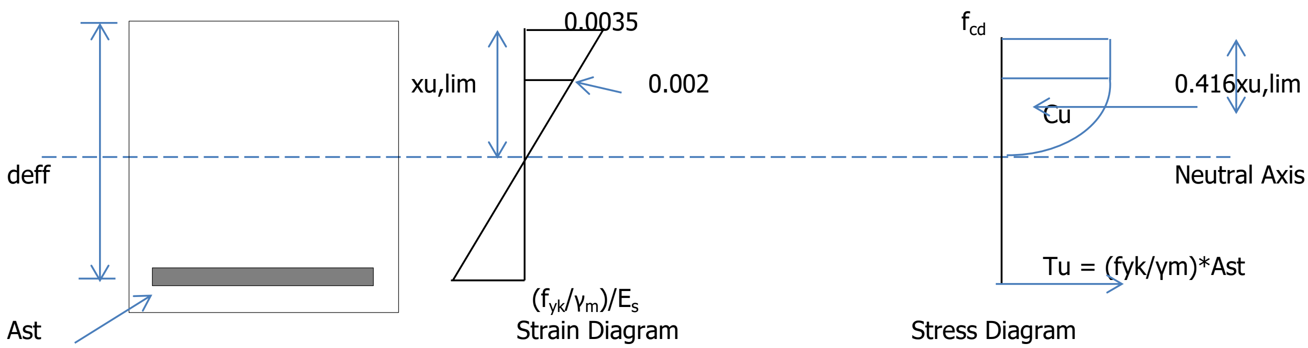
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	128.0		52.2	55.3		11
b	1000		1000	1000		1000
D	500		500	500		500
c	40		40	40		40
d	442.0		442.0	442.0		442.0
f_{cd}	14.40		10.80	14.40		10.80
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



ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 550 mm

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

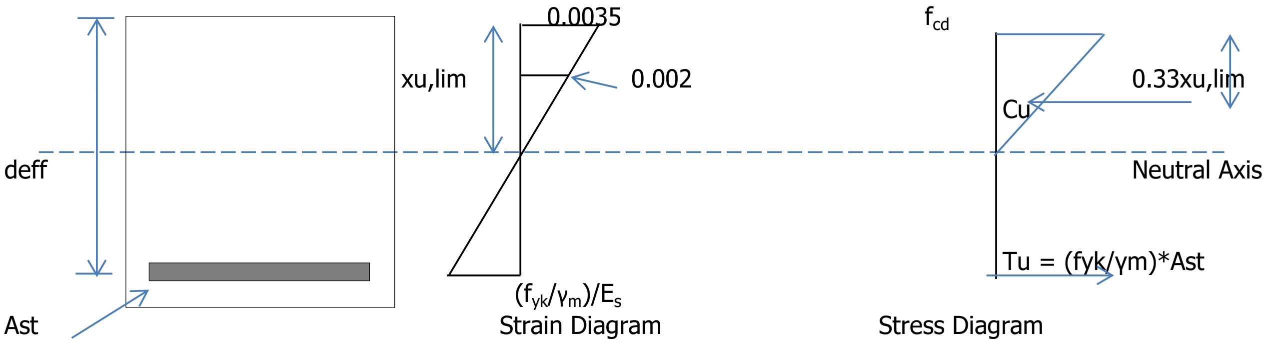
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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

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

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

5.2.2 Verification for serviceability limit state for bottom slab



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 = 550 mm

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

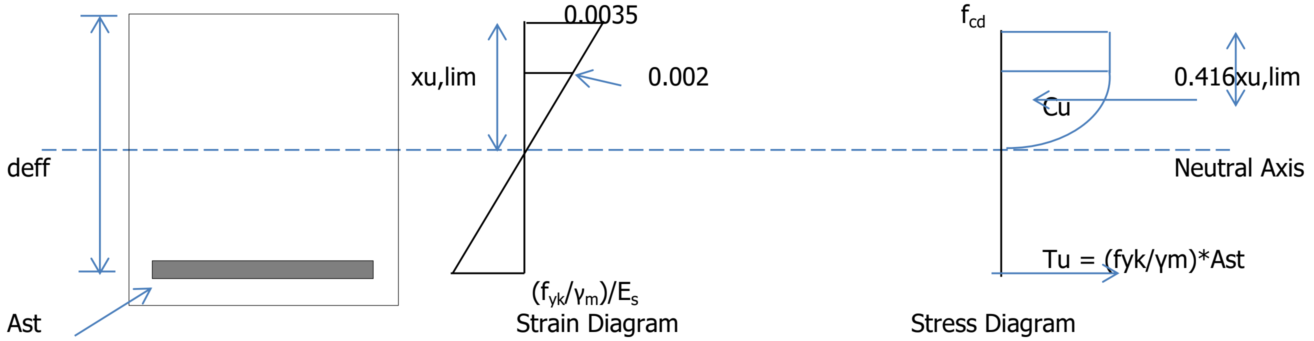
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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



Strain Diagram

Stress Diagram

ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

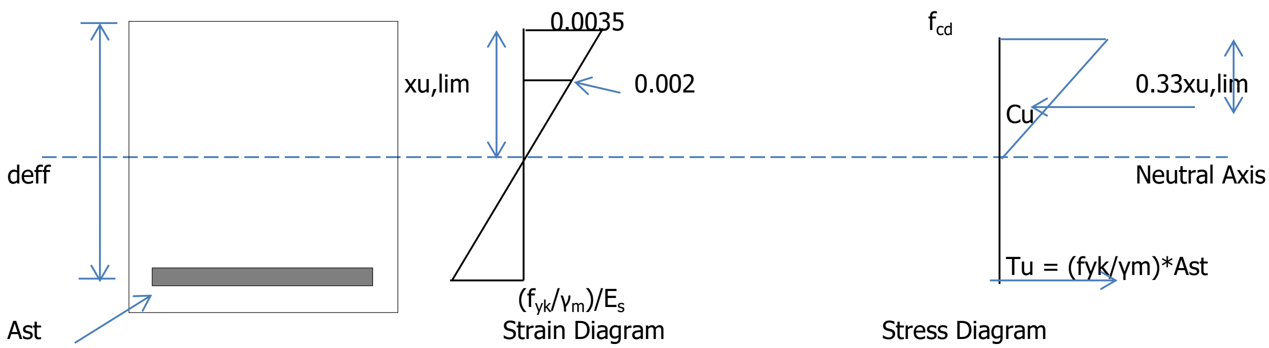
Depth of section D = 500 mm

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

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 = 75

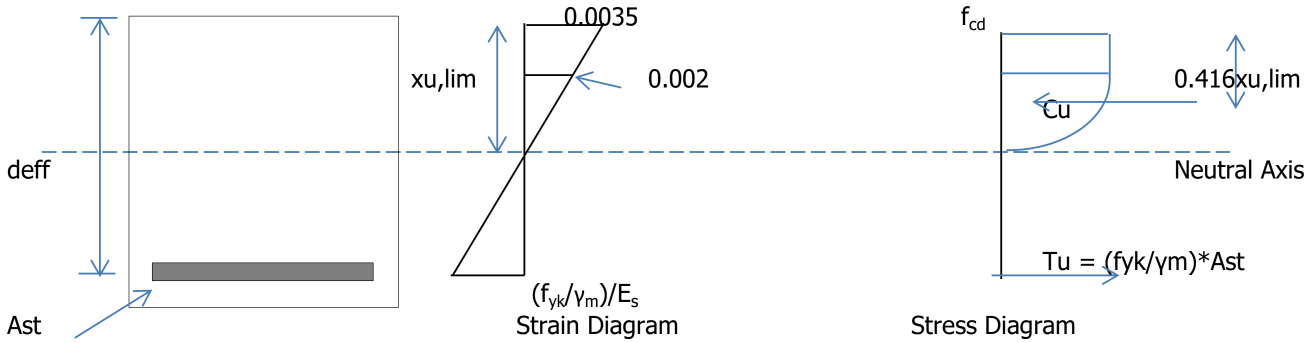
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 4.0 x 4.0	Date & Rev.	-

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



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 $\quad$ 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

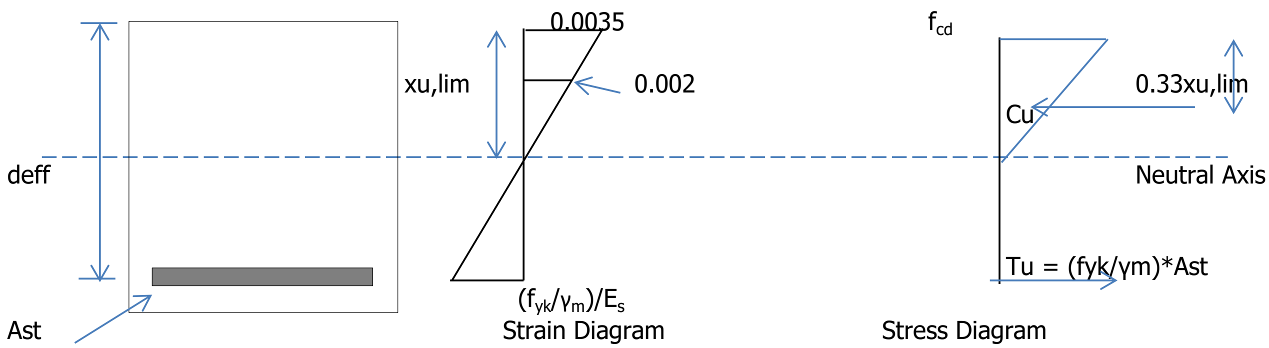
Calculation of Reinforcement

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

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 40

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

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

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

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

6.0 Summary of provided Reinforcement

Top Slab

At top of Mid Span

Area of Steel Provided = 392.7 mm^2/m

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

At bottom of Mid Span

Area of Steel Provided = 1005.3 mm^2/m

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

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

At top of End Support

Area of Steel Provided = 1398.0 mm^2/m

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

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

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

At bottom of End Support

Area of Steel Provided = 1005.3 mm^2/m

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

0mm dia @ 200mmc/c

Bottom Slab

At top of Mid Span

Area of Steel Provided = 1005.3 mm^2/m

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

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

At bottom of Mid Span

Area of Steel Provided = 392.7 mm^2/m

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

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

At top of End Support

Area of Steel Provided = 1005.3 mm^2/m

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

0mm dia @ 200mmc/c

At bottom of End Support

Area of Steel Provided = 1398.0 mm^2/m

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

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

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

Outer Wall

At outer face of top end

Area of Steel Provided			=	1398.0 mm^2/m	
16mm dia	@	200mmc/c	Outer wall (Outer main reinforcement)		
10mm dia	@	200mmc/c	Top slab (Top main reinforcement)		OK
0mm dia	@	200mmc/c	Top corner extra reinforcement		

At inner face of top end

Area of Steel Required			=	608.5 mm^2/m	
Area of Steel Provided			=	1570.8 mm^2/m	
20mm dia	@	200mmc/c	Outer wall (Inner main reinforcement)		OK

At outer face of bottom end

Area of Steel Provided			=	1398.0 mm^2/m	
10mm dia	@	200mmc/c	Bottom slab (Bottom main reinforcement)		
16mm dia	@	200mmc/c	Outer wall (Outer main reinforcement)		OK
0mm dia	@	200mmc/c	Bottom corner extra reinforcement		

At inner face of bottom end

Area of Steel Provided			=	1570.8 mm^2/m	
20mm dia	@	200mmc/c	Outer wall (Inner main reinforcement)		

Inner Wall

Area of Steel Provided			=	1005.3 mm^2/m	
16mm dia	@	200mmc/c	Inner wall (main reinforcement)		
0mm dia	@	200mmc/c	Inner wall (main reinforcement)		OK

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

Top Slab

Req. Reinforcement				=	330 mm^2/m	
Provided Reinforcement				=		
	10mm dia	@	200mmc/c		392.7 mm^2/m	OK

Bottom Slab

Req. Reinforcement				=	367.8 mm^2/m	
Provided Reinforcement				=		
	10mm dia	@	200mmc/c		392.7 mm^2/m	OK

Outer Wall

Req. Reinforcement				=	304.2 mm^2/m	
Provided Reinforcement				=		
	10mm dia	@	200mmc/c		392.7 mm^2/m	OK

Inner Wall

Reinforcement Required				=	180.9 mm^2/m	
Provided Reinforcement				=		
	10mm dia	@	200mmc/c		392.7 mm^2/m	OK

7.0 Base Pressure

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

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

Bearing capacity = 220 KN/sqm

HYDROLOGICAL ANALYSIS FOR MINOR BRIDGE AT CHAINAGE 2+220

PEAK DISCHARGE COMPUTATION BY DIFFERENT METHODS

Sr.No	Bridge Name	Existing Chainage	Proposed Chainage	Discharge (Cumecs)			
				By Dicken method	By Area velocity Method	By Rational Method	Design Discharge (Cumecs)
1	Minor Bridge		2+220	60.249	58.60	57.11	85.66

ABSTRACT OF HYDROLOGICAL AND HYDRAULIC CALCULATIONS

Sr. No	Bridge Name	Existing Chainage	Proposed Chainage	Design Discharge (cumecs)	Design HFL (m)	Velocity (m/s)	Avg. depth (m)	LBL (m)	Proposed FRL	Vertical clearance Required (m)	Proposed Water way (m)	Proposed Soffit Level (m)	Silt Factor	Scour Depth level of Abutment
1	Minor Bridge	0	2+220	85.66	1069.393	3.7	21.26	1068.46	1089.718	0.9	24.00	1070.293	2	1065.950

DICKEN METHOD

Existing Chainage (km)	0
Name of bridge/stream :	Minor Bridge
Proposed Chainage (Km)	2+220

Catchment Area, A	7	Sq.Km
Normal Annual Rainfall	112	cm
C	14	(As per Cl 4.2, IRC SP:13-2004)
Q	**$CxA^{0.75}$**	
Q	**60.25**	Cumecs

Existing Chainage	-	0
Proposed Chainage	-	2+220

FLOOD ESTIMATION

By Rational Method :

Area of catchment, A	=	7.000	km^2	=	700	Hectares
Length of longest stream, L	=	1.720	km			
The fall in level between source and site, H	=	30.0	m			
Co-efficient of Runoff, P	=	0.20		Sandy Soil		
Point Rainfall Intensity (50year - 24hr)	=	34	cm	Plate 11		
Conversion factor (50year - 1hr)	=	0.320		Table 2		
50 years, 1 hour Rainfall, I_o	=	10.88	cm / hr			
f - curve	=	0.99				

Concentration time, t_c

t_c = $(0.87 \times L^3 / H)^{0.385}$

= 0.4787 hours

Critical Intensity of Rainfall, I_c

I_c = $I_o (2 / t_c+1)$

= 14.72 cm / hr

Runoff, Q_d

Q_d = $0.028 \times P \times f \times A \times I_c$

= **57.109** m^3 / sec

HYDRAULIC DESIGN REPORT FOR MINOR BRIDGE AT PROPOSED DESIGN CH: 15+700

Details of the bridge:

General details:			
Span arrangements	=	1 x 25.0	m x m
Clear Opening per span	=	24	m
No of span	=	1	nos.
Wearing coat	=	75	mm
Carriageway width	=	11.5	m
Overall width	=	16	m
Drainage spout	=	As per Specifications	

Levels

Proposed FRL	=	**1089.718**	m
Depth of water (Depth of flow abtained from local enquiry)	=	21.26	m
Lowest Bed Level	=	1068.460	m

Structural Details

No. of Intermediate walls	=	0	nos.
Type of abutment	=	RCC Wall Type	
Type of deck arrangement	=	Slab	
Depth of slab	=	0.25	m
Cross slope	=	2	%

Design discharge:

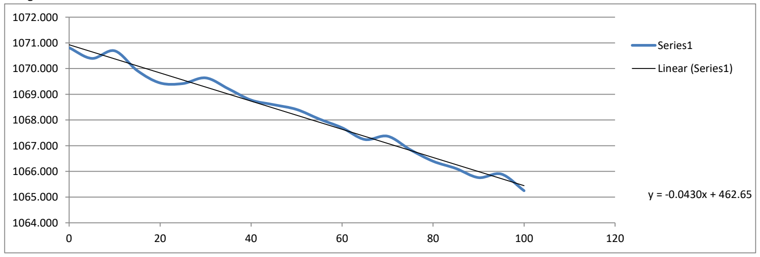
a **By area velocity method based on Manning's Formula**

Calculation of longitudinal slope

Longitudinal slope has been calculated by fitting an equation to the longitudinal section of river bed to find bed slope by using Microsoft Excel program.

x	y		
0	1070.812		
5	1070.396		
10	1070.692		
15	1069.918		
20	1069.441		
25	1069.418		
30	1069.639		
35	1069.214		
40	1068.775		
45	1068.594		
50	1068.410		
55	1068.036		
60	1067.696		
65	1067.241		
70	1067.369		
75	1066.842		
80	1066.395		
85	1066.115		
90	1065.758		
95	1065.896		
100	1065.248	5.56	0.05564

Longitudinal Section of River



Hence, Longitudinal slope (s)	=	0.055640
The longitudinal bed slope is 1 in		18.0

Calculation of flood discharge at different cross sections

Flood discharge Q = A*V

where, A is area of cross section in sq m

V is the velocity of water in m/sec considered uniform throughout cross section

V = $(1/n)*(S)^{1/2}*(R)^{2/3}$

where, R is the hydraulic mean depth = A/P

S is the energy slope which may be taken as bed slope measured reasonably long stretch

n is co-efficient of roughness

P is wetted perimeter in m

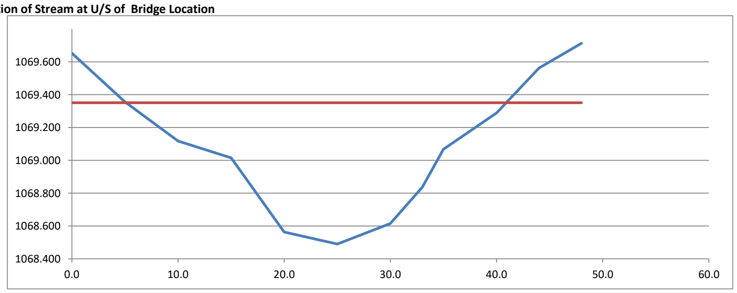
i) Calculation of flood discharge through cross section at U/s stream of river **50.0M**

HFL = **1069.351** m

Distance (m)	Bed level (m)	Mean bed level b/w adjacent pt. Z(m)	Depth of water from HFL to LBL	Mean depth of water b/w adjacent pt. "D" in meter	Distance "X" in meter	Section at area "X D". In Sqm	X*Z	Difference in level b/w adjacent point "Y"(in m)	X2	Y2	Wetted Perimeter = SQRT (X2+Y2)
0.0	1069.653										
5.0	1069.356	1069.505	0.000	0.000	5.000	0.000	5347.52	0.114	25.00	0.013	0.000
10.0	1069.118	1069.237	0.114	0.057	5.000	0.285	5346.19	0.171	25.00	0.029	5.003
15.0	1069.015	1069.067	0.285	0.199	5.000	0.996	5345.33	0.277	25.00	0.077	5.008
20.0	1068.563	1068.789	0.562	0.423	5.000	2.116	5343.95	0.263	25.00	0.069	5.007
25.0	1068.490	1068.527	0.825	0.693	5.000	3.466	5342.63	-0.026	25.00	0.001	5.000
30.0	1068.615	1068.553	0.799	0.812	5.000	4.058	5342.76	-0.173	25.00	0.030	5.003
33.0	1068.836	1068.726	0.626	0.712	3.000	2.136	3206.18	-0.226	9.00	0.051	3.009
35.0	1069.068	1068.952	0.399	0.512	2.000	1.025	2137.90	-0.226	4.00	0.051	2.013
40.0	1069.289	1069.179	0.173	0.286	5.000	1.429	5345.89	-0.173	25.00	0.030	5.003
44.0	1069.562	1069.426	0.000	0.086	4.000	0.345	4277.70	0.000	16.00	0.000	4.000
48.0	1069.713	1069.638	0.000	0.000	4.000	0.000	4278.55	0.000	16.00	0.000	0.000
Total Area						15.856		Total Perimeter			39.045

∑ X*Z 51314.605

Cross Section of Stream at U/S of Bridge Location



Discharge, Q = A * V Cumecs

where A = Area m^2

V = Velocity m/sec

From Manning's formula we have V = $(1/n) \times S^{(1/2)} \times R^{(2/3)}$

where n = Rugosity coefficient

R = Hydraulic mean radius

S = Longitudinal Slope

Referring SP 13. Table 5.1 for section with clean, straight bank, full stage, no rifts or deep pools but some weeds and stones

n = 0.035

Hydraulic Mean Radius, R = Wetted Area/Wetted Perimeter

R = A/P

R = 0.406 m

Longitudinal Slope, S = 0.05564

Velocity, V=$(1/n)*(S)^{1/2}*(R)^{2/3}$ = 3.70 m/sec

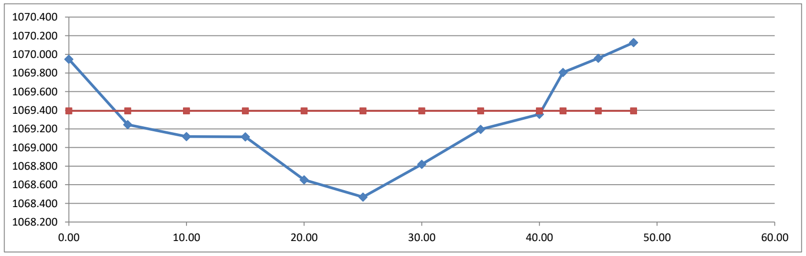
Discharge, Q= A*V = 58.60 Cumecs

ii) Calculation of flood discharge through cross section at bridge location **7m**

HFL = 1069.393 m

Distance (m)	Bed level (m)	Mean bed level b/w adjacent pt. Z(m)	Depth of water from HFL to LBL	Mean depth of water b/w adjacent pt. "D" in meter	Distance "X" in meter	Section at area "X D". In Sqm	X*Z	Difference in level b/w adjacent point "Y"(in m)	X2	Y2	Wetted Perimeter = SQRT (X2+Y2)
0.00	1069.947										
5.00	1069.246	1069.597	0.000	0.000	5	0.000	5347.983	0.211	25	0.045	0.000
10.00	1069.117	1069.182	0.211	0.106	5	0.529	5345.908	0.066	25	0.004	5.000
15.00	1069.115	1069.116	0.277	0.244	5	1.221	5345.580	0.232	25	0.054	5.005
20.00	1068.653	1068.884	0.509	0.393	5	1.965	5344.420	0.323	25	0.105	5.010
25.00	1068.468	1068.561	0.832	0.671	5	3.354	5342.803	-0.083	25	0.007	5.001
30.00	1068.820	1068.644	0.749	0.791	5	3.954	5343.220	-0.363	25	0.132	5.013
35.00	1069.194	1069.007	0.386	0.567	5	2.837	5345.035	-0.268	25	0.072	5.007
40.00	1069.357	1069.276	0.118	0.252	5	1.259	5346.378	-0.118	25	0.014	5.001
42.00	1069.805	1069.581	0.000	0.059	2	0.118	2139.162	0.000	4	0.000	2.000
45.00	1069.959	1069.882	0.000	0.000	3	0.000	3209.646	0.000	9	0.000	0.000
48.00	1070.126	1070.043	0.000	0.000	3	0.000	3210.128	0.000	9	0.000	0.000
Total Area						15.236		Total Perimeter			37.039
		∑ X*Z					51320.261				

Cross Section of Stream at Bridge Location



Discharge, Q = A * V Cumecs

where A = Area m^2

V = Velocity m/sec

From Manning's formula we have V = $(1/n) \times S^{(1/2)} \times R^{(2/3)}$

where n = Rugosity coefficient

R = Hydraulic mean radius

S = Longitudinal Slope

Referring SP 13. Table 5.1 for section with clean, straight bank, full stage, no rifts or deep pools but some weeds and stones

n = 0.035

Hydraulic Mean Radius, R = Wetted Area/Wetted Perimeter

R = A/P

R = 0.411360235 m

Longitudinal Slope, S = 0.05564

Velocity, $V=(1/n)*(S)^{1/2}*(R)^{2/3}$ = 3.73 m/sec

Discharge, Q= A*V = 56.80 Cumecs

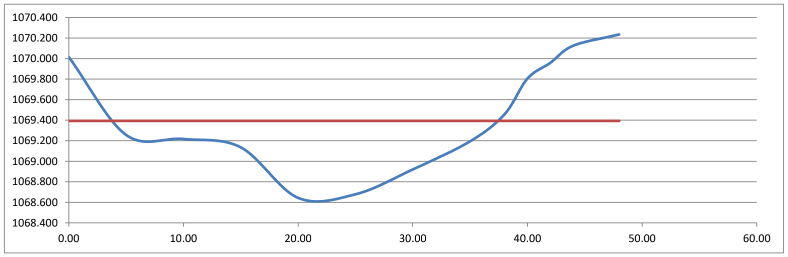
Average depth of water in cross section at bridge location = m which is added to the weighted average bed level at the upstream and downstream cross section to get the HFL at those sections

iii) Calculation of flood discharge through cross section at **D/s** of bridge location **50.0M**

HFL = 1069.393 m

Distance (m)	Bed level (m)	Mean bed level b/w adjacent pt. Z(m)	Depth of water from HFL to LBL	Mean depth of water b/w adjacent pt. "D" in meter	Distance "X" in meter	Section at area "X D". In Sqm	X*Z	Difference in level b/w adjacent point "Y"(in m)	X2	Y2	Wetted Perimeter = SQRT (X2+Y2)
0.00	1070.015										
5.00	1069.256	1069.636	0.000	0.000	5	0.000	5348.18	0.157	25.0	0.024	0.000
10.00	1069.217	1069.237	0.157	0.078	5	0.391	5346.18	0.061	25.0	0.004	5.000
15.00	1069.135	1069.176	0.217	0.187	5	0.934	5345.88	0.287	25.0	0.082	5.008
20.00	1068.643	1068.889	0.504	0.361	5	1.803	5344.45	0.229	25.0	0.052	5.005
25.00	1068.678	1068.661	0.733	0.618	5	3.091	5343.30	-0.139	25.0	0.019	5.002
30.00	1068.920	1068.799	0.594	0.663	5	3.316	5344.00	-0.258	25.0	0.067	5.007
35.00	1069.194	1069.057	0.336	0.465	5	2.325	5345.29	-0.268	25.0	0.072	5.007
38.00	1069.457	1069.326	0.068	0.202	3	0.605	3207.98	-0.068	9.0	0.005	3.001
40.00	1069.805	1069.631	0.000	0.034	2	0.068	2139.26	0.000	4.0	0.000	2.000
42.00	1069.959	1069.882	0.000	0.000	2	0.000	2139.76	0.000	4.0	0.000	0.000
44.00	1070.126	1070.043	0.000	0.000	2	0.000	2140.09	0.000	4.0	0.000	0.000
48.00	1070.235	1070.181	0.000	0.000	4	0.000	4280.72	0.000	16.0	0.000	0.000
Total Area						12.533		Total Perimeter			35.030
		∑ X*Z					45976.90				

Cross Section of Stream at D/s side of Bridge Location



Discharge, Q			=	A * V	Cumecs
	where	A	=	Area	m^2
		V	=	Velocity	m/sec
From Manning's formula we have V			=	$(1/n) \times S^{(1/2)} \times R^{(2/3)}$	
	where	n	=	Rugosity coefficient	
		R	=	Hydraulic mean radius	
		S	=	Longitudinal Slope	

Referring SP 13. Table 5.1 for section with clean, straight bank, full stage, no rifts or deep pools but some weeds and stones

		n	=	0.035	
		Hydraulic Mean Radius, R	=	Wetted Area/Wetted Perimeter	
		R	=	A/P	
		R	=	0.358	m
Longitudinal Slope,	S		=	0.05564	
Velocity, $V=(1/n)*(S)^{1/2}*(R)^{2/3}$			=	3.40	m/sec
Discharge, Q= A*V			=	42.57	Cumecs
Average depth of water in cross section at bridge location			=		m which is added to the weighted

average bed level at the upstream and downstream cross section to get the HFL at those sections

Discharge from Area velocity is taken as highest of all three discharges

Discharge, Q	=	**58.60**	**Cumecs**

CALCULATION OF SCOUR DEPTH FOR ABUTMENT

Proposed Chainage (km)	2+220	
Name of stream/Bridge	-	
Name of bypass	-	
HFL (m)	1069.393	
Q (cumecs)	85.663	
Silt Factor (K_{sf} or f)	2.600	(From Geotech report)
Q_d=1.3xQ (As per IRC: 78-2000)	111.362	
Effective Linear Waterway (Le) (m)	24.000	
Regime Width , W' = 4.8 x (Q_d^ 0.5) (m)	44.426	

By IRC - 5

$D_b = Q_d$ / MIN(W',L_e) (cumecs/m)	4.640
Mean Depth of Scour (m) , **D_{sm} = 1.34 x [(D_b^2/K_{sf})^(1/3)]**	2.711

RECOMMENDATIONS

Final Recommended mean scour depth, d_{sm}	=	2.711	m

Without Floor Protection Work

For Abutments

Maximum Scour Depth Below HFL, d_{sma} = 1.27 * d_{sm}	=	3.443	m
Scour Depth Level = HFL - d_{sma}	=	1065.950	m

DESIGN OF 25M RCC GIRDER @ CH 2+220

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

S.No.	Item
1	Dimensions and Input Data
2	Section properties of various member used in STAAD
3	Bending moment & shear force summary from STAAD
5	SLS (Rare comb.) check of RCC girder
6	Stresses due to Differential Temperature
7	ULS check for Longitudinal Girder
8	SLS check (Quasi.) for Longitudinal Girder
10	Design loads for End Cross Girder
11	ULS check for End Cross Girder
12	SLS check for End Cross Girder
13	Load calculation for Deck slab analysis
14	BM Summary for Deck Slab design from STAAD
15	ULS check for Deck Slab
16	SLS check for Deck Slab
17	*Staad for dead load of girder and deck slab
18	*Staad for SIDL
19	*Staad for live load
20	*Staad for End Cross Girder
21	* Staad for Deck Slab analysis
22	*Staad for deflection

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Dimensions and Input Data

			Values	**Unit**
c/c of bearing of span		=	**25**	**m**
c/c of expansion joint of span		=	**26**	**m**
Projection beyond cL of bearing	0.5 - (0.04/2)	=	**0.48**	m
Expansion gap		=	0.04	m
Total width of superstructure		=	**16**	**m**
Angle of skew		=	**0**	**deg**
Width of crash barrier,	2 no.s	=	0.45	m
Width of Railing	0 no.s	=	0	m
Footpath width provided on	0 sides	=	0	m
Carriageway width	1 no.s of	=	**15.1**	**m**
No. of Girders		=	**5**	**m**
Cantilever at each end of cross section		=	1.6	m
Spacing of girders		=	**3.2**	m
Length of support portion from cL of bearing at end span		=	1.5	m
Length of flaring web portion		=	1.05	m
Length of normal web portion		=	18.5	m
Total girder length =	10.8 + 2 x 0.3 + 2 x 1.5 + 2 x	23.8	24.2	m
Depth of girder		=	1.8	m
Depth of deck slab		=	0.21	m
Thickness of end diaphragm		=	0.4	m
Depth of diaphragm		=	1.55	m
Thickness of Crash Barrier at Top		=	**0.2**	**m**
Thickness of Crash Barrier at Bottom		=	**0.45**	**m**
Height of Crash Barrier		=	**1.2**	**m**

Design Parameters

Grade of concrete for RCC Beams	M	**30**	**N/mm2**
Grade of concrete for deck slabs	M	**30**	**N/mm2**
Grade of steel	Fe	**500**	**N/mm2**
Density of concrete (RCC)	=	**25**	**kN/m3**
Density of concrete (RCC)	=	**25**	**kN/m3**
Density of wearing coat	=	**22**	**kN/m3**
Es	=	**200000**	**N/mm2**
Clear Cover for superstructure	=	**50**	**mm**
Coefficient of thermal expansion	=	1.17.E-05	per degree celciu
fctm Table 6.5 of IRC:112-2012	=	**2.5**	**N/mm2**
fctk,0.05 Table 6.5 of IRC:112-2013	=	**1.7**	**N/mm3**
Permissible stresses of conc. in service conditions (MPa)			

	Days	**fcm**	**Direct comp.**	**Elasticity,E**
RCC beam	28	40	19.2	31000
RCC slab	28	40	19.2	31000

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Loadings

1. **Dead Load**

Self weight is taken for beam, deck and diaphragms in STAAD.

2. **Super-imposed Dead Load**

Wt. of WC per sqm.	=	**1.65**	**kN/m2**
Thickness of wearing coat (assumed for design)	=	75	mm
Weight of crash barrier and pipe	=	**9.75**	**kN/m**
Weight of Railing	=	0	kN/m

3. **Live Load**

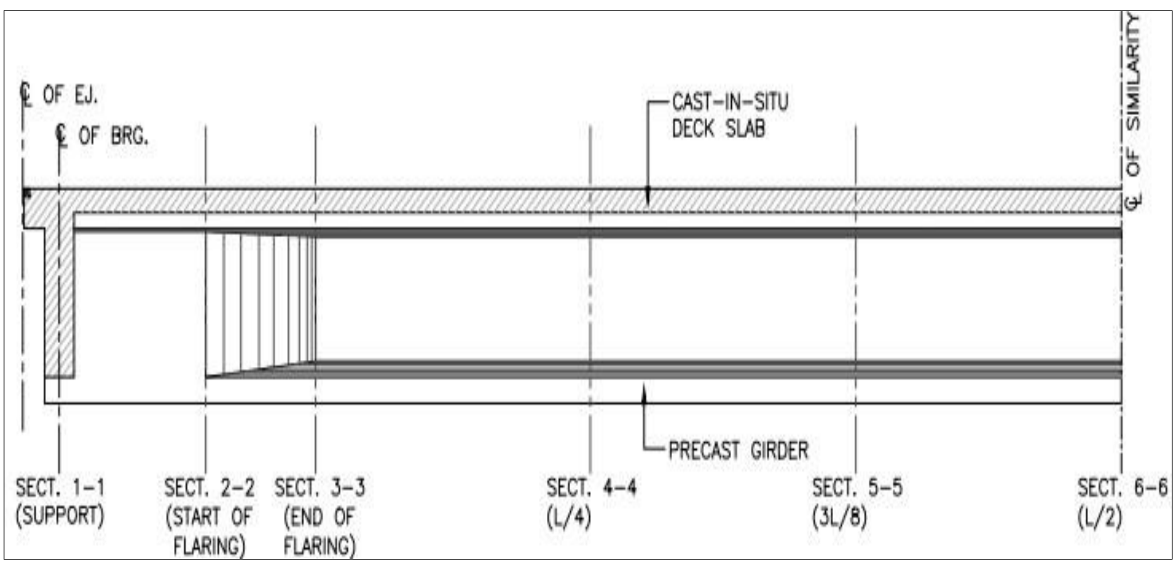
Live load placement as per IRC 6 :2017.

Impact factor	=	1.325

Construction Methodology RCC super structure

1 Casting of Beams at yard
2 Removing of side formwork of beam
3 Transporting beams from yard to site
4 Casting deck and diaphragms
5 Construction of crash barrier
6 Applying wearing coat over deck 7 Live load application

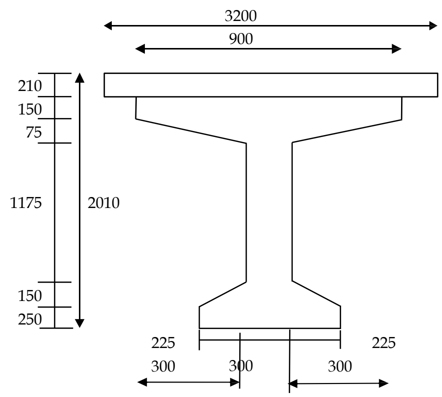
Note:- Curing time (assumed) - 21 days for RCC girder & deck slab.



Section of longitudinal girder

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Section properties of various member used in STAAD
Inner Girder Mid Span Section



Ac =	798750	(girder section)
	672000	(slab section)
	1470750	(Composite)
Per =	5209	(girder section)
	5920	(slab section)

overhang of slab on either side = 1150

Ixx

Section	B	D	Nos.	Area,A	Yt	A.Yt	A.Yt2	Ixo	Ixo+A.Yt2
Deck slab	3200	210	1	672000	105	70560000	7408800000	2469600000	9878400000
Top flange	900	150	1	135000	285	38475000	10965375000	253125000	11218500000
Top flange Haunch	300	75	2	22500	385	8662500	3335062500	7031250	3342093750
Web	300	1400	1	420000	1060	445200000	4.71912E+11	68600000000	5.40512E+11
Bot.Haunch	225	150	2	33750	1710	57712500	98688375000	42187500	98730562500
Bot. flange	750	250	1	187500	1885	353437500	6.6623E+11	976562500	6.67206E+11
Beam Section Only				**798750**		**903487500**	**1.25113E+12**	**69878906250**	**1.32101E+12**
Composite Section				**1470750**		**1877535000**	**1.25854E+12**	**72348506250**	**1.33089E+12**

Beam Section only

Distance of CG from Top ,y'	=	1.131 m	CG from Bot. ,y'	=	0.878873 m
Area	=	0.799 m^2			
Ixx=A .Yt2+Ixo-A .y'2	=	0.299 m^4			

Composite Section

Distance of CG from Top ,y'	=	0.662 m	CG from Bot. ,y'	=	1.347721 m
Area	=	1.471 m^2			
Ixx=A .Yt2+Ixo-A .y'2	=	0.686 m^4			

overhang of deck slab on either side of top flange = 1150 mm
overhang of deck slab on either side of bottom flange = 1225 mm

Iyy

Section	B	D	Nos.	Area,A	Xt	A.Xt	A.Xt^2	Iyo	Iyo+A.Xt2
Deck slab	210	3200	1	672000	1600	1075200000	1.720E+12	5.73E+11	2.294E+12
Top flange	150	900	1	135000	1600	216000000	3.456E+11	9.11E+09	3.547E+11
Top flange Haunch	75	300	1	11250	1350.00	15187500	2.050E+10	5.63E+07	2.056E+10
	75	300	1	11250	1850.00	20812500	3.850E+10	5.63E+07	3.856E+10
Web	1400	300	1	420000	1600	672000000	1.075E+12	3.15E+09	1.078E+12
Bot.Haunch	150	225	1	16875	1375	23203125	3.190E+10	4.75E+07	3.195E+10
	150	225	1	16875	1825.00	30796875	5.620E+10	4.75E+07	5.625E+10
Bot. flange	250	750	1	187500	1600	300000000	4.800E+11	8.79E+09	4.888E+11
Beam Section Only				**798750**		**1278000000**	**2.04791E+12**	**21258984375**	**2.06917E+12**
Composite Section				**1470750**		**2353200000**	**3.76823E+12**	**5.94699E+11**	**4.36293E+12**

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Beam Section only

Distance of cg fr. Left end ,x' = 1.6 m

Iyy=A .X^2+Iyo-A .x'^2 = 0.024 m^4

Composite Section

Distance of cg fr. Left end ,x' = 1.6 m

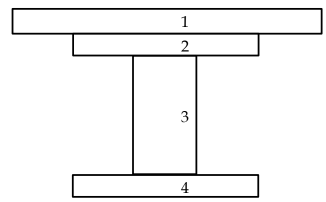
Iyy=A .X^2+Iyo-A .x'^2 = 0.5978 m^4

Torsional Inertia

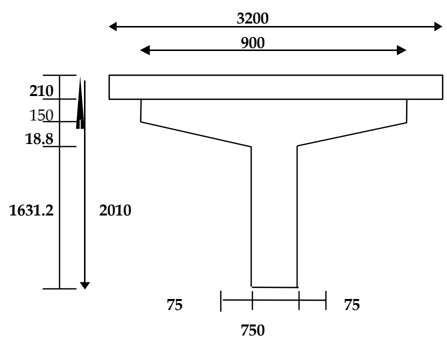
C = k1 x b^3 x bmax

k1 = 1/3{ 1 - 0.63 x b/bmax x (1 - b^4* (12 x b max)}

Section	B	D	bmax	b	k1	c
1	3.2	0.21	3.2	0.21	0.35	0.005
2	0.9	0.2	0.9	0.2	0.29	0.0021
3	0.3	1.175	1.175	0.3	0.29	0.0092
4	0.75	0.40	0.75	0.4	0.23	0.006
Base Section only					=	**0.0170**
Composite Section					=	**0.0221**



Support Section



Ixx

Section	B	D	Nos.	Area,A	Yt	A.Yt	A.Yt^2	Ixo	Ixo+A.Yt2
Deck slab	3200	210	1	672000	105	70560000	7408800000	2469600000	9878400000
Top flange	900	150	1	135000	285	38475000	10965375000	253125000	11218500000
Top flange Haunch	75	18.8	2	1410	366	516436	189153292.3	27686.13333	189180978.4
Web	750	1650	1	1237500	1185	1.47E+09	1.73773E+12	2.80758E+11	2.01849E+12
Beam Section only				**1373910**		**1.51E+09**	**1.75E+12**	**2.81E+11**	**2.03E+12**
Composite Section				**2045910**		**1.58E+09**	**1.76E+12**	**2.83E+11**	**2.04E+12**

Beam Section only

Distance of CG from Top ,y' = 1.096 m CG from Bot. ,y' = 0.914274 m

Area = 1.374 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.380 m^4

Composite Section

Distance of CG from Top ,y' = 0.770 m CG from Bot. ,y' = 1.239688 m

Area = 2.046 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.826 m^4

overhang of deck slab on either side of top flange = 1150 mm

overhang of deck slab on either side of bottom flange = 1225 mm

Iyy

Section	B	D	Nos.	Area,A	X	A.X	A.X^2	Iyo	Ixo+A.Yt2
Deck slab	210	3200	1	672000	1600	1075200000	1.72032E+12	5.7344E+11	2.29376E+12
Top flange	150	900	1	135000	1600	216000000	3.456E+11	9112500000	3.54713E+11
Top flange Haunch	18.8	75	1	705	1200.00	846000	1015200000	220312.5	1015420313
	18.8	75	1	705	2000	1410000	2820000000	220312.5	2820220313
Web	1650	750	1	1237500	1600	1980000000	3.168E+12	58007812500	3.22601E+12
Base Section only				**1373910**		**2198256000**	**3.51744E+12**	**67120753125**	**3.58456E+12**
Composite Section				**2045910**		**3273456000**	**5.23776E+12**	**6.40561E+11**	**5.87832E+12**

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Beam Section only

Distance of cg fr. Left end ,x' = 1.6 m

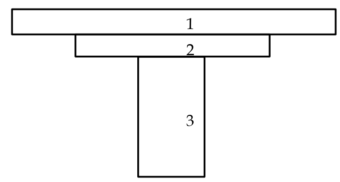
Iyy=A .X^2+Iyo-A .x'^2 = 0.067 m^4

Composite Section

Distance of cg fr. Left end ,x' = 1.6 m

Iyy=A .X^2+Iyo-A .x'^2 = 0.641 m^4

Torsional Inertia



C = k1 x b^3 x bmaxX0.5

k1 = 1/3{ 1 - 0.63 x b/bmax x (1 - b^4* (12 x b max)}

Section	B	D	bmax	b	k1	c
1	3.2	0.21	3.2	0.21	0.35	0.0052
2	0.9	0.0188	0.9	0.0188	0.33	0.00
3	0.75	1.6312	1.6312	0.75	0.20	0.163
Base Section only					=	**0.16**
Composite Section					=	**0.17**

At Flaring section

Ixx

Section	B	D	Nos.	Area,A	Yt	A.Yt	A.Yt2	Ixo	Ixo+A.Yt2
Deck slab	3200	210	1	672000	105	70560000	7408800000	2469600000	9878400000
Top flange	900	150	1	135000	285	38475000	10965375000	253125000	11218500000
Top flange Haunch	187.5	46.9	2	8793.75	225.6333333	1984163.125	447693339.8	1074601.1	448767940.9
Web	525	1203	1	631575	1008.4	636880230	6.4223E+11	76168418681	7.18398E+11
Bot.Haunch	300	150	2	45000	1709.9	76945500	1.31569E+11	56250000	1.31625E+11
Bot. flange	750	250	1	187500	1884.9	353418750	6.66159E+11	976562500	6.67136E+11
Base Section only				**1007869**		**1.11E+09**	**1.45137E+12**	**77455430782**	**1.52883E+12**
Composite Section				**1679869**		**1.18E+09**	**1.45878E+12**	**79925030782**	**1.53871E+12**

Beam Section only

Distance of CG from Top ,y' = 1.099 m CG from Bot. ,y = 0.911 m

Area = 1.008 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.311 m^4

Composite Section

Distance of CG from Top ,y' = 0.701 m CG from Bot. ,y = 1.308 m

Area = 1.680 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.712 m^4

overhang of deck slab on either side of top flange = 1150 mm

overhang of deck slab on either side of bottom flange = 1337.5 mm

Iyy

Section	B	D	Nos.	Area,A	X	A.X	A.X^2	Iyo	Iyo+A.Yt2
Deck slab	210	3200	1	672000	1600	1075200000	1.72032E+12	5.7344E+11	2.29376E+12
Top flange	150	900	1	135000	1600	216000000	3.456E+11	9112500000	3.54713E+11
Top flange Haunch	46.9	187.5	1	4396.875	1350.00	6667099.197	10109500884	8587646.484	10118088531
	46.9	187.5	1	4396.875	1850.00	8134218.75	15048304688	8587646.484	15056892334
Web	1203	525	1	631575	1600.00	1010520000	1.61683E+12	14506488281	1.63134E+12
Bot.Haunch	150	300	1	22500	1375.00	30937500	42539062500	112500000	42651562500
	150	300	1	22500	1825.00	41062500	74939062500	112500000	75051562500
Bot. flange	250	750	1	187500	1600.00	300000000	4.8E+11	8789062500	4.88789E+11
Base Section only				**1007869**		**1613321318**	**2.58507E+12**	**32650226074**	**2.61772E+12**
Composite Section				**1679869**		**2688521318**	**4.30539E+12**	**6.0609E+11**	**4.91148E+12**

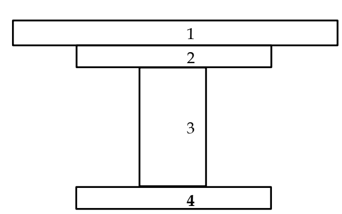
Beam Section only Distance of cg fr. Left end ,x' = 1.6 m

Iyy=A .X^2+Iyo-A .x'^2 = **0.0380** m^4

Composite Section Distance of cg fr. Left end ,x' = 1.6 m

Iyy=A .X^2+Iyo-A .x'^2 = **0.6110** m^4

Torsional Inertia



C = k1 x b^3 x bmaxX0.5

k1 = 1/3{ 1 - 0.63 x b/bmax x (1 - b^4* (12 x b max)}

Section	B	D	bmax	b	k1	c
1	3.20	0.21	3.20	0.21	0.4	0.0052
2	0.90	0.20	0.90	0.20	0.3	0.002
3	0.53	1.20	1.20	0.53	0.4	0.073
3	0.75	0.25	0.75	0.25	0.3	0.0031
Base Section only					=	**0.078**
Composite Section					=	**0.083**

Project	Project Name	Designed by:	KB
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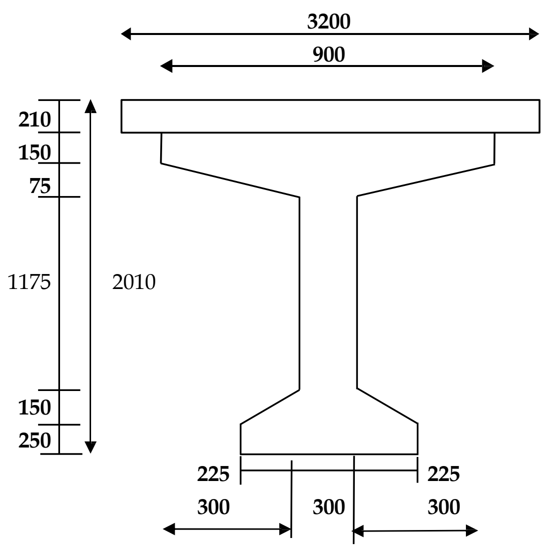
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Section properties of various member used in STAAD
Outer Girder Mid Span Section



Ixx

Section	B	D	Nos.	Area,A	Yt	A.Yt	A.Yt2	Ixo	Ixo+A.Yt2
Deck slab	3200	210	1	672000	105	70560000	7408800000	2469600000	9878400000
Top flange	900	150	1	135000	285	38475000	10965375000	253125000	11218500000
Top flange Haunch	300	75	2	22500	385	8662500	3335062500	7031250	3342093750
Web	300	1400	1	420000	1060	445200000	4.71912E+11	68600000000	5.40512E+11
Bot.Haunch	225	150	2	33750	1710	57712500	98688375000	42187500	98730562500
Bot. flange	750	250	1	187500	1885	353437500	6.6623E+11	976562500	6.67206E+11
Base Section only				**798750**		**903487500**	**1.25113E+12**	**69878906250**	**1.32101E+12**
Composite Section				**1470750**		**974047500**	**1.25854E+12**	**72348506250**	**1.33089E+12**

Beam Section only

Distance of CG from Top ,y' = 1.131 m   CG from Bot. ,y' = 0.87887 m

Area = 0.799 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.299 m^4

Composite Section

Distance of CG from Top ,y' = 0.662 m   CG from Bot. ,y' = 1.348 m

Area = 1.471 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.686 m^4

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overhang of deck slab on either side of top flange = 1150 mm
overhang of deck slab on either side of bottom flange = 1225 mm

Iyy

Section	B	D	Nos.	Area,A	X	A.X	A.X^2	Iyo	Ixo+A.Yt2
Deck slab	210	3200	1	672000	1600	1075200000	1.72032E+12	5.7344E+11	2.29376E+12
Top flange	150	900	1	135000	1600	216000000	3.456E+11	9112500000	3.54713E+11
Top flange Haunch	75	300	1	11250	1350.00	15187500	20503125000	168750000	20671875000
	75	300	1	11250	1850.00	20812500	38503125000	168750000	38671875000
Web	1400	300	1	420000	1600	672000000	1.0752E+12	3150000000	1.07835E+12
Bot.Haunch	150	225	1	16875	1375.00	23203125	31904296875	142382812.5	32046679688
	150	225	1	16875	1825.00	30796875	56204296875	142382812.5	56346679688
Bot. flange	250	750	1	187500	1600	300000000	4.8E+11	8789062500	4.88789E+11
Base Section only				**798750**		**1278000000**	**2.04791E+12**	**21673828125**	**2.06959E+12**
Composite Section				**1470750**		**2.35E+09**	**3.77E+12**	**5.95E+11**	**4.36E+12**

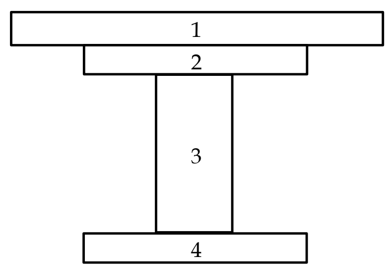
Beam Section only Distance of cg fr. Left end ,x' = 1.6 m
Iyy=A .X^2+Iyo-A .x'^2 = 0.025 m^4

Composite Section Distance of cg fr. Left end ,x' = 1.6 m
Iyy=A .X^2+Iyo-A .x'^2 = 0.598 m^4

Torsional Inertia

C = k1 x b^3 x bmaxX0.5

k1 = 1/3{ 1 - 0.63 x b/bmax x (1 - b^4* (12 x b max)}



Section	B	D	bmax	b	k1	c
1	3.2	0.21	3.2	0.21	0.35	0.005
2	0.9	0.2	0.9	0.2	0.29	0.0021
3	0.3	1.175	1.175	0.3	0.29	0.009
4	0.75	0.4	0.75	0.4	0.23	0.01
Base Section only					=	0.022
Composite Section					=	0.028

Project	Project Name	Designed by:	KB
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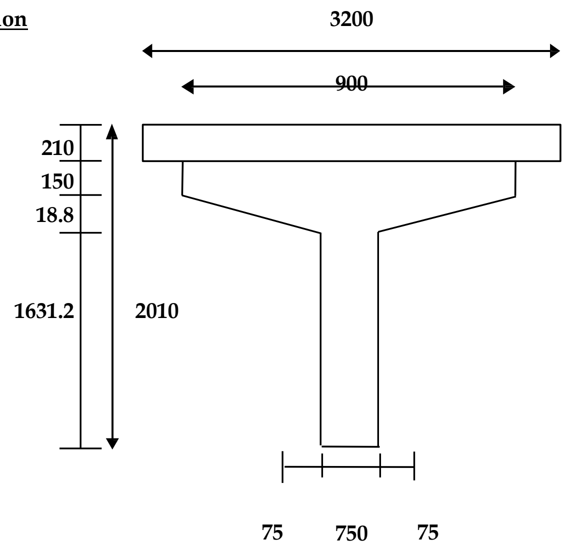
Support Section



Ixx

Section	B	D	Nos.	Area,A	Yt	A.Yt	A.Yt^2	Ixo	Ixo+A.Yt2
Deck slab	3200	210	1	672000	105	70560000	7.41E+09	2.47E+09	9.88E+09
Top flange	900	150	1	135000	285	38475000	1.10E+10	2.53E+08	1.12E+10
Top flange Haunch	75	18.8	2	1410	366	516436	1.89E+08	2.77E+04	1.89E+08
Web	750	1650	1	1237500	1185	1466437500	1.74E+12	2.81E+11	2.02E+12
Base Section only				**1373910**		**1505428936**	**1.74888E+12**	**2.81011E+11**	**2.02989E+12**
Composite Section				**2045910**		**1575988936**	**1.75629E+12**	**2.83481E+11**	**2.03977E+12**

Beam Section only

Distance of CG from Top ,y' = 1.096 m CG from Bot. ,y' = 0.914 m

Area = 1.374 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.380 m4

Composite Section

Distance of CG from Top ,y' = 0.770 m CG from Bot. ,y' = 1.240 m

Area = 2.046 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.826 m4

overhang of deck slab on either side of top flange = 1150 mm

overhang of deck slab on either side of bottom flange = 1225 mm

Iyy

Section	B	D	Nos.	Area,A	X	A.X	A.X^2	Iyo	Ixo+A.Yt2
Deck slab	210	3200	1	672000	1600	1075200000	1.72032E+12	5.7344E+11	2.29376E+12
Top flange	150	900	1	135000	1600	216000000	3.456E+11	9112500000	3.54713E+11
Top flange Haunch	18.8	75	1	705	1200	846000	1015200000	660937.5	1015860938
	18.8	75	1	705	2000.00	1410000	2820000000	660937.5	2820660938
Web	1650	750	1	1237500	1600	1980000000	3.168E+12	58007812500	3.22601E+12
Base Section only				**1373910**		**2.20E+09**	**3.52E+12**	**6.71E+10**	**3.58E+12**
Composite Section				**2045910**		**3.27E+09**	**5.24E+12**	**6.41E+11**	**5.88E+12**

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Beam Section only

Distance of cg fr. Left end ,x' = 1.6 m

Iyy=A .X^2+Iyo-A .x'^2 = 0.067 m^4

Composite Section

Distance of cg fr. Left end ,x' = 1.6 m

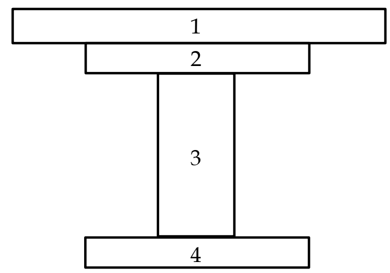
Iyy=A .X^2+Iyo-A .x'^2 = 0.641 m^4

Torsional Inertia

C = k1 x b^3 x bmaxX0.5

k1 = 1/3{ 1 - 0.63 x b/bmax x (1 - b^4* (12 x b max)}

Section	B	D	bmax	b	k1	c
1	3.2	0.21	**3.2**	**0.21**	0.35	0.005
2	0.9	0.0188	**0.9**	**0.0188**	0.33	0.000
2	0.75	1.6312	**1.6312**	**0.75**	0.20	0.163
Base Section only					=	0.163
Composite Section					=	0.168



At Flaring section

Ixx

Section	B	D	Nos.	Area,A	Yt	A.Yt	A.Yt2	Ixo	Ixo+A.Yt2
Deck slab	3200	210	1	672000	105	70560000	7.41E+09	2.47E+09	9.88E+09
Top flange	900	150	1	135000	285	38475000	1.10E+10	2.53E+08	1.12E+10
Top flange Haunch	187.5	46.9	2	8793.75	225.6333	1984163.125	4.48E+08	1.07E+06	4.49E+08
Web	525	1003	1	526575	908.4	478340730	4.35E+11	4.41E+10	4.79E+11
Bot.Haunch	300	150	2	45000	1509.9	67945500	1.03E+11	5.63E+07	1.03E+11
Bot. flange	750	250	1	187500	1684.9	315918750	5.32E+11	9.77E+08	5.33E+11
Base Section only				**902868.75**		**902664143.1**	**1.08082E+12**	**45431944532**	**1.12625E+12**
Composite Section				**1574868.75**		**973224143.1**	**1.08823E+12**	**47901544532**	**1.13613E+12**

Beam Section only

Distance of CG from Top ,y' = 1.000 m   CG from Bot. ,y' = 0.810 m

Area = 0.903 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.224 m4

Composite Section

Distance of CG from Top ,y' = 0.618 m   CG from Bot. ,y' = 1.192 m

Area = 1.575 m^2

Ixx=A .Yt2+Ixo-A .y'2 = 0.535 m4

overhang of deck slab on either side of top flange = 1150 mm

overhang of deck slab on either side of bottom flange = 1225 mm

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Iyy

Section	B	D	Nos.	Area,A	X	A.X	A.X^2	Iyo	Ixo+A.Yt2
Deck slab	210	3200	1	672000	1600	1075200000	1.72E+12	5.73E+11	2.29E+12
Top flange	150	900	1	135000	1600	216000000	3.46E+11	9.11E+09	3.55E+11
Top flange Haunch	46.9	187.5	1	4396.875	1350.00	5935781.25	8.01E+09	8.59E+06	8.02E+09
	46.9	187.5	1	4396.875	1850.00	8134218.75	1.50E+10	8.59E+06	1.51E+10
Web	1003	525	1	526575	1600.00	842520000	1.35E+12	1.21E+10	1.36E+12
Bot.Haunch	150	300	1	22500	1375.00	30937500	4.25E+10	1.13E+08	4.27E+10
	150	300	1	22500	1825.00	41062500	7.49E+10	1.13E+08	7.51E+10
Bot. flange	250	750	1	187500	1600.00	300000000	4.80E+11	8.79E+09	4.89E+11
Base Section only				**902868.75**		**1444590000**	**2.31417E+12**	**30238507324**	**2.34441E+12**
Composite Section				**1574868.75**		**2.52E+09**	**4.03E+12**	**6.04E+11**	**4.64E+12**

Beam Section only

Distance of cg fr. Left end ,x' = 1.600 m

Iyy=A .X^2+Iyo-A .x'^2 = 0.033 m^4

Composite Section

Distance of cg fr. Left end ,x' = 1.600 m

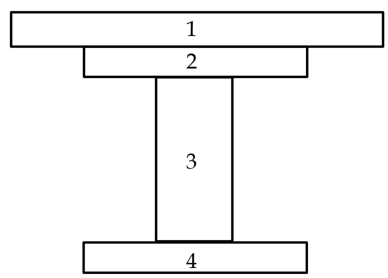
Iyy=A .X^2+Iyo-A .x'^2 = 0.607 m^4

Torsional Inertia

C = k1 x b□x□bmax□

k1 = 1/3{ 1 - 0.63 x b/bmax x (1 - b□/12 x b max)}□

Section	B	D	bmax	b	k1	c
1	3.20	0.21	**3.2**	**0.21**	0.4	0.005235
2	0.90	0.20	**0.9**	**0.1969**	0.3	0.002
3	0.53	1.00	**1.003**	**0.525**	0.2	0.042
4	0.75	0.25	**0.75**	**0.25**	0.3	0.003098
Base Section only					=	**0.047**
Composite Section					=	**0.052**



Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

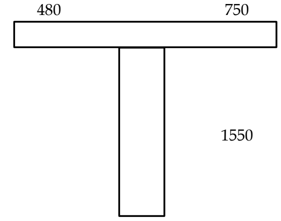
Section properties of various member used in STAAD

End Diaphragm

Depth	=	1550	mm
Thk.	=	400	mm

	B	D	Area,A	Yt	A.Yt	A.Yt^2	Ixo	Yt	A.Yt	A.Yt^2	Iyo
Top Slab 1	1230	210	258300	105	3.00E+07	2.85E+09	949252500	615	1.59E+08	9.77E+10	3.26E+10
Diaphragm	400	1550	620000	985	3.00E+08	6.02E+11	2.86E+10	480	2.98E+08	1.43E+11	8.27E+09
TOTAL			878300		3.30E+08	6.04E+11	2.95E+10		4.56E+08	2.41E+11	4.08E+10

Distance of cg fr. Top ,y'	=	0.726	m	0.519702	m2
Area	=	0.880	m^2	0.880	m2
Ixx=A .Yt^2+Ixo-A .y'^2	=	0.69	m^4		
Iyy	=	0.04	m^4		



Torsional Inertia

C = k1 x b☒bmax□

k1 = 1/3{ 1 - 0.63 x b/bmax x (1 - b□□12 x b max)}□

Section	B	D	bmax	b	k1	c
Deck	1.23	0.21	1.23	0.21	0.30	0.001705
Diaph.	0.4	1.55	1.55	0.4	0.38	0.018612
Total :-						0.0203

87 100 113 97 110 123 PRIS AX0.88 IX0.0203 IY0.04 IZ0.692

Slab Width = 1.000 Thk. = 0.21

Area	=	0.21	m^2
Ixx	=	0.001	m^4
Iyy	=	0.018	m^4

Torsional Inertia

Section	B	D	bmax	b	k1	c
Slab	1.000	0.21	1.000	0.210	0.3	0.0013
Total :-						0.0013

74 84 126 136 PRIS AX0.21 IX0.0013 IY 0.0175 IZ0.0008

Slab Width = 1.275 Thk. = 0.21

Area	=	0.268	m^2
Ixx	=	0.001	m^4
Iyy	=	0.0363	m^4

Torsional Inertia

Section	B	D	bmax	b	k1	c
Slab	1.275	0.21	1.275	0.21	0.3	0.0018
Total :-						0.0018

75 83 88 96 101 109 114 122 127 135 PRIS AX0.268 IX0.0018 IY0.0363 IZ0.001

Slab Width = 1.375 Thk. = 0.21

Area	=	0.289	m^2
Ixx	=	0.0011	m^4
Iyy	=	0.0455	m^4

Torsional Inertia

Section	B	D	bmax	b	k1	c
Slab	1.375	0.21	1.375	0.21	0.3	0.0019
Total :-						0.0019

76 82 89 95 102 108 115 121 128 134 PRIS AX0.289 IX0.0019 IY0.0455 IZ0.0011

Slab Width = 1.9125 Thk. = 0.21

Area	=	0.402	m^2
Ixx	=	0.0015	m^4
Iyy	=	0.1224	m^4

Torsional Inertia

Section	B	D	bmax	b	k1	c
Slab	1.9125	0.21	1.9125	0.21	0.3	0.0028
Total :-						0.0028

77 81 90 94 103 107 116 120 129 133 PRIS AX0.402 IX0.0028 IY0.1224 IZ0.0015

Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

<u>Slab</u> Width = 2.125 Thk. = 0.21

Area = 0.446 m^2

Ixx = 0.0016 m^4

Iyy = 0.1679 m^4

<u>Torsional Inertia</u>

Section	B	D	bmax	b	k1	c
Slab	2.125	0.21	2.125	0.21	0.3	0.0032
						0.0032

78 80 91 93 104 106 117 119 130 132 PRIS AX0.446 IX0.0032 IY0.1679 IZ0.0016

79 92 105 118 131 PRIS AX0.446 IX0.0032 IY0.1679 IZ0.0016

<u>Slab</u> Width = 0.25 Thk. = 0.21

Area = 0.053 m^2

Ixx = 0.0002 m^4

Iyy = 0.0003 m^4

<u>Torsional Inertia</u>

Section	B	D	bmax	b	k1	c
Slab	0.25	0.21	0.25	0.21	0.2	0.0002
			Total :-			0.0002

73 85 86 98 99 111 112 124 125 137 PRIS AX0.053 IX0.0002 IY0.0003 IZ0.0002

Bending moment & shear force summary from STAAD

		S 1-1	**S 2-2**	**S 3-3**	**S 4-4**	**S 5-5**	**S 6-6**	**S 5-5**	**S 4-4**	**S 3-3**	**S 2-2**	**S 1-1**
Outer Girder 1												
1 DL GIRDER	**Mz**	2	357	565	1072	1332	1419	1332	1072	565	357	2
	FY	265	213	185	118	59	0	59	118	185	213	265
	Mx	0	0	0	0	0	0	0	0	0	0	0
2. DL SLAB	**Mz**	1	271	439	855	1068	1140	1068	855	439	271	1
	FY	193	169	152	97	48	0	48	97	152	169	193
	Mx	0	0	0	0	0	0	0	0	0	0	0
1 SIDL CRASH BARRIER & RAILING	**Mz**	16	131	229	474	602	645	602	474	229	131	16
	FY	98	98	90	73	43	15	43	73	90	98	98
	Mx	109	109	88	48	24	8	24	48	88	109	109
2 SIDL SURFACING(WEARING COAT)	**Mz**	1	72	118	231	290	309	290	231	118	72	1
	FY	49	48	43	30	17	4	17	30	43	48	49
	Mx	5	5	5	2	1	0	1	2	5	5	5
3 FPLL	**Mz**	0	0	0	0	0	0	0	0	0	0	0
	FY	0	0	0	0	0	0	0	0	0	0	0
	Mx	0	0	0	0	0	0	0	0	0	0	0
4 LL	**Mz**	46	473	755	1483	1911	2068	1958	1590	840	529	43
	FY	315	295	294	175	114	135	194	258	325	348	87
	Mx	108	95	64	46	25	30	47	71	105	127	24
SUM	**Mz**	**66**	**1304**	**2106**	**4115**	**5203**	**5581**	**5250**	**4222**	**2191**	**1360**	**63**
	FY	**920**	**823**	**764**	**493**	**281**	**154**	**361**	**576**	**795**	**876**	**692**
	Mx	**222**	**209**	**157**	**96**	**50**	**38**	**72**	**121**	**198**	**241**	**138**

Inner Girder 2												
1 SIDL CRASH BARRIER & RAILING	**Mz**	17	21	22	2	12	15	12	2	22	21	17
	FY	1	1	7	7	5	2	5	7	7	1	1
	Mx	23	23	19	9	5	2	5	9	19	23	23
2 SIDL SURFACING(WEARING COAT)	**Mz**	1	69	112	216	270	287	270	216	112	69	1
	FY	47	45	40	27	15	3	15	27	40	45	47
	Mx	0	0	0	0	0	0	0	0	0	0	0
3 FPLL	**Mz**	0	0	0	0	0	0	0	0	0	0	0
	FY	0	0	0	0	0	0	0	0	0	0	0
	Mx	0	0	0	0	0	0	0	0	0	0	0
4 LL	**Mz**	74	543	874	1741	2202	2420	2279	1840	1001	637	64
	FY	387	387	384	220	153	193	252	324	413	452	1
	Mx	112	112	57	40	22	29	43	63	102	126	25
SUM	**Mz**	95	1261	2012	3886	4884	5281	4961	3985	2139	1355	85
	FY	893	815	768	469	280	198	379	573	797	880	507
	Mx	135	135	76	49	27	31	48	72	121	149	48

Note:- Mz - Moment in KNm, FY - Shear in KN, Mx - Torsion in KNm

Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Inner Girder 3												
1 SIDL CRASH BARRIER & RAILING	**Mz**	17	21	22	2	12	15	12	2	22	21	17
	FY	1	1	7	7	5	2	5	7	7	1	1
	Mx	23	23	19	9	5	2	5	9	19	23	23
2 SIDL SURFACING(WEARING COAT)	**Mz**	1	69	112	216	270	287	270	216	112	59	1
	FY	47	45	40	27	15	3	15	27	40	45	47
	Mx	0	0	0	0	0	0	0	0	0	0	0
3 FPLL	**Mz**	0	0	0	0	0	0	0	0	0	0	0
	FY	0	0	0	0	0	0	0	0	0	0	0
	Mx	0	0	0	0	0	0	0	0	0	0	0
4 LL	**Mz**	75	480	772	1556	1923	2062	1923	1566	850	542	61
	FY	371	327	352	247	187	180	227	283	357	391	122
	Mx	103	84	50	50	20	28	39	56	90	113	25
SUM	**Mz**	96	1198	1910	3701	4605	4923	4605	3711	1988	1250	82
	FY	877	755	736	496	314	185	354	532	741	819	628
	Mx	126	107	69	59	25	30	44	65	109	136	48

Outer Girder 4												
1 SIDL CRASH BARRIER & RAILING	**Mz**	16	131	229	474	602	645	602	474	229	131	16
	FY	96	98	90	73	43	15	43	73	90	98	98
	Mx	109	109	88	48	24	8	24	48	88	109	109
2 SIDL SURFACING(WEARING COAT)	**Mz**	1	72	118	231	290	309	290	231	118	72	1
	FY	49	48	43	30	17	4	17	30	43	48	49
	Mx	5	5	5	2	1	0	1	2	5	5	5
3 FPLL	**Mz**	0	0	0	0	0	0	0	0	0	0	0
	FY	0	0	0	0	0	0	0	0	0	0	0
	Mx	0	0	0	0	0	0	0	0	0	0	0
4 LL	**Mz**	32	349	551	1051	1253	1253	1117	884	459	297	37
	FY	229	215	212	115	75	90	90	124	177	193	74
	Mx	98	84	54	34	16	16	34	55	84	98	16
SUM	**Mz**	52	1180	1902	3683	4545	4766	4409	3515	1810	1128	57
	FY	832	743	682	433	242	109	257	442	646	721	679
	Mx	212	198	147	84	41	24	59	106	177	212	130
	Mz	96	1304	2106	4115	5203	5581	5250	4222	2191	1360	85
	FY	920	823	768	496	314	198	379	576	797	880	692
	Mx	222	209	157	96	50	38	72	121	198	241	138

Note:- Mz - Moment in KNm, FY - Shear in KN, Mx - Torsion in KNm

Factor for	**SLS**	**Quasi.**	**ULS**
	Rare		**Basic**
1 DL GIRDER	1	1	1.35
2 DL DECK SLAB & CROSS GIRDER	1	1	1.35
1 SIDL CRASH BARRIER & RAILING	1	1	1.35
2 SIDL SURFACING(WEARING COAT)	1	1	1.75
3 FPLL	1	0	1.5
4 LL	1	0	1.5
4 LL with Impact factor	1.325	0	1.9875

Impact factor = 1.325

Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

		SLS Rare					
		S 1-1	S 2-2	S 3-3	S 4-4	S 5-5	S 6-6
1 DL GIRDER	Mz	2	357	565	1072	1332	1419
	FY	265	213	185	118	59	0
	Mx	0	0	0	0	0	0
K SLAB & CROSS	Mz	1	271	439	855	1068	1140
	FY	193	169	152	97	48	0
	Mx	0	0	0	0	0	0
3 SIDL	Mz	17	203	347	705	892	954
	FY	147	146	133	103	60	19
	Mx	114	114	93	50	25	8
4 FPLL & LL	Mz	61	627	1000	1965	2532	2740
	FY	417	391	390	232	151	179
	Mx	143	126	85	61	33	40
SUM	**Mz**	**81**	**1458**	**2351**	**4597**	**5824**	**6253**
	FY	**1022**	**919**	**860**	**550**	**318**	**198**
	Mx	**257**	**240**	**178**	**111**	**58**	**48**

	Quasi.							**ULS Basic**						
		S 1-1	S 2-2	S 3-3	S 4-4	S 5-5	S 6-6		S 1-1	S 2-2	S 3-3	S 4-4	S 5-5	S 6-6
1 DL GIRDER	Mz	2	357	565	1072	1332	1419	Mz	2.7	481.95	762.75	1447.2	1798.2	1915.65
	FY	265	213	185	118	59	0	FY	357.75	287.55	249.75	159.3	79.65	0
	Mx	0	0	0	0	0	0	Mx	0	0	0	0	0	0
K SLAB & CROSS	Mz	1	271	439	855	1068	1140	Mz	1.35	365.85	592.65	1154.25	1441.8	1539
	FY	193	169	152	97	48	0	FY	260.55	228.15	205.2	130.95	64.8	0
	Mx	0	0	0	0	0	0	Mx	0	0	0	0	0	0
3 SIDL	Mz	17	203	347	705	892	954	Mz	23.35	302.85	515.65	1044.15	1320.2	1411.5
	FY	147	146	133	103	60	19	FY	218.05	216.3	196.75	151.05	87.8	27.25
	Mx	114	114	93	50	25	8	Mx	155.9	155.9	127.55	68.3	34.15	10.8
4 FPLL & LL	Mz	0	0	0	0	0	0	Mz	91.425	940.0875	1500.563	2947.463	3798.11	4110.15
	FY	0	0	0	0	0	0	FY	626.0625	586.3125	584.325	347.8125	226.575	268.313
	Mx	0	0	0	0	0	0	Mx	214.65	188.8125	127.2	91.425	49.6875	59.625
SUM	**Mz**	**20**	**831**	**1351**	**2632**	**3292**	**3513**	**Mz**	**119**	**2091**	**3372**	**6593**	**8358**	**8976**
	FY	**605**	**528**	**470**	**318**	**167**	**19**	**FY**	**1462**	**1318**	**1236**	**789**	**459**	**296**
	Mx	**114**	**114**	**93**	**50**	**25**	**8**	**Mx**	**371**	**345**	**255**	**160**	**84**	**70**

Note:- Mz - Moment in KNm, FY - Shear in KN, Mx - Torsion in KNm

Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

SLS (Rare comb.) check of RCC girder (Outer Girder)

Items	unit	S 1-1	S 2-2	S 3-3	S 4-4	S 5-5	S 6-6
Dia. Of bar	mm	32	32	32	32	32	32
No. of bars in first layer from bottom		9	9	9	9	9	9
No. of bars in second layer from bottom		0	0	0	9	9	9
No. of bars in third layer from bottom		0	0	0	3	3	3
No. of bars in forth layer from bottom		0	0	0	0	0	0
No. of bars in fifth layer from bottom		0	0	0	0	0	0
C.G. of steel from top (d) mm	mm	1722	1722	1722	1676	1676	1676
Area of steel	mm2	7235	7235	7235	16881	16881	16881

Moment due to deck slab & girder load	KNm	3	628	1004	1927	2400	2559
Grade of Concrete fck	Mpa	30	30	30	30	30	30
fcd	Mpa	13.40	13.40	13.4	13.40	13.40	13.40
Grade of steel fy	Mpa	500	500	500	500	500	500
fyd	Mpa	435	435	435	435	435	435
Effective cover (mm)	mm	78	78	78	78	78	78
bw	mm	750	750	300	300	300	300
bf	mm	3200	3200	3200	3200	3200	3200
Df	mm	360	360	360	360	360	360
D	mm	1400	1400	1400	1400	1400	1400
Df / d		0.21	0.21	0.21	0.21	0.21	0.21
Dia. Of bar (mm)	mm	32	32	32	32	32	32
No. of bars in first layer from bottom		9	9	9	9	9	9
No. of bars in second layer from bottom		0	0	0	9	9	9
No. of bars in third layer from bottom		0	0	0	3	3	3
No. of bars in forth layer from bottom		0	0	0	0	0	0
No. of bars in fifth layer from bottom		0	0	0	0	0	0
C.G. of steel from top (d) mm	mm	1722	1722	1722	1676	1676	1676
Area of steel (mm2)	mm2	7235	7235	7235	16881	16881	16881
x	mm	91	91	91	212	212	212
ssc Girder bottom	Mpa	0	-65	-104	-92	-114	-122
sca Girder top	Mpa	0.02	3.24	5.17	4.55	5.67	6.04
Total stress after dead load of deck slab							
ssc Girder bottom	Mpa	**0**	**-65**	**-104**	**-92**	**-114**	**-122**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca Girder top	Mpa	**0.0**	**3.2**	**5.2**	**4.5**	**5.7**	**6.0**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
Moment due to SIDL	KNm	17	203	347	705	892	954
Grade of Concrete fck	Mpa	30	30	30	30	30	30
fcd	Mpa	13.40	13.40	13.40	13.40	13.40	13.40
Grade of steel fy	Mpa	500	500	500	500	500	500
fyd	Mpa	435	435	435	435	435	435
Effective cover (mm)	mm	78	78	78	78	78	78
bw	mm	900	900	900	900	900	900
bf	mm	3200	3200	3200	3200	3200	3200
Df	mm	360	360	360	360	360	360
D	mm	1650	1650	1650	1650	1650	1650
Df / d		0.21	0.21	0.21	0.21	0.21	0.21

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Dia. Of bar (mm)	mm	32	32	32	32	32	32
No. of bars in first layer from bottom		9	9	9	9	9	9
No. of bars in second layer from bottom		0	0	0	9	9	9
No. of bars in third layer from bottom		0	0	0	3	3	3
No. of bars in forth layer from bottom		0	0	0	0	0	0
No. of bars in fifth layer from bottom		0	0	0	0	0	0
C.G. of steel from top (d) mm	mm	1722	1722	1722	1676	1676	1676
Area of steel (mm2)	mm2	7235	7235	7235	16881	16881	16881
x	mm	91	91	91	212	212	212
ssc Girder bottom	Mpa	-2	-21	-36	-34	-42	-45
sca1 Girder top	Mpa	-0.3	-3.7	-6.4	-5.9	-7.5	-8.0
sca2 Deck slab top	Mpa	0.09	1.05	1.79	1.66	2.11	2.25
Total stress after SIDL							
ssc Girder bottom	Mpa	**-2**	**-86**	**-140**	**-125**	**-157**	**-167**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca1 Girder top	Mpa	**-0.3**	**-0.5**	**-1.2**	**-1.4**	**-1.8**	**-2.0**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca2 Deck slab top	Mpa	**0.08**	**1.44**	**2.33**	**2.12**	**2.71**	**2.9**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**

Live load factor		**1**					
Moment due to LL	KNm	60.95	626.725	1000.375	1964.975	2532.075	2740.1
Grade of Concrete fck	Mpa	30	30	30	30	30	30
fcd	Mpa	13.40	13.40	13.40	13.40	13.40	13.40
Grade of steel fy	Mpa	500	500	500	500	500	500
fyd	Mpa	435	435	435	435	435	435
Effective cover (mm)	mm	78	78	78	78	78	78
bw	mm	900	900	900	900	900	900
bf	mm	3200	3200	3200	3200	3200	3200
Df	mm	360	360	360	360	360	360
D	mm	1650	1650	1650	1650	1650	1650
Df / d		0.21	0.21	0.21	0.21	0.21	0.21
Dia. Of bar (mm)	mm	32	32	32	32	32	32
No. of bars in first layer from bottom		9	9	9	9	9	9
No. of bars in second layer from bottom		0	0	0	9	9	9
No. of bars in third layer from bottom		0	0	0	3	3	3
No. of bars in forth layer from bottom		0	0	0	0	0	0
C.G. of steel from top (d) mm	mm	1722	1722	1722	1676	1676	1676
Area of steel (mm2)	mm2	7235	7235	7235	16881	16881	16881
x	mm	91	91	91	212	212	212
ssc Girder bottom	Mpa	-6.33	-65.04	-103.82	-93.43	-120.40	-130.29
sca1 Girder top	Mpa	-1.1	-11.5	-18.3	-16.5	-21.3	-23.0
sca2 Deck slab top	Mpa	0.31	3.23	5.15	4.64	5.98	6.47
Total stress after LL							
ssc Girder bottom	Mpa	**-8.4**	**-151.3**	**-244.0**	**-218.6**	**-276.9**	**-297.3**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca1 Girder top	Mpa	**-1.4**	**-12.0**	**-19.5**	**-17.9**	**-23.1**	**-25.0**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca2 Deck slab top		**0.39**	**4.67**	**7.48**	**6.76**	**8.69**	**9.37**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
Temperature rise							
Girder bottom	Mpa	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47
Girder top	Mpa	-1.57	-1.57	-2.13	-2.13	-2.13	-2.13
Deck slab top	Mpa	3.63	3.63	1.04	1.04	1.04	1.04
Temperature fall							
Girder bottom	Mpa	-2.59	-2.59	-1.30	-1.30	-1.30	-1.30
Girder top	Mpa	-0.60	-0.60	1.53	1.53	1.53	1.53
Deck slab top	Mpa	-1.91	-1.91	-0.36	-0.36	-0.36	-0.36
Total stress after Temp. rise		**SLS factor for Temperature**				**0.6**	
ssc Girder bottom	Mpa	**-9**	**-152**	**-244**	**-219**	**-277**	**-298**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca1 Girder top	Mpa	**-3**	**-14**	**-22**	**-20**	**-25**	**-27**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca2 Deck slab top		**4.02**	**8.30**	**8.53**	**7.80**	**9.73**	**10.41**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
Total stress after temp. fall							
ssc	Mpa	**-10.99**	**-153.86**	**-245.31**	**-219.87**	**-278.22**	**-298.62**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca1	Mpa	**-2.01**	**-12.56**	**-17.98**	**-16.33**	**-21.54**	**-23.44**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**
sca2		**-1.52**	**2.76**	**7.12**	**6.40**	**8.33**	**9.01**
		ok	**ok**	**ok**	**ok**	**ok**	**ok**

Project		Project Name	Designed by:	KB
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Differential shrinkage loss

Grade of concrete of slab		30
Grade of concrete of girder		30
Shrinkage strain	girder	slab
Grade of concrete fck	M30	M30
ts (days)	29	94
t (days)	122	122
bas(t) = (1 - exp(-0.2sqrt(t)) As per cl. 6.4.2.6 of IRC 112-2011	1	1
ec(∞) = 2.5 (f_{ck} - 10) 10-6	0.00005	0.00005
Autogenous Shrinkage strain eca (t) = bas(t) eca(∞)	0.00004	0.00004
Autogenous Shrinkage strain eca (t) Table 6.6 of IRC 112-2011	0.000035	0.000035
Ac	798750.00	1470750
u	5209	5920
ho = 2Ac / u mm	307	497
kh Table 6.7 of IRC 112-2011	0.743	0.748
b (t, t) = (t - t) / ((t-t)+0.04 h 3/2)	0.302	0.059
Relative humidity(%)	**20%**	**20%**
ecd,0 Eq.A2-26 of IRC 112-2011	0.00081	0.00081
ecd,0 Table 6.8 of IRC 112-2011	0.00028	0.00028
Drying Shrinkage strain ecd (t) = bds(t, ts) kh ecd,0	0.00018	0.000036
Total shrinkage strain = eca(t) + ecd(t)	0.00023	0.00008
Factor due to difference in grade of concrete=		1
Shrinkage strian		0.00015
Reduction factor		1
net shrinkage strain		0.00015
For concrete		
Modulus of elasticity of slab Mpa		320000
Area of slab		672000
Force due to shrinkage		31390336

(Cement : Rapid hardening)

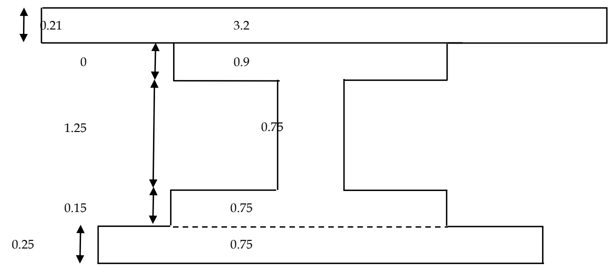
Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

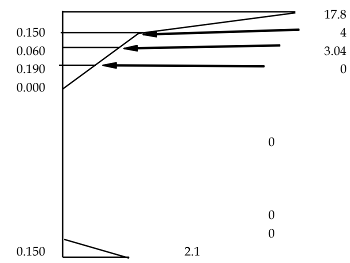
Stresses due to Differential Temperature

Rise in temperature:
Section at Support:

h = 2.01 m

(As per IRC:6 - 2014, Figure 10)





Section	Width	Depth	Area	y	Ay	Ay2	t	At	Aty
1(a)	3.200	0.150	0.480	0.075	0.036	0.003	10.900	5.232	0.392
1(b)	3.200	0.060	0.192	0.180	0.035	0.006	3.520	0.676	0.122
2	0.900	0.190	0.171	0.305	0.052	0.016	1.520	0.260	0.079
3(a)	0.750	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000
3(b)	0.750	0.000	0.000	1.025	0.000	0.000	0.000	0.000	0.000
4	0.750	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000
5(a)	0.750	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000
5(b)	0.750	0.150	0.113	1.975	0.222	0.439	1.050	0.118	0.233
Total			**0.956**		**0.345**	**0.464**		**6.286**	**0.827**

=

Coefficient of thermal expansion α = 0.0000117 /° Centigrade

After solving the above two equations €0 = 0.0000949

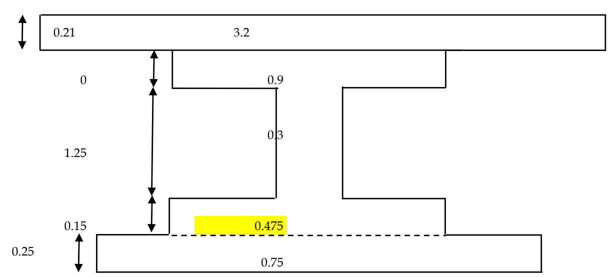
θ = 0.0000498

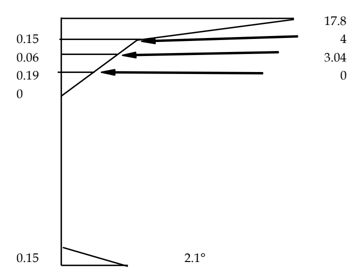
Modulus of elasticity of concrete Ec = 320000 (kg/cm2)

Section	y(m)	yθ	t	αt	A=(€0 - yθ - αt)	Stress=AE (N/mm2)	
1	0	0.0000	17.8	0.0002	-0.0001133	3.63	C
2	0.21	0.0000	3.04	0.0000	0.0000489	-1.57	T
3	0.21	0.0000	3.04	0.0000	0.0000489	-1.57	T
4	1.46	0.0001	0	0.0000	0.0000223	-0.71	T
5	1.61	0.0001	0	0.0000	0.0000148	-0.47	T
6	1.86	0.0001	2.1	0.0000	-0.0000222	0.71	C

Rise in temperature:
Section at Mid Span:

h = 2.01 m





Section	Width	Depth	Area	y	Ay	Ay2	t	At	Aty
1(a)	3.200	0.150	0.480	0.075	0.036	0.003	10.900	5.232	0.392
1(b)	3.200	0.060	0.192	0.180	0.035	0.006	3.520	0.676	0.122
2	0.900	0.190	0.171	0.305	0.052	0.016	1.520	0.260	0.079
3(a)	0.300	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000
3(b)	0.300	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000
4	0.475	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000
5(a)	0.750	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000
5(b)	0.750	0.150	0.113	1.975	0.222	0.439	1.050	0.118	0.233
Total			**0.956**		**0.345**	**0.464**		**6.286**	**0.827**

Now $€0 \sum A - \theta \sum Ay = \alpha \sum At$

$€0 \sum Ay - \theta \sum Ay^2 = \alpha \sum Ayt$

Coefficient of thermal expansion α = 0.000012 /° Centigrade

After solving the above two equations €0 = 0.0000949

θ = 0.0000498

Modulus of elasticity of concrete Ec = 320000 (kg/cm2)

Section	y(m)	yθ	t	αt	A=(€0 - yθ - αt)	Stress=AE (N/mm2)	
1	0	0.0000	10.900	0.00013	-0.0000326	-1.04	T
2	0.21	0.0000	1.520	0.00002	0.0000667	2.13	C
3	0.21	0.0000	0.000	0.00000	0.0000845	2.70	C
4	1.46	0.0001	0.000	0.00000	0.0000223	0.71	C
5	1.61	0.0001	0.000	0.00000	0.0000148	0.47	C
6	1.86	0.0001	1.050	0.00001	-0.0000099	-0.32	T

Project	Project Name	Designed by:	KB
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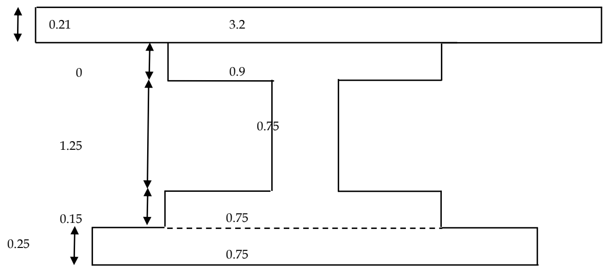
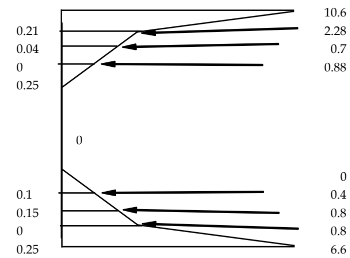
Stresses due to Differential Temperature

Fall in temperature:
Section at Support:
(As per IRC:6 - 2014, Figure 10) h = 2.01 m





Section	Width	Depth	Area	y	Ay	Ay2	t	At	Aty
1(a)	3.200	0.210	0.672	0.105	0.071	0.007	6.440	4.328	0.454
1(b)	0.900	0.040	0.036	0.230	0.008	0.002	1.490	0.054	0.012
2	0.000	0.000	0.000	0.250	0.000	0.000	0.790	0.000	0.000
3(a)	0.900	0.250	0.225	0.375	0.084	0.032	0.440	0.099	0.037
3(b)	0.750	0.450	0.000	0.725	0.000	0.000	0.000	0.000	0.000
3(c)	0.750	0.100	0.075	1.000	0.075	0.075	0.200	0.015	0.015
4	0.650	0.150	0.098	1.125	0.110	0.123	0.600	0.059	0.066
5(a)	0.750	0.000	0.000	1.200	0.000	0.000	0.800	0.000	0.000
5(b)	0.750	0.250	0.188	1.325	0.248	0.329	3.700	0.694	0.919
Total			**1.293**		**0.596**	**0.569**		**5.248**	**1.504**

Now $\epsilon_0 \sum A - \theta \sum Ay = \alpha \sum At$

$\epsilon_0 \sum Ay - \theta \sum Ay^2 = \alpha \sum Ayt$

Coefficient of thermal expansion	α	=	0.0000117	/° Centigrade
After solving the above two equations	ϵ_0	=	0.0000643	
	θ	=	0.0000365	
Modulus of elasticity of concrete	Ec	=	320000	

Section	y(m)	yθ	t	αt	A=(Є0 – yθ – αt)	Stress=AE (N/mm2)	
1	0	0.0000	10.6	0.0001	-0.0000597	-1.91	T
2	0.21	0.0000	6.44	0.0001	-0.0000187	-0.60	T
3	0.21	0.0000	0.44	0.0000	0.0000515	1.65	C
4	1.46	0.0001	0.2	0.0000	0.0000087	0.28	C
5	1.61	0.0001	0.8	0.0000	-0.0000038	-0.12	T
6	1.86	0.0001	6.6	0.0001	-0.0000808	-2.59	T

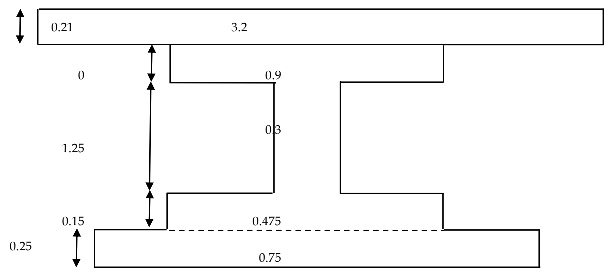
Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

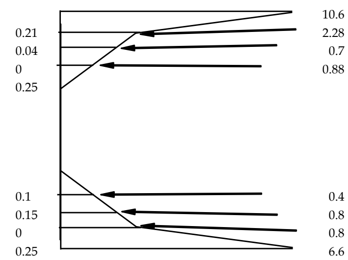
Stresses due to Differential Temperature

Fall in temperature:
Section at Mid Span:

h = 1.41 m

(As per IRC:6 - 2014, Figure 10)





Section	Width	Depth	Area	y	Ay	Ay2	t	At	Aty
1(a)	3.200	0.210	0.672	0.105	0.071	0.007	6.440	4.328	0.454
1(b)	0.900	0.040	0.036	0.230	0.008	0.002	1.490	0.054	0.012
2	0.000	0.000	0.000	0.250	0.000	0.000	0.790	0.000	0.000
3(a)	0.900	0.250	0.225	0.375	0.084	0.032	0.440	0.099	0.037
3(b)	0.300	0.450	0.000	0.725	0.000	0.000	0.000	0.000	0.000
3(c)	0.300	0.100	0.030	1.000	0.030	0.030	0.200	0.006	0.006
4	0.475	0.150	0.071	1.125	0.080	0.090	0.600	0.043	0.048
5(a)	0.475	0.000	0.000	1.200	0.000	0.000	0.800	0.000	0.000
5(b)	0.750	0.250	0.188	1.325	0.248	0.329	3.700	0.694	0.919
Total			**1.222**		**0.522**	**0.490**		**5.223**	**1.477**

Now $Є0 \sum A - \theta \sum Ay = \alpha \sum At$

$Є0 \sum Ay - \theta \sum Ay^2 = \alpha \sum Ayt$

Coefficient of thermal expansion	α	=	0.0000117	/° Centigrade
After solving the above two equations	Є0	=	0.0000641	
	θ	=	0.0000330	
Modulus of elasticity of concrete	Ec	=	320000	(kg/cm2)

Section	y(m)	yθ	t	αt	A=(Є0 – yθ – αt)	Stress=AE (N/mm2)	
1	0.0000	0.0000	6.4400	0.0001	0.0000	-0.3601	T
2	0.2100	0.0000	0.7900	0.0000	0.0000	1.5337	C
3	0.2100	0.0000	0.0000	0.0000	0.0001	1.8295	C
4	1.4600	0.0000	0.2000	0.0000	0.0000	0.4361	C
5	1.6100	0.0001	0.8000	0.0000	0.0000	0.0533	C
6	1.8600	0.0001	3.7000	0.0000	0.0000	-1.2962	T

Project		Project Name	Designed by:	KB
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Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Stresses due to Differential Temperature

ULS check for Longitudinal Girder

Moment on the section						
	S 1-1	S 2-2	S 3-3	S 4-4	S 5-5	S 6-6
Actual moment (KNm)	119	2090.7375	3371.6125	6593.0625	8358.3125	8976.3
Torsional moment (KNm)	371	345	255	160	84	70
Overall depth of beam (D) m	2.01	2.01	2.01	2.01	2.01	2.01
Area of section	2.01	2.01	1.61	1.61	1.61	1.61
Width of beam (b) m	1	1	0.8	0.8	0.8	0.8
Mt = T(1+D)/b/1.7	656	610	564	354	186	156
Total moment (KNm)	775	2701	3935	6947	8544	9132
Grade of Concrete	30	30	30	30	30	30
Grade of steel fy	500	500	500	500	500	500
Effective cover (mm)	78	78	78	78	78	78
bw	900	900	900	900	900	900
bf	3200	3200	3200	3200	3200	3200
Df	210	210	210	210	210	210
D	1650	1650	1650	1650	1650	1650
Df / d	0.11	0.11	0.11	0.11	0.11	0.11
(d) mm						
Dia. Of bar (mm)	32	32	32	32	32	32
No. of bars in first layer from bottom	9	9	9	9	9	9
No. of bars in second layer from bottom	0	0	0	9	9	9
No. of bars in third layer from bottom	0	0	0	3	3	3
No. of bars in forth layer from bottom	0	0	0	0	0	0
No. of bars in fifth layer from bottom	0	0	0	0	0	0
C.G. of steel from top (d) mm	1932	1932	1932	1886	1886	1886
Area of steel (mm2)	7234.56	7234.56	7234.56	16881	16881	16881
x	91	91	91	212	212	212
MRs	5958	5958	5958	13195	13195	13195
MRc	5958	5958	5958	13195	13195	13195
	OK	**OK**	**OK**	**OK**	**OK**	**OK**

Shear on the section	**S 1-1**	**S 2-2**	**S 3-3**	**S 4-4**	**S 5-5**	**S 6-6**
Actual shear (KN)	1462.4125	1318.3125	1236.025	789.1125	458.825	295.5625
Torsional moment (KNm)	371	345	255	160	84	70
Width of beam (b) m	1	1	0.8	0.8	0.8	0.8
Vt = 1.6 T/b	593	552	510	319	168	141
Actual shear VEd (KN)	2055	1870	1746	1109	627	436
Actual shear stress (N/mm2)	1.31	1.19	1.12	0.73	0.41	0.29
Max shear capacity, 0.135 fck(1-fck/310)	3.7	3.7	3.7	3.7	3.7	3.7
	OK	**OK**	**OK**	**OK**	**OK**	**OK**

Min shear capacity, 0.0924 fck(1-fck/310)	2.5	2.5	2.5	2.5	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	21.8	21.8	21.8	21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010						
K = 1+Sqrt(200/d) <= 2.0	1.32	1.32	1.32	1.33	1.33	1.33
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010						
n = 0.031 K3/2 fck1/2 min	0.258	0.258	0.258	0.258	0.258	0.258
cl. 10.3.1 of IRC :112-2011						
r1 = Asl/(bw d) <= 0.02	0.004	0.004	0.005	0.011	0.011	0.011

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Stresses due to Differential Temperature

	OK	**OK**	**OK**	**OK**	**OK**	**OK**
0.12 K (80 r1 f)0.33	0.327	0.327	0.352	0.471	0.471	0.471
ck						
Axial compressive force NEd (KN)	0	0	0	0	0	0
Ac	2045910	2045910	1470750	1470750	1470750	1470750
scp = NEd / Ac <= 0.2 fcd	0	0	0	0	0	0
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010						
V_{Rdc} = [0.12K(80ρ1 f)0.33 + 0.15σ]b d <= Rd.c ck cp w (n min + 0.15 scp) bw d (KN)	569	569	613	800	800	800
	Provide Shear Reinf.	**Provide Shear Reinf.**	**Provide Shear Reinf.**	**OK Provide min r/f**	**OK Provide min r/f**	**OK Provide min r/f**
Min shear stress	0.327	0.327	0.352	0.471	0.471	0.471
Min shear force for providing reinf., VE (N)	2059403	2078817	2050290	1427292	908154	748587
No. of link for shear reinf.	2	2	2	2	2	2
Dia. of bar for shear reinf.	12	12	12	12	12	12
Asw	226	226	226	226	226	226
S = Asw x 0.9 x d x cot Θ x fy / VE	239	237	240	336	529	641
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011						
S l.max = 0.75 d	600	600	600	600	600	600
Spacing required in Long. Direction (mm)	**150**	**150**	**150**	**150**	**250**	**250**
cl. 10.3.3.2 Eq. 10.7 of IRC :112-2011						
z	1620	1620	1620	1620	1620	1620
fywd	348	348	348	348	348	348
VRd.s = ASW z fywd cot Θ / S (KN)	2124	2124	2124	2124	1275	1275
	OK	**OK**	**OK**	**OK**	**OK**	**OK**
acw = (scp = NEd / Ac = 0)	1	1	1	1	1	1
n1 = (0.6* (1-fck/310))	0.5	0.5	0.5	0.5	0.5	0.5
cl. 10.3.3.2 Eq. 10.8 of IRC :112-2011						
VRd.max = acw bw z n1 fcd (KN)	15803	15803	15803	15803	15803	15803
	OK	**OK**	**OK**	**OK**	**OK**	**OK**
cl. 10.3.3.2 Eq. 10.10 of IRC :112-2011						
ASW.max <= 0.5 acw n1 fcd bw S / fywd	2103	2103	2103	2103	3506	3506
	OK	**OK**	**OK**	**OK**	**OK**	**OK**
cl. 10.3.1 of IRC :112-2011						
rw = ASW/(S bw sina)	0.0012	0.0012	0.0012	0.0009	0.0006	0.0005
cl. 10.3.3.5 of IRC :112-2011						
r = (0.072 $f_{ck}^{0.5}$) / fyk	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008

Interface shear

Transverse Shear force (KN) VEd	3626	3626	3626	3626	3626	3626
Inner lever arm of composite section	1969	1969	1969	1948	1948	1948
Interface width bi	900	900	900	900	900	900
Interface area Aj	900000	900000	900000	900000	900000	900000
Proportion of Longitudinal tensile force to total longitudinal force carried in top slab	0.18	0.16	0.16	0.14	0.11	0
VEdi = b VEd /(z bi)	0.36	0.33	0.32	0.28	0.22	0
fyd	500	500	500	500	500	500
m	0.6	0.6	0.6	0.6	0.6	0.6
Shear force due to SIDL & LL (KN)	2059	2078	2050	1427	908	451
Area of section (m2)	2	2	1.43	1.43	1.43	1.43
sn	0.97	1	1.44	1	0.64	0.32
Dia of bar	12	12	12	12	12	12
No. of bars	2	2	2	2	2	2
Spacing of bars	150	150	150	200	250	250
Area of bar per meter As	1508	1508	1508	1131	905	905
Min. 0.15% area	1275	1275	1275	1275	1275	1275
ρ = As / Aj	0.002	0.002	0.002	0.001	0.001	0.001
a	90	90	90	90	90	90
v = 0.6*(1-fck/310)	0.532	0.532	0.532	0.532	0.532	0.532
fcd	15.6	15.6	15.6	15.6	15.6	15.6
VRdi = m sn + ρ fyd (m sina + cosa) <= 0.5v fcd	1.11	1.1	1.09	0.84	0.64	0.48
	OK	**OK**	**OK**	**OK**	**OK**	**OK**

Shear in the flange portion of flanged beams

DM	KNm	6551					
bf	mm	900	900	900	900	900	900
bw	mm	750	750	300	300	300	300
d	mm	1932	1932	1932	1886	1886	1886
Df	mm	150	150	150	150	150	150
DFd = DM (bf-bw)/(2 bf (d-Df/2))	KN	294	294	1176	1205	1205	1205
hf	mm	150	150	150	150	150	150
Dx	mm	5900	5900	5900	5900	5900	5900
VEd = DFd/(hf. Dx)	N/mm2	0.332	0.332	1.329	1.362	1.362	1.362
v = 0.6*(1-fck/310)		0.53	0.53	0.53	0.53	0.53	0.53
fcd	N/mm2	15.6	15.6	15.6	15.6	15.6	15.6
θf		45	45	45	45	45	45
VEd <= ν fcd sinθf cosθf		4.16	4.16	4.16	4.16	4.16	4.16
0.4 fctd		0.507	0.507	0.507	0.507	0.507	0.507
		OK no extra reinforce	OK no extra reinforce	Extra reinforce ment req.	Extra reinforce ment req.	Extra reinforce ment req.	Extra reinforceme n t req.
Dia of bar		12	12	12	12	12	12
Asf	mm2	113	113	113	113	113	113
fyd		435	435	435	435	435	435
Sf = Asf fyd cotθf /VEd/ hf	mm	600	600	275	275	275	275

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Stresses due to Differential Temperature

SLS check (Quasi.) for Longitudinal Girder

Moment on the section	**S 1-1**	**S 2-2**	**S 3-3**	**S 4-4**	**S 5-5**	**S 6-6**
Total moment (KNm)	20	831	1351	2632	3292	3513
Overall depth of beam (D) m	2.01	2.01	2.01	2.01	2.01	2.01
Area of section	2.01	2.01	1.608	1.608	1.608	1.608
Width of beam (b) m	1	1	0.8	0.8	0.8	0.8
Grade of Concrete	30	30	30	30	30	30
Grade of steel fy	500	500	500	500	500	500
Effective cover (mm)	78	78	78	78	78	78
bw	900	900	900	900	900	900
bf	3200	3200	3200	3200	3200	3200
Df	210	210	210	210	210	210
D	1650	1650	1650	1650	1650	1650
Df / d	0.11	0.11	0.11	0.11	0.11	0.11
Dia. Of bar (mm)	32	32	32	32	32	32
No. of bars in first layer from bottom	9	9	9	9	9	9
No. of bars in second layer from bottom	0	0	0	9	9	9
No. of bars in third layer from bottom	0	0	0	3	3	3
No. of bars in forth layer from bottom	0	0	0	0	0	0
No. of bars in fifth layer from bottom	0	0	0	0	0	0
C.G. of steel from top (d) mm	1804	1804	1804	1758	1758	1758
Area of steel (mm2)	7235	7235	7235	16881	16881	16881
x	91	91	91	212	212	212
ssc	-1.77	-73.45	-119.40	-105.50	-131.96	-140.82
	OK	**OK**	**OK**	**OK**	**OK**	**OK**
sca	0.1	3.6	5.9	5.2	6.6	7.0
	OK	**OK**	**OK**	**OK**	**OK**	**OK**
Control of crack	**S 1-1**	**S 2-2**	**S 3-3**	**S 4-4**	**S 5-5**	**S 6-6**
$ø_{eq} = (n1ø1^2 + n2ø2^2) / (n1ø1+n2ø2)$	32	32	32	32	32	32
cl. 12.3.4 (3) of IRC :112-2011						
c	50	50	50	50	50	50
k1	0.8	0	0	0	0	0
k2	0.5	0.5	0.5	0.5	0.5	0.5
For skew slab refer eq. 12.10 of IRC :112-2011						
r p.eff = As / Ac,eff	0.01	0.01	0.01	0.03	0.03	0.03
Sr,max ={ 3.4 c + (0.425 k1 k2 f)/ rp.eff }	556	170	170	170	170	170
cl. 12.3.4 (3) of IRC :112-2011						
kt	0.5	0.5	0.5	0.5	0.5	0.5
fct,eff	2.9	2.9	2.9	2.9	2.9	2.9
Es	200000	200000	200000	200000	200000	200000
Ecm	32000	32000	32000	32000	32000	32000
ae = Es / Ecm	6.25	6.25	6.25	6.25	6.25	6.25
(esm-ecm)=(ssc-kt fct,eff(1+ae rp,eff)/rp,eff	0.0000	0.0002	0.0004	0.0003	0.0004	0.0004
cl. 12.3.4 (2) of IRC :112-2011						
Wk = Sr,max (esm - ecm)	0.00	0.04	0.06	0.05	0.07	0.07
cl. 12.3.4 (1) of IRC :112-2011						
	OK	**OK**	**OK**	**OK**	**OK**	**OK**

Calculation of deflection			
Span (mm)			25000
span/800			31.3
Cl. 12.4.1 (2) of IRC :112-2011	**mm**	**Factors**	
GIRDER	3.83	1	3.83
DECK SLAB & CROSS GIRDER	2.95	1	2.95
SIDL CRASH BARRIER & RAILING	1.70	1	1.70
SIDL SURFACING(WEARING COAT)	0.83	1	0.83
FPLL	0.00	1	0.00
LL	5.23	0.75	3.92
Short term elastic deflection from STAAD			13.22
			OK

Project		Project Name	Designed by:	KB
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Design loads for End Cross Girder

The end diaphragm is designed as a continuous deep beam for bearing replacement condition, continuous over knife supports at the jack locations. . The reaction of main girder due to (DL+SIDL) are applied as loads at the girder location shown as below.

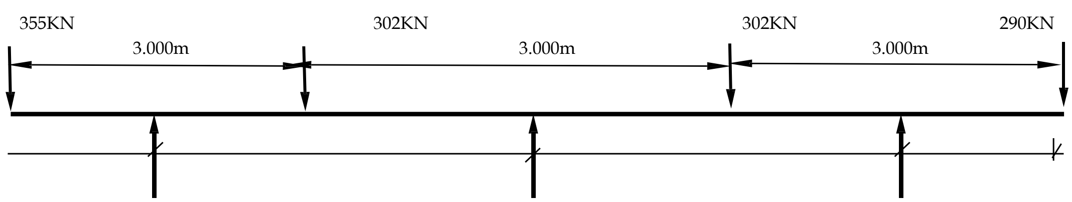
Width of Diaphragm	b	=	400	mm		
Overall Depth of Diaph.	D	=	1760	mm	Including deck slab	210 mm
Concrete Grade	M	=	30			
Reinforcement Grade	Fe	=	500			

	G1	G2	G3	G4	G5
DL Girder	263	263	263	263	263
DL Slab	218.4	218.4	218.4	218.4	218.4
SIDL	141.6	35.6	30.1	35.6	142
Diaphragm	28.16	56.32	56.32	56.32	28.16

651	573	568	573	651	185	3015.62559	185	KN
651	573	568	573	651				

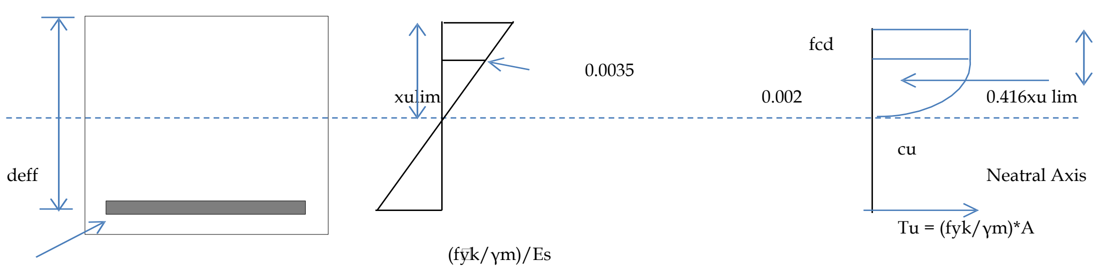
(i) Design under Bearing Repalcement Condition

DL & SIDL reactions from bearings are applied as point loads.



Number of Jacks per End	=	3

ULS check for End Cross Girder



Strain Diagram

Stress Diagram

Grade of Concrete	fck	=	30	N/mm2	
As per clause 6.4.2.8, IRC:112-2011					
	fcd	=	13.4	N/mm2	For Basic Combination

	Ec		=	32000	MPa	
Grade of steel		f_y	=	500	N/mm2	
		f_{yd}	=	435	N/mm2	For Basic Combination

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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 = 200000 MPa Ec = 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

Rlim = Mu,Lim/bd2 = 0.8095 fcd*(xu lim/d)*(1-0.416*xu lim/d)

	BasicComb	AccidentalComb	SeismicComb
xu,lim/d	0.62	0.58	0.62
Rlim = Mu,Lim/bd2	4.97	5.99	5.80

Here Rlim is in Mpa

Calculation of Reinforcement

Width of section b = 400 mm

Depth of section D = 1760 mm

Clear cover = 50

Moment on the section	**Hogging moment**	**Sagging moment**
	Basic Comb	Basic Comb
Actual moment (KNm)	935.7	58.9
Impact factor	1	1
ULS factor	1.35	1.35
Actual moment (KNm)	1263.195	79.515
Grade of Concrete fck	30	30
Grade of steel fY	500	500
b	400	400
D	1760	1760
c	50	50
d	1700	1700
fcd	13.4	13.4
fYd	435	435
xu,lim/d	0.62	0.62
R = M /bd2 sls u,sls	4.97	4.97
Mu,Lim (KNm)	5745	5745
	OK	**OK**
Ast Req.	1307	80
Dia of bar (main tension) (mm)	20	20
No. of bar in first layer	4	4
+ dia of bar (main tension) (mm)	20	20
No. of bar in second layer	4	4
Ast provided (sq mm)	2513	2513
Dia of bar (main compresion) (mm)	20	20
No. of bar in first layer	4	8
Area of main compresion (mm2)	1257	2513
fctm	2.5	2.5
fyk	435	435
cl. 16.6.1 (2) of IRC :112-2011		
AS.min = 0.26 fctm bt d / fyk >= 0.0013 bt d	1016	1016
Act	603212.3161	603212.3161
fct,eff	2.9	2.9
k_C = 0.4 { 1 - s / (k f h/h*) } <= 1	0.4	0.4
For Bending or bending combined with axial force		
k	0.65	0.65
ss	435	435
cl. 12.3.6 (4) of IRC :112-2011		
AS.min = kc k fct,eff Act / ss	1046	1046
	ok	**ok**
As.max = 0.025 Ac (main tension)	17600	17600
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**	**OK**
As.max = 0.04 Ac (tension + compresion)	28160	28160
x (mm)	252	252
x/d	0.15	0.15
	OK	**OK**
z (mm)	1595	1595
MR (KNm)	1744	1744
	OK	**OK**

(from staad)

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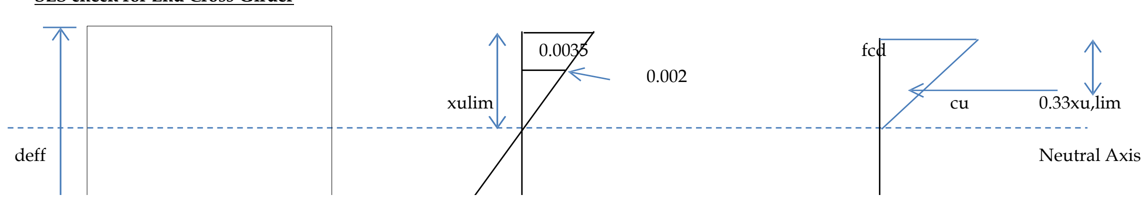
Shear on the section	**Hogging moment**	
Shear from Staad (KN)	623.8	(from staad)
Impact factor	1	
ULS factor	1.35	
Actual shear VEd (KN)	842.1	
Actual shear stress (N/mm2)	1.386	
Max shear capacity, 0.135 fck(1-fck/310)	3.7	**OK**

Shear on the section	**Hogging moment**	
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	1.34	
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010		
nmin = 0.031 K3/2 fck1/2	0.264	
cl. 10.3.1 of IRC :112-2011		
r1 = Asl/(bw d) <= 0.02	0.004	**OK**
0.12 K (80 r1 f)0.33	0.331	
ck		
Axial compressive force NEd (KN)	0	
scp = NEd / Ac <= 0.2 fcd	0	
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010		
V = [0.12K(80ρ1 f)0.33 + 0.15σ]b d <=		
Rd.c ck cp w (n min + 0.15 scp) bw d (KN)	225.2	
	Provide Shear Reinf.	
Min shear stress	0.264	
Min shear force for providing reinf., VE (N)	842117	
No. of link for shear reinf.	2	
Dia. of bar for shear reinf.	12	
S = Asw x 0.9 x d x cot Θ x fy / VE	447	
S (mm)	200	
ASW	226	
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011		
S l.max = 0.75 d	600	
Spacing provided in Long. Direction (mm)	150	
cl. 16.5.2(9) Eq. 16.8 of IRC :112-2011		
z (mm)	1583	
fywd	435	
cl. 10.3.3.3 Eq. 10.17 of IRC :112-2010		
VEd <= ASW fywd (KN)	79	
cl. 10.3.3.2 Eq. 10.7 of IRC :112-2011		
VRd.s = ASW z fywd cot Θ / S (KN)	2076	**OK**
	OK	
acw = (scp = NEd / Ac = 0)	1	
n1	0.5	
cl. 10.3.3.2 Eq. 10.8 of IRC :112-2011		
VRd.max = acw bw z n1 fcd (KN)	4598	**OK**
cl. 10.3.3.2 Eq. 10.10 of IRC :112-2011		
Asw.max <= 0.5 acw n1 fcd bw S / fywd	693	**OK**
cl. 10.3.1 of IRC :112-2011		
rw = Asw/(S bw sina)	0.003	
cl. 10.3.3.5 of IRC :112-2011		
rw,min = (0.072 fck yk	0.001	**OK**

SLS check for End Cross Girder



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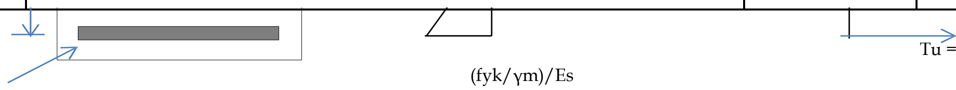
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-



Tu = (fyk/γm)*Ast

(fyk/γm)/Es

Ast

Strain Diagram

Stress Diagram

SERVICEABILITY LIMIT STATE

Grade of Concrete	fck	=	30	N/mm2	
As per clause 12.2.1, IRC:112-2011					
	fcd	=	14.4	N/mm2	For Rare Combination
	fcd	=	10.8	N/mm2	For Quasi-Perma. Combination
As per clause 12.2.2, IRC:112-2011					
Grade of steel	fY	=	500	N/mm2	
	fYd	=	300	N/mm2	For Rare Combination
	fYd	=	300	N/mm2	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 = 2.00E+05 MPa Ec = 32000 MPa

Cu =

= ′2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

Rsls = Mu,sls/bd2 = 0.5fcd*(xu/d)*(1-0.33*xu/d)

			Quasi-
	Rare Comb	Frequent Comb	Perma. Comb
xu,sls/d	0.7	0.7	0.7
R = M /bd2 sls u,sls	3.88	3.88	2.91

Here Rsls is in MPa

Calculation of Reinforcement

Width of section b	=	400	mm
Depth of section d	=	1760	mm
Clear cover	=	50	

Moment on the section	**Hogging moment**			**Sagging moment**		
	Rare Comb		**Quasi-Perma. Comb**	**Rare Comb**		**Quasi-Perma. Comb**
Actual moment (KNm)	935.7		935.7	58.9		58.9
Impact factor	1		1	1		1
ULS factor	1		1	1		1
Actual moment (KNm)	935.7		935.7	58.9		58.9
b	400		400	400		400
D	1760		1760	1760		1760
c	50		50	50		50
d	1700		1700	1700		1700
fcd	14.4		10.8	14.4		10.8

Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
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Moment on the section	**Hogging moment**			**Sagging moment**		
	Rare Comb		**Quasi-Perma. Comb**	**Rare Comb**		**Quasi-Perma. Comb**
fYd	300		300	300		300
xu,sls/d	0.7		0.7	0.7		0.7
Rsls = Mu,sls/bd2	3.88		2.91	3.88		2.91
Mu,sls (KNm)	4485		3364	4485		3364
	OK		**OK**	**OK**		**OK**
Ast Req.	1908		1936	116		116
Dia of bar (main tension) (mm)	20		20	20		20
Spacing (mm)	4		4	4		4
+ dia of bar (main tension) (mm)	20		20	20		20
Spacing (mm)	4		4	4		4
Ast provided (sq mm)	2513		2513	2513		2513
Dia of bar (main compresion) (mm)	20		20	20		20
Spacing (mm)	4		4	8		8
Area of main compresion (mm2)	1257		1257	2513		2513
fctm	2.5		2.5	2.5		2.5
x (mm)	262		349	262		349
x/d	0.154		0.205	0.154		0.205
	OK		**OK**	**OK**		**OK**
z (mm)	1614		1585	1614		1585
MRsls (KNm)	1217		1195	1217		1195
	OK		**OK**	**OK**		**OK**
ssc = M/(As z)	231		235	15		15
	OK		**OK**	**OK**		**OK**
sca = M/(0.8095 z b xu)	11.07		8.46	0.70		0.53
	OK		**OK**	**OK**		**OK**

Calculation of crack width		**Hogging moment**			**Sagging moment**
$ø_{eq}$ = $(n1ø1^2 + n2ø2^2)$ / (n1ø1+n2ø2)		20			20
cl. 12.3.4 (3) of IRC :112-2011					
c		50			50
k1		0.8			0.8
k2		0.5			0.5
For skew slab refer eq. 12.10 of IRC :112-2011					
r p.eff = As / Ac,eff		0.03			0.03
Sr,max ={ 3.4 c + (0.425 k1 k2 f) / rp.eff }		270			270
cl. 12.3.4 (3) of IRC :112-2011					
kt		0.5			0.5
fct,eff		2.9			2.9
Es		200000			200000
Ecm		32000			32000
ae = Es / Ecm		6.25			6.25
(esm-ecm)=(ssc-kt fct,eff(1+ae rp,eff)/rp,eff)/Es		0.0009			0.0001
cl. 12.3.4 (2) of IRC :112-2011					
Wk = Sr,max (esm - ecm)		0.24			0.03
cl. 12.3.4 (1) of IRC :112-2011					

Calculation of deflection	Span
Span (mm)	3200
Permissible limit (span/800)	4.0
cl. 12.4.1 (2) of IRC :112-2011	
Short term elastic deflection from STAAD	0.04
	OK

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Load calculation for Deck slab analysis

Total Width of Superstructure	=		16.00	m
Width of Carriageway	=		15.10	m
Width of crash barrier,	=		0.45	m
Thickness of deck Slab at Centre	=		0.21	m
Thickness of deck Slab at ends (cantilever)	=		0.21	m
Thickness of wearing coat	=		0.08	m
Nos. of Longitudinal Girders	=		5.00	
C/C Spacing of Longitudinal Girder 1	=		3.20	m
Web width of Girder at span	=		0.30	m
Top flange of Girder at span	=		0.90	
Grade of conc. of superstructure	=	M	30.00	
Dry wt. of conc.	=		25.00	kN/m^3
Dry wt. of wearing coat	=		22.00	

70R Track Loading at mid span

Dispersed width for continuous slab : As per Informative Annexure B-3 of IRC-112-2

Impact factor			1.25			
Contact width of tyre			0.84	m		
Contact length of tyre			4.57	m		
Transverse direction bef	=					
b1	=		4.72	m		
l0			2.9	m		
a			0.67	m		
a = 2.5		b/l0 =	1.6			
Transverse direction bef	=		6.02	m	1.47	1.6
Longitudinal direction	=		1.41	m		
Load			35	t		
Intensity of load	=	=	**5.155652**	t/m2		
			51.56	KN/m		

70R Track Loading support at mid

Dispersed width for continuous slab :

Impact factor		1.25	
Contact width of tyre		0.84	m
Contact length of tyre		4.57	m
Transverse direction bef	=		
b1	=	4.72	m
l0		2.9	m
a		1.03	m
a		2.52	
Transverse direction bef	=	6.39	m
Longitudinal direction	=	1.41	m
Load		35	t
Intensity of load	=	**4.852949**	t/m2
		48.53	KN/m

Project			Project Name	Designed by:	KB
Client			Client Name	Checked by:	-
Job Name			Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Bogie Axle (40T) at mid span

Dispersed width for continuous slab :						
Impact factor				1.25		
max. tyre pressure				52.73	t/m2	
c/c of tyre				1.22	m	1.93 m
Contact width of tyre				0.86	m	
Contact length of tyre				0.221	m	
Transverse direction bef	=					
b1	=			0.371	m	
l0				2.9	m	
a				0.68	m	
a				2.5		
Transverse direction bef	=			1.68	m	
				2.77	m	
Longitudinal direction	=			1.43	m	
Load				20	t	
Intensity of load	=		=	**6.308201**	t/m2	
				63.08201	KN/m	

Bogie Axle (40T) support at mid

Dispersed width for continuous slab					
Impact factor				1.25	
max. tyre pressure				52.73	t/m2
c/c of tyre				1.22	m
Contact width of tyre				0.86	m
Contact length of tyre				0.221	m
Transverse direction bef	=				
b1	=			0.371	m
l0				2.9	m
a				0.965	m
a				2.52	
Transverse direction bef	=			1.99	m
		Overlapped		2.93	m
Longitudinal direction	=		=	1.43	m
Load				20	t
Intensity of load	=		=	**5.973256**	**t/m2**
				59.73256	KN/m

Class A at mid span

Dispersed width for continuous slab					
Impact factor				1.5	
c/c of tyre				1.2	m
Contact width of tyre				0.5	m
Contact length of tyre				0.25	m
Transverse direction bef	=				
b1	=			0.4	m
l0				2.9	m
a				0.7	m
a				2.52	
Transverse direction bef	=			1.74	m
		Overlapped		2.67	m
Longitudinal direction	=		=	1.07	m
Load				11.4	t
Intensity of load	=		=	**5.987519**	t/m2
				59.87519	KN/m

Project			Project Name	Designed by:	KB
Client			Client Name	Checked by:	-
Job Name			Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Class A for cantilever					
Dispersed width for conti :					
Impact factor				1.5	
c/c of tyre				1.2	m
Contact width of tyre				0.5	m
Contact length of tyre				0.25	m
Transverse direction bef	=				
b1				0.4	m
a				0.75	m
Transverse direction bef	=			1.3	m
			No Overlap	2.45	m
Longitudinal direction	=		=	1.07	m
Load				5.7	t
Intensity of load	=			**3.261492**	t/m2
				32.61492	KN/m
Class A					
Dispersed width for continuous slab :					
Impact factor				1.25	
c/c of tyre				1.2	m
Contact width of tyre				0.5	m
Contact length of tyre				0.25	m
Transverse direction bef	=				
b1	=			0.4	m
l0				2.9	m
a				1.05	m
a				2.52	
Transverse direction bef	=			2.09	m
			Overlapped	2.84	m
Longitudinal direction	=		=	1.07	m
Load				11.4	t
Intensity of load	=		=	#######	t/m2
				63.8	KN/m

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

BM Summary for Deck Slab design from STAAD

Max. Bending moment at node		***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1 SELF WEIGHT	**Mz**	6.70	1.40	3.80	2.40	4.80	2.40	3.80	1.40	6.70
2 SIDL CB & RAILI	**Mz**	13.20	4.80	3.70	1.00	1.60	0.60	2.80	3.50	9.80
3 SIDL WEARING	**Mz**	1.80	0.40	1.00	0.70	1.30	0.70	1.00	0.40	1.80
4 FPLL	**Mz**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LL		53.00	36.00	48.00	30.00	16.00	7.00	3.60	1.80	0.00
Max. Shear force at node		2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1 SELF WEIGHT	**Fy**	9.30	0.90	8.10	0.30	8.70	0.30	8.10	0.90	9.30
2 SIDL CB & RAILI	**Fy**	9.80	5.30	5.30	1.70	1.70	1.40	4.00	4.00	9.80
3 SIDL WEARING	**Fy**	2.50	0.20	2.20	0.10	2.40	0.10	2.20	0.20	2.50
4 FPLL	**Fy**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LL		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Factor for	**Basic**	**Rare**	**Quasi.**
1 SELF WEIGHT	1.35	1	1
2 SIDL CB & RAILING	1.35	1	1
3 SIDL WEARING COAT	1.75	1	1
4 FPLL	1.5	1	0
LL	1.5	1	0

Max. Bending moment at node	**Basic**									**Rare**								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1 SELF WEIGHT	9	1.9	5.1	3.24	6.5	3.2	5.1	1.9	9	6.7	1.4	3.8	2.4	4.8	2.40	3.8	1.4	6.7
2 SIDL CB & RAILI	18	6.5	5	1.35	2.2	0.8	3.8	4.7	13	13.2	4.8	3.7	1	1.6	0.60	2.8	3.5	9.8
3 SIDL WEARING	2.4	0.7	1.8	1.225	2.3	1.2	1.8	0.7	3.2	1.8	0.4	1	0.7	1.3	0.70	1	0.4	1.8
4 FPLL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0	0
LL	72	54	72	45	24	11	5.4	2.7	0	53	36	48	30	16	7.00	3.6	1.8	0
Sum	101	63	84	50.815	35	16	16	10	25	74.7	43	57	34	23.7	10.7	11.2	7.1	18

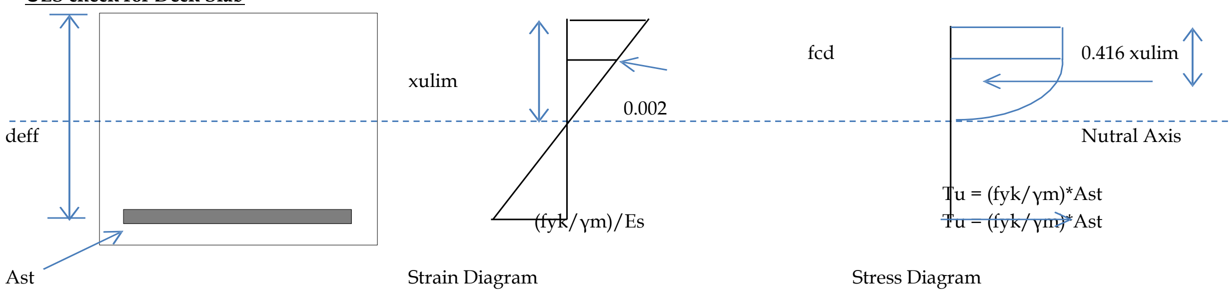
Max. Shear force at node	**Basic**									**Rare**								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1 SELF WEIGHT	13	1.2	11	0.405	12	0.4	11	1.2	13	9.3	0.9	8.1	0.3	8.7	0.3	8.1	0.9	9.3
2 SIDL CB & RAILI	13	7.2	7.2	2.295	2.3	1.9	5.4	5.4	13	9.8	5.3	5.3	1.7	1.7	1.4	4	4	9.8
3 SIDL WEARING	4.4	0.4	3.9	0.175	4.2	0.2	3.9	0.4	4.4	2.5	0.2	2.2	0.1	2.4	0.1	2.2	0.2	2.5
4 FPLL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	30	8.7	22	2.875	18	2.5	20	7	30	21.6	6.4	16	2.1	12.8	1.8	14.3	5.1	22

Max. Bending moment at node	**Quasi.**								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1 SELF WEIGHT	6.7	1.4	3.8	2.4	4.8	2.4	3.8	1.4	6.7
2 SIDL CB & RAILI	13	4.8	3.7	1	1.6	0.6	2.8	3.5	9.8
3 SIDL WEARING	1.8	0.4	1	0.7	1.3	0.7	1	0.4	1.8
4 FPLL	0	0	0	0	0	0	0	0	0
LL	0	0	0	0	0		0	0	0
Sum	22	6.6	8.5	4.1	7.7	3.7	7.6	5.3	18

Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Max. Shear force at node	Quasi.								
	2	3	4	5	6	7	8	9	10
1 SELF WEIGHT	9.3	0.9	8.1	0.3	8.7	0.3	8.1	0.9	9.3
2 SIDL CB & RAILI	9.8	5.3	5.3	1.7	1.7	1.4	4	4	9.8
3 SIDL WEARING	2.5	0.2	2.2	0.1	2.4	0.1	2.2	0.2	2.5
4 FPLL	0	0	0	0	0	0	0	0	0
LL	0	0	0	0	0	0	0	0	0
Sum	22	6.4	16	2.1	13	1.8	14	5.1	22
				Basic		**Rare**		**Quasi.**	
Max. Sagging moment at mid span				63.07		42.6		6.6	
Max. Hogging moment at mid support				83.875		56.5		8.5	
Max. Hogging moment at end support				100.845		42.6		21.7	
Max. Shear Force at mid support				8.72		6.4		6.4	
Max. Shear Force at end support				30.16		21.6		21.6	

ULS check for Deck Slab



ULTIMATE LIMIT STATE

Grade of Concrete — fck = 30 N/mm2

As per clause 6.4.2.8,IRC:112-2011

fcd = 13.40 N/mm2 — For Basic Combination

Ec = 31000 MPa

Grade of steel — fY = 500 N/mm2

fYd = 435 N/mm2 — For Basic 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 = 200000 MPa

Cu = fcd*b*(3/7xu,lim+2/3*4/7xu,lim) — Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

Rlim = Mu,Lim/bd = 0.8095 fcd*(xu lim/d)*(1-0.416*xu lim/d)

	Basic	Accidental	Seismic
xu,lim/d	0.62	0.62	0.62
Rlim = Mu,Lim/bd2	4.97	4.97	4.97

Here Rlim is in Mpa

Calculation of Reinforcement			
Width of section b	=	1000	mm
Depth of section D	=	210	mm
Clear cover	=	50	

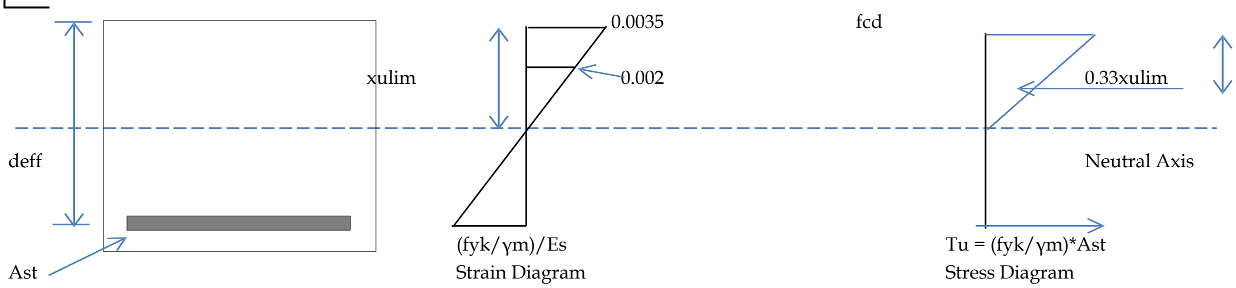
Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Moment on the section Deck slab	Max. Hogging moment at end support	Max. Hogging moment at mid support	Max. Sagging moment at mid span	
Actual moment (KNm)	100.845	83.875	63.07	
b	1000	1000	1000	
D	210	210	210	
c	50	50	50	
d	152	152	152	
fcd	13.40	13.40	13.40	
fYd	435	435	435	
xu,lim/d	0.62	0.62	0.62	
R = M /bd2 sls u,sls	4.97	4.97	4.97	
Mu,Lim (KNm)	115	115	115	**OK**
Ast Req.	1937	1523	1082	
Dia of bar (main tension) (mm)	16	16	16	
Spacing (mm)	130	130	130	
+ dia of bar (main tension) (mm)	12	0	0	
Spacing (mm)	130	130	130	
Ast provided (sq mm)	2417	1547	1547	
Dia of bar (main compresion) (mm)	16	16	12	
Spacing (mm)	130	130	130	
Area of main compresion (mm2)	1547	1547	870	
fctm	2.8	2.8	2.8	
fyk	435	435	435	
cl. 16.6.1 (2) of IRC :112-2011				
AS.min = 0.26 fctm bt d / fyk >= 0.0013 bt d	254	254	254	
Act	120056	152436	152436	
fct,eff	2.9	2.9	2.9	
k = 0.4 { 1 - s / (k f h/h*) } <= 1	0.4	0.4	0.4	
c c 1 ct,eff				
For Bending or bending combined with axial force				
k	1	1	1	
ss	435	435	435	
cl. 12.3.6 (4) of IRC :112-2011				
AS.min = kc k fct,eff Act / ss	320	406	406	**OK**
As.max = 0.025 Ac (main tension)	5250	5250	5250	**OK**
cl. 16.5.1.1 (2) of IRC :112-2011				
As.max = 0.04 Ac (tension + compresion)	8400	8400	8400	
x (mm)	97	62	62	
x/d	0.638	0.408	0.408	**REVISE**
z (mm)	112	126	126	
MR (KNm)	117	85	85	**OK**

Project		Project Name	Designed by:	KB
Client		Client Name	Checked by:	-
Job Name		Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Shear on the section			
Actual shear VEd (KN)	30.16	8.72	
Actual shear stress (N/mm2)	0.231	0.149	
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	2	2	
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
Vmin = 0.031 K3/2 fck1/2 min	0.53	0.53	
cl. 10.3.1 of IRC :112-2011			
r1 = Asl/(bw d) <= 0.02	0.016	0.010	
	Ok	**Ok**	
0.12 K (80 r1 fck)0.33	0.86	0.74	
Axial compressive force NEd (KN)	0	0	
scp = NEd / Ac <= 0.2 fcd	0	0	
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010			
VRd = [0.12K(80ρ1 f)0.33 + 0.15σ]b d <= (n min + 0.15 scp) bw d (KN)	73.00	73.00	
	Ok, Provide min.	**Ok, Provide min.**	
	Top		Bottom
Distribution reinforcement required	252	252	243
Dia of bar (main tension) (mm)	12	12	12
Spacing (mm)	200	200	200
Ast provided (sq mm)	565	565	565
	ok	**ok**	**ok**

SLS check for Deck Slab



SERVICEABILITY LIMIT STATE

Grade of Concrete	fck	=	30	N/mm2	
As per clause 12.2.1,IRC:112-2011					
	fcd	=	14.4	N/mm2	For Rare Combination
	fcd	=	14.4	N/mm2	For Rare Combination
	fcd	=	10.8	N/mm2	For Quasi-Perma. Combination
As per clause 12.2.2, IRC:112-2011					
Grade of steel	fY	=	500	N/mm2	
	fYd	=	300	N/mm2	For Rare Combination
	fYd	=	300	N/mm2	For Rare Combination
	fYd	=	300	N/mm2	For Quasi-Perma. Combination

Project	Project Name	Designed by:	KB
Client	Client Name	Checked by:	-
Job Name	Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 200000 MPa Ec = 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

Rsls = Mu,sls/bd = 0.5 fcd*(xu/d)*(1-0.33*xu/d)

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
Rsis=Mu,sis/bd2	3.88	3.88	2.91

Here Rsls is in Mpa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 210 mm

Clear cover = 50

Moment on the section	**Hogging**			**Sagging**		
	Rare Comb sup	**Rare Comb mid**	**Quasi-Perma. Comb**	**Rare Comb**		**Quasi-Perma. Comb**
Actual moment (KNm)	69.0	52.0	21.7	42.6		6.6
b	1000	1000	1000	1000		1000
D	210	210	210	210		210
c	50	50	50	50		50
d	142.0	142.0	142.0	142.0		154.0
fcd	14.40	14.40	14.40	14.40		14.40
fYd	300	300	300	300		300
xu,sls/d	0.70	0.70	0.70	0.70		0.70
Rsls= Mu,sls/bd2	3.88	3.88	3.88	3.88		3.88
Mu,sls (KNm)	78	78	78	78		92
	OK	**OK**	**OK**	**OK**		**OK**
Ast Req.	2012	1414	537	1122		145
Dia of bar (main tension) (mm)	16	16	16	16		16
Spacing (mm)	140	140	140	140		140
+ dia of bar (main tension) (mm)	12	0	0	0		0
Spacing (mm)	140	140	140	140		140
Ast provided (sq mm)	2244	1436	1436	1436		1436
Dia of bar (main compresion) (mm)	16	16	16	12		12
Spacing (mm)	130	130	130	130		130
Area of main compresion (mm2)	1547	1547	1547	870		870
fctm	2.50	2.50	2.50	2.50		2.80
x (mm)	93.5	59.8	59.8	59.8		59.8
x/d	0.658	0.421	0.421	0.421		0.389
	ok	**ok**	**OK**	**ok**		**OK**
z (mm)	111	122	122	122		134
MRsls (KNm)	75	53	53	53		58
	OK	**OK**	**OK**	**OK**		**OK**
ssc = M/(As z)	277	296	124	243		34
	OK	**OK**	**OK**	**OK**		**OK**
sca = M/(0.5 z b xu)	13.28	14.22	5.93	11.65		1.64
	OK	**OK**	**OK**	**OK**		**OK**

Project			Project Name	Designed by:	KB
Client			Client Name	Checked by:	-
Job Name			Design of RCC Girder 25 m span @ Ch 2+220	Date & Rev.	-

Calculation of crack width			
n_1	7	7	
n_2	7	7	
$ø_{eq} = (n1ø1^2 + n2ø2^2) / (n1ø1+n2ø2)$	14	16	
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			
$r_{p.eff} = A_s / A_{c,eff}$	0.021	0.014	
$S_{r,max} = \{ 3.4\ c + (0.425\ k_1\ k_2\ f) / r_{p.eff} \}$	286	364	
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	
$(e_{sm}-e_{cm})=(s_{sc}-k_t\ f_{ct,eff}(1+a_e\ r_{p,eff})/r_{p,eff})/E_s□>=0.6s_{sc}/E_s$	0.0003	0.0001	
cl. 12.3.4 (2) of IRC :112-2011			
$W_k = S_{r,max} (e_{sm} - e_{cm})$	0.09	0.04	
cl. 12.3.4 (1) of IRC :112-2011			
Calculation of deflection		Span	Cantilever
Span (mm)		3200	1500
Permissible limit		4.0	5.0
cl. 12.4.1 (2) of IRC :112-2011			
Short term elastic deflection from STAAD		0.78	3.33
		Ok	**Ok**

1.6

DESIGN OF SUBSTRUCTURE

Project	***Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya***	***Designed by:***	***KB***
Client	***MP PUBLIC WORKS DEPARTMENT***	***Checked by:***	***HI***
Job Name	***Design of Sub structure and Open foundation of MNBR CH 63+890***	***Date & Rev.***	***10/12/2018 (R0)***

1.01 INTRODUCTION

This design is applicable for Abutments

Abut no.	Top Level (FRL)	GROUND LEVEL	FOUNDING LEVEL	DIFF
A1 & A2	(M)	(M)	(M)	(M)
	479.698	474.208	468.708	**10.990**

Note:- Levels are indicative only.

Design Data

		(m)
Span Arrangement C/C of exp. Joint	=	26.0
Deck width	=	16
Carriageway width	=	15
Structural system	=	Simply supported
construction type	=	RCC
Effective Span	=	25.00
Expansion gap in abutment	=	0.50
No of Lane considered for design	=	4
Bearing type	=	POT PTFE BEARING

Salient Reduced Levels (RL's)

Deck Level (cL of carriageway)	=	479.698
Soffit Level (cL of cariageway)	=	477.838
Abut Cap Top Level	=	477.488
Abut Cap Bottom Level	=	476.988
HFL	=	476.778
Ground Level (LBL)	=	474.208
Foundation Level	=	468.708

Project	*Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya*	*Designed by:*	*KB*
Client	*MP PUBLIC WORKS DEPARTMENT*	*Checked by:*	*HI*
Job Name	*Design of Sub structure and Open foundation of MNBR CH 63+890*	*Date & Rev.*	*10/12/2018 (R0)*

Details of Superstructure and other parameters

Type of structure	=	RCC	
Depth of deck slab(MIN.)	=	0.210	m
Thickness of wearing coat	=	0.075	m
Camber in both direction from CL of deck =	=	2.0%	
Expansion joint Type	=	Filler Type	
Length of abut	=	16.00	m
Depth of abut cap at tip	=	0.50	m
Net safe bearing capacity	=	60.00	t/m2

Material Parameters

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

Grade of concrete for sub structure and foundation		f_{ck}	=	**M35**	
Cube strength of concrete at 28 days		f_{ck}	=	35	Mpa
Modulus of Elasticity		E_c	=	31	Mpa
Mean value of axial tensile strength of concrete		f_{ctm}	=	2.5	Mpa
Wet Density	2 t/m3	Dry Density	=	2.5	t/m3
Density of steel			=	2.5	t/m3
Soil density			=	7.85	t/m3
				2	t/m3

From Staad output :

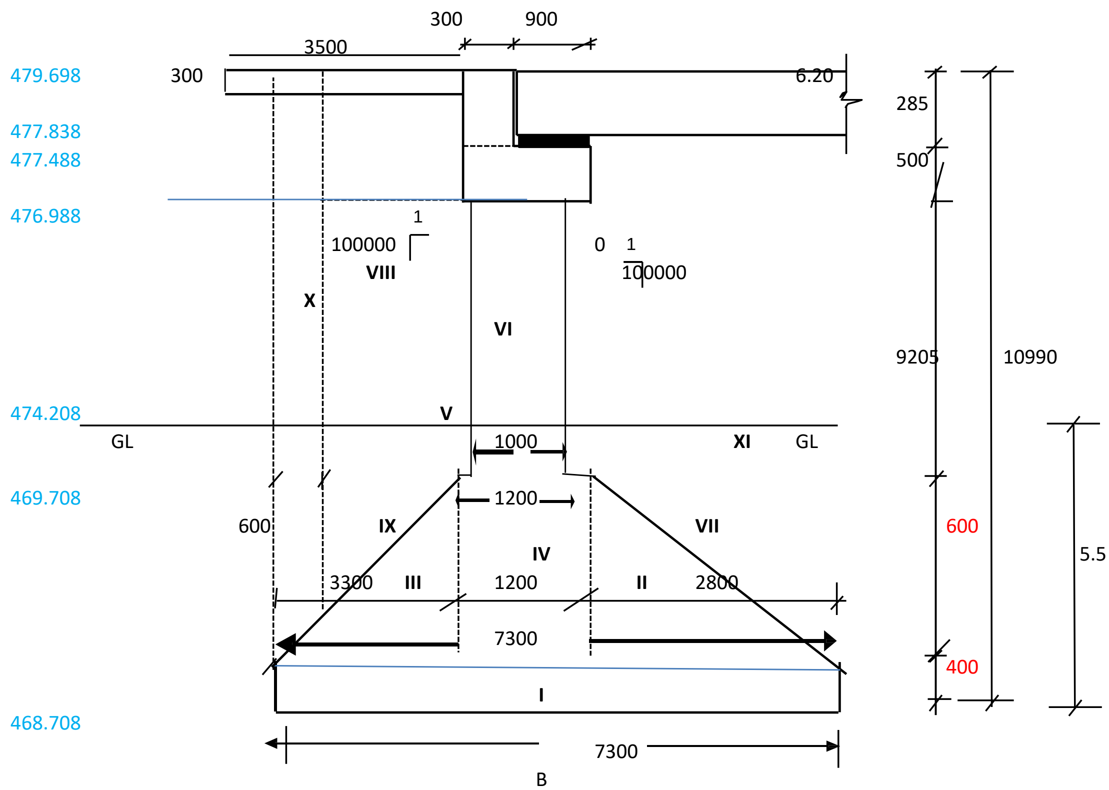
26 m Span Reaction (KN)

Bearing No.	DL	SIDL 1(WC)	SIDL 2(CB)
1	365	34	136
2	397	29	-22
3	388	33	6
4	397	29	-17
5	365	34	136
SUM	**1912**	**159**	**239**

	Project	***Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya***	***Designed by:***	***KB***
	Client	***MP PUBLIC WORKS DEPARTMENT***	***Checked by:***	***HI***
	Job Name	***Design of Sub structure and Open foundation of MNBR CH 63+890***	***Date & Rev.***	***10/12/2018 (R0)***

TYPICAL DESIGN OF PCC ABUTMENT FOR DRY CONDITION

Ht. =	10.99	m	Total span =	26.00	m
Effec. Span =	25.00	m	Depth of deck =	0.285	mm
			including wearing coat		
			Number of spans =	1	



Project	*Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya*	*Designed by:*	*KB*
Client	*MP PUBLIC WORKS DEPARTMENT*	*Checked by:*	*HI*
Job Name	*Design of Sub structure and Open foundation of MNBR CH 63+890*	*Date & Rev.*	*10/12/2018 (R0)*

1.02 PARTIAL SAFETY FACTOR

Ultimate Limit State

Partial Safety for Verification of Structur

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	1.0	1.0	1.05	0.95
Dead Load, SIDL except surfacing, Backfill Weight,						
Settlement, Creep and shrinkage effect						
Surfacing	1.35	1.0	1.0	1.0	1.35	1.0
Earth Pressure due to Backfill	1.50	-	1.0	-	1.0	-
Variable Loads:						
Carriageway Live Load and associated loads						
(braking, tractive and centrifugal forces) and						
pedestrian live load:						
a) Leading Load	1.5	0	0.75	0	-	-
b) Accompanying Load	1.15	0	0.2	0	0.2	0
c) Construction Live Load	1.35	0	1.0	0	1.0	0
Thermal Loads a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	0.5	0	0.5	0
Wind a) As Leading Load	1.5	0	-	-	-	-
b) As Accompanying Load	0.9	0	-	-	-	-
Live Load Surcharge (as accompan	1.2	0	-	-	-	-
i) Vehicle Collision ii) Barge Impact iii) Impact due to floating bodies	-	-	1.0	-	-	-
Seismic Effect a) During Service	-	-	-	-	1.5	-
b) During Construction	-	-	-	-	0.75	-
Counter Weights: a) When density or self weight is w	-	0.9	-	1.0	-	1.0
b) When density or self weight is n	-	0.8	-	1.0	-	1.0
c) Erection effects	1.05	0.95	-	-	-	-
Wind a) As Leading Load	1.50	0	-	-	-	-
b) As Accompanying Load	1.20	0	-	-	-	-
Hydraulic Loads: (Accompanying Load):						
Water Current Forces	1	0	1	-	1	-
Wave Pressure	1	0	1	-	1	-
Hydrodynamic Effect	-	-	-	-	1	-
Buoyancy	1	-	1	-	1	-

Project	***Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya***	***Designed by:***	***KB***
Client	***MP PUBLIC WORKS DEPARTMENT***	***Checked by:***	***HI***
Job Name	***Design of Sub structure and Open foundation of MNBR CH 63+890***	***Date & Rev.***	***10/12/2018 (R0)***

Partial Safety for Verification of Structur

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor		
	Basic Combination	**Accidental Combinat ion**	**Seismic Combination**
(1)	**(2)**	**(3)**	**(4)**
Permanent Loads:			
Dead Load			
SIDL except surfacing			
a) Adding to the effect of variable	1.35	1.00	1.35
b) Relieving the effect of variable l	1.00	1.00	1.00
Surfacing:			
a) Adding to the effect of variable	1.75	1.00	1.75
b) Relieving the effect of variable l	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 accompan	1.20	0.20	0.20
Erection effects	1.00	1.00	1.00
i) Vehicle Collision			
ii) Barge Impact	0.00	1.00	0.00
iii) Impact due to floating bodies			
Seismic Effect			
a) During Service	0.00	0.00	1.50
b) During Construction	0.00	0.00	0.75
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	1.00
Wave Pressure	1.00	1.00	1.00
Hydrodynamic Effect	0.00	0.00	1.00
Buoyancy	0.15	0.15	0.15

Project	*Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya*	*Designed by:*	*KB*
Client	*MP PUBLIC WORKS DEPARTMENT*	*Checked by:*	*HI*
Job Name	*n of Sub structure and Open foundation of MNBR CH 6*	*Date & Rev.*	*10/12/2018 (R0)*

Serviceability Limit State

Partial Safety for Verification of Servicea

Table 3.3, Annex B, IRC:6-2017

Loads	Partial Safety Factor		
	Rare Combination	**Frequent Combination**	**Quasi-permanent Combination**
(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 (Accompanyin	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	*Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya*	*Designed by:*	*KB*
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Combination for Base Pressure and Design of Foundation
Table 3.4, Annex B, IRC:6-2017
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 l	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 accompan 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
For Base Pressure	1.00	1.00	1.00	1.00
For Structural Design	0.15	0.15	0.15	0.15

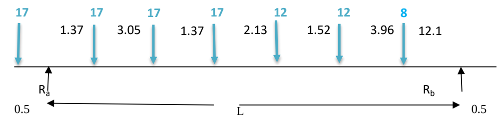
Project	Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya	Designed by:	KB
Client	MP PUBLIC WORKS DEPARTMENT	Checked by:	HI
Job Name	Design of Sub structure and Open foundation of MNBR CH 63+890	Date & Rev.	10/12/2018 (R0)

(iii) Live load Reaction

Maximum Moment case :-

According to IRC 6:2017, CL.

(a) Class 70 R wheel



Effective span L (m) 25.00

x 0.50

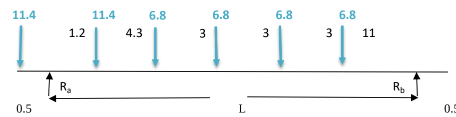
R_a(t)	77.64
R_b(t)	14.36

1.261847

Impact factor = 0.26 (IRC6:2017, Cl:208.3)

R_a including Impact	**97.82**	**t**

(b) Class A



R_a(t)	39.57
R_b(t)	10.43

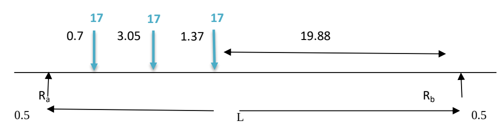
Impact factor = 4.5/(6+L) = 0.26 (IRC6:2017,Cl:208.3)

R_a including Impact	**49.86**	**t**

Maximum Reaction case :-

According to IRC 6:2017, CL.

(a) Class 70 R wheel



Effective span L (m) 25.00

x 0.50

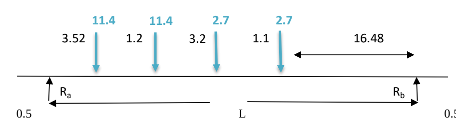
R_a(t)	45.17
R_b(t)	5.83

1.261847

Impact factor = 0.25 (IRC6:2017, Cl:208.3)

R_a including Impact	**56.47**	**t**

(b) Class A



R_a(t)	23.18
R_b(t)	5.02

Impact factor = 4.5/(6+L) = 0.15 (IRC6:2017,Cl:208.3)

R_a including Impact	**26.54**	**t**

Project	***Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya***	***Designed by:***	***KB***
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Job Name	***Design of Sub structure and Open foundation of MNBR CH 63+890***	***Date & Rev.***	***10/12/2018 (R0)***

Taking Moments about founding level

		LHS	RHS	L (Long)	L (Trans)	ML	Mt
		t	t	m	m	t-m	t-m
	Dead Load	191.20	0.00	0.00	0.00	0.00	0.00
	SIDL1 w/c	15.90	0.00	0.00	0.00	0.00	0.00
	SIDL 2 exl w/c	23.90	0.00	0.00	0.00	0.00	0.00
	FPLL	0.00	0.00	0.00	0.00	0.00	0.00
	LL1 (Max Reaction)						
	Class 70R + 2A	109.55	0.00	0.00	2.020	0.00	221.29
	Class 2 70R	112.93	0.00	0.00	2.910	0.00	328.63
	70 R	56.47	0.00	0.00	4.905	0.00	276.96
	Class 4A	106.17	0.00	0.00	0.950	0.00	100.86
	70 R + Class A	83.01	0.00	0.00	3.570	0.00	296.33
	LL2 (Max Moment)						
	Class 70R + 2A	197.55	0.00	0.00	2.020	0.00	399.04
	Class 2 70R	195.65	0.00	0.00	2.910	0.00	569.33
	70 R	97.82	0.00	0.00	4.905	0.00	479.82
	Class 4A	199.45	0.00	0.00	0.950	0.00	189.47
	70 R + Class A	147.69	0.00	0.00	3.570	0.00	527.24

Horizontal Force Due to Braking

		μ =	0.50	(as per cl.211.5 IRC 6:2017)	Fh/2 OR μRg	@foundation		abut Bottom	
		Fh	Rg	Rq	H	Lev	ML	Lev	ML
		t	t	t	t	m	t-m	m	t-m
	Class 4A	55.00	210.32	197.55	105.16	10.71	1125.74	9.70	1020.58
	Class 2 A + 70R	27.50	210.32	195.65	105.16	10.71	1125.74	9.70	1020.58
	Class 70 R	20.00	210.32	97.82	105.16	10.71	1125.74	9.70	1020.58
	Class 2 70R	55.00	210.32	199.45	105.16	10.71	1125.74	9.70	1020.58
	70 R + 1A	20.00	210.32	147.69	105.16	10.71	1125.74	9.70	1020.58

	Horizontal braking force	=		105.16	t
	ML @ foundation	=		1125.74	tm
	ML @ abut bottom	=		1020.58	tm

			P(t)	L (Trans)	Rq (max)	Fh	H
	Governing load	=	199.45	0.950	199.45	55.00	105.16
	Max reaction case	=	112.93	2.91		55	

Project	***Upgradation and Reconstruction of Major District Road in The State of Madhya Pradesh NDB-II (Package-06) Rodiya Multhan,Borawan,Sawada,Bither,Singun,Maltar,Madaraniya***	***Designed by:***	***KB***
Client	***MP PUBLIC WORKS DEPARTMENT***	***Checked by:***	***HI***
Job Name	***Design of Sub structure and Open foundation of MNBR CH 63+890***	***Date & Rev.***	***10/12/2018 (R0)***

1 <u>WIND FORCES ON SUPER STRUCTURE</u> **REF : IRC 6-2017 CL NO: 209.2**

Basic wind speed	=	47	m/s	Plain terrain			
Design wind speed	=	39.59	m/s	at height 10.00m	=	27.8	m/s
Design wind pressure Pz	=	940.60	N/m^2	at height 10.00m	=	463.7	N/m^2

$F_t = P_zA_1GC_D$	460.066	Kg/m^2	G =	2	C_D =	2.40
F_L =	115.02	Kg/m^2				
$Fv = P_zA_3GC_L$	143.77	Kg/m^2	G =	2	C_L =	0.75
F_v (t) =	59.8086	t				

2 <u>WIND FORCES ON LIVE LOAD</u>

Basic wind speed	=	0	m/s	Plain terrain			
Design wind speed	=	0.00	m/s	at height 10.00m	=	27.8	m/s
Design wind pressure Pz	=	0.00	N/m^2	at height 10.00m	=	463.7	N/m^2

$F_t = P_zA_1GC_D$	0	Kg/m^2	G =	2	C_D =	1.10
F_L =	0.00	Kg/m^2				
$Fv = P_zA_3GC_L$	0.00	Kg/m^2	G =	2	C_D =	0.75
F_v (t) =	0	t				

3 <u>WIND FORCES ON SUB STRUCTURE</u> **REF : IRC 6-2017 CL NO: 209.2**

Basic wind speed	=	47	m/s	Plain terrain			
Design wind speed	=	39.59	m/s	at height 10.00m	=	27.8	m/s
Design wind pressure Pz	=	940.60	N/m^2	at height 10.00m	=	463.7	N/m^2

$F_t = P_zA_1GC_D$	95.85	Kg/m^2	G =	2	C_D =	0.50
F_L =	23.96	Kg/m^2				
$Fv = P_zA_3GC_L$	143.77	Kg/m^2	G =	2	C_L =	0.75

TRANSVERSE DIRECTION		**MOMENTS ABOUT FL**			**MOMENTS ABOUT ABUT BOTTOM**	
DESCRIPTION		**H**	**Lev**	**Mt**	**Lev**	**Mt**
		t	**m**	**t-m**	**m**	**t-m**
WIND ON SUPER STR ACT@	478.77	3.41	10.06	34.30	9.06	30.89
WIND ON MOVING LOAD @	-	0.00	0.00	0.00	0.00	0.00
WIND ON ABUT CAP @	477.24	0.06	8.53	0.49	7.53	0.43
WIND ON ABUT WALL @	475.60	0.27	6.89	1.84	5.89	1.57
	TOTAL	**3.73**		**36.62**		**32.89**

LONGITUDINAL DIRECTION		**MOMENTS ABOUT FL**			**MOMENTS ABOUT ABUT BOTTOM**	
DESCRIPTION		**H**	**Lev**	**Mt**	**Lev**	**Mt**
		t	**m**	**t-m**	**m**	**t-m**
WIND ON SUPER STR ACT@	478.77	0.85	10.06	8.57	9.06	7.72
WIND ON MOVING LOAD @	-	0.00	0.00	0.00	0.00	0.00
WIND ON ABUT CAP @	477.24	0.014	8.53	0.12	7.53	0.11
WIND ON ABUT WALL @	475.60	0.07	6.89	0.46	5.89	0.39
	TOTAL	**0.93**		**9.16**		**8.22**

#REF!	*#REF!*	*#REF!*	*#REF!*
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DEAD WEIGHT NORMAL CONDITION

ABUTMENT								
	L	B	H	Qty	UNIT WEIGHT	Wt	L. A. FROM TOE	ML (tm)
	m	m	m	m3		t	m	(tm)
Abut. Cap	16.00	1.20	0.50	9.60	2.50	24.00	3.30	79.20
Dirt wall	16.00	0.30	0.29	1.37	2.50	3.42	3.85	13.17
DL+SIDL load(WC)APPROACH		16	0.86	3.30	2.50	45.41	4.00	181.63
LL (Approach span) 40t boggie		1	6.69	3.30		22.74	4.00	90.96
RECTANGULAR I	16.00	7.30	0.40	46.72	2.50	116.80	3.65	426.32
TRIANGULAR II	16.00	2.80	0.600	13.44	2.50	33.60	1.87	62.72
TRIANGULAR III	16.00	3.30	0.600	15.84	2.50	39.60	5.10	201.96
RECTANGULAR IV	16.00	1.20	0.600	11.52	2.50	28.80	3.40	97.92
TRIANGULAR V	16.00	0.00	9.20	0.00	2.50	0.00	4.00	0.00
RECTANGULAR VI	16.00	1.000	9.20	147.28	2.50	368.20	3.30	1215.06
TRIANGULAR VII	16.00	0.0000	9.20	0.00	2.50	0.00	2.80	0.00
TOTAL						**682.57**		**2368.94**
EARTH								
Soil above Heel								
EARTH VIII	16.00	3.30	9.99	527.47	2.00	1054.94	5.65	5960.43
EARTH IX	16.00	3.30	0.60	15.84	2.00	31.68	6.20	196.42
EARTH X	16.00	0.00	10.590	0.00	2.00	0.00	7.30	0.00
Soil above Toe								
EARTH XI	16.00	2.800	4.500	201.60	2.00	403.20	1.40	564.48
EARTH VII	16.00	2.800	0.600	13.44	2.00	26.88	1.87	50.18
TOTAL				**758.35**		**1516.70**		**6771.51**

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DEAD WEIGHT HFL CONDITION

ABUTMENT

	Qty	UNIT WEIGHT	Wt	L. A. FROM TOE	ML (tm)
	m3		t	m	(tm)
Abut. Cap	9.60	2.50	24.00	3.30	79.20
Dirt wall	1.37	2.50	3.42	3.85	13.17
DL+SIDL load(WC)APPROACH		2.50	45.41	4.00	181.63
LL (Approach span) 40t boggie			22.74		90.96
RECTANGULAR I	46.72	1.5	70.08	3.65	255.79
TRIANGULAR II	13.44	1.5	20.16	1.87	37.63
TRIANGULAR III	15.84	1.5	23.76	5.10	121.18
RECTANGULAR IV	11.52	1.5	17.28	3.40	58.75
TRIANGULAR V	0.00	1.5	0.00	4.00	0.00
RECTANGULAR VI	147.28	1.5	220.92	3.30	729.04
TRIANGULAR VII	0.00	1.5	0.00	2.80	0.00
TOTAL			**447.768**		**1567.35**
EARTH					
Soil above Heel					
EARTH VIII	527.47	1	527.47	5.65	2980.22
EARTH IX	15.84	1	15.84	6.20	98.21
EARTH X	0.00	1	0.00	7.30	0.00
Soil above Toe					
EARTH XI	201.60	1	201.6	1.40	282.24
EARTH VII	13.44	1	13.44	1.87	25.09
TOTAL			**758.35**		**3385.75**

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EARTH PRESSURE AT FOUNDATION LEVEL

EARTH PRESSURE COEFFICIENTS

(Per metre width)

Using Coulombs Wedge Theory

Coefficients of Active Earth pressure=

Ø	=	30	deg
δ	=	20	deg
α	=	90	deg
β	=	0	deg
Ka	=	0.279	

ABUTMENT

Earth Pressure at foundation level	**Units**	**LWL**	**for full width**	**HFL**	**for full width**
Height for Passive earth pressure	m	0.000		0.000	
Dry unit wt. of soil	t/m3	2.00			
wet unit wt. of soil	t/m3	1		1	
Coefficient of active earth pressure		0.279		0.279	
Live load surcharge	m	1.2		1.2	(Acc to IRC)
Height for Active pressure	m	10.99		10.99	
Active earth pressure		6.14		3.07	
Pressure due to live load surcharge		0.67		0.34	
Force due to live load surcharge	t/m	7.37	117.90	3.68	58.95
Moment due to live load surcharge	tm/m	40.49	647.88	20.25	323.94
Force due to active earth pressure	t/m	33.74	539.90	16.87	269.95
Moment due to active earth pressure	tm/m	155.76	2492.09	77.88	1246.04
Earth Pressure at bottom of abutment	**Units**	**LWL**	**for full width**	**HFL**	**for full width**
Height	m	9.99		9.99	
Dry unit wt. of soil	t/m3	2.00			
wet unit wt. of soil	t/m3	1		1	
Coefficient of active earth pressure		0.279		0.279	
Live load surcharge	m	1.20		1.20	
Active earth pressure		5.58		2.79	
Pressure due to live load surcharge	t/m	0.67		0.34	
Force due to live load surcharge	t/m	6.70	107.18	3.35	53.59
Moment due to live load surcharge	tm/m	33.46	535.34	16.73	267.67
Force due to active earth pressure	t/m	27.88	446.12	13.94	223.06
Moment due to active earth pressure	tm/m	116.99	1871.83	58.49	935.92

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STABILITY AGAINST OVERTURNING (LWL)

Restoring moment

	Load (t)	L. A. from toe	ML (tm)	Equilibrium basic PSF	Factored ML (tm)
Dead Load super structure	191.20	3.40	650.08	1.00	650.08
SIDL (1)	15.90	3.40	54.06	1.00	54.06
SIDL (2)	23.90	3.40	81.26	1.00	81.26
LL	199.45	3.40	678.12	1.00	678.12
Abut. Cap	24.00	3.40	81.60	1.00	81.60
Dirt wall	3.42	3.85	13.17	1.00	13.17
DL+SIDL load(WC)A	45.41	4.00	181.63	1.00	181.63
LL (Approach	22.74	4.00	90.96	1.00	90.96
RECTANGULAR I	116.80	3.65	426.32	1.00	426.32
TRIANGULAR II	33.60	1.87	62.72	1.00	62.72
TRIANGULAR III	39.60	5.10	201.96	1.00	201.96
RECTANGULAR IV	28.80	3.40	97.92	1.00	97.92
TRIANGULAR V	0.00	4.00	0.00	1.00	0.00
RECTANGULAR VI	368.20	3.40	1251.88	1.00	1251.88
TRIANGULAR VII	0.00	2.80	0.00	1.00	0.00
Soil above Heel					
EARTH VIII	1054.94	5.65	5960.43	1.00	5960.43
EARTH IX	31.68	7.30	231.26	1.00	231.26
EARTH X	0.00	7.30	0.00	1.00	0.00
Soil above Toe					
EARTH XI	403.20	1.40	564.48	1.00	564.48
EARTH VII	26.88	1.87	50.18	1.00	50.18
TOTAL	**2629.72**				**10678.03**
OVERTURNING MOMENT					
Live load surcharge	117.90		647.88	1.00	647.88
Net earth pressure	539.90		2492.09	1.00	2492.09
Braking force	105.16		1125.74	1.00	1125.74

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Moment due to Wind

Wind on Super str	0.85		8.57	1.00	8.57
Wind on Moving Load	0.00		0.00	1.00	0.00
Wind on Abut Cap	0.01		0.12	1.00	0.12
Wind on Abut Wall	0.07		0.46	1.00	0.46
TOTAL					**4274.87**
FACTOR OF SAFETY AGAINST OVERTURNING					**2.50**
					SAFE
FACTOR OF SAFETY (Abutment cast condition)					**3.55**
					SAFE

#REF!	*#REF!*	*#REF!*	*#REF!*
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#REF!	*#REF!*	*#REF!*	*#REF!*

STABILITY AGAINST OVERTURNING (HFL)					
Restoring moment					
	Load (t)	**L. A. from toe**	**ML (tm)**	**Equilibrium basic PSF**	**Factored ML (tm)**
Dead Load super structure	191.20	3.40	650.08	1.00	650.08
SIDL (1)	15.90	3.40	54.06	1.00	54.06
SIDL (2)	23.90	3.40	81.26	1.00	81.26
LL	199.45	3.40	678.12	1.00	678.12
Abut. Cap	24.0	3.40	81.60	1.00	81.60
Dirt wall	3.4	3.85	13.17	1.00	13.17
DL+SIDL load(WC)APPROACH	45.4	4.00	181.63	1.00	181.63
LL (Approach span) 40t boggie	22.7	4.00	90.96	1.00	90.96
RECTANGULAR I	70.1	3.65	255.79	1.00	255.79
TRIANGULAR II	20.2	1.87	37.63	1.00	37.63
TRIANGULAR III	23.8	5.10	121.18	1.00	121.18
RECTANGULAR IV	17.3	3.40	58.75	1.00	58.75
TRIANGULAR V	0.0	4.00	0.00	1.00	0.00
RECTANGULAR VI	220.9	3.40	751.13	1.00	751.13
TRIANGULAR VII	0.0	2.80	0.00	1.00	0.00
Soil above Heel					
EARTH VIII	527.5	5.65	2980.22	1.00	2980.22
EARTH IX	15.8	7.30	115.63	1.00	115.63
EARTH X	0.0	7.30	0.00	1.00	0.00
Soil above Toe					
EARTH XI	201.6	1.40	282.24	1.00	282.24
EARTH VII	13.4	1.87	25.09	1.00	25.09
TOTAL	**1636.57**				**6458.54**
OVERTURNING MOMENT					
Live load surcharge	58.95		323.94	1.00	323.94
Net earth pressure	269.95		1246.04	1.00	1246.04
Braking force	105.16		1125.74	1.00	1125.74
Moment due to Wind					
Wind on Super str	0.85		8.57	1.00	8.57
Wind on Moving Load	0.00		0.00	1.00	0.00
Wind on Abut Cap	0.01		0.12	1.00	0.12
Wind on Abut Wall	0.07		0.46	1.00	0.46
TOTAL					**2704.88**
FACTOR OF SAFETY AGAINST OVERTURNING					**2.39**
					SAFE
FACTOR OF SAFETY (Abutment Cast condition)					**3.74**
					SAFE

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STABILITY AGAINST SLIDING (LWL)

RESISTING FORCES

	Load (t)			Equilibrium basic PSF	Factored load (t)
Dead Load super structure	191.20			1.00	191.20
SIDL (1)	15.90			1.00	15.90
SIDL (2)	23.90			1.00	23.90
LL	199.45			1.00	199.45
Abut. Cap	24.00			1.00	24.00
Dirt wall	3.4			1.00	3.42
DL+SIDL load(WC)APPROACH	45.41			1.00	45.41
LL (Approach span) 40t boggie	22.74			1.00	22.74
RECTANGULAR I	116.80			1.00	116.80
RECTANGULAR II	33.60			1.00	33.60
TRIANGULAR III	39.60			1.00	39.60
RECTANGULAR IV	28.80			1.00	28.80
TRIANGULAR V	0.00			1.00	0.00
RECTANGULAR VI	368.20			1.00	368.20
TRIANGULAR VII	0.00			1.00	0.00
Soil above Heel					
EARTH VIII	1054.94			1.00	1054.94
EARTH IX	31.68			1.00	31.68
EARTH X	0.00			1.00	0.00
Soil above Toe					
EARTH XI	403.20			1.00	403.20
EARTH VII	26.88			1.00	26.88
TOTAL	**2629.72**				**2629.72**

SLIDING FORCES

		Load (t)		Equilibrium basic PSF	Factored Load (t)
Live load surcharge		117.90		1.00	117.90
Net earth pressure		539.90		1.00	539.90
Braking Force		105.16		1.00	105.16
Force due to wind					
Wind on Super str		3.41		1.00	3.41
Wind on Moving Load		0.00		1.00	0.00
Wind on Abut Cap		0.06		1.00	0.06
Wind on Abut Wall		0.27		1.00	0.27
TOTAL					**766.70**
FACTOR OF SAFETY AGAINST SLIDING					**1.71**
					SAFE
FACTOR OF SAFETY (ABUTMENT CAST CONDITION)					**1.94**
					SAFE

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STABILITY AGAINST SLIDING (HFL)					
RESISTING FORCES					
	Load (t)			Equilibrium basic PSF	Factored load (t)
Dead Load super structure	191.20			1.00	191.20
SIDL (1)	15.90			1.00	15.90
SIDL (2)	23.90			1.00	23.90
LL	199.45			1.00	199.45
Abut. Cap	24.00			1.00	24.00
Dirt wall	3.42			1.00	3.42
DL+SIDL load(WC)APPROACH	45.41			1.00	45.41
LL (Approach span) 40t boggie	22.74			1.00	22.74
RECTANGULAR I	70.08			1.00	70.08
TRIANGULAR II	20.16			1.00	20.16
TRIANGULAR III	23.76			1.00	23.76
RECTANGULAR IV	17.28			1.00	17.28
TRIANGULAR V	0.00			1.00	0.00
RECTANGULAR VI	220.92			1.00	220.92
TRIANGULAR VII	0.00			1.00	0.00
Soil above Heel					
EARTH VIII	527.47			1.00	527.47
EARTH IX	15.84			1.00	15.84
EARTH X	0.00			1.00	0.00
Soil above Toe					
EARTH XI	201.6			1.00	201.6
EARTH VII	13.44			1.00	13.44
TOTAL	**1636.57**				**1636.57**
SLIDING FORCES					
		Load (t)		Equilibrium basic PSF	Factored Load (t)
Live load surcharge		58.95		1.00	58.95
Net earth pressure		269.95		1.00	269.95
Braking force		105.16		1.00	105.16
Force due to wind					
Wind on Super str		3.41		1.00	3.41
Wind on Moving Load		0.00		1.00	0.00
Wind on Abut Cap		0.06		1.00	0.06
Wind on Abut Wall		0.27		1.00	0.27
TOTAL					**437.80**
FACTOR OF SAFETY AGAINST SLIDING					**1.87**
					SAFE
FACTOR OF SAFETY (ABUTMENT CAST CONDITION)					**2.05**
					SAFE

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MOMENT CALCULATION C/L OF FOUNDATION (LWL)

	Load (t)	L. A. at mid of Foundn. (Long)	L(trans)	ML(tm)	MT(tm)
DL Super str.	191.20	0.40	0.00	76.48	0.00
SIDL 1	15.90	0.40	0.00	6.36	0.00
SIDL 2	23.90	0.40	0.00	9.56	0.00
LL1	112.93	0.40	2.91	45.17	328.63
LL2	199.45	0.40	0.95	79.78	189.47
LL3	199.45	0.40	0.95	79.78	189.47
Abut. Cap	24.00	0.25	0.00	6.00	0.00
Dirt wall	3.42	-0.20	0.00	-0.68	0.00
DL+SIDL load(WC)APPROACH	45.41	-0.35	0.00	-15.89	0.00
LL (Approach span) 40t boggie	22.74	-0.35	0.00	-7.96	0.00
RECTANGULAR I	116.80	0.00	0.00	0.00	0.00
TRIANGULAR II	33.60	1.78	0.00	59.92	0.00
TRIANGULAR III	39.60	-1.45	0.00	-57.42	0.00
RECTANGULAR IV	28.80	0.25	0.00	7.20	0.00
TRIANGULAR V	0.00	-0.35	0.00	0.00	0.00
RECTANGULAR VI	368.20	0.35	0.00	128.87	0.00
TRIANGULAR VII	0.00	0.85	0.00	0.00	0.00
Soil above Heel					
EARTH VIII	1054.94	-2.00	0.00	-2109.89	0.00
EARTH IX	31.68	-2.55	0.00	-80.78	0.00
EARTH X	0.00	-0.35	0.00	0.00	0.00
Soil above Toe					
EARTH XI	403.20	2.25	0.00	907.20	0.00
EARTH VII	26.88	1.78	0.00	47.94	0.00
Vertical reaction due to braking LL1B	3.27	0.40	0.00	1.31	0.00
Vertical reaction due to braking LL2B	3.27	0.40	0.00	1.31	0.00
Vertical reaction due to braking LL3B	3.27	0.40	0.00	1.31	0.00

OVER TURNING MOMENT					
Live load surcharge	117.90			647.88	0.00
Net earth pressure	539.90			2492.09	0.00
Braking force	105.16			1125.74	0.00
Moment due to Wind					
Wind on Super str	3.41			8.57	0.00
Wind on Moving Load	0.00			0.00	0.00
Wind on Abut Cap	0.06			0.49	0.00
Wind on Abut Wall	0.27			1.84	0.00

MOMENT CALCULATION C/L OF FOUNDATION (HFL)

	Load (t)	L. A. at mid of Foundn. (Long)	L(trans)	ML(tm)	MT(tm)
DL Super str.	191.20	0.40	0.00	76.48	0.00
SIDL 1	15.90	0.40	0.00	6.36	0.00
SIDL 2	23.90	0.40	0.00	9.56	0.00
LL1 Max Reaction Case	112.93	0.40	2.91	45.17	328.63
LL2 Max Long Mom Case	199.45	0.40	0.95	79.78	189.47
LL3 Max Trans Mom Case	199.45	0.40	0.95	79.78	189.47
Abut. Cap	24.00	0.25	0.00	6.00	0.00
Dirt wall	3.42	-0.20	0.00	-0.68	0.00
DL+SIDL load(WC)APPROACH	45.41	-0.35	0.00	-15.89	0.00
LL (Approach span) 40t boggie	22.74	-0.35	0.00	-7.96	0.00
RECTANGULAR I	70.08	0.00	0.00	0.00	0.00
TRIANGULAR II	20.16	1.78	0.00	35.95	0.00
TRIANGULAR III	23.76	-1.45	0.00	-34.45	0.00
RECTANGULAR IV	17.28	0.25	0.00	4.32	0.00
TRIANGULAR V	0.00	-0.35	0.00	0.00	0.00
RECTANGULAR VI	220.92	0.35	0.00	77.32	0.00
TRIANGULAR VII	0.00	0.85	0.00	0.00	0.00
Soil above Heel					
EARTH VIII	527.47	-2.00	0.00	-1054.94	0.00
EARTH IX	15.84	-2.55	0.00	-40.39	0.00
EARTH X	0.00	-0.35	0.00	0.00	0.00
Soil above Toe					
EARTH XI	201.60	2.25	0.00	453.60	0.00
EARTH VII	13.44	1.78	0.00	23.97	0.00
Vertical reaction due to braking LL1B	3.27	0.40	0.00	1.31	0.00
Vertical reaction due to braking LL2B	3.27	0.40	0.00	1.31	0.00
Vertical reaction due to braking LL3B	3.27	0.40	0.00	1.31	0.00

OVER TURNING MOMENT					
Live load surcharge	58.95			323.94	0.00
Net earth pressure	269.95			1246.04	0.00
Braking Force	105.16			1125.74	0.00
Moment due to Wind					
Wind on Super str	3.41			8.57	
Wind on Moving Load	0.00			0.00	
Wind on Abut Cap	0.06			0.49	
Wind on Abut Wall	0.27			1.84	

COMBINATION FOR DESIGN OF FOUNDATION ULS & BASE PRESSURE

As per Annexure B of IRC 112

SERVICE CONDITION

	V(t)	ML-tm	MT-tm
DL	2367.73	-1079.00	0.00
SIDL 1	15.90	6.36	0.00
SIDL 2	23.90	9.56	0.00
LL1 Max Reaction Case	112.93	45.17	328.63
LL2 Max Long Mom Case	199.45	79.78	189.47
LL3 Max Trans Mom Case	199.45	79.78	189.47
LL1B due to braking	3.27	1125.74	0.00
LL2B due to braking	3.27	1125.74	0.00
LL3B due to braking	3.27	1125.74	0.00
W1 Wind ver down w/o LL	59.81	9.16	36.62
W1 Wind ver up w/o LL	-59.81	9.16	36.62
W3 Wind ver down with LL	59.81	9.16	36.62
W3 Wind ver up with LL	-59.81	9.16	36.62
HFL Water Current Force			
Net Earth Pressure LWL	0.00	2492.09	0.00
LL surcharge LWL	0.00	647.88	0.00
Net Earth Pressure HFL	0.00	1246.04	0.00
LL surcharge HFL	0.00	323.94	0.00

	Combination 1				Combination 2				Combination for base pressure		
	PSF	V(t)	ML-tm	MT-tm	PSF	V(t)	ML-tm	MT-tm	PSF	V(t)	ML-tm
DL	1.35	3196.44	-1456.65	0.00	1.00	2367.73	-1079.00	0.00	1.00	2367.73	-1079.00
SIDL 1	1.75	27.83	11.13	0.00	1.00	15.90	6.36	0.00	1.00	15.90	6.36
SIDL 2	1.35	32.27	12.91	0.00	1.00	23.90	9.56	0.00	1.00	23.90	9.56
LL1 Max Reaction Case	1.50	169.40	67.76	492.94	1.30	146.81	58.72	427.22	1.00	112.93	45.17
LL2 Max Long Mom Case	1.50	299.17	119.67	284.21	1.30	259.28	103.71	246.32	1.00	199.45	79.78
LL3 Max Trans Mom Case	1.50	299.17	119.67	284.21	1.30	259.28	103.71	246.32	1.00	199.45	79.78
LL1B due to braking	1.50	4.90	1688.61	0.00	1.30	4.25	1463.46	0.00	1.00	3.27	1125.74
LL2B due to braking	1.50	4.90	1688.61	0.00	1.30	4.25	1463.46	0.00	1.00	3.27	1125.74
LL3B due to braking	1.50	4.90	1688.61	0.00	1.30	4.25	1463.46	0.00	1.00	3.27	1125.74
W1 Wind ver down w/o LL	0.90	53.83	8.24	32.96	0.80	47.85	7.32	29.30	1.00	59.81	9.16
W2 Wind ver down with LL	0.90	-53.83	8.24	32.96	0.80	-47.85	7.32	29.30	1.00	-59.81	9.16
W3 Wind ver up w/o LL	0.90	53.83	8.24	32.96	0.80	47.85	7.32	29.30	1.00	59.81	9.16
W4 Wind ver up with LL	0.90	-53.83	8.24	32.96	0.80	-47.85	7.32	29.30	1.00	-59.81	9.16
HFL Water Current Force	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
Net Earth Pressure LWL	1.00	0.00	2492.09	0.00	0.85	0.00	2118.27	0.00	1.00	0.00	2492.09
LL surcharge LWL	1.20	0.00	777.46	0.00	1.00	0.00	647.88	0.00	1.00	0.00	647.88
Net Earth Pressure HFL	1.00	0.00	1246.04	0.00	0.85	0.00	1059.14	0.00	1.00	0.00	1246.04
LL surcharge HFL	1.20	0.00	388.73	0.00	1.00	0.00	323.94	0.00	1.00	0.00	323.94

(DL SUP + SW + Earth)

check
MT-tm
0.00
0.00
0.00
328.63
189.47
189.47
0.00
0.00
0.00
36.62
36.62
36.62
36.62
0.00
0.00
0.00
0.00
0.00

Case 1 : Combination 1 (SERVICE CONDITION)				
Load Case	**Factored Forces/Moments**			
		V	**ML**	**MT**
		t	**t-m**	**t-m**
Normal case				
Case 1	DL+SIDL1+SIDL2	3256.53	1059.48	0.00
Case 2	DL+SIDL1+SIDL2+LL1	3430.83	3593.30	492.94
Case 3	DL+SIDL1+SIDL2+LL2	3560.60	3645.21	284.21
Case 4	DL+SIDL1+SIDL2+LL3	3560.60	3645.21	284.21
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	3310.36	1067.72	32.96
Case 6	DL+SIDL1+SIDL2+LL1+Wind	3484.65	3601.54	525.90
Case 7	DL+SIDL1+SIDL2+LL2+Wind	3614.43	3653.45	317.17
Case 8	DL+SIDL1+SIDL2+LL3+Wind	3614.43	3653.45	317.17
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	3202.70	1067.72	32.96
Case 10	DL+SIDL1+SIDL2+LL1+Wind	3377.00	3601.54	525.90
Case 11	DL+SIDL1+SIDL2+LL2+Wind	3506.77	3653.45	317.17
Case 12	DL+SIDL1+SIDL2+LL3+Wind	3506.77	3653.45	317.17

3614.43	3653.45	317.17
3614.43	3653.45	317.17
3484.65	3601.54	525.90

HFL case				
Case 1	DL+SIDL1+SIDL2 + HFl	3256.53	-186.57	0.00
Case 2	DL+SIDL1+SIDL2+LL1 + HFl	3430.83	1958.53	492.94
Case 3	DL+SIDL1+SIDL2+LL2 + HFl	3560.60	2010.44	284.21
Case 4	DL+SIDL1+SIDL2+LL3 + HFl	3560.60	2010.44	284.21
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind + HFl	3310.36	-178.33	32.96
Case 6	DL+SIDL1+SIDL2+LL1+Wind+ HFl	3484.65	1966.77	525.90
Case 7	DL+SIDL1+SIDL2+LL2+Wind+ HFl	3614.43	2018.68	317.17
Case 8	DL+SIDL1+SIDL2+LL3+Wind+ HFl	3614.43	2018.68	317.17
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+ HFl	3202.70	-194.81	-32.96
Case 10	DL+SIDL1+SIDL2+LL1+Wind+ HFl	3377.00	1950.29	459.98
Case 11	DL+SIDL1+SIDL2+LL2+Wind+ HFl	3506.77	2002.20	251.25
Case 12	DL+SIDL1+SIDL2+LL3+Wind+ HFl	3506.77	2002.20	251.25

3614.43	2018.68	317.17
3614.43	2018.68	317.17
3484.65	1966.77	525.90

Case 2 : Combination 2(SERVICE CONDITION)				
Load Case	**Factored Forces/Moments**			
		V	**ML**	**MT**
		t	**t-m**	**t-m**
Normal case				
Case 1	DL+SIDL1+SIDL2	2407.53	1055.20	0.00
Case 2	DL+SIDL1+SIDL2+LL1	2558.59	3225.26	492.94
Case 3	DL+SIDL1+SIDL2+LL2	2671.06	3270.25	284.21
Case 4	DL+SIDL1+SIDL2+LL3	2671.06	3270.25	284.21
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	2455.38	1062.52	32.96
Case 6	DL+SIDL1+SIDL2+LL1+Wind	2606.44	3232.59	525.90
Case 7	DL+SIDL1+SIDL2+LL2+Wind	2718.91	3277.58	317.17
Case 8	DL+SIDL1+SIDL2+LL3+Wind	2718.91	3277.58	317.17
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	2359.69	1062.52	32.96
Case 10	DL+SIDL1+SIDL2+LL1+Wind	2510.74	3232.59	525.90
Case 11	DL+SIDL1+SIDL2+LL2+Wind	2623.21	3277.58	317.17
Case 12	DL+SIDL1+SIDL2+LL3+Wind	2623.21	3277.58	317.17

2718.91	3277.58	317.17
2718.91	3277.58	317.17
2606.44	3232.59	525.90

HFL case				
Case 1	DL+SIDL1+SIDL2 + HFl	2407.53	-3.94	0.00
Case 2	DL+SIDL1+SIDL2+LL1 + HFl	2558.59	1842.18	492.94
Case 3	DL+SIDL1+SIDL2+LL2 + HFl	2671.06	1887.17	284.21
Case 4	DL+SIDL1+SIDL2+LL3 + HFl	2671.06	1887.17	284.21
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind + HFl	2455.38	3.38	32.96
Case 6	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2606.44	1849.51	525.90
Case 7	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2718.91	1894.50	317.17
Case 8	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2718.91	1894.50	317.17
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+ HFl	2359.69	-11.27	-32.96
Case 10	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2510.74	1834.86	459.98
Case 11	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2623.21	1879.85	251.25
Case 12	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2623.21	1879.85	251.25

2718.91	1894.50	317.17
2718.91	1894.50	317.17
2606.44	1849.51	525.90

Case 2 : Combination for base pressure check (SERVICE CONDITION)				
Load Case	**Factored Forces/Moments**			
		V	**ML**	**MT**
		t	**t-m**	**t-m**
Normal case				
Case 1	DL+SIDL1+SIDL2	2407.53	1429.01	0.00
Case 2	DL+SIDL1+SIDL2+LL1	2523.73	3247.80	328.63
Case 3	DL+SIDL1+SIDL2+LL2	2610.25	3282.41	189.47
Case 4	DL+SIDL1+SIDL2+LL3	2610.25	3282.41	189.47
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	2467.34	1438.16	36.62
Case 6	DL+SIDL1+SIDL2+LL1+Wind	2583.54	3256.96	365.25
Case 7	DL+SIDL1+SIDL2+LL2+Wind	2670.05	3291.57	226.10
Case 8	DL+SIDL1+SIDL2+LL3+Wind	2670.05	3291.57	226.10
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	2347.72	1438.16	36.62
Case 10	DL+SIDL1+SIDL2+LL1+Wind	2463.92	3256.96	365.25
Case 11	DL+SIDL1+SIDL2+LL2+Wind	2550.44	3291.57	226.10
Case 12	DL+SIDL1+SIDL2+LL3+Wind	2550.44	3291.57	226.10

Normal Governing cases	2610.25	3282.41	189.47
	2610.25	3282.41	189.47
	2523.73	3247.80	328.63

Governing cases with Wind	2670.05	3291.57	226.10
	2670.05	3291.57	226.10
	2583.54	3256.96	365.25

HFL case				
Case 1	DL+SIDL1+SIDL2 + HFl	2407.53	182.97	0.00
Case 2	DL+SIDL1+SIDL2+LL1 + HFl	2523.73	1677.82	328.63
Case 3	DL+SIDL1+SIDL2+LL2 + HFl	2610.25	1712.42	189.47
Case 4	DL+SIDL1+SIDL2+LL3 + HFl	2610.25	1712.42	189.47
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind + HFl	2467.34	192.12	36.62
Case 6	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2583.54	1686.97	365.25
Case 7	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2670.05	1721.58	226.10
Case 8	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2670.05	1721.58	226.10
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+ HFl	2347.72	173.81	-36.62
Case 10	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2463.92	1668.66	292.01
Case 11	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2550.44	1703.27	152.85
Case 12	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2550.44	1703.27	152.85

Normal Governing cases	2610.25	1712.42	189.47
	2610.25	1712.42	189.47
	2523.73	1677.82	328.63

Governing cases with Wind	2670.05	1721.58	226.10
	2670.05	1721.58	226.10
	2583.54	1686.97	365.25

COMBINATION FOR BASE PRESSURE CHECK

ABUTMENT CAST CONDITION

	V(t)	ML-tm	MT-tm
DL	2131.12	1051.09	0.00
SIDL 1	0.00	0.00	0.00
SIDL 2	0.00	0.00	0.00
LL1 Max Reaction Case	0.00	0.00	0.00
LL2 Max Long Mom Case	0.00	0.00	0.00
LL3 Max Trans Mom Case	0.00	0.00	0.00
LL1B due to braking	0.00	0.00	0.00
LL2B due to braking	0.00	0.00	0.00
LL3B due to braking	0.00	0.00	0.00
W1 Wind ver down w/o LL	59.81	9.16	36.62
W1 Wind ver up w/o LL	-59.81	9.16	36.62
W3 Wind ver down with LL	59.81	9.16	36.62
W3 Wind ver up with LL	-59.81	9.16	36.62
HFL Water Current Force			
Net Earth Pressure LWL	0.00	2492.09	0.00
LL surcharge LWL	0.00	0.00	0.00
Net Earth Pressure HFL	0.00	1246.04	0.00
LL surcharge HFL	0.00	0.00	0.00

	Combination for base pressure check			
	PSF	**V(t)**	**ML-tm**	**MT-tm**
DL	1.00	2131.12	1051.09	0.00
SIDL 1	1.00	0.00	0.00	0.00
SIDL 2	1.00	0.00	0.00	0.00
LL1 Max Reaction Case	1.00	0.00	0.00	0.00
LL2 Max Long Mom Case	1.00	0.00	0.00	0.00
LL3 Max Trans Mom Case	1.00	0.00	0.00	0.00
LL1B due to braking	1.00	0.00	0.00	0.00
LL2B due to braking	1.00	0.00	0.00	0.00
LL3B due to braking	1.00	0.00	0.00	0.00
W1 Wind ver down w/o LL	1.00	59.81	9.16	36.62
W2 Wind ver down with LL	1.00	-59.81	9.16	36.62
W3 Wind ver up w/o LL	1.00	59.81	9.16	36.62
W4 Wind ver up with LL	1.00	-59.81	9.16	36.62
HFL Water Current Force	1.00	0.00	0.00	0.00
Net Earth Pressure LWL	1.00	0.00	2492.09	0.00
LL surcharge LWL	1.00	0.00	0.00	0.00
Net Earth Pressure HFL	1.00	0.00	1246.04	0.00
LL surcharge HFL	1.00	0.00	0.00	0.00

Case 1 : Combination BASE PRESSURE (ABUTMENT CAST CONDITION)				
Load Case	**Factored Forces/Moments**			
		V	**ML**	**MT**
		t	**t-m**	**t-m**
Normal case				
Case 1	DL+SIDL1+SIDL2	2131.12	3543.17	0.00
Case 2	DL+SIDL1+SIDL2+LL1	2131.12	3543.17	0.00
Case 3	DL+SIDL1+SIDL2+LL2	2131.12	3543.17	0.00
Case 4	DL+SIDL1+SIDL2+LL3	2131.12	3543.17	0.00
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	2190.93	3552.33	36.62
Case 6	DL+SIDL1+SIDL2+LL1+Wind	2190.93	3552.33	36.62
Case 7	DL+SIDL1+SIDL2+LL2+Wind	2190.93	3552.33	36.62
Case 8	DL+SIDL1+SIDL2+LL3+Wind	2190.93	3552.33	36.62
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	2071.32	3552.33	36.62
Case 10	DL+SIDL1+SIDL2+LL1+Wind	2071.32	3552.33	36.62
Case 11	DL+SIDL1+SIDL2+LL2+Wind	2071.32	3552.33	36.62
Case 12	DL+SIDL1+SIDL2+LL3+Wind	2071.32	3552.33	36.62

Normal Governing cases	2131.12	3543.17	0.00
	2131.12	3543.17	0.00
	2131.12	3543.17	0.00

Governing cases with Wind	2190.93	3552.33	36.62
	2190.93	3552.33	36.62
	2190.93	3552.329	36.62

HFL case				
Case 1	DL+SIDL1+SIDL2 + HFl	2131.12	2297.13	0.00
Case 2	DL+SIDL1+SIDL2+LL1 + HFl	2131.12	2297.13	0.00
Case 3	DL+SIDL1+SIDL2+LL2 + HFl	2131.12	2297.13	0.00
Case 4	DL+SIDL1+SIDL2+LL3 + HFl	2131.12	2297.13	0.00
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind + HFl	2190.93	2306.29	36.62
Case 6	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2190.93	2306.29	36.62
Case 7	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2190.93	2306.29	36.62
Case 8	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2190.93	2306.29	36.62
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+ HFl	2071.32	2287.97	-36.62
Case 10	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2071.32	2287.97	-36.62
Case 11	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2071.32	2287.97	-36.62
Case 12	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2071.32	2287.97	-36.62

Normal Governing cases	2131.12	2297.13	0.00
	2131.12	2297.13	0.00
	2131.12	2297.13	0.00

Governing cases with Wind	2190.93	2306.29	36.62
	2190.93	2306.29	36.62
	2190.93	2306.29	36.62

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1.04 BASE PRESSURE CHECK

	NORMAL CASE (SERVICE CONDITION)	LWL CASE			HFL CASE		
		£V	$£M_{netL}$	$£M_T$	£V	$£M_{netL}$	$£M_T$
Case1	Maximum Reaction Case	2610.25	3282.41	189.47	2610.25	1712.42	189.47
Case2	Maximum Longitudinal Moment Case	2610.25	3282.41	189.47	2610.25	1712.42	189.47
Case3	Maximum Transverse Moment Case	2523.73	3247.80	328.63	2523.73	1677.82	328.63

	WITH WIND (SERVICE CONDITION)	LWL CASE			HFL CASE		
		£V	$£M_{netL}$	$£M_T$	£V	$£M_{netL}$	$£M_T$
Case1	Maximum Reaction Case	2670.05	3291.57	226.10	2670.05	1721.58	226.10
Case2	Maximum Longitudinal Moment Case	2670.05	3291.57	226.10	2670.05	1721.58	226.10
Case3	Maximum Transverse Moment Case	2583.54	3256.96	365.25	2583.54	1686.97	365.25

Safe Bearing Capacity of Soil (t/m^2)	=	60.00	Ref: Soil report	
Section Properties				
A	=	116.80	m^2	
Zt	=	311.47	m^3	
ZL	=	142.11	m^3	

Normal Case	LWL CASE			HFL CASE		
Base Pressure	**Case1**	**Case2**	**Case3**	**Case1**	**Case2**	**Case3**
£V/A	22.35	22.35	21.61	22.35	22.35	21.61
$£M_{netL}$/ZL	23.10	23.10	22.85	12.05	12.05	11.81
$£M_T$/Zt	0.61	0.61	1.06	0.61	0.61	1.06
(£V/A)+($£M_{netL}$/ZL)+($£M_T$/Zt)max	**46.05**	**46.05**	**45.52**	**35.01**	**35.01**	**34.47**
	Safe	Safe	Safe	Safe	Safe	Safe
(£V/A)+($£M_{netL}$/ZL)-($£M_T$/Zt)	44.84	44.84	43.41	33.79	33.79	32.36
(£V/A)-($£M_{netL}$/ZL)+($£M_T$/Zt)	-0.14	-0.14	-0.19	10.91	10.91	10.86
(£V/A)-($£M_{netL}$/ZL)-($£M_T$/Zt)min	**-1.36**	**-1.36**	**-2.30**	**9.69**	**9.69**	**8.75**
	Fail	Fail	Fail	Safe	Safe	Safe
Stress at face of support of toe	27.87	27.87	27.18	25.30	25.30	24.60
BM at face of support of toe	**156.77**	**156.77**	**154.46**	**124.54**	**124.54**	**122.23**
Stress at face of support of Heel	20.07	20.07	19.31	21.13	21.13	20.37
BM at face of support of Heel	**-31.50**	**-31.50**	**-26.70**	**-73.53**	**-73.53**	**-68.72**

WIND Case	LWL CASE			HFL CASE		
Base Pressure	**Case1**	**Case2**	**Case3**	**Case1**	**Case2**	**Case3**
£V/A	22.86	22.86	22.12	22.86	22.86	22.12
$£M_{netL}$/ZL	23.16	23.16	22.92	12.11	12.11	11.87
$£M_T$/Zt	0.73	1.17	1.17	1.59	0.73	1.17
(£V/A)+($£M_{netL}$/ZL)+($£M_T$/Zt) max	**46.75**	**47.20**	**46.21**	**36.57**	**35.70**	**35.16**
	Safe	Safe	Safe	Safe	Safe	Safe
(£V/A)+($£M_{netL}$/ZL)-($£M_T$/Zt)	45.30	44.85	43.87	33.38	34.25	32.82
(£V/A)-($£M_{netL}$/ZL)+($£M_T$/Zt)	0.42	0.87	0.37	12.34	11.47	11.42
(£V/A)-($£M_{netL}$/ZL)-($£M_T$/Zt) min	**-1.03**	**-1.48**	**-1.97**	**9.15**	**10.02**	**9.08**
	Fail	Fail	Fail	Safe	Safe	Safe
Stress at face of support of toe	28.42	28.53	27.73	26.05	25.85	25.16
BM at face of support of toe	**159.31**	**160.61**	**157.00**	**129.60**	**127.08**	**124.76**
Stress at face of support of Heel	20.57	20.53	19.81	21.55	21.63	20.87
BM at face of support of Heel	**-33.60**	**-31.90**	**-28.79**	**-72.34**	**-75.63**	**-70.82**

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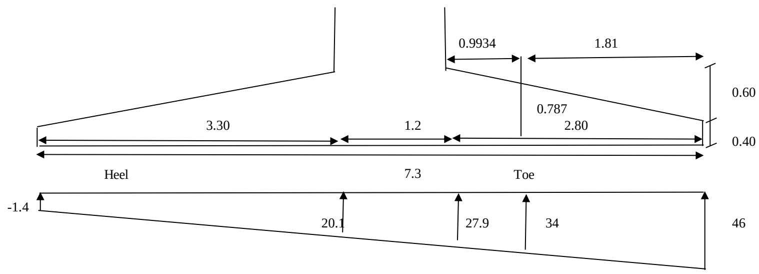
1.04 BASE PRESSURE CHECK

	NORMAL CASE (ABUT CAST CONDITION)	LWL CASE			HFL CASE		
		£V	£M_{netL}	£M_T	£V	£M_{netL}	£M_T
Case1	Maximum Reaction Case	2131.12	3543.17	0.00	2131.12	2297.13	0.00
Case2	Maximum Longitudinal Moment Case	2131.12	3543.17	0.00	2131.12	2297.13	0.00
Case3	Maximum Transverse Moment Case	2131.12	3543.17	0.00	2131.12	2297.13	0.00

	WITH WIND (ABUT CAST CONDITION)	LWL CASE			HFL CASE		
		£V	£M_{netL}	£M_T	£V	£M_{netL}	£M_T
Case1	Maximum Reaction Case	2190.93	3552.33	36.62	2190.93	2306.29	36.62
Case2	Maximum Longitudinal Moment Case	2190.93	3552.33	36.62	2190.93	2306.29	36.62
Case3	Maximum Transverse Moment Case	2190.93	3552.33	36.62	2190.93	2306.29	36.62

Safe Bearing Capacity of Soil (t/m^2)	=	60.00	Ref: Soil report
Section Properties			
A	=	116.80	m^2
Zt	=	311.47	m^3
ZL	=	142.11	m^3

Normal Case	LWL CASE			HFL CASE		
Base Pressure	**Case1**	**Case2**	**Case3**	**Case1**	**Case2**	**Case3**
£V/A	18.25	18.25	18.25	18.25	18.25	18.25
£M_{nettL}/ZL	24.93	24.93	24.93	16.16	16.16	16.16
£M_T/Zt	0.00	0.00	0.00	0.00	0.00	0.00
(£V/A)+(£M_{nettL}/ZL)+(£M_T/Zt)	**43.18**	**43.18**	**43.18**	**34.41**	**34.41**	**34.41**
	Safe	Safe	Safe	Safe	Safe	Safe
(£V/A)+(£M_{nettL}/ZL)-(£M_T/Zt)	43.18	43.18	43.18	34.41	34.41	34.41
(£V/A)-(£M_{nettL}/ZL)+(£M_T/Zt)	-6.69	-6.69	-6.69	2.08	2.08	2.08
(£V/A)-(£M_{nettL}/ZL)-(£M_T/Zt)	**-6.69**	**-6.69**	**-6.69**	**2.08**	**2.08**	**2.08**
	Fail	Fail	Fail	Safe	Safe	Safe



Design Of Toe Slab :-

The Toe Slab Of Abutment is designed as Cantilever for the Net Upward Pressure : -

Maximum BM at face of cantilever

BM = 160.61 Tm

Dover all	=	1000	mm			
Deffe	=	993.4	mm	CC =	50	mm

M.R. available with C.C. M 35 Fe 500

MR = 476.65 Tm > Actual BM

Mu = 0.87 fy Ast d (1-(Ast/bd)(fy/fck))

1606127708	=	432129	Ast *	(1- Ast/	69538	)
3716.78	=	Ast * (1 - Ast/	69538	)		
Ast^2 - 69538		*Ast +	2.58E+08			
Ast required =	**3940.019661**	**mm2**				

Provide bar dia. (mm) = 32

Spacing reqd = 204 mm

Provide 32 mm @ 160 mm c/c.

Ast provided	**=**	***5024.0***	**>**	***Ast reqd***

Distribution Ast required @ 0.12% OF x-sectional area = 840 mm2

Provide 12 mm @ 160 mm c/c.

Ast provided	=	*706.5*	mm2	Spacing reqd =	135	mm

From Cl. 16.5.1 (2) of IRC :112-2011

fcd=	15.63333333	Mpa	fyd =	435	Mpa
fck=	35	Mpa			
fctm =	2.8	Mpa(from Table 65 IRC 112:2011)			
fyk=	435	N/mm2			
bt=	1000	mm			
d=	993.4	mm			

Minimum R.f check

Asmin =0.26$f_{ctm}b_t$d/fyk >= 0.0013b_td

Asmin= 1663.3 >= 1291.42 **OK**

Minimum R.f check

Asmax =0.025Ac(main tension)

Asmax= 25000 mm2 **OK**

SHEAR CHECK:

Shear at distance 1d from face of front wall i.e 0.9934 m

And 1.81 m from edge.

Base pressure at this section = 34 T/m2

S.F. =	**73**	**T**
D overall =	787	mm
D effective =	721	mm

Bending Moment at this section = 68.77 Tm

Relief due to (M/d)X Tanø

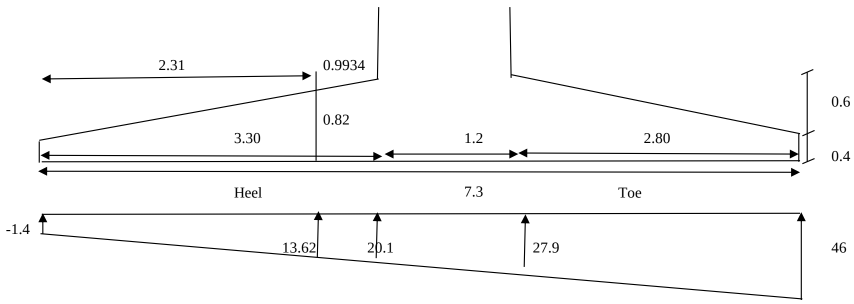
Net SF = S.F - (M/d) X Tanø

V_{ED} =	**72.60**	**T**
Shear stress=	**0.92**	**Mpa**

Max shear capacity, 0.135 fck(1-fck/310)	**4.19 Mpa**	**OK**

cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010		
K = 1+Sqrt(200/d) <= 2.0	1.45	OK
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010		
n_{min} = 0.031 $K^{3/2}$ $fck^{1/2}$	0.32	
cl. 10.3.1 of IRC :112-2011		
r1 = $A_{sl}/(b_w\ d)$ <= 0.02	0.005	OK
Axial compressive force N_{Ed} (KN)	0	
s_{cp} = N_{Ed} / A_c <= 0.2 f_{cd}	0	
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010		
$V_{Rd.c}$ = [0.12K(80r1 $f_{ck})^{0.33}$ + 0.15s_{cp}]b_wd <= (n_{min} + 0.15 s_{cp}) b_w d (KN)	**31.77**	**T**

Design Shear resisitance	**V_{RD}<=V_{ED}**	Provide Shear R/f	



Design Of Heel Slab :-

The Heel Slab Of Abutment is designed as Cantilever for the Net Upward Pressure : -

Maximum BM at face of cantilever

BM = 26.70 Tm

Dover all = 1000 mm

Deffe = 993.4 mm CC = 50 mm

M.R. available with C.C. M 35 Fe 500

MR = 476.65 Tm > Actual BM

Mu = 0.87 fy Ast d (1-(Ast/bd)(fy/fck))

266977993.8 = 432129 Ast * (1- Ast/ 59604)

617.8201274 = Ast * (1 - Ast/ 59604)

Ast^2 - 59604.00 *Ast + 36824551

Ast required=	**624.36**	**mm2**

Provide bar dia. (mm) = 32 mm

Spacing reqd = 1287 mm

Provide 20 mm @ 160 mm c/c.

Ast provided	=	*1962.50*	>	*Ast reqd*

Distribution Ast required @ 0.12% OF x-sectional area = 840 mm2

Provide 12 mm @ 150 mm c/c. Spacing reqd = 135 mm

Ast provided	=	*753.6*	mm2

From Cl. 16.5.1 (2) of IRC :112-2011

fck= 35 Mpa

fctm = 2.8 Mpa(from Table 65 IRC 112:2011)

fyk= 435 N/mm2

bt= 1000 mm

d= 993.4 mm

Minimum R.f check

Asmin =0.26$f_{ctm}b_t$d/fyk >= 0.0013b_td

Asmin= 1663.3 >= 1291.42 **OK**

Minimum R.f check

Asmax =0.025Ac(main tension)

Asmax= 25000 mm2 **OK**

SHEAR CHECK:

Shear at distance 1d from face of front wall i.e 0.9934 m

And 2.31 m from edge.

Base pressure at this section = 14 T/m2

S.F. =	**14**	**T**

D overall = 819 mm

D effective = 753 mm

Bending Moment at this section = 9.67 Tm

Relief due to (M/d)X Tanø

Net SF = S.F - (M/d) X Tanø

V_{ED} =	**14.14**	**T**
Shear stress=	**0.17**	**Mpa**

Max shear capacity, 0.135 fck(1-fck/310)	**4.19 Mpa**	**OK**

cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010		
K = 1+Sqrt(200/d) <= 2.0	1.45	OK
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010		
n_{min} = 0.031 $K^{3/2}$ $fck^{1/2}$	0.32	
cl. 10.3.1 of IRC :112-2011		
r1 = A_{sl}/(b_w d) <= 0.02	0.002	OK
Axial compressive force N_{Ed} (KN)	0	
s_{cp} = N_{Ed} / A_c <= 0.2 f_{cd}	0	
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010		
$V_{Rd.c}$ = [0.12K(80r1 $f_{ck})^{0.33}$ + 0.15s_{cp}]b_wd <= (n_{min} + 0.15 s_{cp}) b_w d	**30.37**	**T**

Design Shear resisitance	**VRd.c >= VED**	Shear R/f not required	

DESIGN OF SHEAR REIFORECEMENT		
cl. 10.3.2(5) Eq. 10.6 of IRC :112-2010		
n = 0.6 (1 - fck / 310)	0.6	
cl. 10.3.2(5) Eq. 10.5 of IRC :112-2011		
0.5 b_w d n f_{cd}	465.9	
	OK	
No. of link for shear reinf.	6.67	
Dia. of bar for shear reinf.	10	mm
S (mm)	150	
A_{SW}	524	
cl. 16.5.2(7) Eq. 16.6 of IRC :112-2011		
$S_{l.max}$ = 0.75 d	745	mm
cl. 16.5.2(9) Eq. 16.8 of IRC :112-2011		
$S_{t.max}$ = 0.75 d <= 600mm	745	mm
x (mm)	173	mm
z (mm)	921	mm
f_{ywd}	348	mm
cl. 10.3.3.2 Eq. 10.7 of IRC :112-2011		
$V_{Rd.s} = A_{SW}\, z\, f_{ywd} \cot\theta / S$ (KN)	2797	KN
a_{cw} = ($s_{cp} = N_{Ed} / A_c = 0$)	1	
n_1	0.6	
cl. 10.3.3.2 Eq. 10.8 of IRC :112-2011		
$V_{Rd.max} = a_{cw}\, b_w\, z\, n_1\, f_{cd}$ (KN)	8638	
	OK	
cl. 10.3.3.2 Eq. 10.10 of IRC :112-2011		
$A_{SW.max} <= 0.5\, a_{cw}\, n_1\, f_{cd}\, b_w\, S / f_{ywd}$	2022.563	mm2
	OK	
cl. 10.3.1 of IRC :112-2011		
$r_w = A_{SW} / (S\, b_w \sin a)$	0.005139	
cl. 10.3.3.5 of IRC :112-2011		
$r_{w,min} = (0.072\, f_{ck}^{0.5}) / f_{yk}$	0.00098	
	OK	
Punching shear check		
a	1986.8	mm
K = 1+Sqrt(200/d) <= 2.0	1.45	
$n_{min} = 0.031\, K^{3/2}\, fck^{1/2}$	0.32	
cl. 10.3.1 of IRC :112-2011		
$r1 = A_{sl}/(b_w\, d) <= 0.02$	0.005	
$V_{RD} = [0.12K(80\rho 1\, f_{ck})^{0.33}]2d/a >= n_{min}\; 2d/a$	0.4	KN
	OK	

COMBINATION FOR DESIGN OF FOUNDATION SLS & BASE PRESSURE
As per Annexure B of IRC 112
SERVICE CONDITION

	V(t)	ML-tm	MT-tm
DL	2390.47	-1086.96	0.00
SIDL 1	15.90	6.36	0.00
SIDL 2	23.90	9.56	0.00
LL1 Max Reaction Case	112.93	45.17	328.63
LL2 Max Long Mom Case	199.45	79.78	189.47
LL3 Max Trans Mom Case	199.45	79.78	189.47
LL1B due to braking	3.27	1125.74	0.00
LL2B due to braking	3.27	1125.74	0.00
LL3B due to braking	3.27	1125.74	0.00
W1 Wind ver down w/o LL	59.81	9.16	36.62
W1 Wind ver up w/o LL	-59.81	9.16	36.62
W3 Wind ver down with LL	59.81	9.16	36.62
W3 Wind ver up with LL	-59.81	9.16	36.62
HFL Water Current Force			
Net Earth Pressure LWL	0.00	2492.09	0.00
LL surcharge LWL	0.00	647.88	0.00
Net Earth Pressure HFL	0.00	1246.04	0.00
LL surcharge HFL	0.00	323.94	0.00

	Rare Combination				Quasi-Perm. Combination			
	PSF	V(t)	ML-tm	MT-tm	PSF	V(t)	ML-tm	MT-tm
DL	1.00	2390.47	-1086.96	0.00	1.00	2390.47	-1086.96	0.00
SIDL 1	1.00	15.90	6.36	0.00	1.00	15.90	6.36	0.00
SIDL 2	1.00	23.90	9.56	0.00	0.00	0.00	0.00	0.00
LL1 Max Reaction Case	1.00	112.93	45.17	328.63	0.00	0.00	0.00	0.00
LL2 Max Long Mom Case	1.00	199.45	79.78	189.47	0.00	0.00	0.00	0.00
LL3 Max Trans Mom Case	1.00	199.45	79.78	189.47	0.00	0.00	0.00	0.00
LL1B due to braking	1.00	3.27	1125.74	0.00	0.00	0.00	0.00	0.00
LL2B due to braking	1.00	3.27	1125.74	0.00	0.00	0.00	0.00	0.00
LL3B due to braking	1.00	3.27	1125.74	0.00	0.00	0.00	0.00	0.00
W1 Wind ver down w/o LL	0.60	35.89	5.49	21.97	0.00	0.00	0.00	0.00
W2 Wind ver down with LL	0.60	-35.89	5.49	21.97	0.00	0.00	0.00	0.00
W3 Wind ver up w/o LL	0.60	35.89	5.49	21.97	0.00	0.00	0.00	0.00
W4 Wind ver up with LL	0.60	-35.89	5.49	21.97	0.00	0.00	0.00	0.00
HFL Water Current Force	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Earth Pressure LWL	1.00	0.00	2492.09	0.00	1.00	0.00	2492.09	0.00
LL surcharge LWL	0.80	0.00	518.31	0.00	0.00	0.00	0.00	0.00
Net Earth Pressure HFL	1.00	0.00	1246.04	0.00	1.00	0.00	1246.04	0.00
LL surcharge HFL	0.80	0.00	259.15	0.00	0.00	0.00	0.00	0.00

Rare Combination				
Load Case	Factored Forces/Moments			
		V	ML	MT
		t	t-m	t-m
Normal case				
Case 1	DL+SIDL1+SIDL2	2430.27	1421.05	0.00
Case 2	DL+SIDL1+SIDL2+LL1	2546.47	3110.27	328.63
Case 3	DL+SIDL1+SIDL2+LL2	2632.99	3144.87	189.47
Case 4	DL+SIDL1+SIDL2+LL3	2632.99	3144.87	189.47
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	2466.16	1426.54	21.97
Case 6	DL+SIDL1+SIDL2+LL1+Wind	2582.36	3115.76	350.60
Case 7	DL+SIDL1+SIDL2+LL2+Wind	2668.87	3150.37	211.45
Case 8	DL+SIDL1+SIDL2+LL3+Wind	2668.87	3150.37	211.45
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	2394.39	1426.54	21.97
Case 10	DL+SIDL1+SIDL2+LL1+Wind	2510.58	3115.76	350.60
Case 11	DL+SIDL1+SIDL2+LL2+Wind	2597.10	3150.37	211.45
Case 12	DL+SIDL1+SIDL2+LL3+Wind	2597.10	3150.37	211.45

2668.87	3150.37	211.45
2668.87	3150.37	211.45
2582.36	3115.76	350.60

HFL case				
Case 1	DL+SIDL1+SIDL2 + HFl	2430.27	175.01	0.00
Case 2	DL+SIDL1+SIDL2+LL1 + HFl	2546.47	1605.07	328.63
Case 3	DL+SIDL1+SIDL2+LL2 + HFl	2632.99	1639.68	189.47
Case 4	DL+SIDL1+SIDL2+LL3 + HFl	2632.99	1639.68	189.47
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind + HFl	2466.16	180.50	21.97
Case 6	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2582.36	1610.56	350.60
Case 7	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2668.87	1645.17	211.45
Case 8	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2668.87	1645.17	211.45
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+ HFl	2394.39	169.51	-21.97
Case 10	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2510.58	1599.58	306.66
Case 11	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2597.10	1634.18	167.50
Case 12	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2597.10	1634.18	167.50

2668.87	1645.17	211.45
2668.87	1645.17	211.45
2582.36	1610.56	350.60

Quasi-Permanent Combination				
Load Case	**Factored Forces/Moments**			
		V	**ML**	**MT**
		t	**t-m**	**t-m**
Normal case				
Case 1	DL+SIDL1+SIDL2	2406.37	1411.49	0.00
Case 2	DL+SIDL1+SIDL2+LL1	2406.37	1411.49	328.63
Case 3	DL+SIDL1+SIDL2+LL2	2406.37	1411.49	189.47
Case 4	DL+SIDL1+SIDL2+LL3	2406.37	1411.49	189.47
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	2406.37	1411.49	21.97
Case 6	DL+SIDL1+SIDL2+LL1+Wind	2406.37	1411.49	350.60
Case 7	DL+SIDL1+SIDL2+LL2+Wind	2406.37	1411.49	211.45
Case 8	DL+SIDL1+SIDL2+LL3+Wind	2406.37	1411.49	211.45
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	2406.37	1411.49	21.97
Case 10	DL+SIDL1+SIDL2+LL1+Wind	2406.37	1411.49	350.60
Case 11	DL+SIDL1+SIDL2+LL2+Wind	2406.37	1411.49	211.45
Case 12	DL+SIDL1+SIDL2+LL3+Wind	2406.37	1411.49	211.45

2406.37	1411.49	0.00
2406.37	1411.49	0.00
2406.37	1411.49	350.60

HFL case				
Case 1	DL+SIDL1+SIDL2 + HFl	2406.37	165.45	0.00
Case 2	DL+SIDL1+SIDL2+LL1 + HFl	2406.37	165.45	328.63
Case 3	DL+SIDL1+SIDL2+LL2 + HFl	2406.37	165.45	189.47
Case 4	DL+SIDL1+SIDL2+LL3 + HFl	2406.37	165.45	189.47
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind + HFl	2406.37	165.45	21.97
Case 6	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2406.37	165.45	350.60
Case 7	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2406.37	165.45	211.45
Case 8	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2406.37	165.45	211.45
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+ HFl	2406.37	165.45	-21.97
Case 10	DL+SIDL1+SIDL2+LL1+Wind+ HFl	2406.37	165.45	306.66
Case 11	DL+SIDL1+SIDL2+LL2+Wind+ HFl	2406.37	165.45	167.50
Case 12	DL+SIDL1+SIDL2+LL3+Wind+ HFl	2406.37	165.45	167.50

2406.37	165.45	0.00
2406.37	165.45	0.00
2406.37	165.45	350.60

#REF!	#REF!	#REF!	#REF!
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1.04 BASE PRESSURE

	Rare Combination	LWL CASE			HFL CASE		
		£V	£M_{nettL}	£M_T	£V	£M_{nettL}	£M_T
Case1	Maximum Reaction Case	2668.87	3150.37	211.45	2668.87	1645.17	211.45
Case2	Maximum Longitudinal Moment Case	2668.87	3150.37	211.45	2668.87	1645.17	211.45
Case3	Maximum Transverse Moment Case	2582.36	3115.76	350.60	2582.36	1610.56	350.60

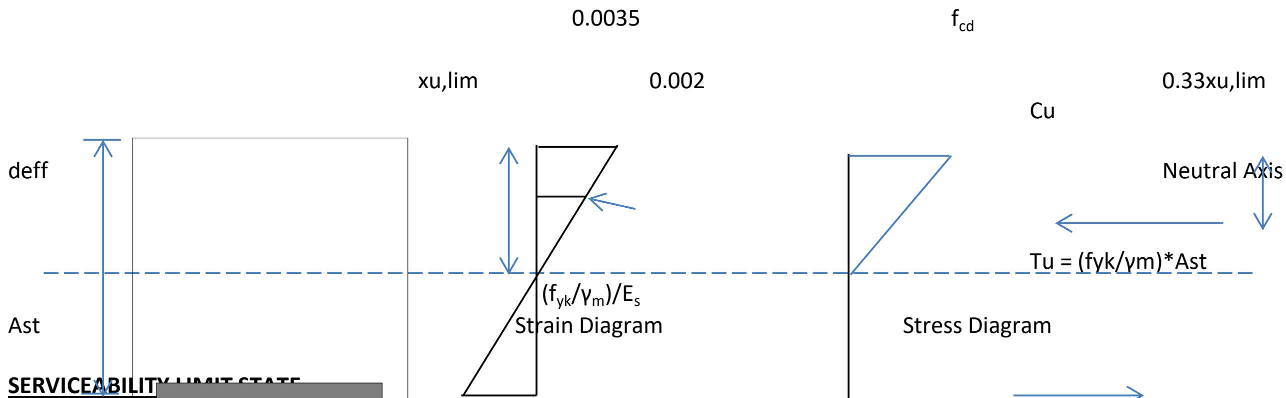
	Quasi-perm Combination	LWL CASE			HFL CASE		
		£V	£M_{nettL}	£M_T	£V	£M_{nettL}	£M_T
Case1	Maximum Reaction Case	2406.37	1411.49	0.00	2406.37	165.45	0.00
Case2	Maximum Longitudinal Moment Case	2406.37	1411.49	0.00	2406.37	165.45	0.00
Case3	Maximum Transverse Moment Case	2406.37	1411.49	350.60	2406.37	165.45	350.60

Safe Bearing Capacity of Soil (t/m^2)	=	60.00	Ref: Soil report	
Section Properties				
A	=	116.80	m^2	
Zt	=	311.47	m^3	
ZL	=	142.11	m^3	

Rare Combination	**LWL CASE**			**HFL CASE**		
Base Pressure	**Case1**	**Case2**	**Case3**	**Case1**	**Case2**	**Case3**
£V/A	22.85	22.85	22.11	22.85	22.85	22.11
£M_{nettL}/ZL	22.17	22.17	21.93	11.58	11.58	11.33
£M_T/Zt	0.68	0.68	1.13	0.68	0.68	1.13
(£V/A)+(£M_{nettL}/ZL)+(£M_T/Zt) max	**45.70**	**45.70**	**45.16**	**35.11**	**35.11**	**34.57**
(£V/A)-(£M_{nettL}/ZL)-(£M_T/Zt) min	**0.00**	**0.00**	**-0.94**	**10.59**	**10.59**	**9.65**
Stress at face of support of toe	28.17	28.17	27.48	25.70	25.70	25.01
BM at face of support of toe	**156.23**	**156.23**	**153.92**	**125.33**	**125.33**	**123.02**
Stress at face of support of Heel	20.66	20.66	19.90	21.67	21.67	20.91
BM at face of support of Heel	**-37.50**	**-37.50**	**-32.70**	**-77.80**	**-77.80**	**-72.99**

Quasi Perm Combination	**LWL CASE**			**HFL CASE**		
Base Pressure	**Case1**	**Case2**	**Case3**	**Case1**	**Case2**	**Case3**
£V/A	20.60	20.60	20.60	20.60	20.60	20.60
£M_{nettL}/ZL	9.93	9.93	9.93	0.53	0.53	0.53
£M_T/Zt	0.00	0.00	1.13	0.00	0.00	1.13
(£V/A)+(£M_{nettL}/ZL)+(£M_T/Zt) max	**30.54**	**30.54**	**31.66**	**21.13**	**21.13**	**22.26**
(£V/A)-(£M_{nettL}/ZL)-(£M_T/Zt) min	**10.67**	**10.67**	**9.54**	**20.07**	**20.07**	**18.95**
Stress at face of support of toe	22.92	22.92	23.18	20.73	20.73	20.99
BM at face of support of toe	**109.74**	**109.74**	**113.03**	**82.31**	**82.31**	**85.60**
Stress at face of support of Heel	19.65	19.65	19.54	20.55	20.55	20.44
BM at face of support of Heel	**-74.40**	**-74.40**	**-70.11**	**-110.16**	**-110.16**	**-105.88**

Verification for serviceability limit state for foundation .



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 = 30000 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 = 1000 mm
Clear cover = 50 mm

Moment on the section	At Face of support at Toe			At Face of support at Heel		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	1562.3		1130.3	327		701
b	1000		1000	1000		1000
D	1000		1000	1000		1000
c	50		50	50		50
d	925.5		925.5	925.5		925.5
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)	3873		2905	3873		2905
	OK		**OK**	**OK**		**OK**
Ast Req.	6101		4399	1196		2644
Dia of bar (main tension) (mm)	25		25	25		25
Spacing (mm)	110		110	110		110
+ dia of bar (main tension) (mm)	0		0	0		0
Spacing (mm)	100		100	100		100
Ast provided (sq mm)	4462		4462	4462		4462
Dia of bar (main compresion) (mm)	0		0	0		0
Spacing (mm)	100		100	100		100
Area of main compresion (mm^2)	0		0	0		0
f_{ctm}	2.8		2.8	2.8		2.8
x (mm)	159.4		212.5	159.4		212.5
x/d	0.172		0.230	0.172		0.230
	OK		**OK**	**OK**		**OK**
z (mm)	873		855	873		855
MR_{sls} (KNm)	1169		1145	1169		1145
	Revise		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s\ z)$	401		296	84		184
	Revise		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095\ z\ b\ x_u)$	22.46		12.44	4.70		7.71
	Revise		**OK**	**OK**		**OK**

#REF!	***#REF!***	***#REF!***	***#REF!***
#REF!	***#REF!***	***#REF!***	***#REF!***
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MOMENT CALCULATION C/L OF ABUTMENT BASE (LWL)

	Load (t)	L. A. at mid of Abutment (Long)	L(trans)	ML(tm)	MT(tm)
DL Super str.	191.20	0.15	0.00	28.68	0.00
SIDL 1	15.90	0.15	0.00	2.39	0.00
SIDL 2	23.90	0.15	0.00	3.59	0.00
LL1	112.93	0.15	2.91	16.94	328.63
LL2	199.45	0.15	0.95	29.92	189.47
LL3	199.45	0.15	0.95	29.92	189.47
Abut. Cap	24.00	0.00	0.00	0.00	0.00
Dirt wall	3.42	-0.45	0.00	-1.54	0.00
DL+SIDL load(WC)APPROACH	45.41	-0.60	0.00	-27.24	0.00
LL (Approach span) 40t boggie	22.74	-0.60	0.00	-13.64	0.00
TRIANGULAR V	0.00	-0.35	0.00	0.00	0.00
RECTANGULAR VI	368.20	0.00	0.00	0.00	0.00
TRIANGULAR VII	0.00	0.85	0.00	0.00	0.00
Vertical reaction due to braking LL1B	3.27	0.15	0.00	0.49	0.00
Vertical reaction due to braking LL2B	3.27	0.15	0.00	0.49	0.00
Vertical reaction due to braking LL3B	3.27	0.15	0.00	0.49	0.00

OVER TURNING MOMENT					
Live load surcharge	107.18			535.34	0.00
Net earth pressure	446.12			1871.83	0.00
Braking force	105.16			1125.74	0.00
Moment due to Wind					
Wind on Super str	3.41			34.30	
Wind on Moving Load	0.00			0.00	
Wind on Abut Cap	0.06			0.49	
Wind on Abut Wall	0.27			1.84	

MOMENT CALCULATION C/L OF ABUTMENT BASE (HFL)

	Load (t)	L. A. at mid of Abutment (Long)	L(trans)	ML(tm)	MT(tm)
DL Super str.	191.20	0.15	0.00	28.68	0.00
SIDL 1	15.90	0.15	0.00	2.39	0.00
SIDL 2	23.90	0.15	0.00	3.59	0.00
LL1	112.93	0.15	2.91	16.94	328.63
LL2	199.45	0.15	0.95	29.92	189.47
LL3	199.45	0.15	0.95	29.92	189.47
Abut. Cap	24.00	0.00	0.00	0.00	0.00
Dirt wall	3.42	-0.45	0.00	-1.54	0.00
DL+SIDL load(WC)APPROACH	45.41	-0.60	0.00	-27.24	0.00
LL (Approach span) 40t boggie	22.74	-0.60	0.00	-13.64	0.00
TRIANGULAR V	0.00	-0.35	0.00	0.00	0.00
RECTANGULAR VI	220.92	0.00	0.00	0.00	0.00
TRIANGULAR VII	0.00	0.85	0.00	0.00	0.00
Vertical reaction due to braking LL1B	3.27	0.15	0.00	0.49	0.00
Vertical reaction due to braking LL2B	3.27	0.15	0.00	0.49	0.00
Vertical reaction due to braking LL3B	3.27	0.15	0.00	0.49	0.00

OVER TURNING MOMENT					
Live load surcharge	53.59			267.67	0.00
Net earth pressure	223.06			935.92	0.00
Braking Force	105.16			1125.74	0.00
Moment due to Wind					
Wind on Super str	3.41			34.30	
Wind on Moving Load	0.00			0.00	
Wind on Abut Cap	0.06			0.49	
Wind on Abut Wall	0.27			1.84	

COMBINATION FOR DESIGN OF ABUTMENT
As per Annexure B of IRC 112
SERVICE CONDITION

	V(t)	ML-tm	MT-tm
DL	632.23	-0.10	0.00
SIDL 1	15.90	2.39	0.00
SIDL 2	23.90	3.59	0.00
LL1 Max Reaction Case	112.93	16.94	328.63
LL2 Max Long Mom Case	199.45	29.92	189.47
LL3 Max Trans Mom Case	199.45	29.92	189.47
LL1B due to braking	3.27	1125.74	0.00
LL2B due to braking	3.27	1125.74	0.00
LL3B due to braking	3.27	1125.74	0.00
W1 Wind ver down w/o LL	59.81	9.16	36.62
W1 Wind ver up w/o LL	-59.81	9.16	36.62
W3 Wind ver down with LL	59.81	9.16	36.62
W3 Wind ver up with LL	-59.81	9.16	36.62
HFL Water Current Force	0.00	0.00	0.00
Net Earth Pressure LWL	0.00	2492.09	0.00
LL surcharge LWL	0.00	647.88	0.00
Net Earth Pressure HFL	0.00	1246.04	0.00
LL surcharge HFL	0.00	323.94	0.00

	Basic Combination			
	PSF	V(t)	ML-tm	MT-tm
DL	1.35	853.51	-0.14	0.00
SIDL 1	1.75	27.83	4.17	0.00
SIDL 2	1.35	32.27	4.84	0.00
LL1 Max Reaction Case	1.50	169.40	25.41	492.94
LL2 Max Long Mom Case	1.50	299.17	44.88	284.21
LL3 Max Trans Mom Case	1.50	299.17	44.88	284.21
LL1B due to braking	1.50	4.90	1688.61	0.00
LL2B due to braking	1.50	4.90	1688.61	0.00
LL3B due to braking	1.50	4.90	1688.61	0.00
W1 Wind ver down w/o LL	0.90	53.83	8.24	32.96
W2 Wind ver down with LL	0.90	-53.83	8.24	32.96
W3 Wind ver up w/o LL	0.90	53.83	8.24	32.96
W4 Wind ver up with LL	0.90	-53.83	8.24	32.96
HFL Water Current Force	1.00	0.00	0.00	0.00
Net Earth Pressure LWL	1.00	0.00	2492.09	0.00
LL surcharge LWL	1.20	0.00	777.46	0.00
Net Earth Pressure HFL	1.00	0.00	1246.04	0.00
LL surcharge HFL	1.20	0.00	388.73	0.00

Case 1 : Combination 1 (SERVICE CONDITION)				
Load Case	**Factored Forces/Moments**			
		V	**ML**	**MT**
		t	**t-m**	**t-m**
Normal case				
Case 1	DL+SIDL1+SIDL2	913.60	2500.96	0.00
Case 2	DL+SIDL1+SIDL2+LL1	1087.89	4992.44	492.94
Case 3	DL+SIDL1+SIDL2+LL2	1217.67	5011.90	284.21
Case 4	DL+SIDL1+SIDL2+LL3	1217.67	5011.90	284.21
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind	967.43	2509.20	32.96
Case 6	DL+SIDL1+SIDL2+LL1+Wind	1141.72	5000.68	525.90
Case 7	DL+SIDL1+SIDL2+LL2+Wind	1271.50	5020.14	317.17
Case 8	DL+SIDL1+SIDL2+LL3+Wind	1271.50	5020.14	317.17
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind	859.77	2509.20	32.96
Case 10	DL+SIDL1+SIDL2+LL1+Wind	1034.07	5000.68	525.90
Case 11	DL+SIDL1+SIDL2+LL2+Wind	1163.84	5020.14	317.17
Case 12	DL+SIDL1+SIDL2+LL3+Wind	1163.84	5020.14	317.17

HFL case				
Case 1	DL+SIDL1+SIDL2 + HFl	913.60	1254.92	0.00
Case 2	DL+SIDL1+SIDL2+LL1 + HFl	1087.89	3357.66	492.94
Case 3	DL+SIDL1+SIDL2+LL2 + HFl	1217.67	3377.13	284.21
Case 4	DL+SIDL1+SIDL2+LL3 + HFl	1217.67	3377.13	284.21
Downward Wind Condition				
Case 5	DL+SIDL1+SIDL2 + Wind + HFl	967.43	1263.16	32.96
Case 6	DL+SIDL1+SIDL2+LL1+Wind+ HFl	1141.72	3365.90	525.90
Case 7	DL+SIDL1+SIDL2+LL2+Wind+ HFl	1271.50	3385.37	317.17
Case 8	DL+SIDL1+SIDL2+LL3+Wind+ HFl	1271.50	3385.37	317.17
Upward Wind Condition				
Case 9	DL+SIDL1+SIDL2 + Wind+ HFl	859.77	1246.68	-32.96
Case 10	DL+SIDL1+SIDL2+LL1+Wind+ HFl	1034.07	3349.42	459.98
Case 11	DL+SIDL1+SIDL2+LL2+Wind+ HFl	1163.84	3368.89	251.25
Case 12	DL+SIDL1+SIDL2+LL3+Wind+ HFl	1163.84	3368.89	251.25

1271.50	5020.14	317.17
1271.50	5020.14	317.17
1141.72	5000.68	525.90

#REF!	*#REF!*	*#REF!*	*#REF!*
#REF!	*#REF!*	*#REF!*	*#REF!*
#REF!	*#REF!*	*#REF!*	*#REF!*

Design Of Vertical Wall :-

Vertical wall shall be designed for net design Moment - Moment due to active earth pressure, LL surcharge ,wind forces & horizontal braking force and Moment due to self weight of abutment wall and super structure.

		£V	**£M$_{netL}$**	**£M$_T$**
Case1	Maximum Reaction Case	1271.50	5020.14	317.17
Case2	Maximum Longitudinal Moment Case	1271.50	5020.14	317.17
Case3	Maximum Transverse Moment Case	1141.72	5000.68	525.90

Net Design Moment M =	**5020.14**	**Tm**

M.R. available with C.C. M 30 N/mm2 Fe 415

Deff required = Sqroot(M/Q/B)

3482.23 mm

Doverall = 1000 mm

Deff available 937.50 mm CC = 50 mm

Ast required

Mu = 0.87 fy Ast d (1-(Ast/bd)(fy/fck))

50201446103 = 338484 Ast * (1- Ast/ 67771.08)

148312.4475 = Ast * (1 - Ast/ 67771.08)

Ast^2 - 67771.084 *Ast + 1.01E+10

Ast = #NUM! mm2

Requirements & Proposed Provision of Reinforcement

(a) Vertical Bars :-

Provide bar dia. = 25 mm

Spacing = #NUM! **mm**

Provide 25.00 mm @ 150.00 mm c/c

Ast provided = 3270.83 mm2 > Ast required.

Vertical R/f for Wal type Abutment as per IRC: 112-2011 , Cl:16.3.1

Minimum vertical R/f = 0.0012Ac on each face

19200.00 mm2

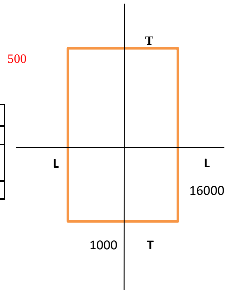
#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!

Design Of Vertical Wall :-

Checking for stress in Wall type Abutment Shaft :

Assuming the rectangular section will take all the loads.

Biaxial Bending check for M 30 and Fe 500



		£V	£M_{nettL}	£M_T
Case1	Maximum Reaction Case	1271.50	5020.14	317.17
Case2	Maximum Longitudinal Moment Case	1271.50	5020.14	317.17
Case3	Maximum Transverse Moment Case	1141.72	5000.68	525.90

Case 1

Pu =	12714.96	**KN**
MLL =	50201.45	**KNm**
MTT =	3171.72	**KNm**

Section Reinforcement :

Dia of Bars	=	16.00	mm
No. Of Bars Along Width	=	6.00	
No. Of Bars Along Breadth	=	100	
Total No. of Bars	=	208	
Total Ast	=	41821	mm2
% of R/f	=	0.26	**%**

% of reinforcement p = 0.26 %Ag
Clear Cover = 50 mm
Effective cover depth d' = **58** mm dia = 16 mm
Total depth D = 16000 mm
B = 1000 mm
p/fck= 0.01
d'/D = 0.05
Pu/(fck*BD)= 0.028
$M_{LL'}$/(fck*BD^2)= **0.034** **(Refer SP 16 Chart no.** 35 for d'/D = 0.05 for Fe 500 M 30

Therefore, $M_{LL'}$ = **261120** **KNm**

Similarly for $M_{TT'}$.
Total depth D = 1000 mm
B = 16000 mm
p/fck= 0.01
d'/D= 0.1
Pu/(fck*BD)= 0.028
$M_{TT'}$/(fck*BD^2)= **0.034** **(Refer SP 16 Chart no.** 36 for d'/D = 0.1 for Fe 500 M 30

Therefore, $M_{TT'}$ = **16320** **KNm**

Now Check for section for Biaxial Bending :

For p= 0.3 %
From Chart 63 SP 16,
Puz/Ag= 14.8 N/mm2
therefore Puz = 236800 KN
Pu/Puz= 0.05
x= 1
Now,

(MLL/MLL')^x + (MTT/MTT')^x = 0.39 <= 1
SAFE

Vertical R/f for wall type Abutment as per IRC: 112-2011 , Cl: 16.3.1

Minimum Vertical R/f = **0.0012Ag** on each face.
= **19200** mm2

Provided Vertrical R/f = 20106 mm2 on Longer Face
OK

Spacing Between Vertical R/f = 160 ***mm*** < 200 mm
OK

Horizontal R/f for Wall type Abutment As per IRC : 112-2011 , Cl : 16.3.2

Maximum Of following = 0.25 * Ast or 0.001Ag
10455.22 16000
Minimum Horizontal R/f = 16000 mm2

Minimum Diameter Of Bar = 0.25 X dia of ver bar or 8mm
4 or 8
Maximum Spacing between horizontal bars = 300 mm

Therefore provide 2L dia 12 @ 160 mmc/c
18096 mm2
OK

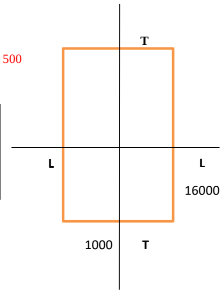
#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!

Design Of Vertical Wall :-

Checking for stress in Wall type Abutment Shaft :

Assuming the rectangular section will take all the loads.

Biaxial Bending check for M 30 and Fe 500



		£V	$£M_{nettL}$	$£M_T$
Case1	Maximum Reaction Case	1271.50	5020.14	317.17
Case2	Maximum Longitudinal Moment Case	1271.50	5020.14	317.17
Case3	Maximum Transverse Moment Case	1141.72	5000.68	525.90

Case 2

Pu =	12714.96	**KN**
MLL =	50201.45	**KNm**
MTT =	5259.04	**KNm**

Section Reinforcement :

Dia of Bars	=	16.00	mm
No. Of Bars Along Width	=	6.00	
No. Of Bars Along Breadth	=	100	
Total No. of Bars	=	208	
Total Ast	=	41821	mm2
% of R/f	=	0.26	**%**

% of reinforcement p = 0.26 %Ag

Clear Cover = 50 mm

Effective cover depth d' = **58** mm   dia = 16 mm

Total depth D = 16000 mm

B = 1000 mm

p/fck= 0.01

d'/D = 0.05

Pu/(fck*BD)= 0.028

$M_{LL'}$/(fck*BD^2)= **0.034** **(Refer SP 16 Chart no.** 35 for d'/D = 0.05 for Fe 500 M 30

Therefore, $M_{LL'}$ = **261120** **KNm**

Similarly for $M_{TT'}$.

Total depth D = 1000 mm

B = 16000 mm

p/fck= 0.01

d'/D= 0.1

Pu/(fck*BD)= 0.028

$M_{TT'}$/(fck*BD^2)= **0.034** **(Refer SP 16 Chart no.** 36 for d'/D = 0.1 for Fe 500 M 30

Therefore, $M_{TT'}$ = **16320** **KNm**

Now Check for section for Biaxial Bending :

For p= 0.3 %

From Chart 63 SP 16,

Puz/Ag= 14.8 N/mm2

therefore Puz = 236800 KN

Pu/Puz= 0.05

x= 1

Now,

(MLL/MLL')^x + (MTT/MTT')^x = 0.51 <= 1

SAFE

Vertical R/f for wall type Abutment as per IRC: 112-2011 , Cl: 16.3.1

Minimum Vertical R/f = **0.0012Ag** on each face.

= **19200** mm2

Provided Vertrical R/f = 20106 mm2 on Longer Face

OK

Spacing Between Vertical R/f = 160 ***mm*** < 200 mm

OK

Horizontal R/f for Wall type Abutment As per IRC : 112-2011 , Cl : 16.3.2

Maximum Of following = 0.25 * Ast or 0.001Ag

10455.22 16000

Minimum Horizontal R/f = 16000 mm2

Minimum Diameter Of Bar = 0.25 X dia of ver bar or 8mm

4 or 8

Maximum Spacing between horizontal bars = 300 mm

Therefore provide 2L dia 12 @ 160 mmc/c

18096 mm2

OK

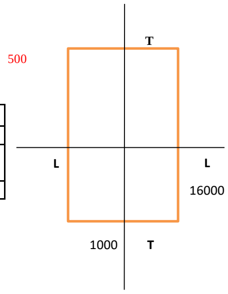
#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!

Design Of Vertical Wall :-

Checking for stress in Wall type Abutment Shaft :

Assuming the rectangular section will take all the loads.

Biaxial Bending check for M 30 and Fe 500



		£V	£M_{nettL}	£M_T
Case1	Maximum Reaction Case	1271.50	5020.14	317.17
Case2	Maximum Longitudinal Moment Case	1271.50	5020.14	317.17
Case3	Maximum Transverse Moment Case	1141.72	5000.68	525.90

Case 3

Pu =	11417.23	**KN**
MLL =	50006.79	**KNm**
MTT =	5259.04	**KNm**

Section Reinforcement :

Dia of Bars	=	25.00	mm
No. Of Bars Along Width	=	6.00	
No. Of Bars Along Breadth	=	90	
Total No. of Bars	=	188	
Total Ast	=	92284	mm2
% of R/f	=	0.58	**%**

% of reinforcement p =	0.58	%Ag
Clear Cover =	50	mm
Effective cover depth d' =	**58**	mm
Total depth D =	16000	mm
B =	1000	mm
p/fck=	0.02	
d'/D =	0.05	
Pu/(fck*BD)=	0.024	
$M_{LL'}$/(fck*BD^2)=	**0.052**	**(Refer SP 16 Chart no.** 35 for d'/D = 0.05 for Fe 500
Therefore, $M_{LL'}$ =	**399360**	**KNm** M 30

Diam = 16 mm

Similarly for $M_{TT'}$

Total depth D =	1000	mm
B =	16000	mm
p/fck=	0.02	
d'/D=	0.1	
Pu/(fck*BD)=	0.024	
$M_{TT'}$/(fck*BD^2)=	**0.052**	**(Refer SP 16 Chart no.** 36 for d'/D = 0.1 for Fe 500
Therefore, $M_{TT'}$ =	**24960**	**KNm** M 30

Now Check for section for Biaxial Bending :

For p=	0.6	%
From Chart 63 SP 16,		
Puz/Ag=	15.8	N/mm2
therefore Puz =	252800	KN
Pu/Puz=	0.05	
x=	1	
Now,		
(MLL/MLL')^x + (MTT/MTT')^x =	0.34	<= 1
	SAFE	

Vertical R/f for wall type Abutment as per IRC: 112-2011 , Cl: 16.3.1

Minimum Vertical R/f = **0.0012Ag** on each face.

= **19200** mm2

Provided Vertrical R/f = 44179 mm2 on Longer Face

OK

Spacing Between Vertical R/f = 178 ***mm*** < 200 mm

OK

Horizontal R/f for Wall type Abutment As per IRC : 112-2011 , Cl : 16.3.2

Maximum Of following = 0.25 * Ast or 0.001Ag

23071.07 16000

Minimum Horizontal R/f = 23071 mm2

Minimum Diameter Of Bar = 0.25 X dia of ver bar or 8mm

6.25 or 8

Maximum Spacing between horizontal bars = 300 mm

Therefore provide 2L dia 12 @ 120 mmc/c

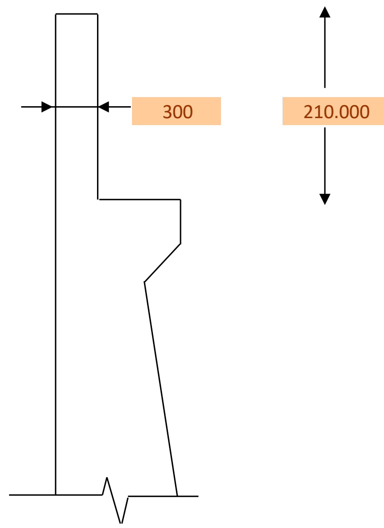
18096 mm2

REVISE

#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!

Design of Dirt wall

Input Data



1	Angle of internal friction, f	=	30	°
2	Angle of earthface of wall with horizontal,	=	90	°
3	Angle of backfill surface with horizontal, b	=	0	°
4	d = 2/3 * f	=	20	°
5	Co-efficient of active eartf pressure, K_a	=		
		=	0.297	
6	Horizontal component of K_a, K_{ah}	=	K_a * cos d	
		=	0.2794	
7	Unit weight of backfill	=	2	T/m^3
8	Grade of concrete	M	30	
9	Permissible stress in steel, s_{st}	=	240	N/mm^2
10	Clear cover to reinforcement	=	40	mm
13	height of CLL surcharge		1.2	m

#REF!	***#REF!***	***#REF!***	***#REF!***
#REF!	***#REF!***	***#REF!***	***#REF!***
#REF!	***#REF!***	***#REF!***	***#REF!***

Forces considered in design

I. Earth pressure inc luding LL surcharge on backfill

Live Load surcharge on backfill, p1 = 0.67056
= 0.67056 T/m2
Earth pressure due to backfill, p2 = 0.117348
= 0.117348 T/m2

Forces per m width
P1 = 0.1408176
= 0.1408176 T/m
P2 = 0.0246431
= 0.0246431 T/m

Moments about the base of dirt wall
M1 = 0.0147858
= 0.0147858 Tm/m
M2 = 0.0021735
= 0.0021735 Tm/m
Total = 0.017 Tm/m
Design moment, M = 0.017 Tm/m

Design of section

Design moment, M = 0.017 Tm/m
Concrete grade M 30
k = 0.294
j = 0.902
Q = 1.326 N/mm^2
s_{cbc} = 10 N/mm^2
s_{st} = 240 N/mm^2
d_{reqd} = sqrt(M / Qb)
= 11.31 mm
D_{reqd} = 11.31 + 50 + 10 / 2
= 66 mm
$D_{provided}$ = 300 mm
$d_{provided}$ = 300 - 50 - 5
= 245 mm **OK**

$A_{st\ reqd}$ = $M/s_{st}.j.d$
= 3 mm^2/m
Provide 10 Tor @ 150 mm c/c on earth face
Area provided = 524 **OK**

Minimum steel required = 0.12% of 300 * 1000
= 360 mm^2/m
Provide 10 Tor @ 150 mm c/c on other face
Area provided = 524 **OK**

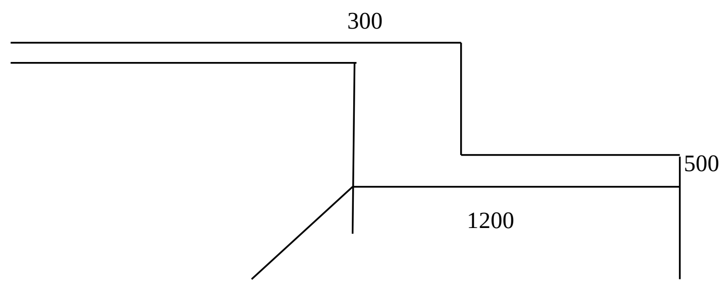
Check for shear stress

Shear force = 0.1654607
= 0.165 T
Shear stress, τ_v = 0.0067535
= 0.007 N/mm^2
% of steel provided = 0.214
τ_c = 0.219 N/mm^2

Since $\tau_v < \tau_c$, No shear reinforcement is required

#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!

DESIGN OF ABUTMENT CAP



The Abutment Cap is supported on front wall through entire length is currently direction and cantilever in traffic direction rest on earth filling. Hence minimum 0.2% steel is provided.

Cap area	=	70X30 cm^2	=	6000	cm^2
0.20%	=	2100X0.2/100	=	12	cm^3

Provided Reinforcement

4	Nos	ø	12	at top	=	4.5216	cm2	+
4	Nos	ø	12	at top	=	4.5216	cm2	

& 2 Legged ø 10 @ 150 mm c/c

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

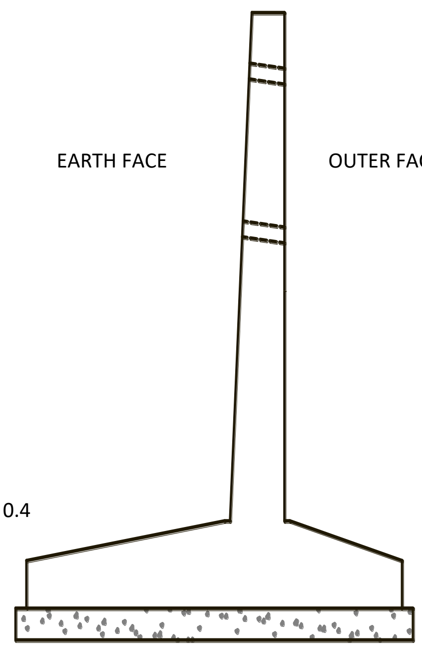
INDEX

	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
Levels				
FRL		=	100.000	m (Assumed)
Wall shaft top level		=	100.000	m
Ground level/LBL/MSL		=	97.000	m (Assumed)
Foundation level		=	95.000	
Shaft bottom level		=	95.500	m
Coeff. Of Friction	μ	=	0.500	
FRL - FND LVL.	H	=	5.000	m
SBC of soil-Normal Case		=	220.000	kN/m2
Permissible FOS against Sliding		=	1.500	Normal Case
Permissible FOS against Overturning		=	2.000	Normal Case
Wall				
Thickness of Wall shaft at Top		=	0.300	m
Thickness of Wall shaft at Bottom		=	0.550	m
Foundation				
Total Width of Footing		=	3.650	m
Width of Toe Slab		=	1.100	m
Width of Heel Slab		=	2.000	m
Thickness of Toe slab at tip		=	0.300	m
Thickness of Toe slab near shaft		=	0.500	m
Thickness of heel slab at tip		=	0.300	m
Thickness of heel slab near shaft		=	0.500	m
Depth of Footing below GL		=	2.000	m



Material Specification				
Concrete Grade		=	30	M
Characteristic Compressive Strength of Concrete,fck		=	30.00	Mpa at 28 days
Design Compressive strength of Concrete, fcd		=	13.400	Mpa at 28 (0.67/1.5 * fck)
Tensile strength of concrete , fctm		=	2.50	Mpa
Strain at reaching Characteistic Strength, ϵc2		=	0.02	
Ultimate Strain, ϵcu2		=	0.035	
Modulus of Elasticity of Concrete (Ec)		=	27386.128	N/mm2 (5000 x sqrt (fck)
Ecm		=	31000	N/mm2
Steel Grade		=	500	Fe (HYSD Steel) D
Yield Strength of Reinforcement, fy or fyk		=	500	Mpa
Design Yield Strength of Reinforcement, fyd		=	434.783	Mpa (1/1.15 * fy)
Modulus of Elasticity of Steel (Es)		=	200000	Mpa
Dry weight of Concrete		=	25	kN/m^3
Dry unit weight of soil		=	20	kN/m^3
Permissible Crack Width		=	0.3	mm - For Moderate Exposure Condition
Maximum compressive stress in concrete under rare combination		=	0.48	fck
		=	14.4	N/mm^2
Maximum tensile stress in steel under rare combination		=	0.8	fyk
		=	400	N/mm^2
σcbc		=	10.00	
σst		=	240	
m		=	9.3333333	
k		=	0.280	
j		=	0.907	
Q		=	1.27	
As per Cl. 214.1 of IRC :6 -2014	(Y fluid)	=	4.8	

Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
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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*
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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*
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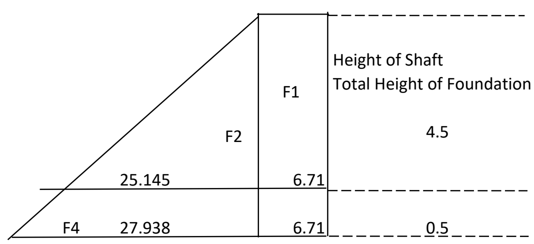
Earth Pressure : Normal Dry Case

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	**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*
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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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Stability Check of Foundation

Foundation Lvl = 95.000 m

Properties of Footing Base:

		B		L			
A	=	3.650	x	1.000	=	3.650	m^2
ZL	=	1.000	x	2.220	=	2.220	m^3
ZT	=	3.650	x	0.167	=	0.608	m^3

Normal Dry Case

For SBC Calculation **For Equilibrium Calculation**

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1.000	25	1.913	47.8125	0.506	24.211
Back filling over heel slab	1.000	20	9.200	184	-0.771	-141.936
Back filling on flared portion of shaft	1.000	20	0.563	11.25	0.258	2.906
Front Filling over toe slab RCC Railing or Crash Barrier or	1.000	20	1.760	35.2	1.280	45.054
Crash Barrier	1.000			0	0.725	0.000
Heel slab	1.000	25	0.800	20	-0.727	-14.539
Toe slab	1.000	25	0.440	11	1.221	13.432
portion between heel & toe	1.000	25	0.250	6.25	0.45	2.813
Total				315.513		-68.059

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
1.000	47.8125	-1.319	-63.047
1.000	184	-2.596	-477.736
1.000	11.25	-1.567	-17.625
1.000	35.2	-0.545	-19.186
1.000	0	-1.1	0.000
1.000	20	-2.552	-51.039
1.000	11	-0.604	-6.643
1.000	6.25	-1.375	-8.594
	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
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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

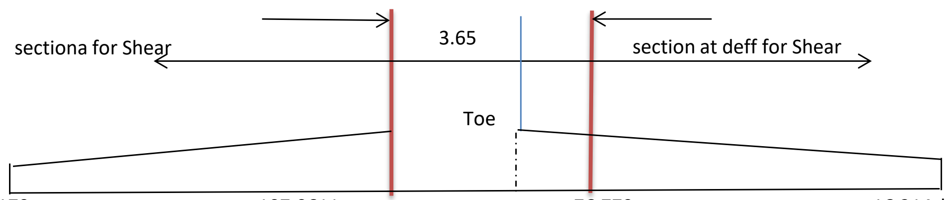
		load factor					
Moment due to active earth pressure	=	1.500	x	146.6764098	=	220.015	kNm
Moment due to Live load surcharge	=	1.200	x	83.8151	=	100.578	kNm
						320.593	

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)		$\frac{M\ tanb}{d}$		=	37.89	KN								
Downward force due to self weight of toe slab	=	1.35		x	0.377386364	x	0.681	x	1	x	25	=	8.674	KN
Net Shear Force at deff	=	22.872		-8.674	-37.8928637	=	-23.695	KN						
Net Shear Force / unit meter	=	-23.695		/	1	=	-23.695	KN/m						

Design Input :

Design length	=	1000	mm		
Clear Cover	=	75	mm		
Grade of Concrete for Footing	=	M 30			
fck	=	30	N/mm²		30
fctm	=	2.5	N/mm²		
Ec	=	27386.13	N/mm²		
Grade of Reinforcement Steel	=	500.00	Fe D	(HYSD Bars)	
fy or fyk	=	500.00	N/mm²		
fyd	=	434.78	N/mm²	(fy/1.15)	
Es	=	200000.00	N/mm²		

Project	*-*	*Designed by:*	*KB*
Client	*-*	*Checked by:*	*-*
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	m^2
ZL	=	2.220	m^3
ZT	=	0.608	m^3

Creep Coeff = 1.2 For Dry atmosperic condition

Ecm = 31000 N/mm2

Es = 200000 N/mm2

Eceff = $\frac{Ecm}{(1 + \phi)}$ = 14090.91

Modular Ratio (m) = Es/ Eceff = 14.19

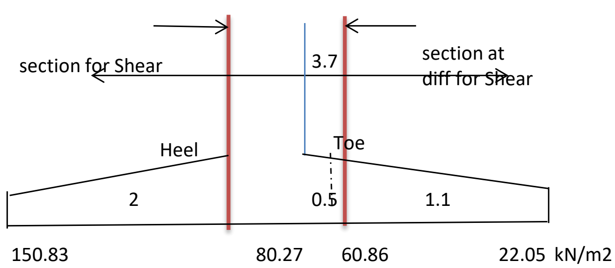
Normal Dry Case

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

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

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

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



Normal Dry Case

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		

Project:	-	Designed by:	KB
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Icr	=	625441124.5	617669624.3	mm4	
Maximum compressive stress in concrete	=	4.297	3.003	< 14.4, SAFE	
Maximum tensile stress in concrete	=	15.172	10.309		
Maximum Tensile stress in steel	=	113.835	76.872	< 400, SAFE	

Check For Crack Width					
Crack width , Wk	=	Sr max (εsm - εcm)			
Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+ϕ/2)					
5*(c+ϕ/2)	=	405.000	405.000	mm	
Provided Spacing	=	65.000	65.000	mm	
Check for Applicability of Formula	=	OK	OK		
Maximum crack spacing , Sr max	=	3.4 c +	0.425 k1 k2 ϕ / r r eff		
K1	=	0.800	0.800	for deformed bars	
K2	=	0.500	0.500	for bending	
depth of neutral axis , yc	=	92.472	94.512	mm	
r r eff = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.			
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	209.500	209.500	mm	
Ac, eff = Dx * hc,eff	=	209500.000	209500.000	mm	
r r eff = As/Ac eff	=	0.003	0.003		
Maximum crack spacing , Sr max	=	935.281	935.281	mm	
(εsm - εcm)	=	$\sigma sc - \frac{k_t f_{ct\,eff} (1 + \alpha_e \rho_{p\,eff})}{\rho_{p}\,eff}$	/ Es		
tensile stress in steel, ,σsc	=	113.835	76.872	N/mm2	
Kt	=	0.500	0.500		
Tensile strength of concrete = fct eff = fctm	=	2.500	2.500	N/mm2	424.9
αe = Es/Ecm	=	6.452	6.452		
(εsm - εcm)	=	-0.002	-0.0017		
Crack width , Wk=Sr max (εsm - εcm)	=	**0.000**	**0.000**		
Check	=	**SAFE**	**SAFE**		

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

Calculation of Forces For Design of Wall

Wall bottom level = 95.5 m

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL) (m)	ML = PxeL (kNm)
Shaft	1.35	25	1.913	64.546875	0.056	3.639
RCC Railing or Crash Barrier	1.35			0	0.275	0.000
Total				**64.547**		**3.639**

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

Total Horizontal Force = 121.07 KN

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

Total Moment due to Horizontal Force = 326.637 kNm

Summary of Forces:

P	64.547	KN
ML	330.276	kNm
FL	121.071	KN

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

Design of Wall:

Grade of Concrete = 30.00 M 30

fck = 30.00 N/mm2
fcd = 13.40 N/mm2
Grade of steel 500.00 Fe
fy = 500.00 N/mm2
fyd = 434.78 N/mm2
Es = 200000.00 N/mm2

Cross section of Wall:

Thickness of Wall (B) = 0.55 m
Depth of Wall (D) = 1 m
Area of Concrete (Ac) = 0.55 m2
Clear Cover to earth faces = 75 mm
Clear Cover to non earth faces = 40 mm
Maximum Dia of Vertical Reinf. = 16 mm
Dia of Horizontal Reinf. = 12 mm

Summary of Design Forces:

	P(kN)	ML (kNm)	FL (kN)
Case 1 : Normal Dry Case	64.55	330.28	121.07
MAX	64.55	330.28	121.07

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = 64.55 kN
0.1 fcd Ac
= 0.1 13.4 550000
= 737000 N
= 737.0 kN

Since Axial Force is less than axial capacity of section , Section will design as bending element . Neglecting axial force

PART 1: LONGITUDINAL MOMENT : VERTICAL REINFORCEMENT ON EARTH FACE

Ultimate Design bending moment (ML) = 330.28 kNm = 330.28 kNm/m

Check For Depth of Wall :

Mult = 0.167 x fck x b x d^2
= 330.28 kNm/m
b = 1000 mm

Effective Depth Required (dreq) = SQRT(597.03 x 1000000) / 0.167 x 30.00 x 1000
(dreq) 256.76 mm
Total Depth Required (Dreq) = 339.76 mm
Total Depth Provided (Dprov) = 550 mm OK
Effective depth provided(deff) = 467 mm
R= Mu/(b d^2) = 1.514
Minimum Longitudinal Reinforcement in wall on each face
=
= 0.0012 x b x D -Refer Clause 16.9 of IRC:112-2011'

Ast min = 660 mm2/m

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

Area of Steel Required:

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

= 0.0037

Ast_{req} = 2041.14 mm2/m

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

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

Percentage of steel = 0.381 %

Check for Moment of Resistance of Section due to Steel

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

= 288.07 mm

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

= 84.30 mm

OK

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

z = d - 0.416 x X

= 431.93 mm

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

MR = fyd . Ast . Z

= 393268377.6

= 3.93E+08 Nmm /m

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

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

LONGITUDINAL REINFORCEMENT ON NON EARTH FACE

Minimum Longitudinal Reinforcement in wall on each face

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

Ast min = 660 mm2/m

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

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

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

= 0.001 x 5.50E+05 = 550.00

Minimum Horizontal Reinf. provided 712.0 mm2 per meter

Min dia of bar = 0.25 x 16 = 4 mm

or 8 mm

Maximum Spacing between bars <= 300 mm/cc

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

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

SLS CHECK OF WALL

Foundation Lvl = 95.5 m

Creep Coeff (¢ = 1.2 For Dry atmosperic condition

Ecm = 31000

Es = 200000 N/mm2

Eceff = $\frac{Ecm}{(1 + \phi)}$ = 14090.90909

Modular Ratio (m) = Es/ Eceff = 14.19

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL) (m)	ML = PxeL (kNm)
Shaft	1.000	25	1.913	47.8125	0.056372549	2.695313
RCC Railing or Crash Barrier	1.000			0	0.275	0
Total				**47.813**		**2.695**

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

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

Summary of Forces:

P	47.813	KN
ML	163.935	kNm
FL	80.714	KN

Bending Moment, M	=	163.93	kNm
Dx	=	1.00	m
Dy	=	0.55	m
Section Modulus (ZL) of uncracked secti	=	0.05	m3
Bending Stress (M/ZL)	=	3.252	N/mm2
Tensile stress of concrete , fctm	=	2.500	N/mm2
Cracked or Uncracked Section	**=**	**Cracked**	
Section properties of Cracked section:			
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.			
Clear Cover, c	=	75.000	mm
Maximum dia used (Vertical), f	=	16.000	mm
Horizontal Reinf. Dia used	=	12.000	mm
Effective Depth deff (dy)	=	467.000	mm
Ast provided	=	2094.133	mm2/m
Percentage of steel , pt	=	0.0071	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.359	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	167.664	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	299.336	mm

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

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

Check For Crack Width			
Crack width , Wk	=	Sr max (εsm - εcm)	
Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+ϕ/2)			
5*(c+ϕ/2)	=	415.000	mm
Provided Spacing	=	160.000	mm
Check for Applicability of Formula	=	OK	
Maximum crack spacing , $S_{r\ max}$	=	3.4 c +	0.425 k1 k2 ϕ / $p_{p\ eff}$
K1	=	0.700	for deformed b
K2	=	0.500	for bending
depth of neutral axis , yc	=	167.664	mm
$\Sigma_{r\ eff}$ = 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		
Client	-	Checked by:	-		
Job Name	Design of Breast Wall for height 3 m from G.L	Date & Rev.	-		

Stability Check Summary

Description	P (kN/m2 max)	P (kN/m2 min)	Sliding	Overturning	Shear (Heel slab)	Shear (Toe slab)
Normal Dry case	159.60	13.29	1.53	2.79	0.130	-0.070
Permissible	220	0	1.5	2	3.658	3.658
Remarks	OK	OK	OK	OK	OK	OK

Reinforcement summary

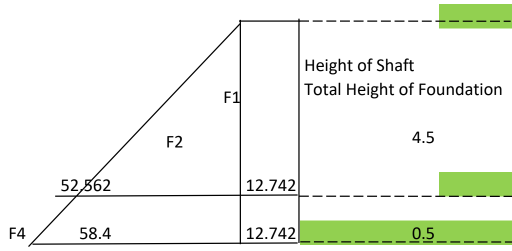
Type of reinforcement	Area of steel required	Area of steel provided						
Straight Portion of Shaft								
Vertical steel at earth face	2041	16	mm bar @	150	mm c/c (i.e.)	2094	mm2	OK
		12	mm bar @	150	mm c/c (i.e.)			
Vertical steel at non-earth face	660	12	mm bar @	150	mm c/c (i.e.)	754	mm2	OK
Distribution steel	712	12	mm 2 Legged bar @	200	mm c/c (i.e.)	1130	mm2	OK
Heel Slab								
Main steel at top face	545	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
		0	mm bar @	180	mm c/c (i.e.)			
Steel at bottom face	250	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
Distribution reinforcement	126	10	mm bar @	200	mm c/c (i.e.)	393	mm2	OK
Shear Reinforcement	No Shear R/f required							
Toe Slab								
Main steel at bottom face	545	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
		0	mm bar @	180	mm c/c (i.e.)			
Steel at top face	250	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
Distribution reinforcement	126	10	mm bar @	200	mm c/c (i.e.)	393	mm2	OK
Shear Reinforcement	No Shear R/f required							

Earth Pressure : Normal Dry Case

Properties of backfill material :

c	=	0				
ϕ	=	**30**	degree	0.524	radians	0.866
θ	=	87.11	degree	1.520	radians	0.050
θ1	=	90	degree	1.571	radians	0.000
β	=	26.5	degree	0.462512252	radians	0.895
δ	=	**20**	degree	0.349	radians	0.940
Kah	=	0.279	active component			
Kph	=	5.737	Passive component			
γ	=	20	kN/m3			
Equivalent Live Load Surcharge height	=	1.2	m			

Assuming



100 (Deck Level)

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

95.5 shaft bottom level

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

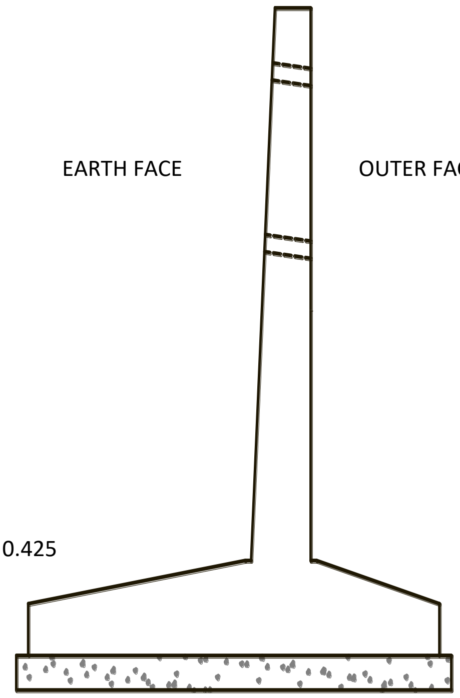
INDEX

	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	

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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*
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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*
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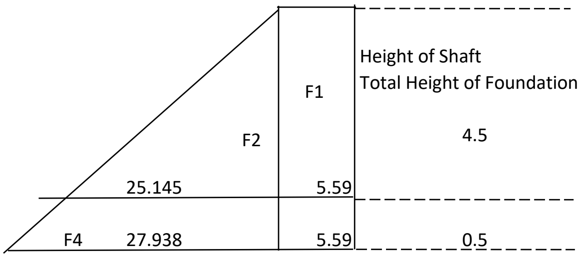
Earth Pressure : Normal Dry Case

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

4.5

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 =	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**			

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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** $\mathbf{kN/m^2}$

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

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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	

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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**				

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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*
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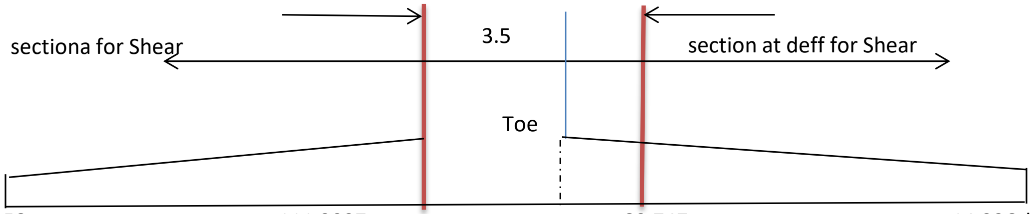
Normal Dry Case

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



214.058 111.2927 82.747 14.236 kN/m2

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

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Toe Slab - Shear Calculation at deff from Face of Wall

For shear, critical section is assumed to be located at a distance equal to effective depth from face of wall

Depth of slab at critical section	=	0.430	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)		$\frac{M\ tanb}{d}$		=	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		

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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
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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

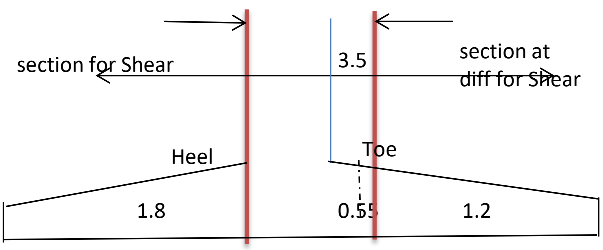
Normal Dry Case

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

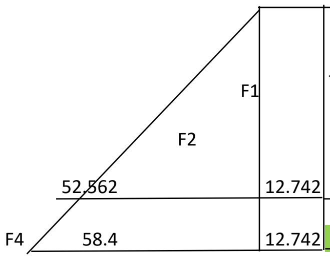
Type of reinforcement	Area of steel required	Area of steel provided						
Straight Portion of Shaft								
Vertical steel at earth face	2163	16	mm bar @	140	mm c/c (i.e.)	2244	mm2	OK
		12	mm bar @	140	mm c/c (i.e.)			
Vertical steel at non-earth face	600	12	mm bar @	140	mm c/c (i.e.)	808	mm2	OK
Distribution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

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
0	2,762,618.4361m	553,297.7926m	N35° 22' 45.58"W
50	2,762,659.1915m	553,268.8272m	N35° 54' 22.87"W
100	2,762,691.5124m	553,231.6035m	N67° 01' 56.41"W
150	2,762,701.1817m	553,182.7122m	N82° 31' 13.83"W
200	2,762,707.8586m	553,133.1614m	N80° 41' 59.91"W
250	2,762,725.1431m	553,086.7404m	N54° 48' 03.29"W
300	2,762,760.4784m	553,051.5587m	N40° 39' 56.61"W
350	2,762,798.4046m	553,018.9764m	N40° 39' 56.61"W
400	2,762,836.3309m	552,986.3942m	N40° 39' 56.61"W
450	2,762,874.2571m	552,953.8120m	N40° 39' 56.61"W
500	2,762,912.5046m	552,921.6233m	N35° 53' 05.21"W
550	2,762,958.0948m	552,901.7846m	N17° 13' 51.45"W
600	2,763,005.8508m	552,886.9734m	N17° 13' 51.45"W
650	2,763,053.6067m	552,872.1622m	N17° 13' 51.45"W
700	2,763,101.6119m	552,858.2224m	N13° 05' 42.96"W
750	2,763,151.0283m	552,850.9952m	N3° 32' 45.50"W
800	2,763,200.9590m	552,852.0661m	N6° 00' 11.97"E
850	2,763,250.0216m	552,861.4001m	N15° 24' 35.16"E
900	2,763,297.8685m	552,875.9093m	N17° 08' 16.63"E
950	2,763,345.6484m	552,890.6429m	N17° 08' 16.63"E
1000	2,763,393.7185m	552,904.3390m	N12° 24' 30.25"E
1050	2,763,442.9171m	552,913.2347m	N9° 50' 23.86"E
1100	2,763,492.1816m	552,921.7795m	N9° 50' 23.86"E

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
1150	2,763,541.4460m	552,930.3243m	N9° 50' 23.86"E
1200	2,763,590.4994m	552,939.8602m	N17° 07' 27.27"E
1250	2,763,631.5923m	552,967.3365m	N44° 19' 46.78"E
1300	2,763,667.3467m	553,002.2882m	N44° 20' 58.91"E
1350	2,763,705.2522m	553,033.9764m	N8° 33' 22.26"E
1400	2,763,716.6702m	552,999.2993m	S49° 08' 01.84"W
1450	2,763,683.8386m	552,961.5901m	S47° 32' 12.64"W
1500	2,763,646.6667m	552,928.2744m	S36° 08' 25.51"W
1550	2,763,603.6176m	552,903.0067m	S24° 40' 52.55"W
1600	2,763,556.4444m	552,886.6510m	S14° 46' 37.43"W
1650	2,763,508.0827m	552,873.9568m	S14° 42' 20.99"W
1700	2,763,459.7206m	552,861.2640m	S14° 42' 20.99"W
1750	2,763,440.5034m	552,827.7427m	N42° 22' 01.18"W
1800	2,763,488.6593m	552,829.9993m	N12° 03' 17.66"E
1850	2,763,537.5567m	552,840.4418m	N12° 03' 17.66"E
1900	2,763,586.4541m	552,850.8842m	N12° 03' 17.66"E
1950	2,763,635.3515m	552,861.3269m	N12° 04' 46.85"E
2000	2,763,682.5123m	552,877.3637m	N27° 36' 09.38"E
2050	2,763,726.1171m	552,901.8279m	N29° 28' 05.15"E
2100	2,763,769.8302m	552,926.0925m	N26° 46' 46.69"E
2150	2,763,816.4150m	552,944.0240m	N15° 19' 23.81"E
2200	2,763,865.6336m	552,952.3431m	N3° 51' 50.85"E
2250	2,763,915.5238m	552,950.7182m	N7° 35' 42.11"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
2300	2,763,964.0968m	552,939.2140m	N19° 03' 15.07"W
2350	2,764,009.4160m	552,918.2892m	N30° 30' 48.04"W
2400	2,764,050.2079m	552,889.4420m	N37° 32' 28.79"W
2450	2,764,090.5776m	552,859.9667m	N34° 44' 01.04"W
2500	2,764,131.6681m	552,831.4786m	N34° 44' 01.04"W
2550	2,764,172.7745m	552,803.0136m	N34° 12' 16.32"W
2600	2,764,217.1367m	552,780.3646m	N17° 52' 56.62"W
2650	2,764,266.3801m	552,773.1517m	N1° 12' 58.32"E
2700	2,764,315.2839m	552,782.4166m	N19° 43' 19.25"E
2750	2,764,361.6397m	552,801.1464m	N22° 21' 30.69"E
2800	2,764,407.8808m	552,820.1665m	N22° 21' 30.69"E
2850	2,764,454.7817m	552,837.3434m	N13° 42' 36.00"E
2900	2,764,504.4377m	552,841.6295m	N0° 58' 37.62"W
2950	2,764,554.4291m	552,840.7036m	N1° 03' 47.31"W
3000	2,764,604.4205m	552,839.7759m	N1° 03' 47.31"W
3050	2,764,654.4119m	552,838.8482m	N1° 03' 47.31"W
3100	2,764,704.4033m	552,837.9204m	N1° 03' 47.31"W
3150	2,764,754.3963m	552,837.1886m	N0° 52' 10.25"E
3200	2,764,803.7350m	552,844.4632m	N13° 21' 03.92"E
3250	2,764,852.5059m	552,855.4246m	N8° 13' 44.74"E
3300	2,764,900.9054m	552,847.1582m	N28° 42' 34.63"W
3350	2,764,939.3038m	552,815.3368m	N42° 49' 35.73"W
3400	2,764,977.6588m	552,783.4140m	N31° 14' 40.65"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
3450	2,765,024.5050m	552,766.9947m	N7° 35' 46.77"W
3500	2,765,074.3610m	552,763.2977m	N3° 43' 13.52"W
3550	2,765,124.2556m	552,760.0533m	N3° 43' 13.52"W
3600	2,765,174.1502m	552,756.8089m	N3° 43' 13.52"W
3650	2,765,224.0449m	552,753.5645m	N3° 43' 13.52"W
3700	2,765,273.9395m	552,750.3201m	N3° 43' 13.52"W
3750	2,765,323.8560m	552,747.4665m	N2° 02' 20.59"W
3800	2,765,373.8498m	552,746.9299m	N0° 02' 43.67"E
3850	2,765,423.8498m	552,746.9695m	N0° 02' 43.67"E
3900	2,765,473.8490m	552,746.8508m	N1° 04' 39.41"W
3950	2,765,523.7136m	552,743.4674m	N6° 44' 38.53"W
4000	2,765,572.9916m	552,735.1248m	N12° 28' 25.01"W
4050	2,765,621.1905m	552,721.9044m	N18° 12' 11.50"W
4100	2,765,667.8301m	552,703.9410m	N23° 50' 55.80"W
4150	2,765,713.2442m	552,683.0246m	N24° 53' 31.06"W
4200	2,765,758.5994m	552,661.9792m	N24° 53' 31.06"W
4250	2,765,803.9545m	552,640.9337m	N24° 53' 31.06"W
4300	2,765,849.3096m	552,619.8882m	N24° 54' 28.98"W
4350	2,765,892.3579m	552,594.7425m	N38° 52' 05.53"W
4400	2,765,925.3893m	552,557.5154m	N57° 58' 00.46"W
4450	2,765,947.6572m	552,512.7859m	N65° 11' 01.68"W
4500	2,765,969.7321m	552,467.9653m	N56° 54' 41.40"W
4550	2,766,008.3747m	552,437.7043m	N18° 58' 24.14"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
4600	2,766,057.6165m	552,437.1332m	N13° 32' 31.10"E
4650	2,766,106.0268m	552,449.6400m	N14° 32' 41.73"E
4700	2,766,154.4243m	552,462.1970m	N14° 32' 41.73"E
4750	2,766,202.8219m	552,474.7539m	N14° 32' 41.73"E
4800	2,766,251.2216m	552,487.3023m	N14° 20' 19.61"E
4850	2,766,300.3542m	552,496.2237m	N5° 08' 29.85"E
4900	2,766,350.2498m	552,499.4318m	N3° 26' 20.98"E
4950	2,766,400.1597m	552,502.4312m	N3° 26' 20.98"E
5000	2,766,450.0697m	552,505.4306m	N3° 26' 20.98"E
5050	2,766,499.9797m	552,508.4301m	N3° 26' 20.98"E
5100	2,766,549.8979m	552,511.2716m	N1° 58' 31.78"E
5150	2,766,599.5578m	552,507.0084m	N12° 28' 14.28"W
5200	2,766,647.9195m	552,494.3297m	N15° 08' 07.61"W
5250	2,766,696.1851m	552,481.2746m	N15° 08' 07.61"W
5300	2,766,744.4506m	552,468.2195m	N15° 08' 07.61"W
5350	2,766,792.7162m	552,455.1644m	N15° 08' 07.61"W
5400	2,766,840.9818m	552,442.1093m	N15° 08' 07.61"W
5450	2,766,889.2473m	552,429.0542m	N15° 08' 07.61"W
5500	2,766,937.5129m	552,415.9991m	N15° 08' 07.61"W
5550	2,766,985.7785m	552,402.9441m	N15° 08' 07.61"W
5600	2,767,033.9455m	552,389.5452m	N18° 01' 20.00"W
5650	2,767,078.2469m	552,366.8586m	N36° 38' 18.03"W
5700	2,767,115.4687m	552,333.5164m	N43° 18' 04.89"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
5750	2,767,151.8565m	552,299.2246m	N43° 18' 04.89"W
5800	2,767,188.6798m	552,265.4163m	N38° 59' 55.46"W
5850	2,767,231.9759m	552,240.8719m	N20° 00' 07.73"W
5900	2,767,280.9188m	552,231.8425m	N0° 54' 12.80"W
5950	2,767,330.2553m	552,238.8188m	N14° 28' 38.82"E
6000	2,767,378.6219m	552,251.4946m	N14° 40' 51.16"E
6050	2,767,427.9220m	552,255.1342m	N12° 49' 29.35"W
6100	2,767,470.1678m	552,229.7752m	N44° 36' 30.86"W
6150	2,767,505.3381m	552,194.2359m	N45° 20' 08.17"W
6200	2,767,540.4857m	552,158.6741m	N45° 20' 08.17"W
6250	2,767,575.6334m	552,123.1123m	N45° 20' 08.17"W
6300	2,767,610.7810m	552,087.5505m	N45° 20' 08.17"W
6350	2,767,645.9286m	552,051.9887m	N45° 20' 08.17"W
6400	2,767,681.0763m	552,016.4268m	N45° 20' 08.17"W
6450	2,767,716.2239m	551,980.8650m	N45° 20' 08.17"W
6500	2,767,751.3716m	551,945.3032m	N45° 20' 08.17"W
6550	2,767,786.8810m	551,910.1169m	N40° 39' 28.88"W
6600	2,767,832.0697m	551,890.7369m	N6° 42' 34.54"W
6650	2,767,881.9422m	551,887.2181m	N3° 43' 56.75"W
6700	2,767,931.8362m	551,883.9632m	N3° 43' 56.75"W
6750	2,767,981.7301m	551,880.7083m	N3° 43' 56.75"W
6800	2,768,031.6241m	551,877.4535m	N3° 43' 56.75"W
6850	2,768,081.5180m	551,874.1986m	N3° 43' 56.75"W

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
6900	2,768,131.4039m	551,870.8325m	N5° 03' 37.89"W
6950	2,768,179.9100m	551,859.5436m	N21° 17' 33.43"W
7000	2,768,226.0443m	551,840.2684m	N22° 50' 08.38"W
7050	2,768,272.1253m	551,820.8639m	N22° 50' 08.38"W
7100	2,768,318.2064m	551,801.4595m	N22° 50' 08.38"W
7150	2,768,364.2875m	551,782.0550m	N22° 50' 08.38"W
7200	2,768,408.5864m	551,759.1345m	N35° 33' 25.61"W
7250	2,768,446.3361m	551,726.3950m	N42° 28' 20.62"W
7300	2,768,484.8217m	551,694.6593m	N28° 56' 58.48"W
7350	2,768,532.3601m	551,679.6467m	N14° 03' 11.91"W
7400	2,768,580.8560m	551,667.4754m	N14° 48' 39.69"W
7450	2,768,624.2146m	551,643.8153m	N41° 17' 23.75"W
7500	2,768,660.7655m	551,609.7844m	N52° 55' 44.77"W
7550	2,768,655.3206m	551,565.5417m	S35° 28' 46.88"W
7600	2,768,608.6580m	551,570.4368m	S28° 54' 13.60"E
7650	2,768,564.7581m	551,594.3611m	S25° 24' 47.15"E
7700	2,768,516.0443m	551,600.4142m	S11° 57' 31.02"W
7750	2,768,468.4896m	551,585.0377m	S18° 45' 25.72"W
7800	2,768,419.5646m	551,578.0020m	S8° 54' 37.31"E
7850	2,768,373.8992m	551,597.6097m	S29° 10' 37.21"E
7900	2,768,330.2433m	551,621.9852m	S29° 10' 37.21"E
7950	2,768,286.5862m	551,646.3585m	S29° 05' 42.39"E
8000	2,768,241.6728m	551,668.2351m	S21° 31' 25.52"E

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
8050	2,768,193.8494m	551,682.6275m	S11° 58' 28.05"E
8100	2,768,144.3010m	551,688.8867m	S2° 25' 30.59"E
8150	2,768,094.4009m	551,686.8393m	S7° 07' 26.88"W
8200	2,768,045.5278m	551,676.5560m	S16° 24' 11.76"W
8250	2,767,997.8660m	551,661.4477m	S17° 46' 43.39"W
8300	2,767,950.2538m	551,646.1806m	S17° 46' 43.39"W
8350	2,767,902.6417m	551,630.9135m	S17° 46' 43.39"W
8400	2,767,855.0296m	551,615.6464m	S17° 46' 43.39"W
8450	2,767,807.1717m	551,601.2506m	S11° 01' 18.04"W
8500	2,767,758.1995m	551,606.8213m	S19° 55' 28.35"E
8550	2,767,711.1068m	551,623.5203m	S11° 28' 58.70"E
8600	2,767,672.8967m	551,600.3671m	S78° 33' 06.81"W
8650	2,767,692.7773m	551,556.5133m	N51° 01' 48.40"W
8700	2,767,724.2172m	551,517.6348m	N51° 14' 51.84"W
8750	2,767,750.8659m	551,475.5310m	N66° 22' 53.12"W
8800	2,767,768.4578m	551,428.7353m	N69° 57' 49.11"W
8850	2,767,788.2683m	551,382.9228m	N59° 08' 46.41"W
8900	2,767,820.5265m	551,345.0237m	N40° 02' 51.47"W
8950	2,767,863.2273m	551,319.3587m	N24° 17' 32.69"W
9000	2,767,909.2414m	551,299.8559m	N17° 17' 48.27"W
9050	2,767,958.3180m	551,300.8747m	N20° 15' 30.17"E
9100	2,767,998.9835m	551,329.3840m	N41° 30' 10.38"E
9150	2,768,036.4296m	551,362.5169m	N41° 30' 10.38"E

PCL Coordinates

Alignment Name:Tamenglong-Dialong

Description:

Station Range: Start: 00.000, End: 10.0000

Station Increment: 50.00

Chainage	Northing	Easting	Tangential Direction
9200	2,768,074.3790m	551,395.0426m	N35° 20' 23.31"E
9250	2,768,121.3211m	551,409.4064m	N2° 02' 33.79"W
9300	2,768,167.1289m	551,391.7456m	N39° 14' 23.24"W
9350	2,768,203.0073m	551,356.9441m	N44° 55' 42.20"W
9400	2,768,238.4068m	551,321.6329m	N44° 55' 42.20"W
9450	2,768,273.8063m	551,286.3218m	N44° 55' 42.20"W
9500	2,768,313.1511m	551,256.1113m	N22° 06' 58.73"W
9550	2,768,361.5860m	551,243.9276m	N12° 18' 19.85"W
9600	2,768,410.4212m	551,233.2001m	N13° 34' 02.89"W
9650	2,768,453.7927m	551,209.9208m	N46° 38' 56.60"W
9700	2,768,474.0329m	551,165.1837m	N83° 29' 29.01"W
9750	2,768,475.9713m	551,115.2327m	N88° 25' 29.74"W
9800	2,768,477.3456m	551,065.2516m	N88° 25' 29.74"W
9850	2,768,485.0134m	551,016.2368m	N65° 42' 27.93"W
9900	2,768,516.5279m	550,977.8900m	N43° 39' 47.29"W
9950	2,768,552.6985m	550,943.3691m	N43° 39' 47.29"W
10000	2,768,588.8687m	550,908.8479m	N43° 41' 50.00"W