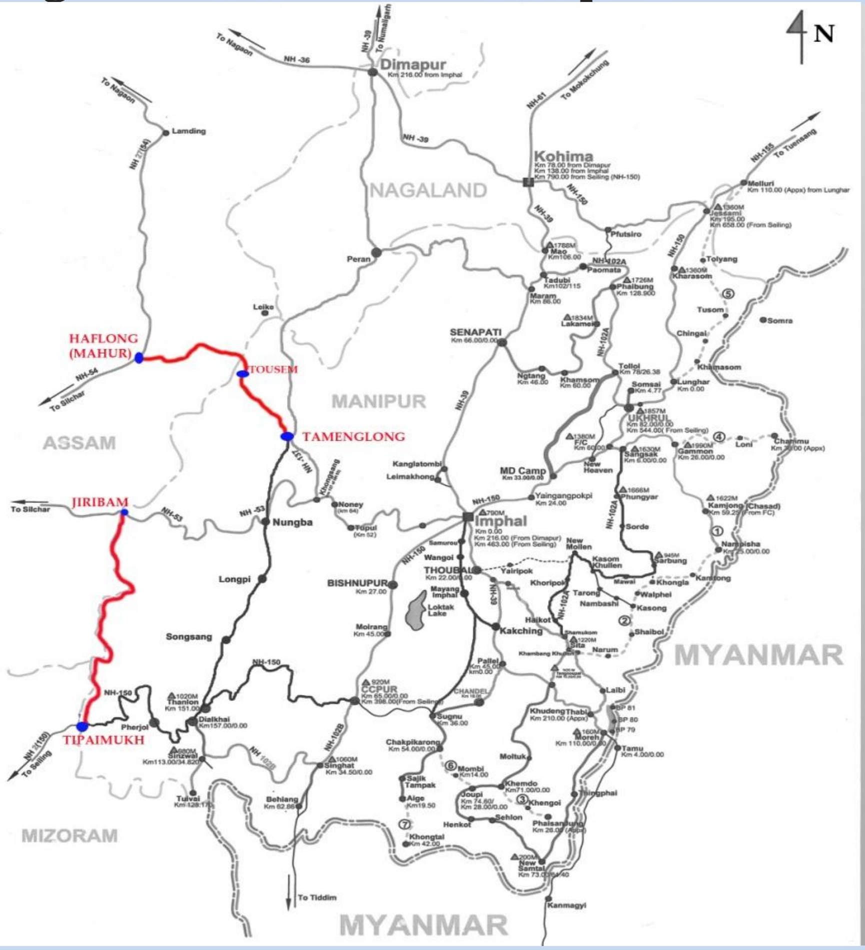
NATIONAL HIGHWAY INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

BUILDING INFRASTRUCTURE - BUILDING THE NATION

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-2
DIALONG-OLD TAMENGLONG SECTION
(FROM KM 10+000 TO KM 20+500) LENGTH-10.5KM

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

L = K x A,

Where L = Length of vertical curve in metres;

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

Summit or Crest Curves

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

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

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

Valley or Sag Curves

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

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

1.2 Bridges and Cross Drainage Structures

1.2.1 General

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

1.2.1.1 Bridges and Culvert

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

1.3 Hydrological and Hydraulic Investigations

Hydrological Data

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

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

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

1.4 Hydrological Design Methodology

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

The following assumptions have been made during peak discharge calculation:

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

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

1.4.1.1 Assessment of Peak Discharge

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

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

Dickens Method

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

Q = CM (0.75)

Where,

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

M Is the catchment area in sq.km and

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

14-19, in Madhya Pradesh; and

32, in Western Ghats.

Area – Velocity Method (Manning's Formula)

Q = A x V

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

Where, Q = the discharge in cumecs ;

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

V = Velocity in m/sec;

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

P = Wetted perimeter of the stream in m.;

S = Bed slope of the stream; and

n = Rugosity Co-efficient.

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

1.4.1.2 Hydraulic Analysis for Design HFL

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

1.4.1.3 Afflux Calculation

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

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

Where, h = Afflux in meters;

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

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

and

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

1.4.1.4 Scour Depth Calculation

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

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

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

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

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

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

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

1.4.1.5 Maximum Depth of Scour for Design of Foundation

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

In the vicinity of pier: dsmp = 2 x Dsm

In the vicinity of abutment: dsma = 1.27 x Dsm

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

In a straight reach: 1.27 x Dsm

In a bend: 1.50 x Dsm

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

1.4.1.6 Additional Balancing Culvert on Main Carriage Way

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

1.4.1.7 Pipe Culvert

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

1.4.1.8 Various Codes and Publication to be adopted

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

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

1.4.1.9 Design Live Load

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

1.4.1.10 Vertical Load

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

1.4.1.11 Longitudinal Forces

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

1.4.1.12 Seismic Zone

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

1.4.1.13 Condition of Exposure

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

1.4.1.14 Grade of Concrete

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

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

1.5 Miscellaneous

1.5.1 Road Signs

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

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

1.5.2 Road Markings

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

1.5.3 Traffic Barriers

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

1.5.4 River Training work

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

2.0 PAVEMENT DESIGN

2.1 General

2.1.1 Objectives

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

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

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

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

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

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

2.1.2 Scope

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

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

2.2 Analysis Of Data For Pavement Design

2.2.1 General

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

2.2.2 Pavement Condition Study Data

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

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

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

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

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

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

2.2.3 Classified Traffic Volume Data

2.2.3.1 Vehicle Classes Considered for Pavement Design

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

Heavy Commercial vehicles consisting of heavy trucks with two axles

Heavy Commercial vehicles consisting of heavy trucks with rigid body and tandem axles

Heavy Commercial Vehicles, such as tractor-trailer units with Multiple Axles and agricultural tractors with trailers and other heavy vehicles , Buses , Light Commercial Vehicles of gross weight exceeding 3 t and mini-buses.

The average volume of the above groups of vehicles on different sections of each corridor as on the year 2014 were made use of for determining the initial traffic by the year 2017, when the pavement improvement works of the project roads are expected to be completed.

2.2.3.2 Traffic Growth Rate

The mean growth rate of the above groups of vehicle classes for the Manipur as a whole have been worked out and presented in Chapter 4, "Traffic Survey Analysis and Forecast". It was observed that the traffic growth rates were different for the periods

As already mentioned, it was decided to consider the initial traffic as on the year 2017 for pavement design. The fifteen year design period considered for design of flexible pavement overlays and for the design of new flexible pavement is :

20 years life, for the period 2020 to 2040

Therefore the weighted average growth rates were worked out for the above five vehicle groups in order to work out the CSA values of each vehicle class during the respective design periods.

2.2.5 Design C.S.A. Values

The CSA values were calculated using the relationship given below :

Ns = [365 A D F{ (1 + r)x - 1 }/r] ¸ msa

Design CSA on the design - lane = Tf. Ns, msa

Where,

Ns = Cumulative Standard Axles (CSA) on the road section during the design period (2014to 2029), msa

A = the initial traffic (number of the particular vehicle class per day) on the road section under consideration by the year 2009

r = the rate of growth of the vehicle class during the design life of 15 years

x = design life, years (15 years)

F = Vehicle Damage Factor (VDF) determined from axle load studies on the respective corridor

D = Lane Distribution Factor

Tf = Traffic Distribution Factor on the design lane

= 0.75 for intermediate-lane, two-way traffic road

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

2.3.2 Calculation of VDF

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

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

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

2.3.3 Computation of design traffic

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

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

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

Where

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

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

r = Annual growth rate of commercial vehicles, %

x = Design life in years

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

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

1.6 PAVEMENT DESIGN OF PROJECT ROAD

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

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

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

1.7 Average Annual Daily Traffic and it Composition

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

Table 1.4: Annual Average Daily Traffic (AADT)

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

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

Traffic growth rate during the design life in percentage

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

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

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

Vehicle Damage Factor

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

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

Hence, The Adopted VDF is 2.5.

Cumulative Mean Standard Axles (CMSA)

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

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

Adopted MSA is 20 as per IRC SP 73:2018

<u>For Details of Traffic Surveys and Analysis Please refer Chapter-5</u>

1.4. PAVEMENT DESIGN

As per plate No.-4 of IRC-37:2019 the Pavement Design is:-

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

Table 1.5

Homogenous Section (Km)			CBR (%)	MSA	Adopted Pavement Composition (mm)			
From	**To**	**Length (in Km)**		**Adopted**	**BC**	**DBM**	**WWM**	**GSB**
10+000	20+500	10.500	8	20	30	90	250	200

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

DESIGN OF CULVERTS & BRIDGES

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

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

Index

1.0 Design Report

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

1.1 Introduction:-

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

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

1.2 Reference documents :-

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

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

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

1.4 Loads:-

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

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

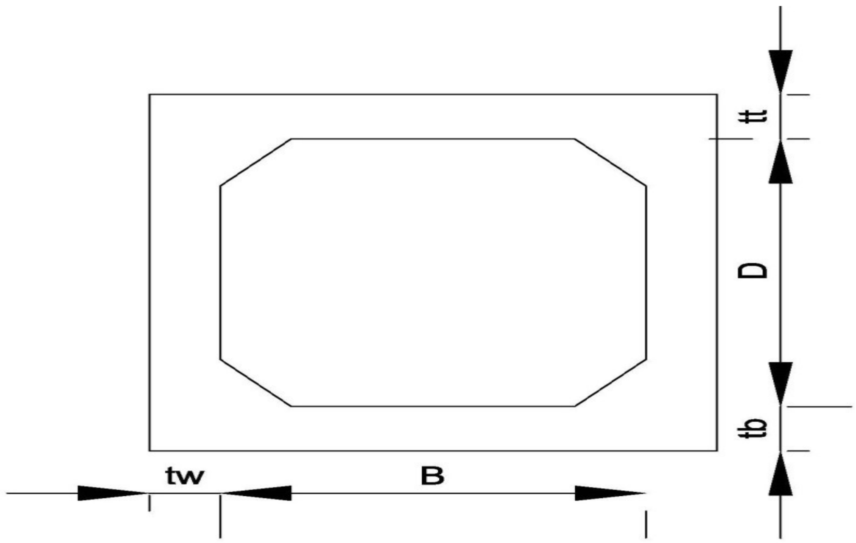
1.5 Load combinations

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

1.6 Material properties

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

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

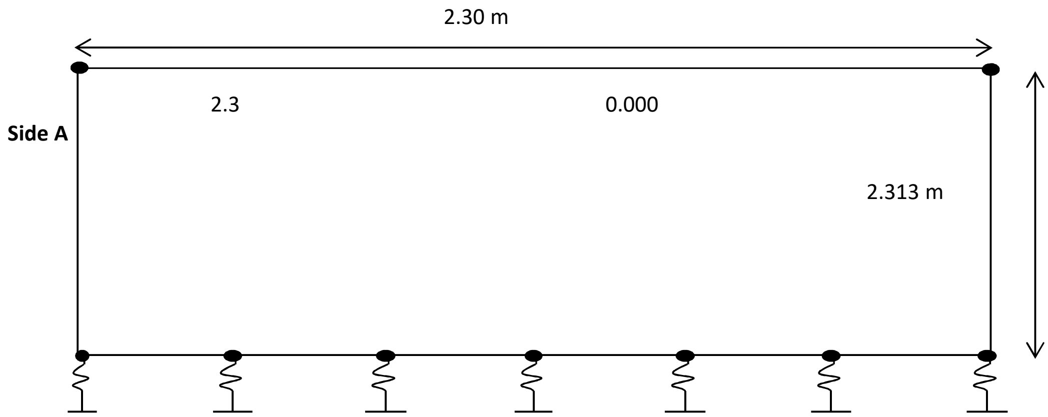
Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpres:	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge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

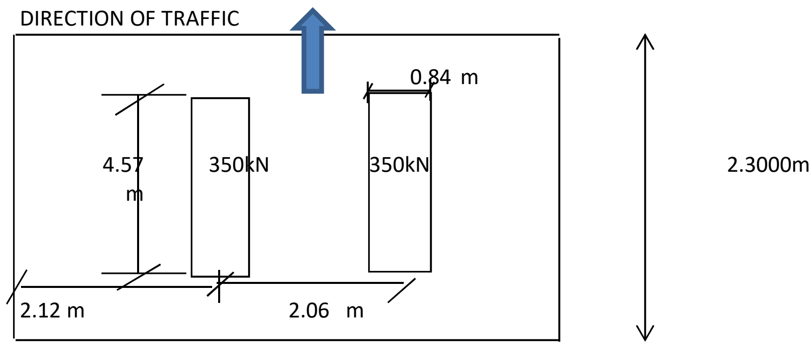
2) e Load due to water on Bottom Slab

Uniform Load = 13.75 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span

DIRECTION OF TRAFFIC



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

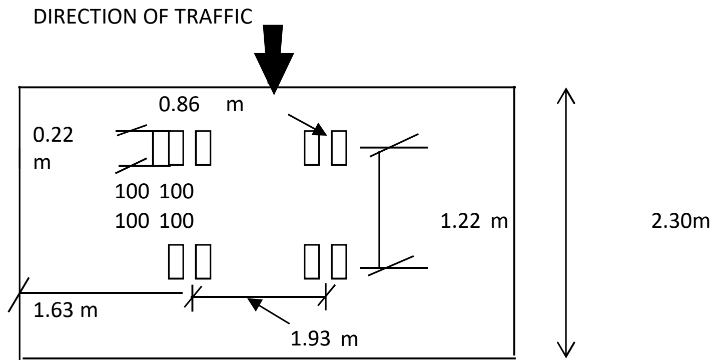
<u>Effective width of Loading</u>

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

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

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

B) 40T Boggie Load at Mid Span



Total Load = 400kN

Effective width of Loading

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

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

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

C) 40T Boggie Load at Support

Effective width of Loading

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

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

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

D) 70R Track at Support

Effective width of Loading

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

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

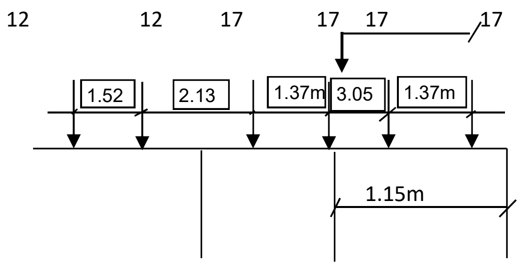
Effective width	=	4.55	m
Width along span	=	2.300	m
Load Intensity	=	33.66	kN/m^2

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

Increase due to impact = 42.08 kN/m^2

Say **42.10** kN/m^2

F) 70R Wheel Case 1

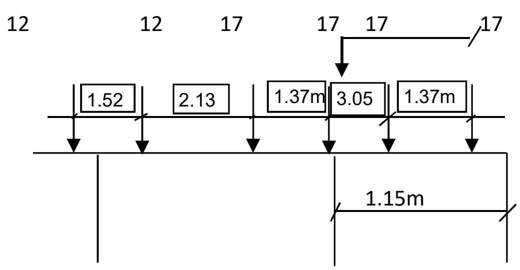


0.86m 1.93m 0.86m

Width along span = 0.970m

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

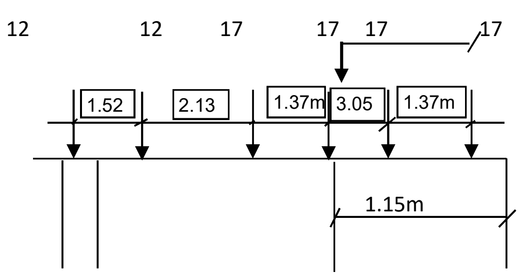
F) 70R Wheel Case 2



Width along span = 0.970m

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

G) 70R Wheel Case 3



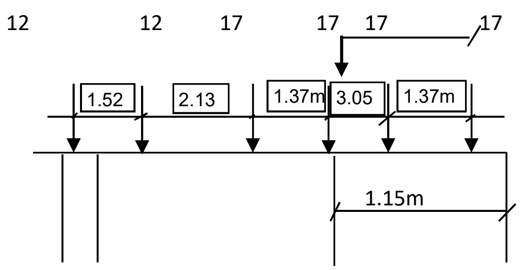
Width along span = 0.970m

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

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

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

H) 70R Wheel Case 4



Width along span = 0.970m

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

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

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

3.2 Temperature load calculation

Effective Bridge Temperature

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

Effect of temperature gradient

The box has been checked for temperature differential.

F = E_c aDt A

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

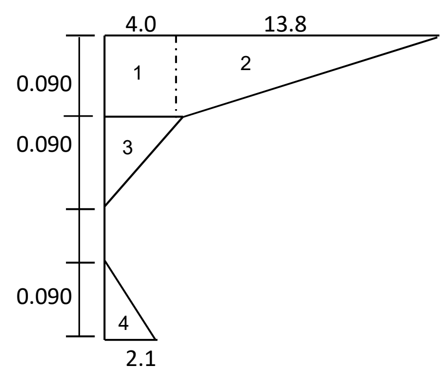
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 300 mm

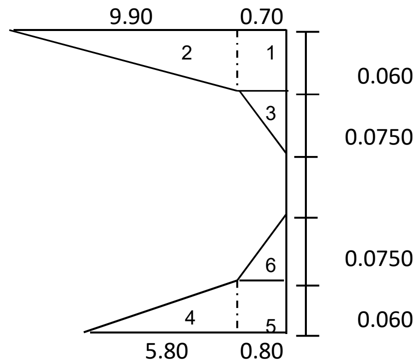
EFFECT OF TEMPERATURE RISE



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

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

EFFECT OF TEMPERATURE FALL



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

3.3 Summary of factored moments

Grade of Concrete = M30

Grade of Steel = Fe500

Summary of factored moments

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

4.0 Partial Safety Factors

Material Parameters

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

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

Partial Safety Factor for Materials

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

Partial Safety Factor for Loads

Ultimate Limit State

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

Also refer IRC Amendment dated 28th July, 2012

Loads	Partial Safety Factor					
	Basic Combination		Accidental Combination		Seismic Combination	
(1)	(2)	(3)	(4)	(5)	(4)	(3)
	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect	Overturning or Sliding or Uplift Effect	Restoring or Resisting Effect
Permanent Loads:	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 iii) Impact due to floating bodies	0.00	1.00	0.00
Seismic Effect			
a) During Service	0.00	0.00	1.50
b) During Construction	0.00	0.00	0.75
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	1.00
Wave Pressure	1.00	1.00	1.00
Hydrodynamic Effect	0.00	0.00	1.00
Buoyancy	0.15	0.15	0.15

Serviceability Limit State

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

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

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

Combination for Base Pressure and Design of Foundation

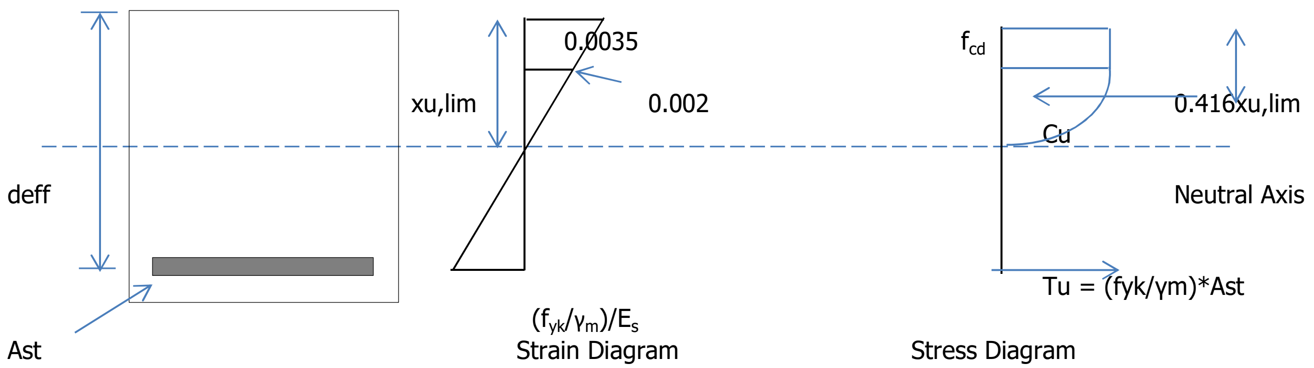
Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

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

	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



ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel — f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

E_c = 31000 MPa

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

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 300 mm

Clear cover = 50

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

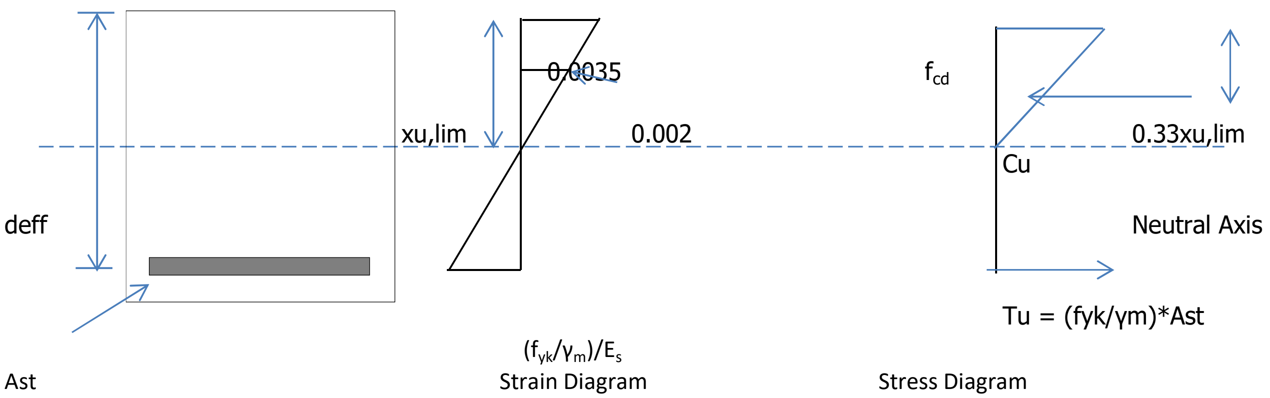
Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Basic Comb			Basic Comb		
Actual moment (KNm)	57.0			48.3		
b	1000			1000		
D	300			300		
c	50			50		
d	232.0			233.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97		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

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

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

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

5.1.2 Verification for serviceability limit state for top slab



SERVICEABILITY LIMIT STATE

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

As per clause 12.2.1, IRC:112-2011

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

As per clause 12.2.2, IRC:112-2011

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

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

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

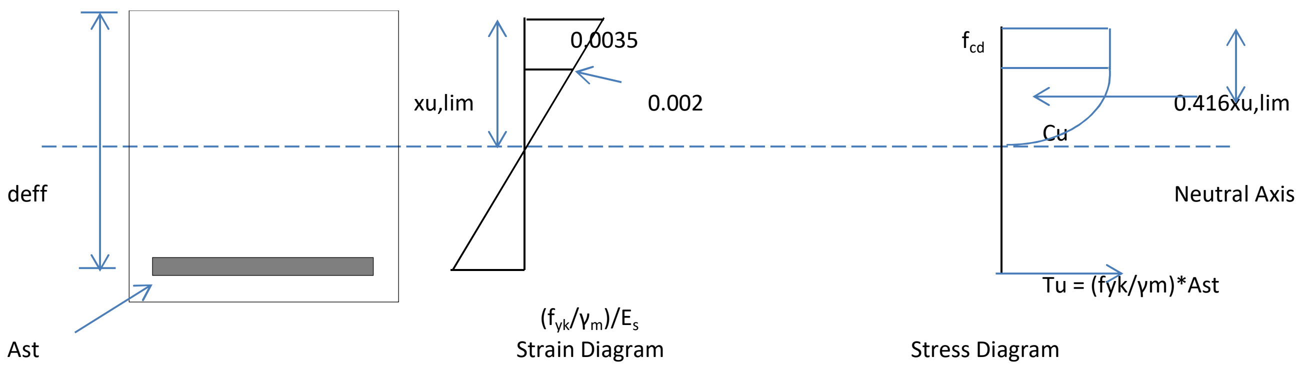
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	243.0		243.0
f_{cd}	14.40		10.80	14.40		10.80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

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

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

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

5.2.1 Verification of structural strength for bottom slab



ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 325 mm

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

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

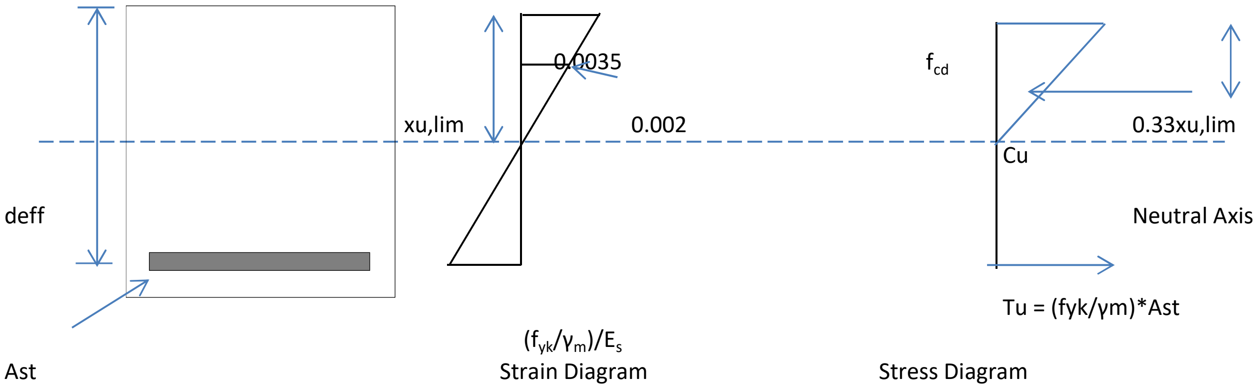
Moment on the section	**Bottom End support**			**Top Mid Span**		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	86.0		80.0	65.0		58.0
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}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

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

Shear on the section	**Bottom End support**		
Actual shear V_{Ed} (KN)	123.0		122.0
Actual shear stress (N/mm2)	0.589		0.584
Max shear capacity, 0.135 fck(1-fck/310)	3.7		3.7
	OK.		**OK.**
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		2.5
$\Theta = 0.5 \times \sin^{-1}$ (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.**

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

5.2.2 Verification for serviceability limit state for bottom slab



SERVICEABILITY LIMIT STATE

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

As per clause 12.2.1, IRC:112-2011

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

As per clause 12.2.2, IRC:112-2011

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

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

Tu = fyd*Ast

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 325 mm

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

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

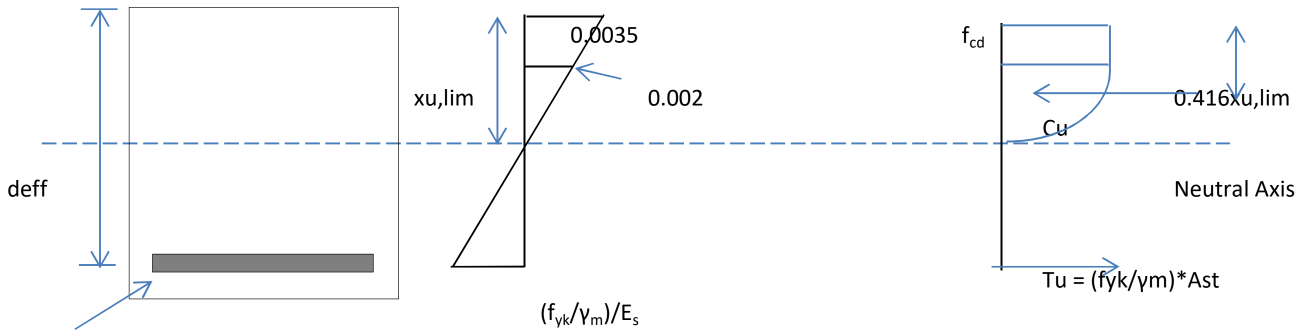
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	65.0		15.0	43		6
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}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

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

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

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

5.3.1 Verification of structural strength for outer wall



Ast Strain Diagram Stress Diagram

ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

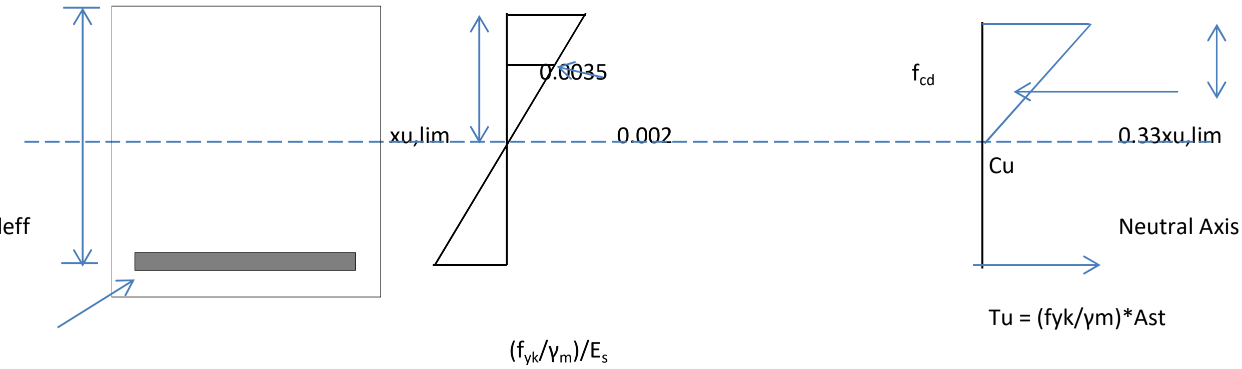
Depth of section D = 300 mm

Clear cover = 75

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

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

5.3.2 Verification for serviceability limit state for outer wall



Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

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

As per clause 12.2.1, IRC:112-2011

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

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

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

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 75

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

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

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

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

6.0 Summary of provided Reinforcement

Provided Reinforcement

Top Slab

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

Bottom Slab

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

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

Outer Wall

At outer face of top end

Area of Steel Provided = 1615.7 mm^2/m

12mm dia @ 140mmc/c Outer wall (Outer main reinforcement)

12mm dia @ 140mmc/c Top slab (Top main reinforcement) OK

0mm dia @ 140mmc/c Top corner extra reinforcement

At inner face of top end

Area of Steel Required = 313.8 mm^2/m

Area of Steel Provided = 561.0 mm^2/m

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

At outer face of bottom end

Area of Steel Provided = 1615.7 mm^2/m

12mm dia @ 140mmc/c Bottom slab (Bottom main reinforcement)

12mm dia @ 140mmc/c Outer wall (Outer main reinforcement) OK

0mm dia @ 140mmc/c Bottom corner extra reinforcement

At inner face of bottom end

Area of Steel Provided = 561.0 mm^2/m

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

Shear Reinforcement

Bottom Slab

12mm dia 225mmc/c (Long. Direc 0 198.304 kN

12mm dia 140mmc/c (Trans. Direction)

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

Top Slab

Req. Reinforcement = 174 mm^2/m

Provided Reinforcement =

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

Bottom Slab

Req. Reinforcement = 200.3 mm^2/m

Provided Reinforcement =

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

Outer Wall

Req. Reinforcement = 192.7 mm^2/m

Provided Reinforcement =

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

	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.

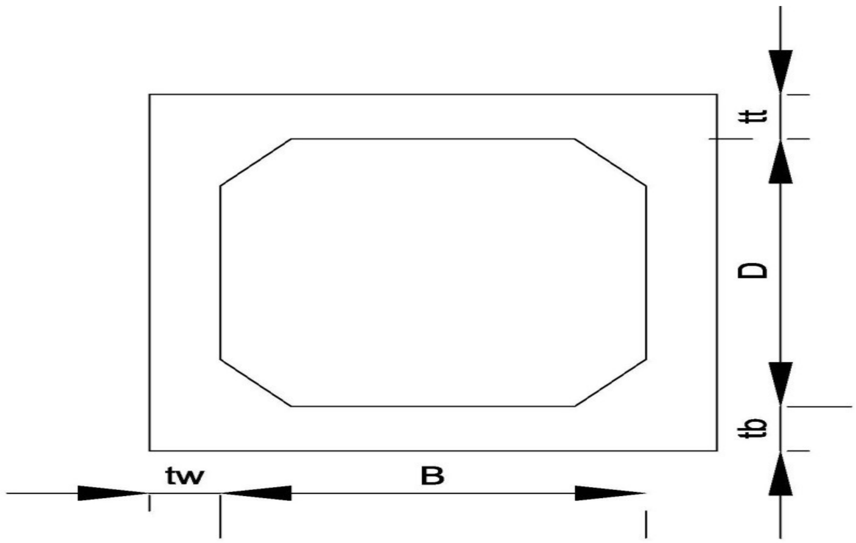
1.5 Load combinations

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

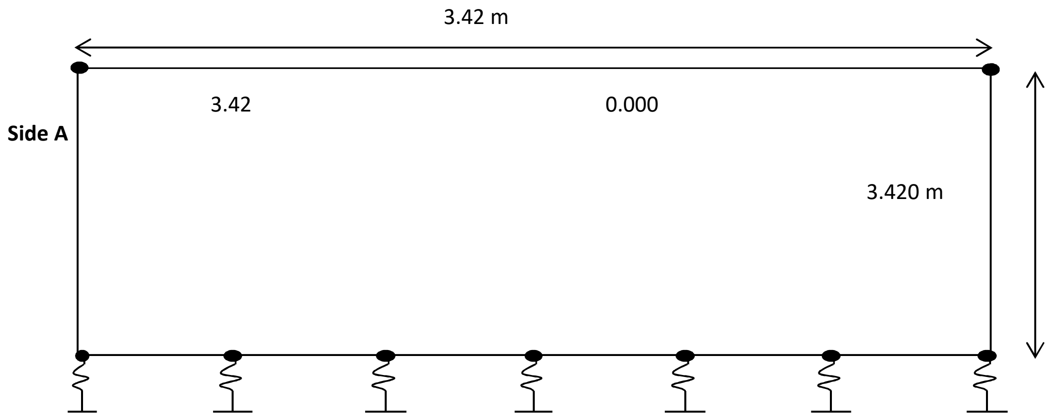
2.2 Basic Parameters

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

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

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

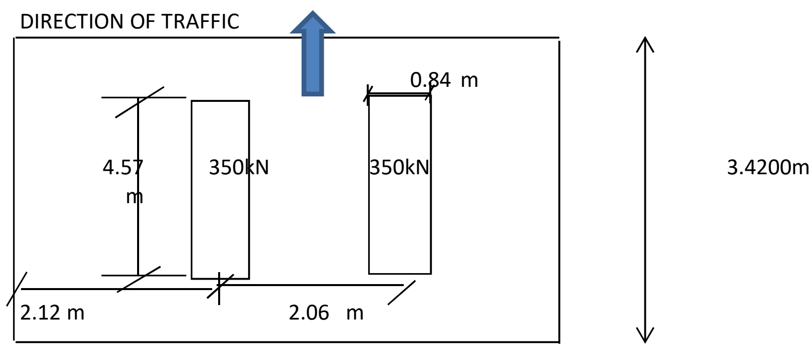
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 24.95 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



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

Effective width of Loading

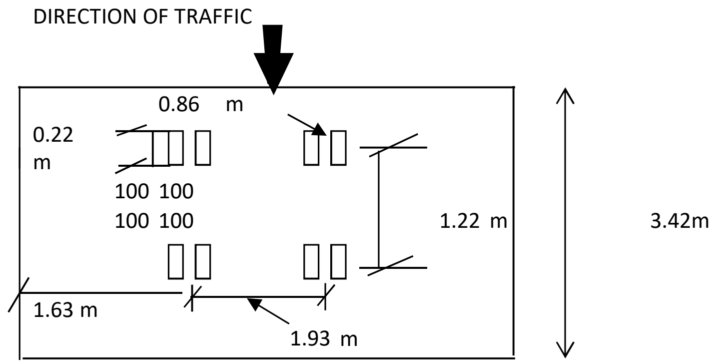
a	=	1.71 m
b1	=	0.99 m
b/lo	=	3.51
a	=	2.60
beff	=	3.21 m

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***

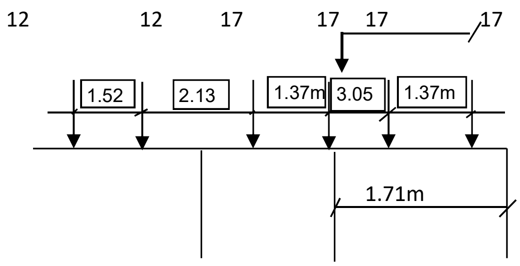
Effective width	=	5.27 m
Width along span	=	3.420 m
Load Intensity	=	29.07 kN/m^2

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

Increase due to impact = 36.34 kN/m^2

Say **36.40** kN/m^2

F) 70R Wheel Case 1

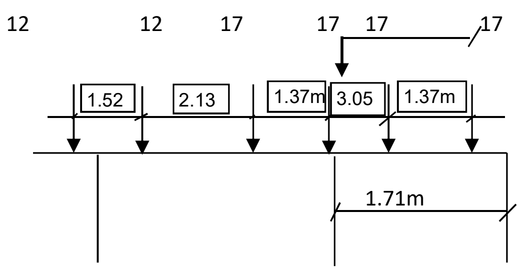


0.86m 1.93m 0.86m

Width along span = 1.210m

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

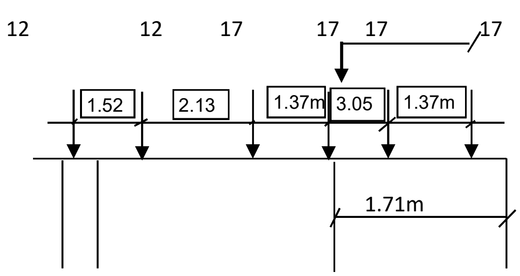
F) 70R Wheel Case 2



Width along span = 1.210m

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

G) 70R Wheel Case 3



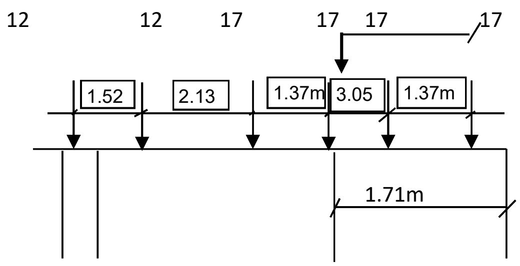
Width along span = 1.210m

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

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

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

H) 70R Wheel Case 4



Width along span = 1.210m

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

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

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

3.2 Temperature load calculation

Effective Bridge Temperature

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

Effect of temperature gradient

The box has been checked for temperature differential.

F = E_c aDt A

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

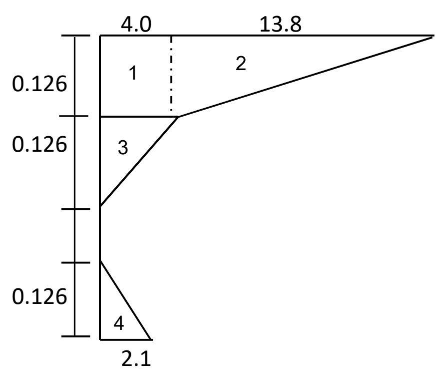
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 420 mm

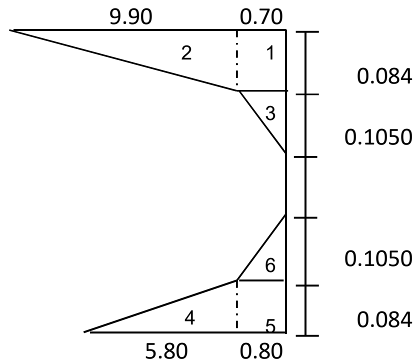
EFFECT OF TEMPERATURE RISE



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

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

EFFECT OF TEMPERATURE FALL



Sr. No.	Dt	b	t	A = b x t	F (force)	Acting at	Eccentricity e*
1	0.70	1.0	0.084	0.084	2.27	0.042m from top	0.168
2	$\frac{9.90}{2}$	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

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

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

Serviceability Limit State

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

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

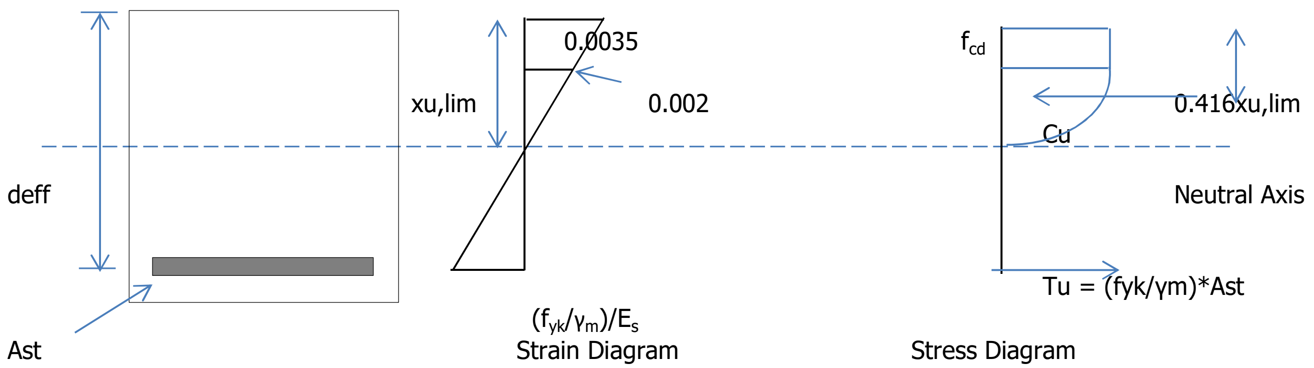
Combination for Base Pressure and Design of Foundation

Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

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

5.1.1 Verification of structural strength for top slab



ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

E_c = 31000 MPa

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

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

Clear cover = 50

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

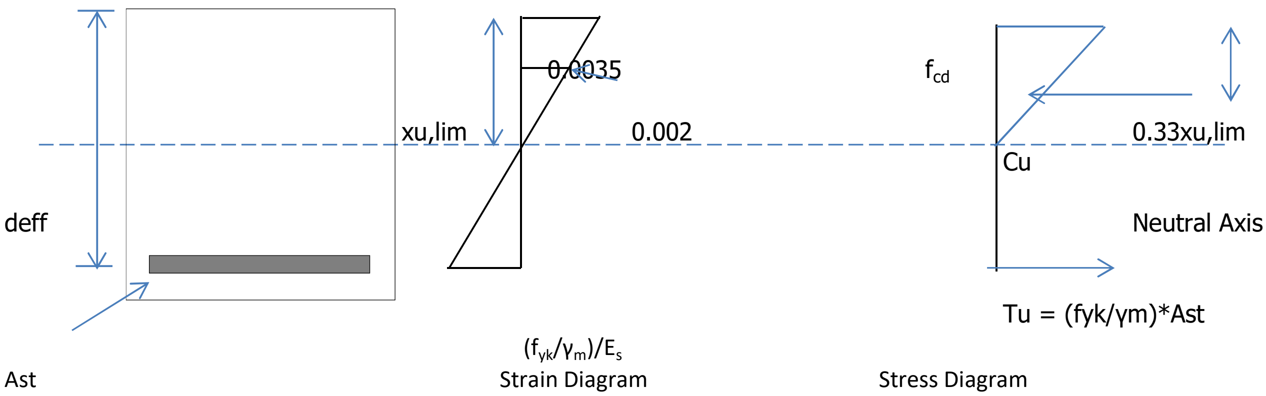
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	80.0			70.0		
b	1000			1000		
D	420			420		
c	50			50		
d	352.0			353.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$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

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

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

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

5.1.2 Verification for serviceability limit state for top slab



SERVICEABILITY LIMIT STATE

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

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

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

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

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

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

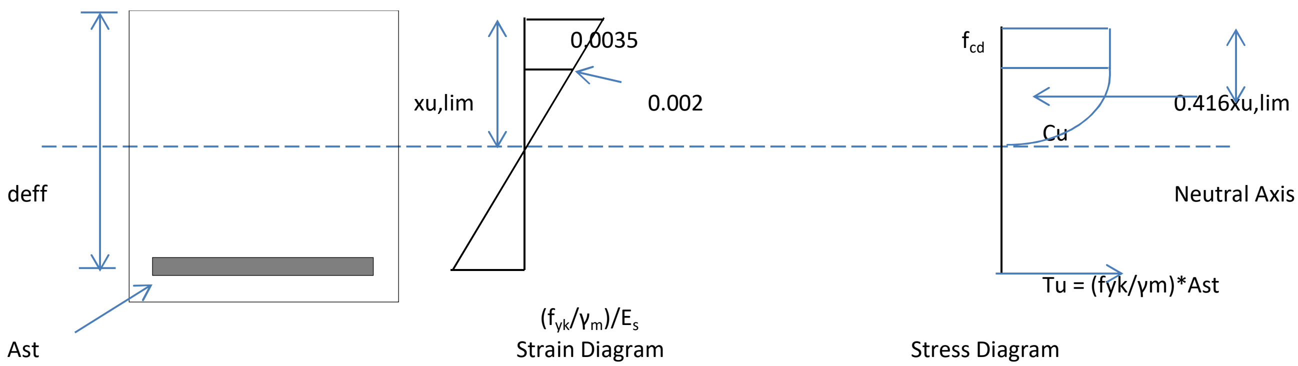
Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	68.0		26.0	53		14
b	1000		1000	1000		1000
D	420		420	420		420
c	40		40	40		40
d	362.0		362.0	363.0		363.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}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

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

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

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

5.2.1 Verification of structural strength for bottom slab



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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

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

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

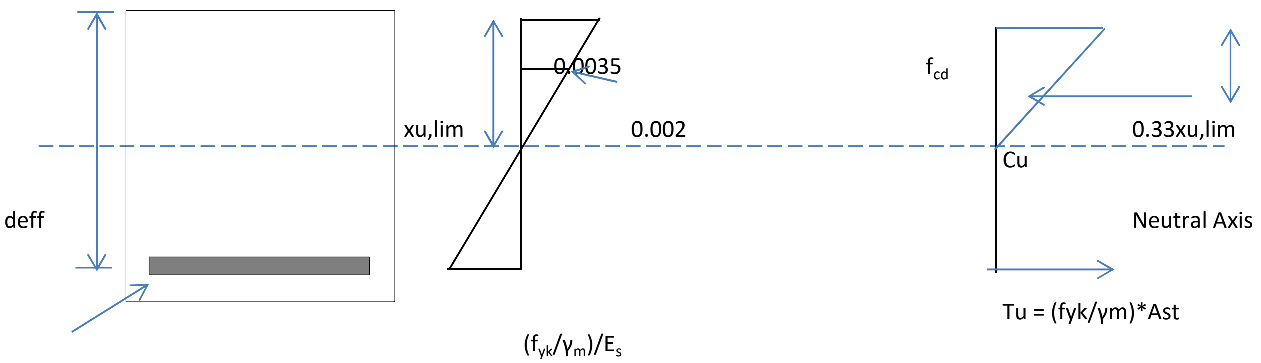
Moment on the section	Bottom End support			Top Mid Span		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	130.0		107.0	111.0		93.0
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435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

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

Shear on the section	**Bottom End support**		
Actual shear V_{Ed} (KN)	187.0		162.0
Actual shear stress (N/mm2)	0.635		0.550
Max shear capacity, 0.135 fck(1-fck/310)	3.7		3.7
	OK.		**OK.**
Min shear capacity, 0.0924 fck(1-fck/310)	2.5		2.5
$\Theta = 0.5 \times \sin^{-1}$ (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

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 420 mm

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

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

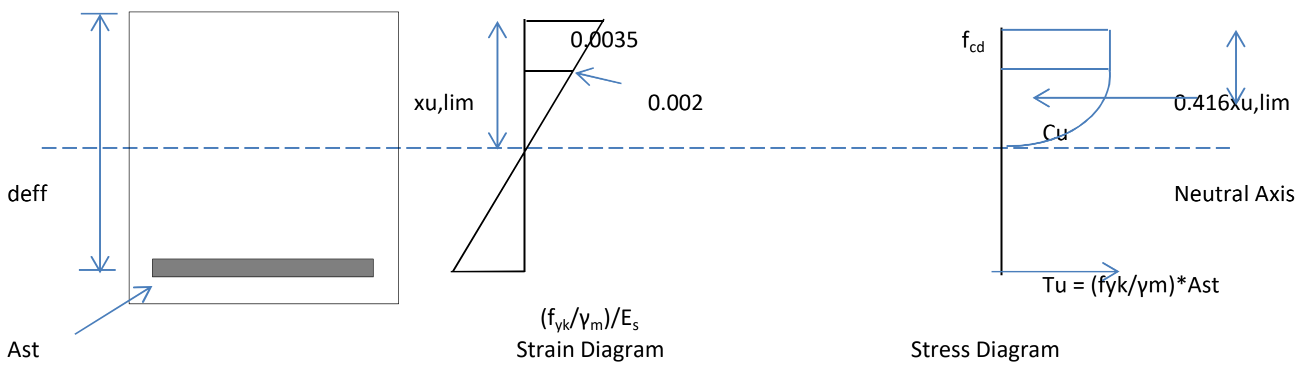
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	91.0		28.0	77		24
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}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

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

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

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

5.3.1 Verification of structural strength for outer wall



ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

Grade of steel

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

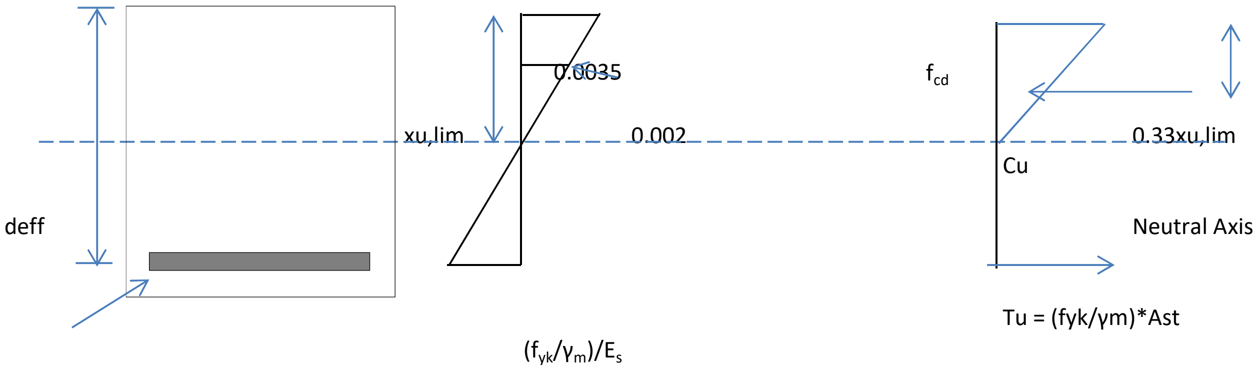
Width of section b	=	1000	mm
Depth of section D	=	420	mm
Clear cover	=	75	

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

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

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

5.3.2 Verification for serviceability limit state for outer wall



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 = 75

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

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

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

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

6.0 Summary of provided Reinforcement

Provided Reinforcement

Top Slab

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

Bottom Slab

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

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

Outer Wall

<u>At outer face of top end</u>

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

<u>At inner face of top end</u>

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

<u>At outer face of bottom end</u>

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

<u>At inner face of bottom end</u>

Area of Steel Provided = 523.6 mm^2/m

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

Shear Reinforcement

Bottom Slab

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

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

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

Top Slab

Req. Reinforcement = 264 mm^2/m

Provided Reinforcement =

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

Bottom Slab

Req. Reinforcement = 271.3 mm^2/m

Provided Reinforcement =

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

Outer Wall

Req. Reinforcement = 244.4 mm^2/m

Provided Reinforcement =

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

7.0 Base Pressure

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

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

Bearing capacity = 100 KN/sqm

Design note
for
RCC BOX OF SIZE 2 x 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

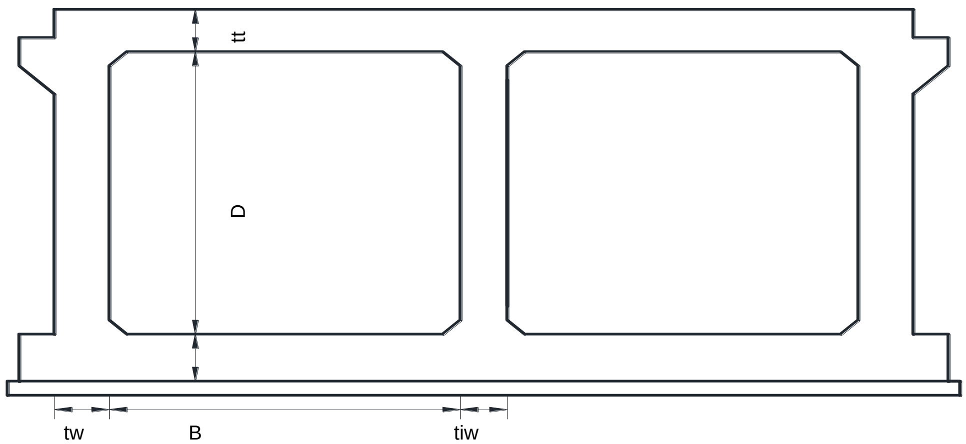
Load combinations as per IRC 6: 2017 have been considered in staad load combination.

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

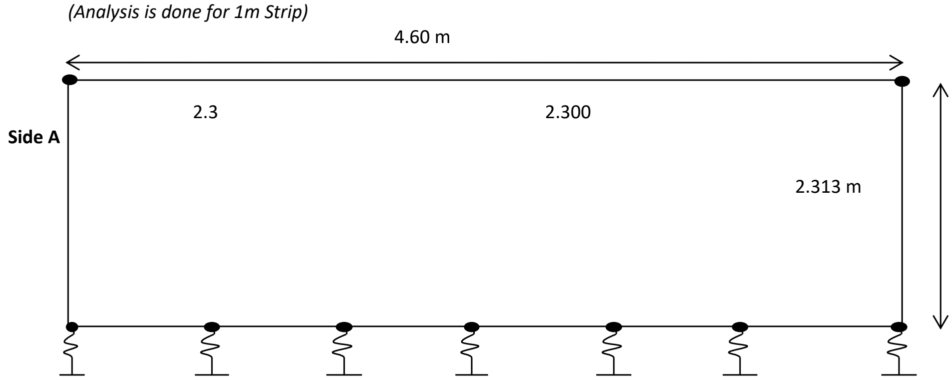
Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpressı	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge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

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

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

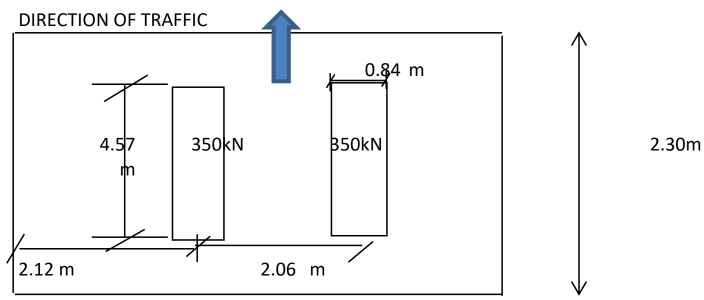
Live Load Surcharge = 12.000 kN/m

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>

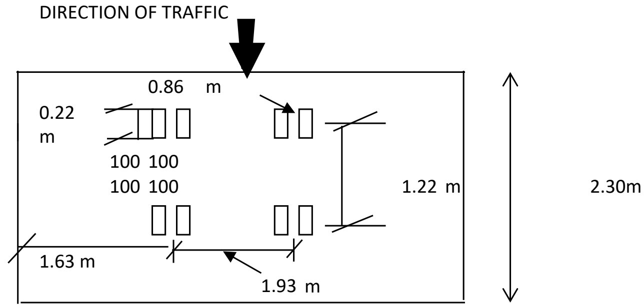
a	=	1.15 m
b1	=	0.99 m
b/lo	=	5.22
a	=	2.60
beff	=	2.49 m

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***

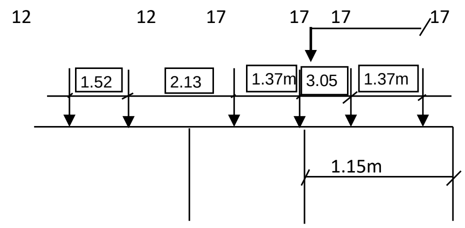
Effective width		4.54	m
Width along span		2.3	m
Load Intensity		33.74	kN/m^2
Increase due to impact		42.18	kN/m^2
	Say	**42.20**	kN/m^2

E) Live Load Case for Bottom Slab

Uniform Load = 42.10 kN/m^2

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

F) 70R Wheel Case 1 (at support)



9.44
10.66

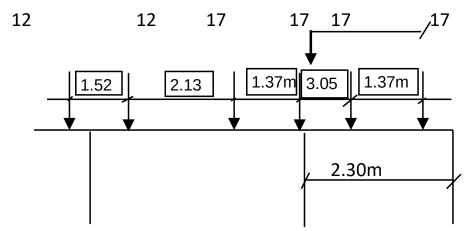
0.86m 1.93m 0.86m

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

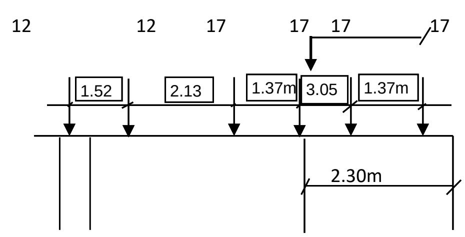
F) 70R Wheel Case 2 (at mid)



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

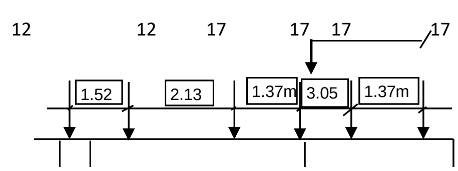
G) 70R Wheel Case 3 (outerwall)



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)



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

Width along span = 0.970m

S.No.	Load	a	a	beff	Overlap	Eff. Width	Load Int.	With Imp.
1	166.77	0.685	2.60	2.26m	Yes	4.19m	41.0 kN/sqm	51 kN/sqm
2	166.77	0.245	2.60	1.58m	No	1.58m	54.4 kN/sqm	68 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	0.00m	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0.0 kN/sqm	0 kN/sqm
0	0	0.000	0.00	0.00m	No	**0.00m**	0.0 kN/sqm	0 kN/sqm

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

A) 70R Track at Inner Wall

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

4) COLLISION LOAD

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

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

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

3.2 Temperature load calculation

Effective Bridge Temperature

Maximum Air Shade temperature	=	47.9	/oC (as per Annexure F of IRC:6-2017)
Minimum Air Shade temperature	=	0.2	/°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

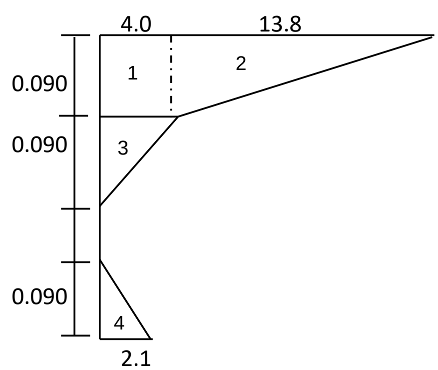
a = Coefficient of Thermal expansion = 1.20E-05 /°C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 300 mm

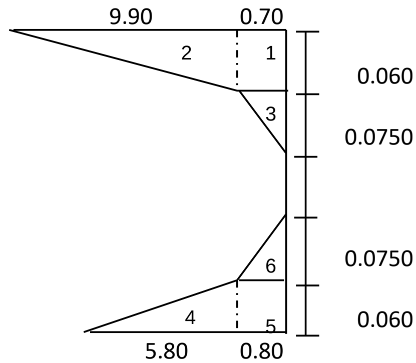
EFFECT OF TEMPERATURE RISE



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

Partial Safety Factor for Loads

Ultimate Limit State

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

Also refer IRC Amendment dated 28th July, 2012

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

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

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

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

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

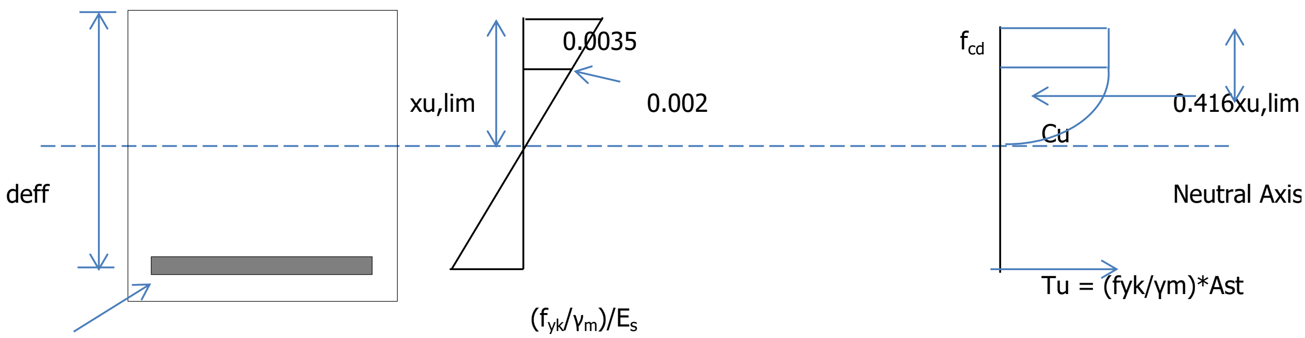
Table 3.4, Annex B, IRC:6-2014

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	-	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



Ast 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.	-

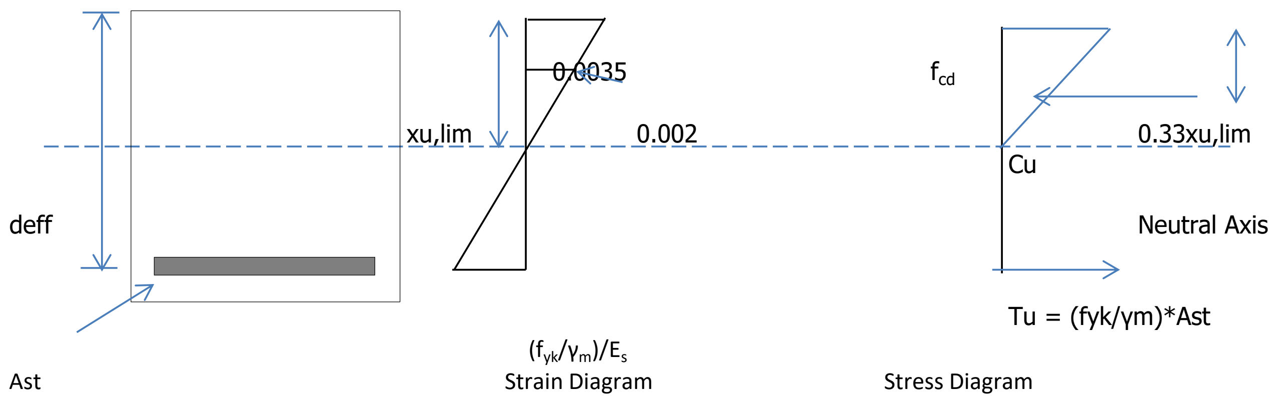
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	57.0			48.3		
b	1000			1000		
D	300			300		
c	50			50		
d	232.0			232.0		
f_{cd}	15.63			15.63		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	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



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

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

Tu = fyd*Ast

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

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

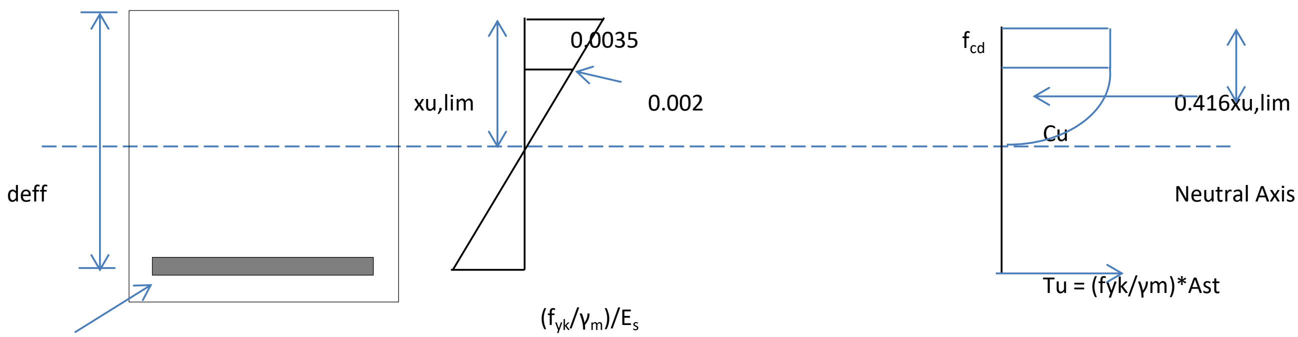
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	242.0		242.0
f_{cd}	16.80		12.60	16.80		12.60
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 E_c = 32000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	5.80	6.99	5.80

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 325 mm

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

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

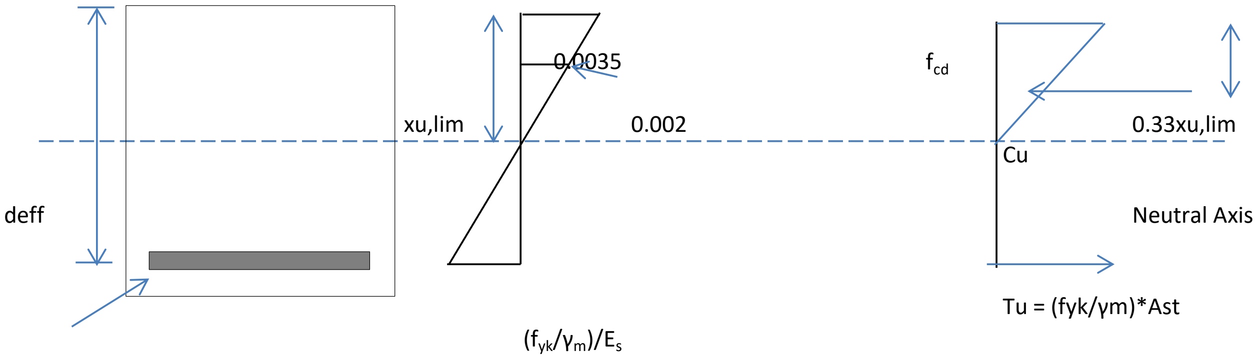
Moment on the section	Bottom End support			Top Mid Span		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	86.0		80.0	65.0		58.0
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	267.0		267.0
f_{cd}	15.63		15.63	15.63		15.63
f_{Yd}	435		435	435		435
$xu_{,lim}/d$	0.62		0.62	0.62		0.62
$R_{sls} = M_{u,sls}/bd^2$	5.80		5.80	5.80		5.80
$M_{u,Lim}$ (KNm)	312		312	414		414
	OK		**OK**	**OK**		**OK**
Ast Req.	903		836	578		514
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
+ dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Ast provided (sq mm)	1257		1257	1257		1257
Dia of bar (main compresion) (mm)	12		12	12		12
Spacing (mm)	180		180	180		180
Area of main compresion (mm^2)	628		628	628		628
f_{ctm}	2.8		2.8	2.8		2.8
f_{yk}	435		435	435		435
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S.min} = 0.26\ f_{ctm}\ b_t\ d\ /\ f_{yk} >= 0.0013\ b_t\ d$	388		388	447		447
A_{ct}	281827		281827	281827		281827
$f_{ct,eff}$	2.9		2.9	2.9		2.9
$k_c = 0.4 \{ 1 - s_c / (k_1 f_{ct,eff} h/h^*) \} <= 1$	0.4		0.4	0.4		0.4
For Bending or bending combined with axial force						
k	0.9825		0.9825	0.9825		0.9825
s_s	435		435	435		435
As.max = 0.025 Ac (main tension)	8125		8125	8125		8125
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**		**OK**	**OK**		**OK**
As.max = 0.04 Ac (tension + compresion)	13000		13000	13000		13000
x (mm)	43		43	43		43
x/d	0.186		0.186	0.162		0.162
	OK		**OK**	**OK**		**OK**
z (mm)	214		214	249		249
MR (KNm)	117		117	136		136
	OK		**OK**	**OK**		**OK**

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

Shear on the section	**Bottom End support**		
Actual shear V_{Ed} (KN)	123.0		122.0
Actual shear stress (N/mm2)	0.589		0.584
Max shear capacity, 0.135 fck(1-fck/310)	4.2		4.2
	OK.		**OK.**
Min shear capacity, 0.0924 fck(1-fck/310)	2.9		2.9
Θ = 0.5 x $\sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))			
Min angle of inclination, Θ (deg)	21.8		21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010			
K = 1+Sqrt(200/d) <= 2.0	1.928		1.928
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010			
$n_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.491		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



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 = 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.	-

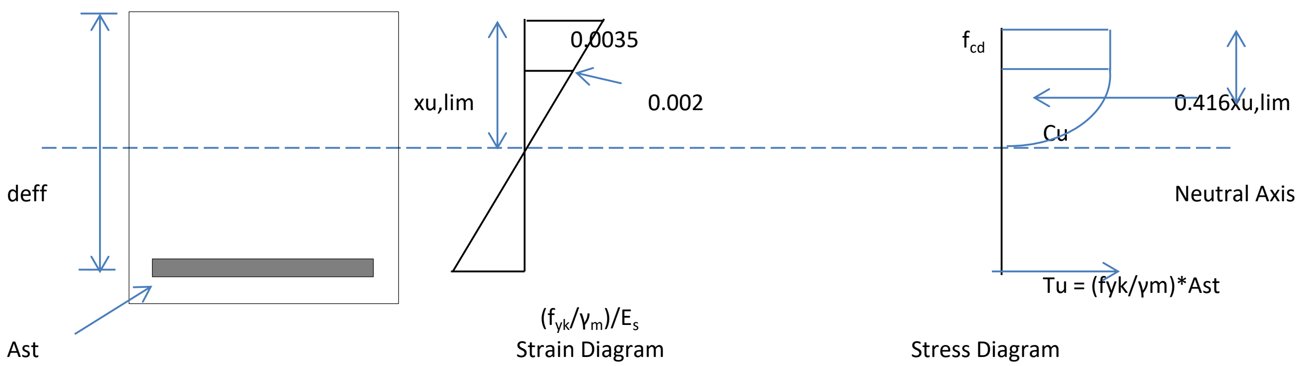
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	65.0		15.0	43		6
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	267.0		267.0
f_{cd}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



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

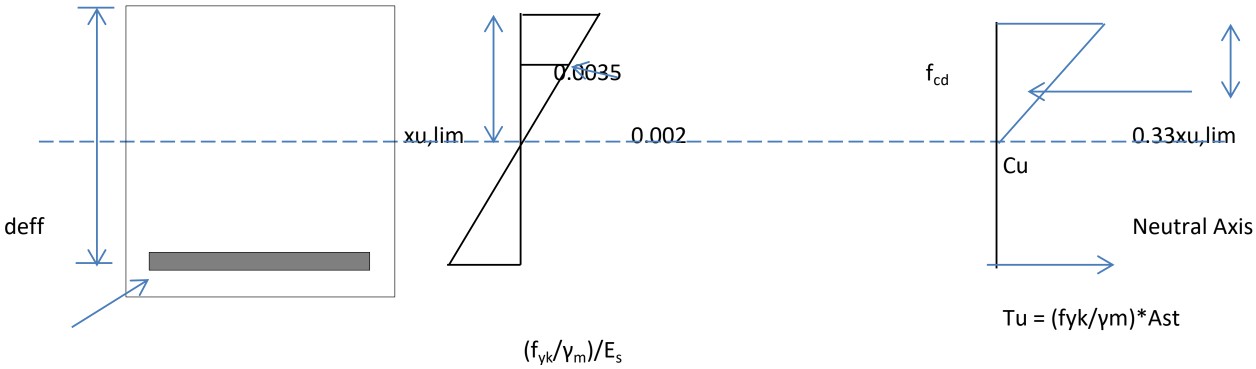
Clear cover = 75

	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

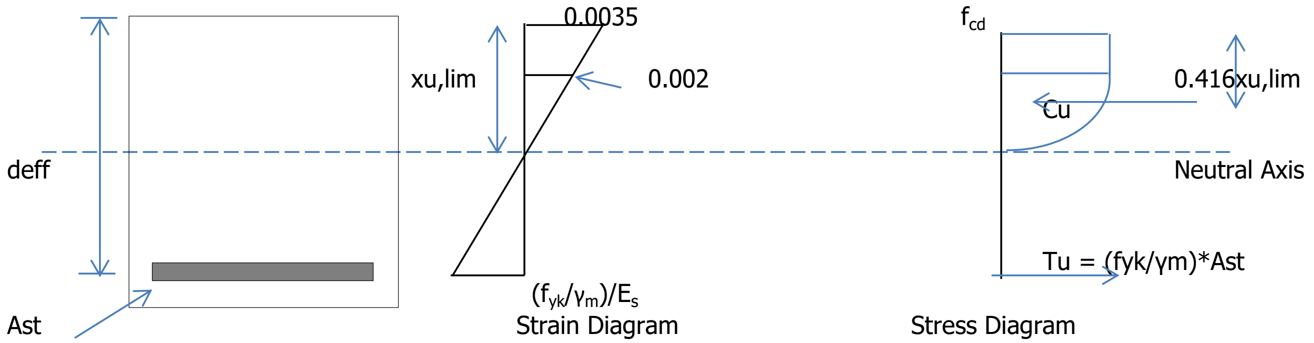
	Project	-	Designed by	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

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	

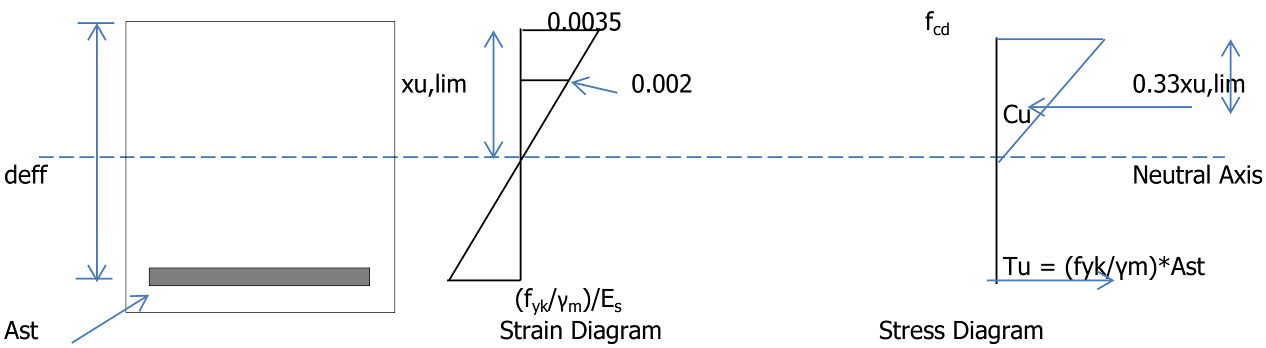
	Project	-	Designed by:	KB
	Client	-	Checked by:	-
	Job Name	RCC BOX OF SIZE 2 x 2 x 2	Date & Rev.	-

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
$\Theta = 0.5 \times \sin^{-1}$ (Applied shear stress / 0.135/fck/(1-fck/310))	
Min angle of inclination, Θ (deg)	21.8
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010	
K = 1+Sqrt(200/d) <= 2.0	1.925
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010	
$\nu_{min} = 0.031\ K^{3/2}\ fck^{1/2}$	0.490
cl. 10.3.1 of IRC :112-2011	
$\rho 1 = A_{sl}/(b_w\ d) <= 0.02$	0.003
	OK
$0.12\ K\ (80\ \rho 1\ f_{ck})^{0.33}$	0.454
Axial compressive force N_{Ed} (KN)	18
$\sigma_{cp} = N_{Ed} / A_c <= 0.2\ f_{cd}$	0.1
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010	
$V_{Rd.c} = [0.12K(80\rho 1\ f_{ck})^{0.33} + 0.15\sigma_{cp}]b_w d <= (\nu_{min} + 0.15\ \sigma_{cp})\ b_w\ d$ (KN)	108
	OK

5.4.2 Verification for serviceability limit state for inner wall



SERVICEABILITY LIMIT STATE

Grade of Concrete	f_{ck}	=	35	N/mm^2	
As per clause 12.2.1, IRC:112-2011					
	f_{cd}	=	16.80	N/mm^2	For Rare Combination
	f_{cd}	=	16.80	N/mm^2	For Frequent Combination
	f_{cd}	=	12.60	N/mm^2	For Quasi-Perma. Combination
As per clause 12.2.2, IRC:112-2011					
Grade of steel	f_Y	=	500	N/mm^2	
	f_{Yd}	=	300	N/mm^2	For Rare Combination
	f_{Yd}	=	300	N/mm^2	For Frequent Combination
	f_{Yd}	=	300	N/mm^2	For Quasi-Perma. Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 32000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

	Rare Comb	Frequent Comb	Quasi-Perma. Comb
xu,sls/d	0.70	0.70	0.70
$R_{sls} = M_{u,sls}/bd^2$	4.52	4.52	3.39

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 50

Moment on the section	**Bottom End support**			**Top End support**		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	31.0		1.0	20		1
b	1000		1000	1000		1000
D	300		300	300		300
c	50		50	50		50
d	234.0		234.0	234.0		234.0
f_{cd}	16.80		12.60	16.80		12.60
f_{Yd}	300		300	300		300
xu,sls/d	0.70		0.70	0.70		0.70
$R_{sls} = M_{u,sls}/bd^2$	4.52		3.39	4.52		3.39
$M_{u,sls}$ (KNm)	248		186	248		186
	OK		**OK**	**OK**		**OK**
Ast Req.	452		14	289		14
Dia of bar (main tension) (mm)	12		12	12		12
Spacing (mm)	175		175	175		175
+ dia of bar (main tension) (mm)	0		0	0		0
Spacing (mm)	175		175	175		175
Ast provided (sq mm)	646		646	646		646
Dia of bar (main compresion) (mm)	12		12	12		12
Spacing (mm)	175		175	175		175
Area of main compresion (mm^2)	646		646	646		646
f_{ctm}	2.8		2.8	2.8		2.8
x (mm)	23.1		30.8	23.1		30.8
x/d	0.099		0.132	0.099		0.132
	OK		**OK**	**OK**		**OK**
z (mm)	226		224	226		224
MR_{sls} (KNm)	44		43	44		43
	OK		**OK**	**OK**		**OK**
$\sigma_{sc} = M/(A_s z)$	212		7	137		7
	OK		**OK**	**OK**		**OK**
$\sigma_{ca} = M/(0.8095 z b x_u)$	11.87		0.29	7.66		0.29
	OK		**OK**	**OK**		**OK**

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

Calculation of crack width	**Bottom End support**			**Top End support**		
n_1			6			6
n_2			6			6
$\phi_{eq} = (n_1\phi_1^2 + n_2 \phi_2^2) / (n_1\phi_1+n_2\phi_2)$			12			12
cl. 12.3.4 (3) of IRC :112-2011						
c			50			50
k1			0.8			0.8
k2			0.50			0.50
For skew slab refer eq. 12.10 of IRC :112-2011						
$\rho_{p.eff} = A_s / A_{c,eff}$			0.005			0.005
$S_{r,max} = \{ 3.4\ c + (0.425\ k_1\ k_2\ \phi) / \rho_{p.eff} \}$			612			612
cl. 12.3.4 (3) of IRC :112-2011						
k_t			0.5			0.5
$f_{ct,eff}$			2.90			2.90
E_s			200000			200000
E_{cm}			32000			32000
$\alpha_e = E_s / E_{cm}$			6.25			6.25
$(\varepsilon_{sm}-\varepsilon_{cm})=(\sigma_{sc}-k_t\ f_{ct,eff}(1+\alpha_e\ \rho_{p,eff})/\rho_{p,eff})/E_s$ $>=0.6\sigma_{sc}/E_s$			0.0000			0.0000
cl. 12.3.4 (2) of IRC :112-2011						
$W_k = S_{r,max}\ (\varepsilon_{sm} - \varepsilon_{cm})$			0.01			0.01
cl. 12.3.4 (1) of IRC :112-2011						
			OK			**OK**

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 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.**	-

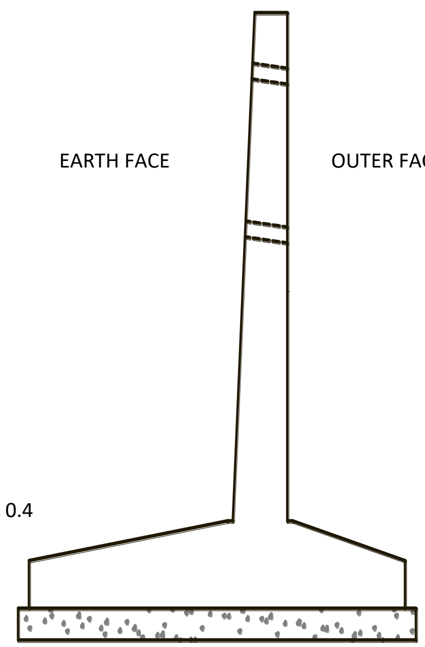
DESIGN OF STRAIGHT BREAST WALL FOR HEIGHT 3 M FROM G.L

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

Load Factors (As per IRC:6-2014)

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination
Dead Laod+SIDL except wearing course	1.350
Wearing Course only	1.750
Back Filling Weight	1.500
Earth Pressure due to back filling	1.500
Live Load Surcharge	1.200

Table 3.3 Partial Safety Factor For Verification of Servicibilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination
Dead Laod+SIDL except wearing course	1.35
Wearing Course only	1.750
Back Filling Weight	1.350
Earth Pressure due to back filling	1.500
Live Load Surcharge	1.200

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

VOLUME CALCULATION

C.G. Of Footing = 1.825 m

C.G. Of shaft from toe tip = 1.375 m

Distance between c.g. Of shaft and footing = 0.45 m

Description	No.	LENGTH		WIDTH	HEIGHT		VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe
		m		m	m		m^3	m	m	m
Shaft	1	1.00		0.425	4.500		1.913	0.056	0.506	-1.319
Footing										
Heel Slab	1	1.00		2.000	0.400		0.800		-0.727	-2.552
Toe Slab	1	1.00		1.100	0.400		0.440		1.221	-0.604
Portion between Heel and Toe	1	1.00		0.500	0.500		0.250		0.450	-1.375
Back filling over Heel Slab	1	1.00		2.000	4.600		9.200		-0.771	-2.596
Front Filling over Toe Slab	1	1.00		1.100	1.600		1.760		1.280	-0.545
Back fill on flared portion of stem	1	1.00		0.250	4.500		0.563		0.258	-1.567
				L				eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barrier	1	0	kN/m	1.000	0	kN		0.275	0.725	-1.100

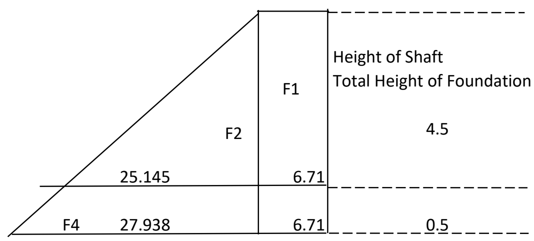
Project	-	*Designed by:*	*KB*	
Client	-	*Checked by:*	-	
Job Name	*Design of Breast Wall for height 3 m from G.L*	*Date & Rev.*	-	

Earth Pressure : Normal Dry Case

Properties of backfill material :

c	=	0						
ϕ	=	**30**	degree	0.524	radians	0.866	0.5	0.333333
θ	=	86.37	degree	1.507	radians	0.063		
α	=	90	degree	1.571	radians	0.000		
β	=	0	degree	0.000000000	radians	1.000		
δ	=	**20**	degree	0.349	radians	0.940		
Kah	=	0.279	active component					0.279384
Kph	=	5.737	Passive component					
γ	=	20	kN/m3					
Equivalent Live Load Surcharge height	=	1.2	m					

Assuming



100 (Deck Level)

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

95.5 shaft bottom level

95 Foundation Lvl.

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

@ RL 95 m (at Foundation Level)

Due to Live Load Surcharge

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

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

=	0.279	x	20	x	4.5	=		25.145	kN/m^2
F2 =	0.5	x	25.145	x	4.5	x	1	=	**56.575** KN

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC 6-2000

M2 =	56.575	x	1.89	=	**106.927**	**kN.m**	**at Shaft Bottom**

Intensity for triangular portion (At Foundation level)

=	0.279	x	20	x	5	=		27.938	kN/m^2
F4 =	0.5	x	27.938	x	5	x	1	=	**69.846** KN
M4 =	69.846	x	2.1	=	**146.676**	**kN.m at Foundation**			

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014 Y fluid = 4.8 kN/m3

Intensity for triangular portion (At Shaft bottom level)

=	4.8	x	4.5	=	21.600	kN/m^2			
F =	0.5	x	21.600	x	4.5	x	1	=	**48.600** KN
M =	48.600	x	1.5	=	**72.900**	**kN.m at Shaft Bottom**			

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

Intensity for triangular portion (At Foundation level)

=	4.8	x	5	=	24.000	kN/m^2				
F =	0.5	x	24.000	x	5	x	1	=	60.000 KN	
M =	60.000	x	1.67	=	100.000	kN.m at Foundation				

Intensity of Passive pressure (Considered half depth of embedment of footing)

=	5.7371596	x	20	x	2	=		**229.486**	**kN/m^2**

Force due to passive @ Foundation, F

=	0.5	x	229.486	x	2	x	1	=	229.486 KN

Moment due to passive @ Foundation, M

=	229.486	x	0.667	=	**152.991**	**kN.m at Foundation**

Summary of Moment and Horizontal Force

		MOMENTS		HORIZONTAL FORCE	
	Consider (Y or N)	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl Kn	At Foundation Lvl kN
Due to active Earth Pressure	Y	106.927	146.676	56.575	69.846
Due to Minimum Fluid Pressure	Y	72.900	100.000	48.600	60.000
Governing of Two	Y	**106.927**	**146.676**	**56.575**	**69.846**
Due to Live Load Surcharge	Y	67.890	83.815	30.173	33.526
Due to Passive pressure	N		0.000		0.000

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

Stability Check of Foundation

Foundation Lvl = 95.000 m

Properties of Footing Base:

		B		L			
A	=	3.650	x	1.000	=	3.650	m^2
ZL	=	1.000	x	2.220	=	2.220	m^3
ZT	=	3.650	x	0.167	=	0.608	m^3

Normal Dry Case

For SBC Calculation_ For Equilibrium Calculation

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
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
Client	-	Checked by:	-
Job Name	Design of Breast Wall for height 3 m from G.L	Date & Rev.	-

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

Check Against Sliding:

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

Check Against Overturning

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

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

Design of Foundation

Foundation Lvl = 95.000 m

Properties of Footing Base:

A = 3.650 m^2

ZL = 2.220 m^3

ZT = 0.608 m^3

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1.35	25	1.913	64.547	0.450	29.046
Back filling over heel slab	1.350	20	9.200	248.400	-0.771	-191.61
Back filling on flared portion of shaft	1.350	20	0.563	15.188	0.129	1.96
Front Filling over toe slab	1.350	20	1.760	47.520	1.280	60.823
RCC Railing or Crash Barrier	1.35			0.000	0.725	0.000
Heel slab	1.35	25	0.800	27.000	-0.727	-19.63
Toe slab	1.35	25	0.440	14.850	1.221	18.13301471
portion between heel & toe	1.35	25	0.250	8.438	0.450	3.797
Total				425.942		-97.480

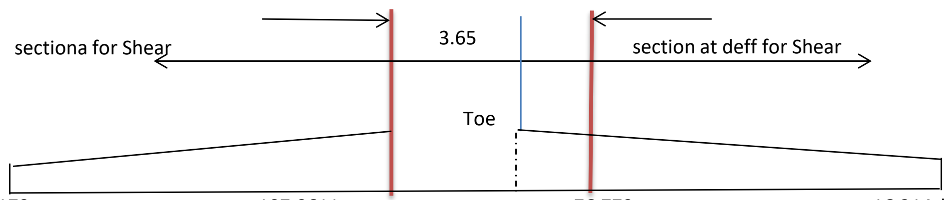
		load factor					
Moment due to active earth pressure	=	1.500	x	146.6764098	=	220.015	kNm
Moment due to Live load surcharge	=	1.200	x	83.8151	=	100.578	kNm
						320.593	

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

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

Normal Dry Case

Ultimate Base Pressure (kN/m^2)	**Max**	**217.179**
	Min	**16.214**



Normal Dry Case

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=	162.12 kN/m2												
Upward moment due to Base pressure	=	324.24 kNm/m												
	factor			VOL										
Downward moment due to backfill	=	1.350	x	9.2	/	1	x	20	x	1	=	248.400	kNm/m	
Downward moment due to self weight of Heel	=	1.35	x	0.8	/	1	x	25	x	0.902	=	24.353	kNm/m	
Net Moment at face of shaft	=	324.24	-248.40	-24.35		51.49	kNm/m	OK						

Heel Slab - Shear Calculation at Face of Wall

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

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

Average Base Pressure for Design of Toe Slab												
	=	46.50	kN/m2									
Upward moment due to Base pressure	=	28.13	kNm/m									
Downward moment due to self weight of Toe	=	1.35	x	0.44	/	1	x	25	x	0.496	=	7.367 kNm/m
Net Moment at face of shaft	=	28.13		-7.367	=	20.764	kNm/m	OK				

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

Toe Slab - Shear Calculation at deff from Face of Wall

For shear, critical section is assumed to be located at a distance equal to effective depth from face of wall

Depth of slab at critical section	=	0.455	m													
effective depth at critical section	=	0.374	m													
Base pressure at deff from face of wall	=	50.956	kN/m2													
upward shear force due to base pressure	=	33.585	x		0.681	x	1	=	22.872	kN						
C.g. Of base pressure	=	4.144	m													
moment due to upward pressure at critical section	=	94.780	kNm													
tanb		0.182														
reduction in shear force (Vccd)		M tanb / d		=	37.89	KN										
Downward force due to self weight of toe slab	=	1.35		x	0.377386364	x	0.681	x	1	x	25	=	8.674	KN		
Net Shear Force at deff	=	22.872		-8.674	-37.8928637	=	-23.695	KN								
Net Shear Force / unit meter	=	-23.695		/	1	=	-23.695	KN/m								

Design Input :

Design length	=	1000	mm		
Clear Cover	=	75	mm		
Grade of Concrete for Footing	=	M 30			
fck	=	30	N/mm²		30
fctm	=	2.5	N/mm²		
Ec	=	27386.13	N/mm²		
Grade of Reinforcement Steel	=	500.00	Fe D	(HYSD Bars)	
fy or fyk	=	500.00	N/mm²		
fyd	=	434.78	N/mm²	(fy/1.15)	
Es	=	200000.00	N/mm²		

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

Flexural Reinforcement Calculation:

		Heel Slab	Toe Slab
Ultimate bending moment,Mu (kNm/m)	=	51.487	20.76
Effective depth required (dreq) (mm)	=	111.52	70.82
Effective depth provided (dpro) (mm)	=	419.00	419.00
Check for provided depth	=	SAFE	SAFE
R = Mu/(b d2)	=	0.29	0.12
Total depth provided (mm)	=	500.00	500.00
Limiting depth of neutral axis (mm)	=	259.78	259.78
Actual depth of neutral axis (mm)	=	37.94	37.94
Check for Neutral axis depth	=	OK	OK
Lever arm (z) , mm	=	403.07	403.07
Moment of Resistance w.r.to steel	=	165.16	165.16
Check for Moment Capacity	=	SAFE	SAFE
Ast reqd (mm2 / m)	=	316.974	127.755
cl. 16.6.1 (2) of IRC :112-2011			
AS.min = 0.26 fctm bt d / fyk >= 0.0013 bt d	=	544.70	544.70
Governing Ast (mm2 / m)	=	544.70	544.70
Tension Reinforcement			
Dia (mm)	=	12.00	12.00
Spacing (mm)	=	207.53	207.53
Spacing provided	=	180.00	180.00
+ Dia (mm)	=	0.00	0.00
Spacing (mm)	=	180.00	180.00
Ast provided (mm2 / m)	=	628.24	628.24
Check for Ast provided	=	OK	OK
As per Clause 16.6.1.1. of IRC:112-2011 , Secondary Reinforcement shall be at least 20 % of the main reinforcement			
Secondary Reinforcement (mm2/m)	=	125.65	125.65
Dia (mm)	=	10.00	10.00
Spacing (mm)	=	200.00	200.00
Ast provided (mm2 /m)	=	392.65	392.65
Check for Ast provided	=	OK	OK

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

Shear Reinforcement Calculation:

		Heel Slab	Toe Slab	
Ultimate Shear Force (VEd)	=	48.840	-23.695	kN/m
Ast provided	=	628.240	628.24	mm2/m
Depth of slab at critical section	=	500.000	454.773	mm
Effective depth at critical section	=	419.000	373.773	mm
percentage of steel provided (r1)	=	0.0022	0.0023	
cl. 10.3.1 of IRC :112-2011				
r1 = $A_{sl}/(b_w d)$ <= 0.02	=	OK	OK	
Actual shear stress=vED = (VEd/b*0.9d)	=	0.130	0.070	N/mm2
Max shear capacity, 0.135 fck(1-fck/310)	=	3.658	3.658	N/mm2
Depth Check for Shear Resistance	=	SAFE	SAFE	
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010				
K = 1+Sqrt(200/d) <= 2.0	=	1.691	1.731	
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010				
V_{min} = 0.031 K3/2 fck1/2	=	0.373	0.387	N/mm2
0.12 K (80 r1 fck)^0.33	=	0.351	0.366	N/mm2
scp = NEd / Ac <= 0.2 fcd	=	0.000	0.000	
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010				
$V_{Rd.c}$ = [0.12K(80ρ1 fck)^0.33 + 0.15σcp]b_wd subjected to minimum (v min + 0.15 σcp) b_w d	=	147.26	136.76	kN
Check for Shear Reinforcement		No Shear R/f required	No Shear R/f required	

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

SLS CHECK OF FOUNDATION

Foundation Lvl = 95.000 m

Properties of Footing Base:

A	=	3.650	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

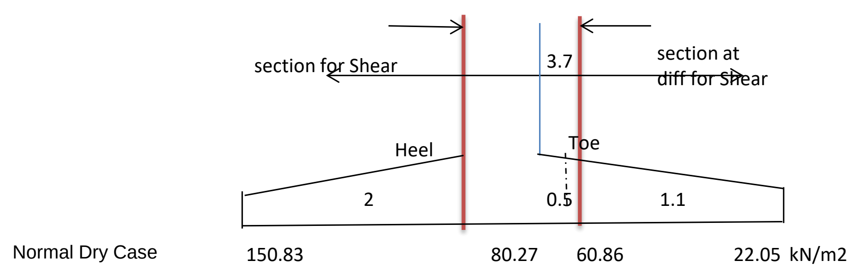
Normal Dry Case

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



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

Calculation of Forces For Design of Wall

Wall bottom level = 95.5 m

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL) (m)	ML = PxeL (kNm)
Shaft	1.35	25	1.913	64.546875	0.056	3.639
RCC Railing or Crash Barrier	1.35			0	0.275	0.000
Total				**64.547**		**3.639**

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

Total Horizontal Force = 121.07 KN

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

Total Moment due to Horizontal Force = 326.637 kNm

Summary of Forces:

P	64.547	KN
ML	330.276	kNm
FL	121.071	KN

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

Design of Wall:

Grade of Concrete = 30.00 M 30

fck = 30.00 N/mm2

fcd = 13.40 N/mm2

Grade of steel 500.00 Fe

fy = 500.00 N/mm2

fyd = 434.78 N/mm2

Es = 200000.00 N/mm2

Cross section of Wall:

Thickness of Wall (B) = 0.55 m

Depth of Wall (D) = 1 m

Area of Concrete (Ac) = 0.55 m2

Clear Cover to earth faces = 75 mm

Clear Cover to non earth faces = 40 mm

Maximum Dia of Vertical Reinf. = 16 mm

Dia of Horizontal Reinf. = 12 mm

Summary of Design Forces:

	P(kN)	ML (kNm)	FL (kN)
Case 1 : Normal Dry Case	64.55	330.28	121.07
MAX	64.55	330.28	121.07

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = 64.55 kN

0.1 fcd Ac

= 0.1 13.4 550000

= 737000 N

= 737.0 kN

Since Axial Force is less than axial capacity of section , Section will design as bending element . Neglecting axial force

PART 1: LONGITUDINAL MOMENT : VERTICAL REINFORCEMENT ON EARTH FACE

Ultimate Design bending moment (ML) = 330.28 kNm = 330.28 kNm/m

Check For Depth of Wall :

Mult = 0.167 x fck x b x d^2

= 330.28 kNm/m

b = 1000 mm

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

(dreq) 256.76 mm

Total Depth Required (Dreq) = 339.76 mm

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

Effective depth provided(deff) = 467 mm

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

Minimum Longitudinal Reinforcement in wall on each face

=

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

Ast min = 660 mm2/m

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

SLS CHECK OF WALL

Foundation Lvl = 95.5 m

Creep Coeff (¢ = 1.2 For Dry atmosperic condition

Ecm = 31000

Es = 200000 N/mm2

Eceff = Ecm / (1 + ø) = 14090.90909

Modular Ratio (m) = Es/ Eceff = 14.19

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL) (m)	ML = PxeL (kNm)
Shaft	1.000	25	1.913	47.8125	0.056372549	2.695313
RCC Railing or Crash Barrier	1.000			0	0.275	0
Total				**47.813**		**2.695**

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

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

Summary of Forces:

P	47.813	KN
ML	163.935	kNm
FL	80.714	KN

Bending Moment, M	=	163.93	kNm
Dx	=	1.00	m
Dy	=	0.55	m
Section Modulus (ZL) of uncracked secti	=	0.05	m3
Bending Stress (M/ZL)	=	3.252	N/mm2
Tensile stress of concrete , fctm	=	2.500	N/mm2
Cracked or Uncracked Section	**=**	**Cracked**	
Section properties of Cracked section:			
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.			
Clear Cover, c	=	75.000	mm
Maximum dia used (Vertical), f	=	16.000	mm
Horizontal Reinf. Dia used	=	12.000	mm
Effective Depth deff (dy)	=	467.000	mm
Ast provided	=	2094.133	mm2/m
Percentage of steel , pt	=	0.0071	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.359	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	167.664	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	299.336	mm

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

Project	-	Designed by:	KB
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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 / $\rho_{p\ eff}$
K1	=	0.700	for deformed b
K2	=	0.500	for bending
depth of neutral axis , yc	=	167.664	mm
$\rho_{r\ eff}$ = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.	
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	207.500	mm
Ac, eff = Dx * hc,eff	=	207500.000	mm
$\rho_{r\ eff}$ = As/Ac eff	=	0.010	
Maximum crack spacing , $S_{r\ max}$	=	490.825	mm
(ε_{sm} - ε_{cm})	=	σsc - kt fct eff (1 + αe r r eff) / r r eff	/ Es
tensile stress in steel, ,σsc	=	172.295	N/mm2
Kt	=	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.500	N/mm2
αe = Es/Ecm	=	6.452	
(εsm - εcm)	=	0.00020	
Crack width , Wk=Sr max (εsm - εcm)	=	**0.099**	
Check	=	**SAFE**	

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

Stability Check Summary

Description	P (kN/m2 max)	P (kN/m2 min)	Sliding	Overturning	Shear (Heel slab)	Shear (Toe slab)
Normal Dry case	159.60	13.29	1.53	2.79	0.130	-0.070
Permissible	220	0	1.5	2	3.658	3.658
Remarks	OK	OK	OK	OK	OK	OK

Reinforcement summary

Type of reinforcement	Area of steel required	Area of steel provided						
Straight Portion of Shaft								
Vertical steel at earth face	2041	16	mm bar @	150	mm c/c (i.e.)	2094	mm2	OK
		12	mm bar @	150	mm c/c (i.e.)			
Vertical steel at non-earth face	660	12	mm bar @	150	mm c/c (i.e.)	754	mm2	OK
Distribution steel	712	12	mm 2 Legged bar @	200	mm c/c (i.e.)	1130	mm2	OK
Heel Slab								
Main steel at top face	545	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
		0	mm bar @	180	mm c/c (i.e.)			
Steel at bottom face	250	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
Distribution reinforcement	126	10	mm bar @	200	mm c/c (i.e.)	393	mm2	OK
Shear Reinforcement	No Shear R/f required							
Toe Slab								
Main steel at bottom face	545	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
		0	mm bar @	180	mm c/c (i.e.)			
Steel at top face	250	12	mm bar @	180	mm c/c (i.e.)	628	mm2	OK
Distribution reinforcement	126	10	mm bar @	200	mm c/c (i.e.)	393	mm2	OK
Shear Reinforcement	No Shear R/f required							

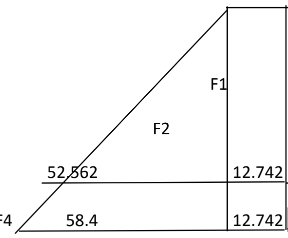
Earth Pressure : Normal Dry Case

Properties of backfill material :

c	=	0				
ϕ	=	**30**	degree	0.524	radians	0.866
θ	=	87.11	degree	1.520	radians	0.050
θ1	=	90	degree	1.571	radians	0.000
β	=	26.5	degree	0.462512252	radians	0.895
δ	=	**20**	degree	0.349	radians	0.940
Kah	=	0.279	active component			
Kph	=	5.737	Passive component			
γ	=	20	kN/m3			
Equivalent Live Load Surcharge height	=	1.2	m			

Assuming

100 (Deck Level)



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

4.5

95.5 shaft bottom level

0.5

95 Foundation Lvl.

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

DESIGN OF STRAIGHT RETAINING WALL FOR HEIGHT 5 M FROM G.L

INDEX

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

Design Input:

Skew Angle of Bridge 0 Degree 0 Radians COS θ = 1

SIN θ = 0

Design Length of Wall = 1.000 m

Levels

FRL = 100.000 m (Assumed)

Wall shaft top level = 100.000 m

Ground level/LBL/MSL = 95.000 m (Assumed)

Foundation level = 93.000

Shaft bottom level = 93.550 m

Coeff. Of Friction μ = 0.500

FRL - FND LVL. H = 7.000 m

SBC of soil-Normal Case = 220.000 kN/m2

Permissible FOS against Sliding = 1.500 Normal Case

Permissible FOS against Overturning = 2.000 Normal Case

Wall

Thickness of Wall shaft at Top = 0.300 m

Thickness of Wall shaft at Bottom = 0.700 m

Foundation

Total Width of Footing = 4.600 m

Width of Toe Slab = 1.500 m

Width of Heel Slab = 2.400 m

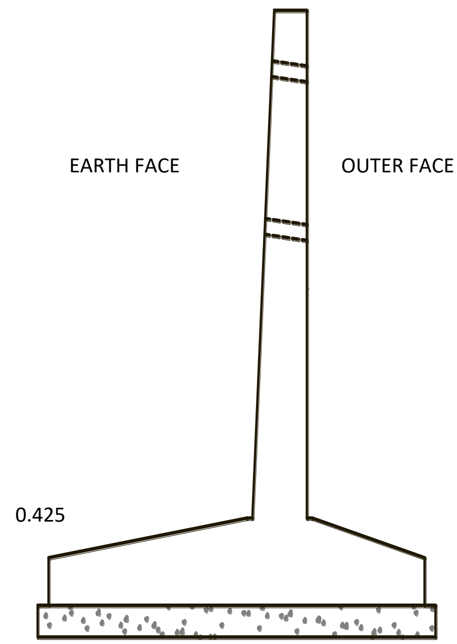
Thickness of Toe slab at tip = 0.300 m

Thickness of Toe slab near shaft = 0.550 m

Thickness of heel slab at tip = 0.300 m

Thickness of heel slab near shaft = 0.550 m

Depth of Footing below GL = 2.000 m



Material Specification

Concrete Grade = 30 M

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

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

Tensile strength of concrete , fctm = 2.50 Mpa

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

Ultimate Strain, $\varepsilon cu2$ = 0.035

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

Ecm = 31000 N/mm2

Steel Grade = 500 Fe (HYSD Steel) D

Yield Strength of Reinforcement, fy or fyk = 500 Mpa

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

Modulus of Elasticity of Steel (Es) = 200000 Mpa

Dry weight of Concrete = 25 kN/m^3

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

Permissible Crack Width = 0.3 mm - For Moderate Exposure Condition

Maximum compressive stress in concrete under rare combination = 0.48 fck

= 14.4 N/mm^2

Maximum tensile stress in steel under rare combination = 0.8 fyk

= 400 N/mm^2

σcbc = 10.00

σst = 240

m = 9.3333333

k = 0.280

j = 0.907

Q = 1.27

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

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

Load Factors (As per IRC:6-2014)

Table 3.2 Partial Safety Factor For Verification of Structural Strength: Ultimate Limit State

-Refer Table 3.2 of IRC:6-2014

Loads	Basic Combination
Dead Laod+SIDL except wearing course	1.350
Wearing Course only	1.750
Back Filling Weight	1.500
Earth Pressure due to back filling	1.500
Live Load Surcharge	1.200

Table 3.3 Partial Safety Factor For Verification of Servicibilty Limit State

-Refer Table 3.3 of IRC:6-2014

Loads	Rare Combination	Frequent Combination	Quasi-Permanent Combination
Dead Laod+SIDL including wearing course	1.000	1.00	1.00
Back Filling Weight	1.000	1.00	1.00
Shrinkage Creep Effect	1.000	1.00	1.00
Earth Pressure due to back filling	1.000	1.000	1.000
Live Load Surcharge	0.800	0.00	0.00

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

Loads	Basic Combination
Dead Laod+SIDL except wearing course	1.35
Wearing Course only	1.750
Back Filling Weight	1.350
Earth Pressure due to back filling	1.500
Live Load Surcharge	1.200

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

VOLUME CALCULATION

C.G. Of Footing = 2.3 m

C.G. Of shaft from toe tip = 1.85 m

Distance between c.g. Of shaft and footing = 0.45 m

Description	No.	LENGTH		WIDTH	HEIGHT		VOLUME	Ecce.(eL) @ abut. Shaft	Ecce.(eL1) @ c.g.of footing	Ecce.(eL2) @ Toe
		m		m	m		m^3	m	m	m
Shaft	1	1.00		0.500	6.450		3.225	0.087	0.537	-1.763
Footing										
Heel Slab	1	1.00		2.400	0.425		1.020		-0.940	-3.240
Toe Slab	1	1.00		1.500	0.425		0.638		1.450	-0.850
Portion between Heel and Toe	1	1.00		0.550	0.550		0.303		0.450	-1.850
Back filling over Heel Slab	1	1.00		2.400	6.575		15.780		-1.004	-3.304
Front Filling over Toe Slab	1	1.00		1.500	1.575		2.363		1.558	-0.742
Back fill on flared portion of stem	1	1.00		0.400	6.450		1.290		0.233	-2.067
				L				eL	eL1	eL2
RCC Railing/Parapet Wall Weight/Crash Barrier	1	0	kN/m	1.000	0	kN		0.350	0.800	-1.500

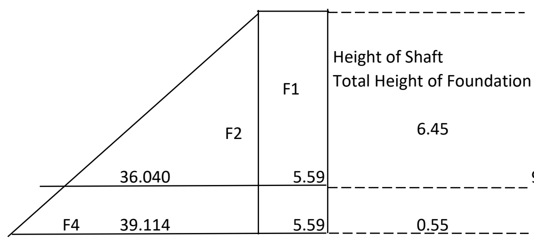
Project	-	Designed by:	KB
Client	-	Checked by:	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	Date & Rev.	-

Earth Pressure : Normal Dry Case

Properties of backfill material :

c	=	0						
ϕ	=	**30**	degree	0.524	radians	0.866	0.5	0.333333
θ	=	86.37	degree	1.507	radians	0.063		
α	=	90	degree	1.571	radians	0.000		
β	=	0	degree	0.000000000	radians	1.000		
δ	=	**20**	degree	0.349	radians	0.940		
Kah	=	0.279	active component					0.279384
Kph	=	5.737	Passive component					
γ	=	20	kN/m3					
Equivalent Live Load Surcharge height	=	1.2	m					

Assuming



100 (Deck Level)

Height of Shaft	6.45	m	6.45
Total Height of Foundation	7	m	7

6.45

93.55 shaft bottom level

93 Foundation Lvl.

Horizontal Forces and Moments @ RL 93.55 m (at Shaft Base)

@ RL 93 m (at Foundation Level)

Due to Live Load Surcharge

Intensity for = rectangular portion	0.279	x	20	x	1.2	=	5.59	kN/m^2
F1 =	5.5876728	x	6.45	x	1	=	36.040	kN
M1 =	36.040	x	3.225	=	116.231	**kN.m at Shaft Bottom**		
F3 =	5.5876728	x	7	x	1	=	39.114	kN
M3 =	39.114	x	3.5	=	136.898	**kN.m at Foundation**		

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

=	0.279	x	20	x	6.45	=		36.040	kN/m^2
F2 =	0.5	x	36.040	x	6.45	x	1	=	**116.231** KN

(Centre of pressure considered at an elevation of 0.42m of the height of the shaft as per cl. 217.1 of IRC 6-2000

M2 =	116.231	x	2.71	=	**314.869**	**kN.m**	**at Shaft Bottom**

Intensity for triangular portion (At Foundation level)

=	0.279	x	20	x	7	=		39.114	kN/m^2
F4 =	0.5	x	39.114	x	7	x	1	=	**136.898** KN
M4 =	136.898	x	2.94	=	**402.480**	**kN.m at Foundation**			

Force Due To Fluid Pressure

As per Cl. 214.1 of IRC :6 -2014	Y fluid	=	4.8	kN/m3

Intensity for triangular portion (At Shaft bottom level)

=	4.8	x	6.45	=	30.960	kN/m^2			
F =	0.5	x	30.960	x	6.45	x	1	=	**99.846** KN
M =	99.846	x	2.15	=	**214.669**	**kN.m at Shaft Bottom**			

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

Intensity for triangular portion (At Foundation level)

= 4.8 x 7 = 33.600 kN/m^2

F = 0.5 x 33.600 x 7 x 1 = 117.600 KN

M = 117.600 x 2.33 = 274.400 kN.m at Foundation

Intensity of Passive pressure (Considered half depth of embedment of footing)

= 5.7371596 x 20 x 2 = **229.486** **kN/m^2**

Force due to passive @ Foundation, F

= 0.5 x 229.486 x 2 x 1 = 229.486 KN

Moment due to passive @ Foundation, M

= 229.486 x 0.667 = **152.991** **kN.m at Foundation**

Summary of Moment and Horizontal Force

		MOMENTS		HORIZONTAL FORCE	
	Consider (Y or N)	At Shaft Bottom kN-m	At Foundation Lvl kN-m	At Shaft Bottom Lvl Kn	At Foundation Lvl kN
Due to active Earth Pressure	Y	314.869	402.480	116.231	136.898
Due to Minimum Fluid Pressure	Y	214.669	274.400	99.846	117.600
Governing of Two	Y	**314.869**	**402.480**	**116.231**	**136.898**
Due to Live Load Surcharge	Y	116.231	136.898	36.040	39.114
Due to Passive pressure	N		0.000		0.000

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

Stability Check of Foundation

Foundation Lvl = 93.000 m

Properties of Footing Base:

		B		L			
A	=	4.600	x	1.000	=	4.600	m^2
ZL	=	1.000	x	3.527	=	3.527	m^3
ZT	=	4.600	x	0.167	=	0.767	m^3

Normal Dry Case

For SBC Calculation **For Equilibrium Calculation**

Loads	Load Factor	Unit Weights (kN/m^3)	Volume (m^3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)	Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
Shaft	1.000	25	3.225	80.625	0.537	43.269	1.000	80.625	-1.763	-142.169
Back filling over heel slab	1.000	20	15.780	315.6	-1.004	-316.844	1.000	315.6	-3.304	-1042.724
Back filling on flared portion of shaft	1.000	20	1.290	25.8	0.233	6.020	1.000	25.8	-2.067	-53.320
Front Filling over toe slab RCC Railing or Crash Barrier or	1.000	20	2.363	47.25	1.558	73.593	1.000	47.25	-0.742	-35.082
Crash Barrier	1.000			0	0.8	0.000	1.000	0	-1.5	0.000
Heel slab	1.000	25	1.020	25.5	-0.940	-23.970	1.000	25.5	-3.240	-82.620
Toe slab	1.000	25	0.638	15.9375	1.450	23.109	1.000	15.9375	-0.850	-13.547
portion between heel & toe	1.000	25	0.303	7.5625	0.45	3.403	1.000	7.5625	-1.85	-13.991
Total				518.275		-191.420		518.275		-1383.453

For Safe Bearing Capacity Calculation :

load factor

Moment due to active earth pressure	=	1	x	402.480	x	402.480068	kNm
Moment due to Live load surcharge	=	1	x	136.898	x	136.897982	kNm
						539.378051	
Moment due to passive relief	=	1	x	**0**	=	0	
						539.378051	

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

P	518.275	KN	
ML	347.958	kNm	
MT	0	kNm	
A	4.600	m^2	
ZL	3.527	m^3	
ZT	0.767	m^3	
P/A+ML/ZL+MT/ZT (Max)	211.333	kN/m2	**SAFE**
P/A-ML/ZL-MT/ZT (Min)	14.004	kN/m2	**SAFE**

Check Against Sliding:

		load factor									
Due to Earth pressure	=	1.000	x	136.898	=	136.897982	KN				
Due to Live load Surcharge	=	1.000	x	39.114	=	39.1137093	KN				
						176.012					
Total Sliding Force	=	176.012 KN									
Total Restoring Force	=	mP + c.A + Fp =		0.5	x	518.275	+	0	=	259.1375	KN
FOS against sliding	=	1.5	>	1.5	SAFE						

Check Against Overturning

		load factor						
Moment due to active earth pressure	=	1 x		402.480	=	402.480	kNM	
Moment due to Live load surcharge	=	1 x		136.898	=	136.898	kNM	
						539.378		
Overturning Moment	=	539.378 kNm						
Restoring Moment	=	S P.e Toe+		Mp		=	1383.453	kNm
FOS against overturnng	=	2.5649034	>	2	**SAFE**			

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

Design of Foundation

Foundation Lvl = 93.000 m

Properties of Footing Base:

A = 4.600 m^2

ZL = 3.527 m^3

ZT = 0.767 m^3

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1.35	25	3.225	108.844	0.450	48.980
Back filling over heel slab	1.350	20	15.780	426.060	-1.004	-427.74
Back filling on flared portion of shaft	1.350	20	1.290	34.830	0.117	4.06
Front Filling over toe slab	1.350	20	2.363	63.788	1.558	99.350
RCC Railing or Crash Barrier	1.35			0.000	0.800	0.000
Heel slab	1.35	25	1.020	34.425	-0.940	-32.36
Toe slab	1.35	25	0.638	21.516	1.450	31.19765625
portion between heel & toe	1.35	25	0.303	10.209	0.450	4.594
Total				699.671		-271.914

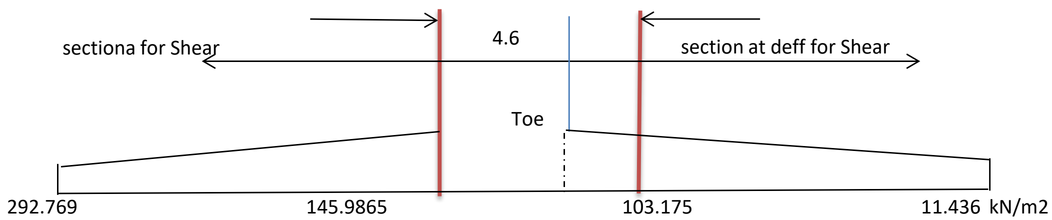
		load factor					
Moment due to active earth pressure	=	1.500	x	402.4800684	=	603.720	kNm
Moment due to Live load surcharge	=	1.200	x	136.8980	=	164.278	kNm
						767.998	

P	699.671	KN
ML	496.084	kNm
MT	0.000	kNm
A	4.600	m2
ZL	3.527	m3
ZT	0.767	m3
P/A+ML/ZL+MT/ZT (Max)	292.769	kN/m2
P/A-ML/ZL-MT/ZT (Min)	11.436	kN/m2

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

Normal Dry Case

Ultimate Base Pressure (kN/m^2)	**Max**	**292.769**
	Min	**11.436**



Normal Dry Case

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=		219.38 kN/m2											
Upward moment due to Base pressure	=		631.81 kNm/m											
	factor				VOL									
Downward moment due to backfill	=	1.350		x	15.78	/	1	x	20	x	1.2	=	511.272	kNm/m
Downward moment due to self weight of Heel	=	1.35		x	1.02	/	1	x	25	x	1.040	=	35.802	kNm/m

Net Moment at face of shaft	=	631.81	-511.27	-35.80	84.73	kNm/m	OK

Heel Slab - Shear Calculation at Face of Wall

Shear Force due to upward pressure at Face of wall	=	219.38	x	2.4	x	1	=	526.507	KN	
	factor									
Downward Force due to backfill	=	1.350	x	15.78	x	20	=	426.060	KN	
Downward Force due to self weight of Heel slab	=	1.35	x	1.02	x	25	=	34.425	KN	
Net Shear Force	=	526.507	-426.060	-34.425			=	**66.022**	KN	
Net Shear Force / unit meter	=	66.022	/	1			=	**66.022**	KN/m	

Toe Slab - Moment Calculation

Average Base Pressure for Design of Toe Slab													
	=	57.31	kN/m2										
Upward moment due to Base pressure	=	64.47	kNm/m										
Downward moment due to self weight of Toe	=	1.35	x	0.6375	/	1	x	25	x	0.650	=	13.985	kNm/m

Net Moment at face of shaft	=	64.47	-13.985	=	50.483	kNm/m	OK

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

Toe Slab - Shear Calculation at deff from Face of Wall

For shear, critical section is assumed to be located at a distance equal to effective depth from face of wall

Depth of slab at critical section	=	0.575	m													
effective depth at critical section	=	0.494	m													
Base pressure at deff from face of wall	=	65.317	kN/m2													
upward shear force due to base pressure	=	38.377	x		1.031	x	1 =		39.566 kN							
C.g. Of base pressure	=	4.144	m													
moment due to upward pressure at critical section	=	163.963	kNm													
tanb		0.167														
reduction in shear force (Vccd)		$\frac{M\ tanb}{d}$		=	47.53	KN										
Downward force due to self weight of toe slab	=	1.35		x	0.437466667	x	1.031	x	1	x	25	=	15.222	KN		
Net Shear Force at deff	=	39.566		-15.222	-47.53094	=	-23.187	KN								
Net Shear Force / unit meter	=	-23.187		/	1	=	-23.187	KN/m								

Design Input :

Design length	=	1000	mm		
Clear Cover	=	75	mm		
Grade of Concrete for Footing	=	M 30			
fck	=	30	N/mm²		30
fctm	=	2.5	N/mm²		
Ec	=	27386.13	N/mm²		
Grade of Reinforcement Steel	=	500.00	Fe D	(HYSD Bars)	
fy or fyk	=	500.00	N/mm²		
fyd	=	434.78	N/mm²	(fy/1.15)	
Es	=	200000.00	N/mm²		

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

Flexural Reinforcement Calculation:

		Heel Slab	Toe Slab
Ultimate bending moment,Mu (kNm/m)	=	84.734	50.48
Effective depth required (dreq) (mm)	=	143.06	110.43
Effective depth provided (dpro) (mm)	=	469.00	469.00
Check for provided depth	=	SAFE	SAFE
R = Mu/(b d2)	=	0.39	0.23
Total depth provided (mm)	=	550.00	550.00
Limiting depth of neutral axis (mm)	=	290.78	290.78
Actual depth of neutral axis (mm)	=	37.94	37.94
Check for Neutral axis depth	=	OK	OK
Lever arm (z) , mm	=	453.07	453.07
Moment of Resistance w.r.to steel	=	185.64	185.64
Check for Moment Capacity	=	SAFE	SAFE
Ast reqd (mm2 / m)	=	394.729	235.087
cl. 16.6.1 (2) of IRC :112-2011			
AS.min = 0.26 fctm bt d / fyk >= 0.0013 bt d	=	609.70	609.70
Governing Ast (mm2 / m)	=	609.70	609.70
Tension Reinforcement			
Dia (mm)	=	12.00	12.00
Spacing (mm)	=	185.40	185.40
Spacing provided	=	120.00	120.00
+ Dia (mm)	=	0.00	0.00
Spacing (mm)	=	120.00	120.00
Ast provided (mm2 / m)	=	942.36	942.36
Check for Ast provided	=	OK	OK
As per Clause 16.6.1.1. of IRC:112-2011 , Secondary Reinforcement shall be at least 20 % of the main reinforcement			
Secondary Reinforcement (mm2/m)	=	188.47	188.47
Dia (mm)	=	10.00	10.00
Spacing (mm)	=	200.00	200.00
Ast provided (mm2 /m)	=	392.65	392.65
Check for Ast provided	=	OK	OK

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

Shear Reinforcement Calculation:

		Heel Slab	Toe Slab	
Ultimate Shear Force (VEd)	=	66.022	-23.187	kN/m
Ast provided	=	942.360	942.36	mm2/m
Depth of slab at critical section	=	550.000	574.933	mm
Effective depth at critical section	=	469.000	493.933	mm
percentage of steel provided (r1)	=	0.0019	0.0019	
cl. 10.3.1 of IRC :112-2011				
r1 = $A_{sl}/(b_w d)$ <= 0.02	=	OK	OK	
Actual shear stress=vED = (VEd/b*0.9d)	=	0.156	0.052	N/mm2
Max shear capacity, 0.135 fck(1-fck/310)	=	3.658	3.658	N/mm2
Depth Check for Shear Resistance	=	SAFE	SAFE	
cl. 10.3.2(2) Eq. 10.2 of IRC :112-2010				
K = 1+Sqrt(200/d) <= 2.0	=	1.653	1.636	
cl. 10.3.2(2) Eq. 10.3 of IRC :112-2010				
V_{min} = 0.031 K3/2 fck1/2	=	0.361	0.355	N/mm2
0.12 K (80 r1 fck)^0.33	=	0.330	0.324	N/mm2
scp = NEd / Ac <= 0.2 fcd	=	0.000	0.000	
cl. 10.3.2(2) Eq. 10.1 of IRC :112-2010				
$V_{Rd.c}$ = [0.12K(80ρ1 fck)^0.33 + 0.15σcp]b_wd subjected to minimum (v min + 0.15 σcp) b_w d	=	154.79	159.92	kN
Check for Shear Reinforcement		No Shear R/f required	No Shear R/f required	

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

SLS CHECK OF FOUNDATION

Foundation Lvl = 93.000 m

Properties of Footing Base:

A	=	4.600	m^2
ZL	=	3.527	m^3
ZT	=	0.767	m^3

Creep Coeff = 1.2 For Dry atmosperic condition

Ecm = 31000 N/mm2

Es = 200000 N/mm2

Eceff = $\frac{Ecm}{(1 + \phi)}$ = 14090.91

Modular Ratio (m) = Es/ Eceff = 14.19

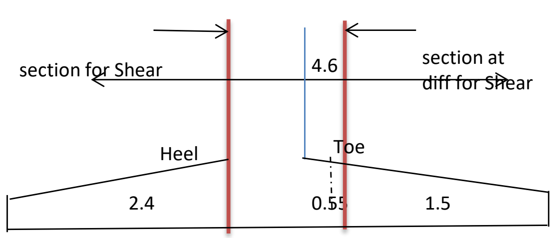
Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL1) (m)	ML = PxeL1 (kNm)
Shaft	1	25	3.225	80.625	0.450	36.281
Back filling over heel slab	1	20	15.780	315.600	-1.004	316.844
Back filling on flared portion of shaft	1	20	1.290	25.800	0.233	6.020
Front Filling over toe slab	1	20	2.363	47.250	1.558	73.593
RCC Railing or Crash Barrier	1			0.000	0.800	0.000
Heel slab	1	25	1.020	25.500	-0.940	23.970
Toe slab	1	25	0.638	15.938	1.450	23.109
portion between heel & toe	1	25	0.303	7.563	0.450	3.403
Total				**518.275**		**-198.408**

		load factor					
Moment due to active earth pressure	=	1.0	x	402.480	=	402.480	kNm
Moment due to Live load surcharge	=	0.8	x	136.898	=	109.518	kNm
						511.998	

P	518.275	KN
ML	313.591	kNm
MT	0.000	kNm
A	4.600	m2
ZL	3.527	m3
ZT	0.767	m3
P/A+ML/ZL+MT/ZT (Max)	201.588	kN/m2
P/A-ML/ZL-MT/ZT (Min)	23.749	kN/m2

		Normal Dry Case
Base Pressure (kN/m2)	Max	201.588
	Min	23.749



Normal Dry Case 201.59 108.80 81.74 23.75 kN/m2

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

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=	155.20	kN/m2									
Upward moment due to Base pressure	=	446.96	kNm/m									
	factor											
Downward moment due to backfill	=	1.00		x	15.78	x	20	x	1.2	=	378.72	kNm/m
Downward moment due to self weight of Heel	=	1.00		x	1.020	x	25	x	1.040	=	26.52	kNm/m
Net Moment at face of shaft	=	446.96			-378.72		-26.52			=	41.72	kNm/m
					Tension at Bottom of Heel Slab							

Toe Slab - Moment Calculation

Average Base Pressure for Design of Toe Slab	=	52.74	kN/m2									
Upward moment due to Base pressure	=	59.34	kNm/m									
Downward moment due to self weight of Toe	=	1		x	0.6375	x	25	x	0.650	=	10.36	kNm/m
Net Moment at face of shaft	=	59.34			-10.36					=	48.98	kNm/m
					Tension at Bottom of Heel Slab							

		Heel Slab	Toe Slab	
Working bending moment, M	=	41.72	48.98	kNm/m
Dx	=	1.00	1.00	m
Dy	=	0.70	0.70	m
Section Modulus (ZL) of uncracked sectio	=	0.08	0.08	m3
Bending Stress (M/ZL)	=	0.511	0.600	N/mm2
Tensile stress of concrete , fctm	=	2.500	2.500	N/mm2
Cracked or Uncracked Section	=	Uncracked	Uncracked	
Section properties of Cracked section:				
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.				
Clear Cover, c	=	75.000	75.000	
Maximum dia used, f	=	12.000	12.000	
Effective Depth deff (dy)	=	469.000	469.000	mm
Ast provided	=	942.360	942.360	mm2/m
Percentage of steel , pt	=	0.0019	0.0019	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.209	0.207	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	98.100	96.922	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	370.900	372.078	mm
Depth of neutral axis from c.g. Of tension steel (ys)	=	289.900	291.078	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2		

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

Icr	=	1210265626	1217947941	mm4
Maximum compressive stress in concrete	=	3.382	3.898	< 14.4, SAFE
Maximum tensile stress in concrete	=	12.786	14.963	
Maximum Tensile stress in steel	=	97.018	113.889	< 400, SAFE

Check For Crack Width					
Crack width , Wk	=	Sr max (εsm - εcm)			
Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+ϕ/2)					
5*(c+ϕ/2)	=	405.000	405.000	mm	
Provided Spacing	=	65.000	65.000	mm	
Check for Applicability of Formula	=	OK	OK		
Maximum crack spacing , Sr max	=	3.4 c +	0.425 k1 k2 ϕ / r r eff		
K1	=	0.800	0.800	for deformed bars	
K2	=	0.500	0.500	for bending	
depth of neutral axis , yc	=	98.100	96.922	mm	
r r eff = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.			
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	234.500	234.500	mm	
Ac, eff = Dx * hc,eff	=	234500.000	234500.000	mm	
r r eff = As/Ac eff	=	0.004	0.004		
Maximum crack spacing , Sr max	=	762.640	762.640	mm	
(εsm - εcm)	=	$\left(\sigma sc - \frac{k_t f_{ct\,eff} (1 + \alpha_e \rho_{p\,eff})}{\rho_p\,eff}\right)$	/ Es		
tensile stress in steel, ,σsc	=	97.018	113.889	N/mm2	
Kt	=	0.500	0.500		
Tensile strength of concrete = fct eff = fctm	=	2.500	2.500	N/mm2	319.12
αe = Es/Ecm	=	6.452	6.452		
(εsm - εcm)	=	-0.001	-0.0010		
Crack width , Wk=Sr max (εsm - εcm)	=	**0.000**	**0.000**		
Check	=	**SAFE**	**SAFE**		

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

Calculation of Forces For Design of Wall

Wall bottom level = 93.55 m

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL) (m)	ML = PxeL (kNm)
Shaft	1.35	25	3.225	108.84375	0.087	9.433
RCC Railing or Crash Barrier	1.35			0	0.35	0.000
Total				**108.844**		**9.433**

Horizontal Force :	load factor						
Due to Earth pressure		1.5	x	116.23	=	174.35	KN
Due to Live load Surcharge		1.2	x	36.04	=	43.25	KN
						217.59	

Total Horizontal Force = 217.59 KN

Moment Due to Horizontal Force:		load factor					
Moment due to active earth pressure	=	1.5	x	293.753	=	440.629	kNm
Moment due to Live load surcharge	=	1.2	x	116.231	=	139.4767	kNm
						580.105	

Total Moment due to Horizontal Force = 580.105 kNm

Summary of Forces:

P	108.844	KN
ML	589.539	kNm
FL	217.594	KN

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

Design of Wall:

Grade of Concrete	=	30.00	M 30
fck	=	30.00	N/mm2
fcd	=	13.40	N/mm2
Grade of steel		500.00	Fe
fy	=	500.00	N/mm2
fyd	=	434.78	N/mm2
Es	=	200000.00	N/mm2

Cross section of Wall:

Thickness of Wall (B)	=	0.7	m
Depth of Wall (D)	=	1	m
Area of Concrete (Ac)	=	0.7	m2
Clear Cover to earth faces	=	75	mm
Clear Cover to non earth faces	=	40	mm
Maximum Dia of Vertical Reinf.	=	16	mm
Dia of Horizontal Reinf.	=	12	mm

Summary of Design Forces:

	P(kN)	ML (kNm)	FL (kN)
Case 1 : Normal Dry Case	108.84	589.54	217.59
MAX	108.84	589.54	217.59

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = 108.84 kN

0.1 fcd Ac

= 0.1 13.4 700000

= 938000 N

= 938.0 kN

Since Axial Force is less than axial capacity of section , Section will design as bending element . Neglecting axial force

PART 1: LONGITUDINAL MOMENT : VERTICAL REINFORCEMENT ON EARTH FACE

Ultimate Design bending moment (ML) = 589.54 kNm = 589.54 kNm/m

Check For Depth of Wall :

Mult = 0.167 x fck x b x d^2

= 589.54 kNm/m

b = 1000 mm

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

(dreq) 343.03 mm

Total Depth Required (Dreq) = 426.03 mm

Total Depth Provided (Dprov) = 700 mm **OK**

Effective depth provided(deff) = 617 mm

R= Mu/(b d^2) = 1.549

Minimum Longitudinal Reinforcement in wall on each face

=

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

Ast min = 840 mm2/m

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

Area of Steel Required:

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

= 0.0038

Ast_{req} = 2660.74 mm2/m

Ast required = max(Astmin, Astreq) = 2660.74 mm2/m

Provide	16	mm dia	@	120	mm c/c	=	1675.31	2617.67	mm²/m	REVISE
	12	mm dia	@	120	mm c/c	=	942.36			

Percentage of steel = 0.374 %

Check for Moment of Resistance of Section due to Steel

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

= 380.60 mm

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

= 105.38 mm

OK

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

z = d - 0.416 x X

= 573.16 mm

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

MR = fyd . Ast . Z

= 652324195.0

= 6.52E+08 Nmm /m

= **6.52E+02** kNm/m > **589.54** kNm/m

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

LONGITUDINAL REINFORCEMENT ON NON EARTH FACE

Minimum Longitudinal Reinforcement in wall on each face

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

Ast min = 840 mm2/m

Provide	12	mm dia	120	mm c/c	=	942.36	mm²/m	OK

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

maximum of following = 0.25 x 3560.03 = 890.01 **As per IRC:112-2011' Clause 16.32.2**

= 0.001 x 7.00E+05 = 700.00

Minimum Horizontal Reinf. provided 890.0 mm2 per meter

Min dia of bar = 0.25 x 16 = 4 mm

or 8 mm

Maximum Spacing between bars <= 300 mm/cc

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

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

SLS CHECK OF WALL

Foundation Lvl = 93.55 m

Creep Coeff (¢ = 1.2 For Dry atmosperic condition

Ecm = 31000

Es = 200000 N/mm2

Eceff = Ecm / (1 + ø) = 14090.90909

Modular Ratio (m) = Es/ Eceff = 14.19

Normal Dry Case

Loads	Load Factor	Unit Weights (kN/m3)	Volume (m3)	Vertical Load(P) kN.	Long. Ecc. (eL) (m)	ML = PxeL (kNm)
Shaft	1.000	25	3.225	80.625	0.086666667	6.9875
RCC Railing or Crash Barrier	1.000			0	0.35	0
Total				**80.625**		**6.988**

Horizontal Force :		load factor				
Due to Earth pressure	=	1.000	x	116.2305779	=	116.2306 KN
Due to Live load Surcharge	=	0.800	x	36.04048926	=	28.83239 KN
Total Horizontal Force	=	145.0629693	KN			

Moment Due to Horizontal Force:		load factor				
Moment due to active earth pressure	=	1.000	x	314.869	=	314.869 kNm
Moment due to Live load surcharge	=	0.8	x	116.231	=	92.984 kNm
Total Moment due to Horizontal Force	=	407.853097721	kNm			

Summary of Forces:

P	80.625	KN
ML	414.841	kNm
FL	145.063	KN

Bending Moment, M	=	414.84	kNm
Dx	=	1.00	m
Dy	=	0.70	m
Section Modulus (ZL) of uncracked secti	=	0.08	m3
Bending Stress (M/ZL)	=	5.080	N/mm2
Tensile stress of concrete , fctm	=	2.500	N/mm2
Cracked or Uncracked Section	**=**	**Cracked**	
Section properties of Cracked section:			
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.			
Clear Cover, c	=	75.000	mm
Maximum dia used (Vertical), f	=	16.000	mm
Horizontal Reinf. Dia used	=	12.000	mm
Effective Depth deff (dy)	=	617.000	mm
Ast provided	=	2617.667	mm2/m
Percentage of steel , pt	=	0.0048	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.307	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	189.642	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	427.358	mm

Depth of neutral axis from c.g. Of tesnion steel (ys)	=	344.358	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast	* (dy - k * dy)^2
Icr	=	4464336844	mm4
Maximum compressive stress in concrete	=	17.6	< 14.4, SAFE
Maximum tensile stress in concrete	=	39.712	
Maximum Tensile stress in steel	=	262.226	< 400, SAFE

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

Check For Crack Width			
Crack width , Wk	=	Sr max (εsm - εcm)	
Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+ϕ/2)			
5*(c+ϕ/2)	=	415.000	mm
Provided Spacing	=	120.000	mm
Check for Applicability of Formula	=	OK	
Maximum crack spacing , $S_{r\ max}$	=	3.4 c +	0.425 k1 k2 ϕ / $p_{p\ eff}$
K1	=	0.700	for deformed b
K2	=	0.500	for bending
depth of neutral axis , yc	=	189.642	mm
$\Sigma_{r\ eff}$ = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.	
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	207.500	mm
Ac, eff = Dx * hc,eff	=	207500.000	mm
$\Sigma_{r\ eff}$ = As/Ac eff	=	0.013	
Maximum crack spacing , $S_{r\ max}$	=	443.660	mm
(ε_{sm} - ε_{cm})	=	σsc - kt fct eff (1 + αe r r eff) / r r eff	/ Es
tensile stress in steel, ,σsc	=	262.226	N/mm2
Kt	=	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.500	N/mm2
αe = Es/Ecm	=	6.452	
(εsm - εcm)	=	0.00078	
Crack width , Wk=Sr max (εsm - εcm)	=	**0.344**	
Check	=	**UNSAFE**	

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

Stability Check Summary

Description	P (kN/m2 max)	P (kN/m2 min)	Sliding	Overturning	Shear (Heel slab)	Shear (Toe slab)
Normal Dry case	211.33	14.00	1.47	2.56	0.156	-0.052
Permissible	220	0	1.5	2	3.658	3.658
Remarks	OK	OK	REVISE	OK	OK	OK

Reinforcement summary

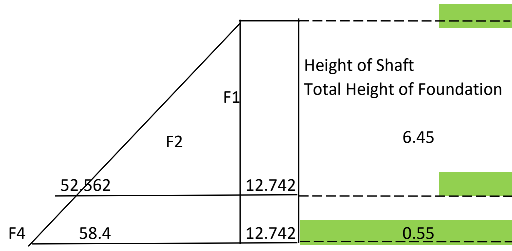
Type of reinforcement	**Area of steel required**	**Area of steel provided**						
				Straight Portion of Shaft				
Vertical steel at earth face	2661	16	mm bar @	120	mm c/c (i.e.)	2618	mm2	REVISE
		12	mm bar @	120	mm c/c (i.e.)			
Vertical steel at non-earth face	840	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
Distribution steel	890	12	mm 2 Legged bar @	200	mm c/c (i.e.)	1130	mm2	OK
				Heel Slab				
Main steel at top face	610	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
		0	mm bar @	120	mm c/c (i.e.)			
Steel at bottom face	250	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
Distribution reinforcement	188	10	mm bar @	200	mm c/c (i.e.)	393	mm2	OK
Shear Reinforcement	No Shear R/f required							
				Toe Slab				
Main steel at bottom face	610	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
		0	mm bar @	120	mm c/c (i.e.)			
Steel at top face	250	12	mm bar @	120	mm c/c (i.e.)	942	mm2	OK
Distribution reinforcement	188	10	mm bar @	200	mm c/c (i.e.)	393	mm2	OK
Shear Reinforcement	No Shear R/f required							

Earth Pressure : Normal Dry Case

Properties of backfill material :

c	=	0				
ϕ	=	**30**	degree	0.524	radians	0.866
θ	=	87.11	degree	1.520	radians	0.050
θ1	=	90	degree	1.571	radians	0.000
β	=	26.5	degree	0.462512252	radians	0.895
δ	=	**20**	degree	0.349	radians	0.940
Kah	=	0.279	active component			
Kph	=	5.737	Passive component			
γ	=	20	kN/m3			
Equivalent Live Load Surcharge height	=	1.2	m			

Assuming



100 (Deck Level)

Height of Shaft	6.45	m	6.45
Total Height of Foundation	7	m	7

6.45

93.55 shaft bottom level

93 Foundation Lvl.

HORIZONTAL ALIGNMENT REPORT

Horizontal Alignment Report											
No.	**Type**	**Start Station**	**End Station**	**Length**	**Radius**	**A**	**Direction**	**Delta angle**	**Start Direction**	**End Direction**	**Incurve**
1	Line	10000	10118.684	118.684			N52° 43' 54.29"E				
2	Spiral-Curve-Spiral	10118.684	10148.684	30		47.434m		11.4592 (d)	N52° 43' 54.29"E	N41° 16' 21.33"E	Incurve
3	Spiral-Curve-Spiral	10148.684	10160.683	11.999	75.000m			9.1668 (d)	N41° 16' 21.33"E	N32° 06' 20.97"E	
4	Spiral-Curve-Spiral	10160.683	10190.683	30		47.434m		11.4592 (d)	N32° 06' 20.97"E	N20° 38' 48.01"E	Outcurve
5	Line	10190.683	10343.076	152.393			N20° 38' 48.01"E				
6	Spiral-Curve-Spiral	10343.076	10373.076	30		47.434m		11.4592 (d)	N20° 38' 48.01"E	N9° 11' 15.04"E	Incurve
7	Spiral-Curve-Spiral	10373.076	10510.501	137.426	75.000m			104.9856 (d)	N9° 11' 15.04"E	S84° 12' 06.96"W	
8	Spiral-Curve-Spiral	10510.501	10540.501	30		47.434m		11.4592 (d)	S84° 12' 06.96"W	S72° 44' 33.99"W	Outcurve
9	Line	10540.501	10667.071	126.57			S72° 44' 33.99"W				
10	Spiral-Curve-Spiral	10667.071	10697.071	30		94.868m		2.8648 (d)	S72° 44' 33.99"W	S75° 36' 27.23"W	Incurve
11	Spiral-Curve-Spiral	10697.071	10941.996	244.925	300.000m			46.7772 (d)	S75° 36' 27.23"W	N57° 36' 54.72"W	
12	Spiral-Curve-Spiral	10941.996	10971.996	30		94.868m		2.8648 (d)	N57° 36' 54.72"W	N54° 45' 01.48"W	Outcurve
13	Line	10971.996	11296.996	325			N54° 45' 01.48"W				
14	Spiral-Curve-Spiral	11296.996	11341.996	45		82.158m		8.5944 (d)	N54° 45' 01.48"W	N46° 09' 21.76"W	Incurve
15	Spiral-Curve-Spiral	11341.996	11451.765	109.769	150.000m			41.9285 (d)	N46° 09' 21.76"W	N4° 13' 39.19"W	
16	Spiral-Curve-Spiral	11451.765	11496.765	45		82.158m		8.5944 (d)	N4° 13' 39.19"W	N4° 22' 00.53"E	Outcurve
17	Line	11496.765	11531.148	34.384			N4° 22' 00.53"E				
18	Spiral-Curve-Spiral	11531.148	11561.148	30		67.082m		5.7296 (d)	N4° 22' 00.53"E	N1° 21' 45.95"W	Incurve
19	Spiral-Curve-Spiral	11561.148	11659.89	98.742	150.000m			37.7166 (d)	N1° 21' 45.95"W	N39° 04' 45.74"W	
20	Spiral-Curve-Spiral	11659.89	11689.89	30		67.082m		5.7296 (d)	N39° 04' 45.74"W	N44° 48' 32.22"W	Outcurve
21	Line	11689.89	11943.308	253.418			N44° 48' 32.22"W				
22	Spiral-Curve-Spiral	11943.308	11973.308	30		47.434m		11.4592 (d)	N44° 48' 32.22"W	N33° 20' 59.25"W	Incurve
23	Spiral-Curve-Spiral	11973.308	12063.571	90.263	75.000m			68.9560 (d)	N33° 20' 59.25"W	N35° 36' 22.33"E	
24	Spiral-Curve-Spiral	12063.571	12093.571	30		47.434m		11.4592 (d)	N35° 36' 22.33"E	N47° 03' 55.29"E	Outcurve
25	Line	12093.571	12591.579	498.008			N47° 03' 55.29"E				
26	Spiral-Curve-Spiral	12591.579	12621.579	30		86.603m		3.4377 (d)	N47° 03' 55.29"E	N50° 30' 11.18"E	Incurve
27	Spiral-Curve-Spiral	12621.579	12646.025	24.446	250.000m			5.6026 (d)	N50° 30' 11.18"E	N56° 06' 20.66"E	
28	Spiral-Curve-Spiral	12646.025	12676.025	30		86.603m		3.4377 (d)	N56° 06' 20.66"E	N59° 32' 36.55"E	Outcurve
29	Line	12676.025	13037.555	361.53			N59° 32' 36.55"E				
30	Spiral-Curve-Spiral	13037.555	13067.555	30		67.082m		5.7296 (d)	N59° 32' 36.55"E	N65° 16' 23.03"E	Incurve
31	Spiral-Curve-Spiral	13067.555	13151.96	84.405	150.000m			32.2403 (d)	N65° 16' 23.03"E	S82° 29' 11.97"E	
32	Spiral-Curve-Spiral	13151.96	13181.96	30		67.082m		5.7296 (d)	S82° 29' 11.97"E	S76° 45' 25.49"E	Outcurve
33	Line	13181.96	13455.987	274.027			S76° 45' 25.49"E				
34	Spiral-Curve-Spiral	13455.987	13485.987	30		122.474m		1.7189 (d)	S76° 45' 25.49"E	S75° 02' 17.55"E	Incurve
35	Spiral-Curve-Spiral	13485.987	13605.044	119.056	500.000m			13.6429 (d)	S75° 02' 17.55"E	S61° 23' 43.22"E	
36	Spiral-Curve-Spiral	13605.044	13635.044	30		122.474m		1.7189 (d)	S61° 23' 43.22"E	S59° 40' 35.28"E	Outcurve
37	Line	13635.044	13838.166	203.122			S59° 40' 35.28"E				
38	Spiral-Curve-Spiral	13838.166	13858.166	20		89.443m		1.4324 (d)	S59° 40' 35.28"E	S61° 06' 31.90"E	Incurve
39	Spiral-Curve-Spiral	13858.166	13942.386	84.22	400.000m			12.0636 (d)	S61° 06' 31.90"E	S73° 10' 20.90"E	
40	Spiral-Curve-Spiral	13942.386	13962.386	20		89.443m		1.4324 (d)	S73° 10' 20.90"E	S74° 36' 17.52"E	Outcurve
41	Line	13962.386	14018.423	56.038			S74° 36' 17.52"E				

Horizontal Alignment Report											
No.	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Start Direction	End Direction	Incurve
42	Spiral-Curve-Spiral	14018.423	14048.423	30		94.868m		2.8648 (d)	S74° 36' 17.52"E	S77° 28' 10.76"E	Incurve
43	Spiral-Curve-Spiral	14048.423	14089.093	40.67	300.000m			7.7674 (d)	S77° 28' 10.76"E	S85° 14' 13.35"E	
44	Spiral-Curve-Spiral	14089.093	14119.093	30		94.868m		2.8648 (d)	S85° 14' 13.35"E	S88° 06' 06.59"E	Outcurve
45	Line	14119.093	14308.714	189.62			S88° 06' 06.59"E				
46	Spiral-Curve-Spiral	14308.714	14338.714	30		30.000m		28.6479 (d)	S88° 06' 06.59"E	N63° 15' 01.01"E	Incurve
47	Spiral-Curve-Spiral	14338.714	14401.694	62.981	30.000m			120.2840 (d)	N63° 15' 01.01"E	N57° 02' 01.52"W	
48	Spiral-Curve-Spiral	14401.694	14431.694	30		30.000m		28.6479 (d)	N57° 02' 01.52"W	N85° 40' 53.92"W	Outcurve
49	Line	14431.694	14681.823	250.128			N85° 40' 53.92"W				
50	Spiral-Curve-Spiral	14681.823	14711.823	30		94.868m		2.8648 (d)	N85° 40' 53.92"W	N82° 49' 00.68"W	Incurve
51	Spiral-Curve-Spiral	14711.823	14836.026	124.204	300.000m			23.7212 (d)	N82° 49' 00.68"W	N59° 05' 44.51"W	
52	Spiral-Curve-Spiral	14836.026	14866.026	30		94.868m		2.8648 (d)	N59° 05' 44.51"W	N56° 13' 51.27"W	Outcurve
53	Line	14866.026	15055.707	189.68			N56° 13' 51.27"W				
54	Spiral-Curve-Spiral	15055.707	15065.707	10		104.881m		0.2604 (d)	N56° 13' 51.27"W	N56° 29' 28.84"W	Incurve
55	Spiral-Curve-Spiral	15065.707	15549.124	483.417	1100.000m			25.1798 (d)	N56° 29' 28.84"W	N81° 40' 16.05"W	
56	Spiral-Curve-Spiral	15549.124	15559.124	10		104.881m		0.2604 (d)	N81° 40' 16.05"W	N81° 55' 53.62"W	Outcurve
57	Line	15559.124	15617.996	58.872			N81° 55' 53.62"W				
58	Spiral-Curve-Spiral	15617.996	15637.996	20		100.000m		1.1459 (d)	N81° 55' 53.62"W	N83° 04' 38.92"W	Incurve
59	Spiral-Curve-Spiral	15637.996	15981.856	343.86	500.000m			39.4035 (d)	N83° 04' 38.92"W	S57° 31' 08.57"W	
60	Spiral-Curve-Spiral	15981.856	16001.856	20		100.000m		1.1459 (d)	S57° 31' 08.57"W	S56° 22' 23.27"W	Outcurve
61	Line	16001.856	16318.702	316.846			S56° 22' 23.27"W				
62	Spiral-Curve-Spiral	16318.702	16338.702	20		31.623m		11.4592 (d)	S56° 22' 23.27"W	S67° 49' 56.23"W	Incurve
63	Spiral-Curve-Spiral	16338.702	16372.534	33.832	50.000m			38.7688 (d)	S67° 49' 56.23"W	N73° 23' 55.95"W	
64	Spiral-Curve-Spiral	16372.534	16392.534	20		31.623m		11.4592 (d)	N73° 23' 55.95"W	N61° 56' 22.99"W	Outcurve
65	Line	16392.534	16453.902	61.368			N61° 56' 22.99"W				
66	Spiral-Curve-Spiral	16453.902	16473.902	20		31.623m		11.4592 (d)	N61° 56' 22.99"W	N50° 28' 50.03"W	Incurve
67	Spiral-Curve-Spiral	16473.902	16525.368	51.466	50.000m			58.9755 (d)	N50° 28' 50.03"W	N8° 29' 41.64"E	
68	Spiral-Curve-Spiral	16525.368	16545.368	20		31.623m		11.4592 (d)	N8° 29' 41.64"E	N19° 57' 14.60"E	Outcurve
69	Line	16545.368	16683.041	137.673			N19° 57' 14.60"E				
70	Spiral-Curve-Spiral	16683.041	16708.041	25		44.721m		8.9525 (d)	N19° 57' 14.60"E	N11° 00' 05.72"E	Incurve
71	Spiral-Curve-Spiral	16708.041	16776.613	68.572	80.000m			49.1112 (d)	N11° 00' 05.72"E	N38° 06' 34.72"W	
72	Spiral-Curve-Spiral	16776.613	16801.613	25		44.721m		8.9525 (d)	N38° 06' 34.72"W	N47° 03' 43.60"W	Outcurve
73	Line	16801.613	17359.981	558.368			N47° 03' 43.60"W				
74	Spiral-Curve-Spiral	17359.981	17379.981	20		100.000m		1.1459 (d)	N47° 03' 43.60"W	N45° 54' 58.30"W	Incurve
75	Spiral-Curve-Spiral	17379.981	17618.568	238.587	500.000m			27.3400 (d)	N45° 54' 58.30"W	N18° 34' 34.20"W	
76	Spiral-Curve-Spiral	17618.568	17638.568	20		100.000m		1.1459 (d)	N18° 34' 34.20"W	N17° 25' 48.91"W	Outcurve
77	Line	17638.568	17759.268	120.7			N17° 25' 48.91"W				
78	Spiral-Curve-Spiral	17759.268	17779.268	20		89.443m		1.4324 (d)	N17° 25' 48.91"W	N18° 51' 45.53"W	Incurve
79	Spiral-Curve-Spiral	17779.268	17989.83	210.562	400.000m			30.1608 (d)	N18° 51' 45.53"W	N49° 01' 24.34"W	
80	Spiral-Curve-Spiral	17989.83	18009.83	20		89.443m		1.4324 (d)	N49° 01' 24.34"W	N50° 27' 20.96"W	Outcurve
81	Line	18009.83	18129.526	119.696			N50° 27' 20.96"W				
82	Spiral-Curve-Spiral	18129.526	18139.526	10		100.000m		0.2865 (d)	N50° 27' 20.96"W	N50° 44' 32.28"W	Incurve

Horizontal Alignment Report											
No.	**Type**	**Start Station**	**End Station**	**Length**	**Radius**	**A**	**Direction**	**Delta angle**	**Start Direction**	**End Direction**	**Incurve**
83	Spiral-Curve-Spiral	18139.526	18238.008	98.482	1000.000m			5.6426 (d)	N50° 44' 32.28"W	N56° 23' 05.62"W	
84	Spiral-Curve-Spiral	18238.008	18248.008	10		100.000m		0.2865 (d)	N56° 23' 05.62"W	N56° 40' 16.94"W	Outcurve
85	Line	18248.008	18539.732	291.725			N56° 40' 16.94"W				
86	Spiral-Curve-Spiral	18539.732	18549.732	10		70.711m		0.5730 (d)	N56° 40' 16.94"W	N57° 14' 39.59"W	Incurve
87	Spiral-Curve-Spiral	18549.732	18685.899	136.167	500.000m			15.6035 (d)	N57° 14' 39.59"W	N72° 50' 52.31"W	
88	Spiral-Curve-Spiral	18685.899	18695.899	10		70.711m		0.5730 (d)	N72° 50' 52.31"W	N73° 25' 14.96"W	Outcurve
89	Line	18695.899	18885.885	189.986			N73° 25' 14.96"W				
90	Spiral-Curve-Spiral	18885.885	18910.885	25		44.721m		8.9525 (d)	N73° 25' 14.96"W	N64° 28' 06.08"W	Incurve
91	Spiral-Curve-Spiral	18910.885	18984.929	74.044	80.000m			53.0302 (d)	N64° 28' 06.08"W	N11° 26' 17.45"W	
92	Spiral-Curve-Spiral	18984.929	19009.929	25		44.721m		8.9525 (d)	N11° 26' 17.45"W	N2° 29' 08.57"W	Outcurve
93	Line	19009.929	19251.591	241.662			N2° 29' 08.57"W				
94	Spiral-Curve-Spiral	19251.591	19281.591	30		30.000m		28.6479 (d)	N2° 29' 08.57"W	N31° 08' 00.98"W	Incurve
95	Spiral-Curve-Spiral	19281.591	19332.166	50.575	30.000m			96.5904 (d)	N31° 08' 00.98"W	S52° 16' 33.72"W	
96	Spiral-Curve-Spiral	19332.166	19362.166	30		30.000m		28.6479 (d)	S52° 16' 33.72"W	S23° 37' 41.31"W	Outcurve
97	Line	19362.166	19458.307	96.141			S23° 37' 41.31"W				
98	Spiral-Curve-Spiral	19458.307	19488.307	30		94.868m		2.8648 (d)	S23° 37' 41.31"W	S20° 45' 48.07"W	Incurve
99	Spiral-Curve-Spiral	19488.307	19540.453	52.146	300.000m			9.9592 (d)	S20° 45' 48.07"W	S10° 48' 14.83"W	
100	Spiral-Curve-Spiral	19540.453	19570.453	30		94.868m		2.8648 (d)	S10° 48' 14.83"W	S7° 56' 21.59"W	Outcurve
101	Line	19570.453	19827.827	257.374			S7° 56' 21.59"W				
102	Spiral-Curve-Spiral	19827.827	19847.827	20		77.460m		1.9099 (d)	S7° 56' 21.59"W	S9° 50' 57.09"W	Incurve
103	Spiral-Curve-Spiral	19847.827	20071.232	223.404	300.000m			42.6671 (d)	S9° 50' 57.09"W	S52° 30' 58.57"W	
104	Spiral-Curve-Spiral	20071.232	20091.232	20		77.460m		1.9099 (d)	S52° 30' 58.57"W	S54° 25' 34.06"W	Outcurve
105	Line	20091.232	20500	408.768			S54° 25' 34.06"W				

VERTICAL ALIGNMENT REPORT

Vertical Alignment Report										
No.	PVI Station	PVI Elevation	Grade In	Grade Out	A (Grade Change)	Profile Curve Type	Sub-Entity Type	Profile Cur	K Value	Curve Radius
1	8097.122m	777.542m	-4.97%	-5.00%	0.03%	Crest	Symmetric Parabola	109.098m	4341.291	434129.136m
2	10390.703m	662.963m	-5.00%	0.00%	5.00%	Sag	Symmetric Parabola	50.000m	10.009	1000.869m
3	10499.856m	662.963m	0.00%	-4.97%	4.97%	Crest	Symmetric Parabola	50.000m	10.068	1006.850m
4	12337.714m	571.695m	-4.97%	-5.33%	0.37%	Crest	Symmetric Parabola	516.899m	1407.057	140705.697m
5	14409.878m	461.180m	-5.33%	-3.04%	2.29%	Sag	Symmetric Parabola	596.637m	260.229	26022.934m
6	16353.597m	402.079m	-3.04%	0.00%	3.04%	Sag	Symmetric Parabola	50.311m	16.546	1654.628m
7	16506.347m	402.079m	0.00%	-5.22%	5.22%	Crest	Symmetric Parabola	66.941m	12.827	1282.652m
8	20598.384m	188.518m	-5.22%	0.00%	5.22%	Sag	Symmetric Parabola	50.710m	9.717	971.661m

PCL COORDINATES

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
10000	2,768,906.3191m	550,774.4013m	N52° 43' 54.29"E
10025	2,768,921.4578m	550,794.2966m	N52° 43' 54.29"E
10050	2,768,936.5965m	550,814.1918m	N52° 43' 54.29"E
10075	2,768,951.7352m	550,834.0870m	N52° 43' 54.29"E
10100	2,768,966.8739m	550,853.9823m	N52° 43' 54.29"E
10125	2,768,982.0274m	550,873.8661m	N52° 13' 25.57"E
10150	2,768,998.8656m	550,892.2818m	N40° 16' 01.06"E
10175	2,769,020.1679m	550,905.1904m	N23° 46' 41.68"E
10200	2,769,043.4571m	550,914.2711m	N20° 38' 48.01"E
10225	2,769,066.8514m	550,923.0862m	N20° 38' 48.01"E
10250	2,769,090.2457m	550,931.9013m	N20° 38' 48.01"E
10275	2,769,113.6400m	550,940.7164m	N20° 38' 48.01"E
10300	2,769,137.0344m	550,949.5315m	N20° 38' 48.01"E
10325	2,769,160.4287m	550,958.3466m	N20° 38' 48.01"E
10350	2,769,183.8316m	550,967.1387m	N20° 02' 10.25"E
10375	2,769,207.9111m	550,973.6727m	N7° 43' 02.52"E
10400	2,769,232.7828m	550,972.8772m	N11° 22' 52.41"W
10425	2,769,256.0252m	550,963.9876m	N30° 28' 47.35"W
10450	2,769,275.0796m	550,947.9825m	N49° 34' 42.29"W
10475	2,769,287.8485m	550,926.6239m	N68° 40' 37.22"W
10500	2,769,292.9260m	550,902.2630m	N87° 46' 32.16"W
10525	2,769,289.9730m	550,877.5297m	S75° 48' 08.21"W
10550	2,769,282.8212m	550,853.5776m	S72° 44' 33.99"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
10575	2,769,275.4046m	550,829.7030m	S72° 44' 33.99"W
10600	2,769,267.9881m	550,805.8284m	S72° 44' 33.99"W
10625	2,769,260.5715m	550,781.9539m	S72° 44' 33.99"W
10650	2,769,253.1550m	550,758.0793m	S72° 44' 33.99"W
10675	2,769,245.7472m	550,734.2020m	S72° 56' 34.39"W
10700	2,769,238.9562m	550,710.1456m	S76° 10' 00.95"W
10725	2,769,233.9967m	550,685.6498m	S80° 56' 29.68"W
10750	2,769,231.0933m	550,660.8263m	S85° 42' 58.42"W
10775	2,769,230.2662m	550,635.8472m	N89° 30' 32.85"W
10800	2,769,231.5211m	550,610.8860m	N84° 44' 04.12"W
10825	2,769,234.8494m	550,586.1158m	N79° 57' 35.38"W
10850	2,769,240.2280m	550,561.7087m	N75° 11' 06.65"W
10875	2,769,247.6194m	550,537.8339m	N70° 24' 37.91"W
10900	2,769,256.9725m	550,514.6572m	N65° 38' 09.18"W
10925	2,769,268.2223m	550,492.3395m	N60° 51' 40.45"W
10950	2,769,281.2828m	550,471.0303m	N56° 17' 25.79"W
10975	2,769,295.5494m	550,450.5018m	N54° 45' 01.48"W
11000	2,769,309.9779m	550,430.0856m	N54° 45' 01.48"W
11025	2,769,324.4063m	550,409.6695m	N54° 45' 01.48"W
11050	2,769,338.8348m	550,389.2533m	N54° 45' 01.48"W
11075	2,769,353.2633m	550,368.8372m	N54° 45' 01.48"W
11100	2,769,367.6918m	550,348.4211m	N54° 45' 01.48"W
11125	2,769,382.1203m	550,328.0049m	N54° 45' 01.48"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
11150	2,769,396.5488m	550,307.5888m	N54° 45' 01.48"W
11175	2,769,410.9772m	550,287.1726m	N54° 45' 01.48"W
11200	2,769,425.4057m	550,266.7565m	N54° 45' 01.48"W
11225	2,769,439.8342m	550,246.3403m	N54° 45' 01.48"W
11250	2,769,454.2627m	550,225.9242m	N54° 45' 01.48"W
11275	2,769,468.6912m	550,205.5081m	N54° 45' 01.48"W
11300	2,769,483.1202m	550,185.0923m	N54° 42' 43.61"W
11325	2,769,497.9854m	550,164.9964m	N51° 25' 19.52"W
11350	2,769,514.8290m	550,146.5530m	N43° 05' 55.64"W
11375	2,769,534.4192m	550,131.0682m	N33° 32' 58.17"W
11400	2,769,556.3068m	550,119.0479m	N24° 00' 00.70"W
11425	2,769,579.8852m	550,110.8253m	N14° 27' 03.24"W
11450	2,769,604.5010m	550,106.6281m	N4° 54' 05.77"W
11475	2,769,629.4815m	550,106.2633m	N2° 21' 22.92"E
11500	2,769,654.4256m	550,107.9128m	N4° 22' 00.53"E
11525	2,769,679.3530m	550,109.8164m	N4° 22' 00.53"E
11550	2,769,704.2964m	550,111.4723m	N2° 06' 15.65"E
11575	2,769,729.2555m	550,110.6022m	N6° 39' 13.43"W
11600	2,769,753.7315m	550,105.6543m	N16° 12' 10.90"W
11625	2,769,777.0475m	550,096.7146m	N25° 45' 08.37"W
11650	2,769,798.5573m	550,084.0307m	N35° 18' 05.83"W
11675	2,769,817.7519m	550,068.0476m	N43° 23' 50.86"W
11700	2,769,835.5740m	550,050.5164m	N44° 48' 32.22"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
11725	2,769,853.3105m	550,032.8977m	N44° 48' 32.22"W
11750	2,769,871.0470m	550,015.2791m	N44° 48' 32.22"W
11775	2,769,888.7835m	549,997.6605m	N44° 48' 32.22"W
11800	2,769,906.5201m	549,980.0419m	N44° 48' 32.22"W
11825	2,769,924.2566m	549,962.4232m	N44° 48' 32.22"W
11850	2,769,941.9931m	549,944.8046m	N44° 48' 32.22"W
11875	2,769,959.7296m	549,927.1860m	N44° 48' 32.22"W
11900	2,769,977.4661m	549,909.5674m	N44° 48' 32.22"W
11925	2,769,995.2026m	549,891.9487m	N44° 48' 32.22"W
11950	2,770,012.9547m	549,874.3459m	N44° 14' 19.61"W
11975	2,770,032.2195m	549,858.4890m	N32° 03' 26.31"W
12000	2,770,055.2084m	549,848.9630m	N12° 57' 31.37"W
12025	2,770,080.0487m	549,847.4831m	N6° 08' 23.57"E
12050	2,770,104.0060m	549,854.2123m	N25° 14' 18.50"E
12075	2,770,124.5164m	549,868.3272m	N42° 40' 26.51"E
12100	2,770,141.8852m	549,886.2994m	N47° 03' 55.29"E
12125	2,770,158.9143m	549,904.6027m	N47° 03' 55.29"E
12150	2,770,175.9434m	549,922.9060m	N47° 03' 55.29"E
12175	2,770,192.9725m	549,941.2093m	N47° 03' 55.29"E
12200	2,770,210.0016m	549,959.5126m	N47° 03' 55.29"E
12225	2,770,227.0307m	549,977.8158m	N47° 03' 55.29"E
12250	2,770,244.0598m	549,996.1191m	N47° 03' 55.29"E
12275	2,770,261.0889m	550,014.4224m	N47° 03' 55.29"E

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
12300	2,770,278.1180m	550,032.7257m	N47° 03' 55.29"E
12325	2,770,295.1471m	550,051.0290m	N47° 03' 55.29"E
12350	2,770,312.1761m	550,069.3322m	N47° 03' 55.29"E
12375	2,770,329.2052m	550,087.6355m	N47° 03' 55.29"E
12400	2,770,346.2343m	550,105.9388m	N47° 03' 55.29"E
12425	2,770,363.2634m	550,124.2421m	N47° 03' 55.29"E
12450	2,770,380.2925m	550,142.5454m	N47° 03' 55.29"E
12475	2,770,397.3216m	550,160.8486m	N47° 03' 55.29"E
12500	2,770,414.3507m	550,179.1519m	N47° 03' 55.29"E
12525	2,770,431.3798m	550,197.4552m	N47° 03' 55.29"E
12550	2,770,448.4089m	550,215.7585m	N47° 03' 55.29"E
12575	2,770,465.4380m	550,234.0618m	N47° 03' 55.29"E
12600	2,770,482.4573m	550,252.3741m	N47° 20' 10.39"E
12625	2,770,498.8771m	550,271.2190m	N51° 17' 13.61"E
12650	2,770,513.5131m	550,291.4741m	N56° 57' 22.84"E
12675	2,770,526.5202m	550,312.8214m	N59° 32' 22.10"E
12700	2,770,539.1923m	550,334.3718m	N59° 32' 36.55"E
12725	2,770,551.8644m	550,355.9221m	N59° 32' 36.55"E
12750	2,770,564.5365m	550,377.4725m	N59° 32' 36.55"E
12775	2,770,577.2086m	550,399.0228m	N59° 32' 36.55"E
12800	2,770,589.8807m	550,420.5732m	N59° 32' 36.55"E
12825	2,770,602.5528m	550,442.1235m	N59° 32' 36.55"E
12850	2,770,615.2249m	550,463.6739m	N59° 32' 36.55"E

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
12875	2,770,627.8970m	550,485.2242m	N59° 32' 36.55"E
12900	2,770,640.5691m	550,506.7746m	N59° 32' 36.55"E
12925	2,770,653.2412m	550,528.3249m	N59° 32' 36.55"E
12950	2,770,665.9133m	550,549.8753m	N59° 32' 36.55"E
12975	2,770,678.5855m	550,571.4256m	N59° 32' 36.55"E
13000	2,770,691.2576m	550,592.9760m	N59° 32' 36.55"E
13025	2,770,703.9297m	550,614.5263m	N59° 32' 36.55"E
13050	2,770,716.5400m	550,636.1126m	N60° 31' 46.17"E
13075	2,770,727.5686m	550,658.5269m	N68° 07' 00.83"E
13100	2,770,734.9147m	550,682.3930m	N77° 39' 58.29"E
13125	2,770,738.1996m	550,707.1471m	N87° 12' 55.76"E
13150	2,770,737.3324m	550,732.1031m	S83° 14' 06.77"E
13175	2,770,732.7782m	550,756.6721m	S77° 03' 55.60"E
13200	2,770,727.0634m	550,781.0101m	S76° 45' 25.49"E
13225	2,770,721.3364m	550,805.3453m	S76° 45' 25.49"E
13250	2,770,715.6094m	550,829.6805m	S76° 45' 25.49"E
13275	2,770,709.8824m	550,854.0157m	S76° 45' 25.49"E
13300	2,770,704.1554m	550,878.3509m	S76° 45' 25.49"E
13325	2,770,698.4284m	550,902.6860m	S76° 45' 25.49"E
13350	2,770,692.7014m	550,927.0212m	S76° 45' 25.49"E
13375	2,770,686.9744m	550,951.3564m	S76° 45' 25.49"E
13400	2,770,681.2474m	550,975.6916m	S76° 45' 25.49"E
13425	2,770,675.5204m	551,000.0268m	S76° 45' 25.49"E

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
13450	2,770,669.7934m	551,024.3620m	S76° 45' 25.49"E
13475	2,770,663.9921m	551,048.6794m	S76° 04' 00.06"E
13500	2,770,657.4511m	551,072.8061m	S73° 25' 56.80"E
13525	2,770,649.7265m	551,096.5801m	S70° 34' 03.56"E
13550	2,770,640.8233m	551,119.9382m	S67° 42' 10.32"E
13575	2,770,630.7639m	551,142.8222m	S64° 50' 17.08"E
13600	2,770,619.5733m	551,165.1749m	S61° 58' 23.84"E
13625	2,770,607.3559m	551,186.9846m	S59° 52' 08.83"E
13650	2,770,594.7436m	551,208.5699m	S59° 40' 35.28"E
13675	2,770,582.1215m	551,230.1496m	S59° 40' 35.28"E
13700	2,770,569.4995m	551,251.7293m	S59° 40' 35.28"E
13725	2,770,556.8774m	551,273.3091m	S59° 40' 35.28"E
13750	2,770,544.2553m	551,294.8888m	S59° 40' 35.28"E
13775	2,770,531.6333m	551,316.4685m	S59° 40' 35.28"E
13800	2,770,519.0112m	551,338.0482m	S59° 40' 35.28"E
13825	2,770,506.3892m	551,359.6279m	S59° 40' 35.28"E
13850	2,770,493.7970m	551,381.2249m	S60° 10' 40.72"E
13875	2,770,481.9680m	551,403.2450m	S63° 31' 12.66"E
13900	2,770,471.5272m	551,425.9560m	S67° 06' 04.21"E
13925	2,770,462.5254m	551,449.2747m	S70° 40' 55.76"E
13950	2,770,454.9887m	551,473.1076m	S74° 03' 19.89"E
13975	2,770,448.3137m	551,497.2000m	S74° 36' 17.52"E
14000	2,770,441.6769m	551,521.3029m	S74° 36' 17.52"E

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
14025	2,770,435.0451m	551,545.4073m	S74° 44' 33.15"E
14050	2,770,428.9677m	551,569.6542m	S77° 46' 14.74"E
14075	2,770,424.6957m	551,594.2792m	S82° 32' 43.48"E
14100	2,770,422.4642m	551,619.1729m	S86° 56' 29.09"E
14125	2,770,421.5073m	551,644.1541m	S88° 06' 06.59"E
14150	2,770,420.6792m	551,669.1404m	S88° 06' 06.59"E
14175	2,770,419.8511m	551,694.1267m	S88° 06' 06.59"E
14200	2,770,419.0230m	551,719.1129m	S88° 06' 06.59"E
14225	2,770,418.1950m	551,744.0992m	S88° 06' 06.59"E
14250	2,770,417.3669m	551,769.0855m	S88° 06' 06.59"E
14275	2,770,416.5388m	551,794.0718m	S88° 06' 06.59"E
14300	2,770,415.7107m	551,819.0581m	S88° 06' 06.59"E
14325	2,770,415.6821m	551,844.0355m	N83° 27' 18.92"E
14350	2,770,426.1961m	551,866.0703m	N41° 41' 42.47"E
14375	2,770,449.3137m	551,873.5023m	N6° 03' 04.87"W
14400	2,770,470.3593m	551,861.3885m	N53° 47' 52.21"W
14425	2,770,477.8620m	551,837.8588m	N84° 15' 18.62"W
14450	2,770,479.7998m	551,812.9344m	N85° 40' 53.92"W
14475	2,770,481.6823m	551,788.0053m	N85° 40' 53.92"W
14500	2,770,483.5647m	551,763.0763m	N85° 40' 53.92"W
14525	2,770,485.4472m	551,738.1473m	N85° 40' 53.92"W
14550	2,770,487.3297m	551,713.2183m	N85° 40' 53.92"W
14575	2,770,489.2121m	551,688.2892m	N85° 40' 53.92"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
14600	2,770,491.0946m	551,663.3602m	N85° 40' 53.92"W
14625	2,770,492.9770m	551,638.4312m	N85° 40' 53.92"W
14650	2,770,494.8595m	551,613.5021m	N85° 40' 53.92"W
14675	2,770,496.7419m	551,588.5731m	N85° 40' 53.92"W
14700	2,770,498.7352m	551,563.6531m	N84° 37' 47.68"W
14725	2,770,501.9468m	551,538.8666m	N80° 18' 00.68"W
14750	2,770,507.1803m	551,514.4279m	N75° 31' 31.95"W
14775	2,770,514.4298m	551,490.5096m	N70° 45' 03.21"W
14800	2,770,523.6450m	551,467.2778m	N65° 58' 34.48"W
14825	2,770,534.7620m	551,444.8936m	N61° 12' 05.74"W
14850	2,770,547.6611m	551,423.4852m	N57° 02' 54.52"W
14875	2,770,561.4937m	551,402.6610m	N56° 13' 51.27"W
14900	2,770,575.3899m	551,381.8789m	N56° 13' 51.27"W
14925	2,770,589.2861m	551,361.0968m	N56° 13' 51.27"W
14950	2,770,603.1822m	551,340.3146m	N56° 13' 51.27"W
14975	2,770,617.0784m	551,319.5325m	N56° 13' 51.27"W
15000	2,770,630.9746m	551,298.7504m	N56° 13' 51.27"W
15025	2,770,644.8708m	551,277.9683m	N56° 13' 51.27"W
15050	2,770,658.7670m	551,257.1862m	N56° 13' 51.27"W
15075	2,770,672.5826m	551,236.3507m	N56° 58' 31.48"W
15100	2,770,685.9682m	551,215.2368m	N58° 16' 39.31"W
15125	2,770,698.8705m	551,193.8241m	N59° 34' 47.15"W
15150	2,770,711.2829m	551,172.1237m	N60° 52' 54.99"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
15175	2,770,723.1990m	551,150.1469m	N62° 11' 02.82"W
15200	2,770,734.6125m	551,127.9050m	N63° 29' 10.66"W
15225	2,770,745.5177m	551,105.4094m	N64° 47' 18.49"W
15250	2,770,755.9088m	551,082.6718m	N66° 05' 26.33"W
15275	2,770,765.7805m	551,059.7039m	N67° 23' 34.17"W
15300	2,770,775.1276m	551,036.5177m	N68° 41' 42.00"W
15325	2,770,783.9455m	551,013.1250m	N69° 59' 49.84"W
15350	2,770,792.2295m	550,989.5379m	N71° 17' 57.68"W
15375	2,770,799.9753m	550,965.7687m	N72° 36' 05.51"W
15400	2,770,807.1790m	550,941.8296m	N73° 54' 13.35"W
15425	2,770,813.8367m	550,917.7330m	N75° 12' 21.19"W
15450	2,770,819.9452m	550,893.4913m	N76° 30' 29.02"W
15475	2,770,825.5012m	550,869.1170m	N77° 48' 36.86"W
15500	2,770,830.5018m	550,844.6228m	N79° 06' 44.70"W
15525	2,770,834.9445m	550,820.0213m	N80° 24' 52.53"W
15550	2,770,838.8270m	550,795.3251m	N81° 42' 53.17"W
15575	2,770,842.3473m	550,770.5742m	N81° 55' 53.62"W
15600	2,770,845.8562m	550,745.8217m	N81° 55' 53.62"W
15625	2,770,849.3594m	550,721.0684m	N82° 04' 19.55"W
15650	2,770,852.3606m	550,696.2512m	N84° 27' 10.94"W
15675	2,770,854.1542m	550,671.3182m	N87° 19' 04.18"W
15700	2,770,854.6994m	550,646.3268m	S89° 49' 02.58"W
15725	2,770,853.9949m	550,621.3393m	S86° 57' 09.34"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
15750	2,770,852.0424m	550,596.4183m	S84° 05' 16.10"W
15775	2,770,848.8468m	550,571.6260m	S81° 13' 22.86"W
15800	2,770,844.4162m	550,547.0244m	S78° 21' 29.62"W
15825	2,770,838.7614m	550,522.6750m	S75° 29' 36.38"W
15850	2,770,831.8968m	550,498.6386m	S72° 37' 43.14"W
15875	2,770,823.8395m	550,474.9753m	S69° 45' 49.90"W
15900	2,770,814.6095m	550,451.7444m	S66° 53' 56.66"W
15925	2,770,804.2301m	550,429.0038m	S64° 02' 03.42"W
15950	2,770,792.7270m	550,406.8103m	S61° 10' 10.18"W
15975	2,770,780.1291m	550,385.2195m	S58° 18' 16.94"W
16000	2,770,766.5506m	550,364.2300m	S56° 22' 58.80"W
16025	2,770,752.7061m	550,343.4134m	S56° 22' 23.27"W
16050	2,770,738.8616m	550,322.5969m	S56° 22' 23.27"W
16075	2,770,725.0170m	550,301.7803m	S56° 22' 23.27"W
16100	2,770,711.1725m	550,280.9638m	S56° 22' 23.27"W
16125	2,770,697.3279m	550,260.1472m	S56° 22' 23.27"W
16150	2,770,683.4834m	550,239.3307m	S56° 22' 23.27"W
16175	2,770,669.6388m	550,218.5142m	S56° 22' 23.27"W
16200	2,770,655.7943m	550,197.6976m	S56° 22' 23.27"W
16225	2,770,641.9497m	550,176.8811m	S56° 22' 23.27"W
16250	2,770,628.1052m	550,156.0645m	S56° 22' 23.27"W
16275	2,770,614.2606m	550,135.2480m	S56° 22' 23.27"W
16300	2,770,600.4161m	550,114.4314m	S56° 22' 23.27"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
16325	2,770,586.6063m	550,093.5921m	S57° 30' 33.68"W
16350	2,770,577.0851m	550,070.6824m	S80° 46' 42.83"W
16375	2,770,579.2831m	550,046.0392m	N70° 44' 51.71"W
16400	2,770,590.2320m	550,023.5925m	N61° 56' 22.99"W
16425	2,770,601.9921m	550,001.5311m	N61° 56' 22.99"W
16450	2,770,613.7521m	549,979.4698m	N61° 56' 22.99"W
16475	2,770,626.8392m	549,958.2340m	N49° 13' 20.20"W
16500	2,770,647.1305m	549,944.0795m	N20° 34' 27.80"W
16525	2,770,671.7238m	549,941.3859m	N8° 04' 24.60"E
16550	2,770,695.6199m	549,948.5681m	N19° 57' 14.60"E
16575	2,770,719.1191m	549,957.0998m	N19° 57' 14.60"E
16600	2,770,742.6182m	549,965.6314m	N19° 57' 14.60"E
16625	2,770,766.1174m	549,974.1631m	N19° 57' 14.60"E
16650	2,770,789.6166m	549,982.6947m	N19° 57' 14.60"E
16675	2,770,813.1157m	549,991.2264m	N19° 57' 14.60"E
16700	2,770,836.7453m	549,999.3731m	N15° 50' 03.27"E
16725	2,770,861.4241m	550,002.7138m	N1° 08' 40.56"W
16750	2,770,885.9369m	549,998.3487m	N19° 02' 58.31"W
16775	2,770,907.9205m	549,986.6588m	N36° 57' 16.06"W
16800	2,770,926.0407m	549,969.4846m	N47° 01' 29.45"W
16825	2,770,943.0711m	549,951.1825m	N47° 03' 43.60"W
16850	2,770,960.1012m	549,932.8802m	N47° 03' 43.60"W
16875	2,770,977.1314m	549,914.5779m	N47° 03' 43.60"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
16900	2,770,994.1615m	549,896.2756m	N47° 03' 43.60"W
16925	2,771,011.1916m	549,877.9733m	N47° 03' 43.60"W
16950	2,771,028.2217m	549,859.6709m	N47° 03' 43.60"W
16975	2,771,045.2519m	549,841.3686m	N47° 03' 43.60"W
17000	2,771,062.2820m	549,823.0663m	N47° 03' 43.60"W
17025	2,771,079.3121m	549,804.7640m	N47° 03' 43.60"W
17050	2,771,096.3423m	549,786.4617m	N47° 03' 43.60"W
17075	2,771,113.3724m	549,768.1594m	N47° 03' 43.60"W
17100	2,771,130.4025m	549,749.8571m	N47° 03' 43.60"W
17125	2,771,147.4326m	549,731.5547m	N47° 03' 43.60"W
17150	2,771,164.4628m	549,713.2524m	N47° 03' 43.60"W
17175	2,771,181.4929m	549,694.9501m	N47° 03' 43.60"W
17200	2,771,198.5230m	549,676.6478m	N47° 03' 43.60"W
17225	2,771,215.5532m	549,658.3455m	N47° 03' 43.60"W
17250	2,771,232.5833m	549,640.0432m	N47° 03' 43.60"W
17275	2,771,249.6134m	549,621.7409m	N47° 03' 43.60"W
17300	2,771,266.6435m	549,603.4385m	N47° 03' 43.60"W
17325	2,771,283.6737m	549,585.1362m	N47° 03' 43.60"W
17350	2,771,300.7038m	549,566.8339m	N47° 03' 43.60"W
17375	2,771,317.7751m	549,548.5702m	N46° 24' 57.19"W
17400	2,771,335.4356m	549,530.8790m	N43° 37' 19.81"W
17425	2,771,353.9568m	549,514.0910m	N40° 45' 26.57"W
17450	2,771,373.2939m	549,498.2497m	N37° 53' 33.33"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
17475	2,771,393.3985m	549,483.3946m	N35° 01' 40.09"W
17500	2,771,414.2205m	549,469.5630m	N32° 09' 46.85"W
17525	2,771,435.7077m	549,456.7892m	N29° 17' 53.61"W
17550	2,771,457.8066m	549,445.1054m	N26° 26' 00.37"W
17575	2,771,480.4617m	549,434.5406m	N23° 34' 07.13"W
17600	2,771,503.6166m	549,425.1213m	N20° 42' 13.89"W
17625	2,771,527.2119m	549,416.8669m	N17° 57' 27.37"W
17650	2,771,551.0513m	549,409.3386m	N17° 25' 48.91"W
17675	2,771,574.9034m	549,401.8500m	N17° 25' 48.91"W
17700	2,771,598.7554m	549,394.3613m	N17° 25' 48.91"W
17725	2,771,622.6075m	549,386.8727m	N17° 25' 48.91"W
17750	2,771,646.4596m	549,379.3841m	N17° 25' 48.91"W
17775	2,771,670.2870m	549,371.8182m	N18° 18' 59.68"W
17800	2,771,693.7687m	549,363.2504m	N21° 49' 56.45"W
17825	2,771,716.6700m	549,353.2342m	N25° 24' 48.00"W
17850	2,771,738.9011m	549,341.8071m	N28° 59' 39.55"W
17875	2,771,760.3750m	549,329.0138m	N32° 34' 31.10"W
17900	2,771,781.0079m	549,314.9043m	N36° 09' 22.65"W
17925	2,771,800.7192m	549,299.5335m	N39° 44' 14.20"W
17950	2,771,819.4320m	549,282.9616m	N43° 19' 05.75"W
17975	2,771,837.0732m	549,265.2533m	N46° 53' 57.30"W
18000	2,771,853.5907m	549,246.4918m	N50° 06' 35.38"W
18025	2,771,869.5228m	549,227.2261m	N50° 27' 20.96"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
18050	2,771,885.4396m	549,207.9478m	N50° 27' 20.96"W
18075	2,771,901.3565m	549,188.6694m	N50° 27' 20.96"W
18100	2,771,917.2733m	549,169.3911m	N50° 27' 20.96"W
18125	2,771,933.1901m	549,150.1127m	N50° 27' 20.96"W
18150	2,771,949.0110m	549,130.7560m	N51° 20' 32.74"W
18175	2,771,964.3820m	549,111.0405m	N52° 46' 29.36"W
18200	2,771,979.2553m	549,090.9469m	N54° 12' 25.98"W
18225	2,771,993.6217m	549,070.4878m	N55° 38' 22.60"W
18250	2,772,007.4961m	549,049.6917m	N56° 40' 16.94"W
18275	2,772,021.2321m	549,028.8034m	N56° 40' 16.94"W
18300	2,772,034.9681m	549,007.9150m	N56° 40' 16.94"W
18325	2,772,048.7041m	548,987.0267m	N56° 40' 16.94"W
18350	2,772,062.4402m	548,966.1384m	N56° 40' 16.94"W
18375	2,772,076.1762m	548,945.2501m	N56° 40' 16.94"W
18400	2,772,089.9122m	548,924.3617m	N56° 40' 16.94"W
18425	2,772,103.6482m	548,903.4734m	N56° 40' 16.94"W
18450	2,772,117.3842m	548,882.5851m	N56° 40' 16.94"W
18475	2,772,131.1202m	548,861.6968m	N56° 40' 16.94"W
18500	2,772,144.8562m	548,840.8085m	N56° 40' 16.94"W
18525	2,772,158.5922m	548,819.9201m	N56° 40' 16.94"W
18550	2,772,172.2980m	548,799.0121m	N57° 16' 29.97"W
18575	2,772,185.2819m	548,777.6512m	N60° 08' 23.21"W
18600	2,772,197.1819m	548,755.6680m	N63° 00' 16.46"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
18625	2,772,207.9684m	548,733.1176m	N65° 52' 09.70"W
18650	2,772,217.6143m	548,710.0562m	N68° 44' 02.94"W
18675	2,772,226.0956m	548,686.5416m	N71° 35' 56.18"W
18700	2,772,233.4786m	548,662.6580m	N73° 25' 14.96"W
18725	2,772,240.6121m	548,638.6974m	N73° 25' 14.96"W
18750	2,772,247.7456m	548,614.7367m	N73° 25' 14.96"W
18775	2,772,254.8791m	548,590.7761m	N73° 25' 14.96"W
18800	2,772,262.0126m	548,566.8154m	N73° 25' 14.96"W
18825	2,772,269.1461m	548,542.8547m	N73° 25' 14.96"W
18850	2,772,276.2796m	548,518.8941m	N73° 25' 14.96"W
18875	2,772,283.4131m	548,494.9334m	N73° 25' 14.96"W
18900	2,772,290.7702m	548,471.0430m	N70° 34' 00.78"W
18925	2,772,302.0539m	548,448.8343m	N54° 21' 32.40"W
18950	2,772,319.5344m	548,431.1040m	N36° 27' 14.64"W
18975	2,772,341.6192m	548,419.6066m	N18° 32' 56.89"W
19000	2,772,366.1477m	548,415.1714m	N3° 53' 51.99"W
19025	2,772,391.1200m	548,414.0057m	N2° 29' 08.57"W
19050	2,772,416.0965m	548,412.9215m	N2° 29' 08.57"W
19075	2,772,441.0730m	548,411.8372m	N2° 29' 08.57"W
19100	2,772,466.0495m	548,410.7529m	N2° 29' 08.57"W
19125	2,772,491.0259m	548,409.6687m	N2° 29' 08.57"W
19150	2,772,516.0024m	548,408.5844m	N2° 29' 08.57"W
19175	2,772,540.9789m	548,407.5002m	N2° 29' 08.57"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
19200	2,772,565.9554m	548,406.4159m	N2° 29' 08.57"W
19225	2,772,590.9318m	548,405.3317m	N2° 29' 08.57"W
19250	2,772,615.9083m	548,404.2474m	N2° 29' 08.57"W
19275	2,772,640.5666m	548,400.8150m	N19° 55' 41.80"W
19300	2,772,658.4732m	548,384.3860m	N66° 17' 30.91"W
19325	2,772,658.4032m	548,360.1032m	S65° 57' 41.75"W
19350	2,772,640.9015m	548,342.9195m	S28° 20' 21.48"W
19375	2,772,618.1385m	548,332.5975m	S23° 37' 41.31"W
19400	2,772,595.2343m	548,322.5775m	S23° 37' 41.31"W
19425	2,772,572.3302m	548,312.5576m	S23° 37' 41.31"W
19450	2,772,549.4260m	548,302.5376m	S23° 37' 41.31"W
19475	2,772,526.4877m	548,292.5967m	S22° 44' 28.01"W
19500	2,772,503.1254m	548,283.7140m	S18° 31' 48.32"W
19525	2,772,479.1180m	548,276.7652m	S13° 45' 19.59"W
19550	2,772,454.6182m	548,271.8230m	S9° 16' 15.28"W
19575	2,772,429.8808m	548,268.2131m	S7° 56' 21.59"W
19600	2,772,405.1205m	548,264.7600m	S7° 56' 21.59"W
19625	2,772,380.3601m	548,261.3069m	S7° 56' 21.59"W
19650	2,772,355.5997m	548,257.8538m	S7° 56' 21.59"W
19675	2,772,330.8394m	548,254.4007m	S7° 56' 21.59"W
19700	2,772,306.0790m	548,250.9475m	S7° 56' 21.59"W
19725	2,772,281.3186m	548,247.4944m	S7° 56' 21.59"W
19750	2,772,256.5582m	548,244.0413m	S7° 56' 21.59"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
19775	2,772,231.7979m	548,240.5882m	S7° 56' 21.59"W
19800	2,772,207.0375m	548,237.1351m	S7° 56' 21.59"W
19825	2,772,182.2771m	548,233.6820m	S7° 56' 21.59"W
19850	2,772,157.5622m	548,229.9298m	S10° 15' 50.94"W
19875	2,772,133.1763m	548,224.4559m	S15° 02' 19.67"W
19900	2,772,109.3306m	548,216.9712m	S19° 48' 48.41"W
19925	2,772,086.1906m	548,207.5276m	S24° 35' 17.14"W
19950	2,772,063.9170m	548,196.1906m	S29° 21' 45.87"W
19975	2,772,042.6644m	548,183.0391m	S34° 08' 14.61"W
20000	2,772,022.5802m	548,168.1641m	S38° 54' 43.34"W
20025	2,772,003.8039m	548,151.6691m	S43° 41' 12.08"W
20050	2,771,986.4657m	548,133.6684m	S48° 27' 40.81"W
20075	2,771,970.6848m	548,114.2879m	S53° 10' 05.45"W
20100	2,771,956.0448m	548,094.0234m	S54° 25' 34.06"W
20125	2,771,941.5010m	548,073.6893m	S54° 25' 34.06"W
20150	2,771,926.9572m	548,053.3551m	S54° 25' 34.06"W
20175	2,771,912.4134m	548,033.0210m	S54° 25' 34.06"W
20200	2,771,897.8696m	548,012.6868m	S54° 25' 34.06"W
20225	2,771,883.3258m	547,992.3527m	S54° 25' 34.06"W
20250	2,771,868.7820m	547,972.0185m	S54° 25' 34.06"W
20275	2,771,854.2382m	547,951.6844m	S54° 25' 34.06"W
20300	2,771,839.6944m	547,931.3502m	S54° 25' 34.06"W
20325	2,771,825.1506m	547,911.0161m	S54° 25' 34.06"W

PCL Coordinates

Alignment Name:Dialong-Old Tamenglong

Description:

Station Range: Start: 10.000, End: 20.5000

Station Increment: 25.00

Chainage	Northing	Easting	Tangential Direction
20350	2,771,810.6068m	547,890.6819m	S54° 25' 34.06"W
20375	2,771,796.0630m	547,870.3478m	S54° 25' 34.06"W
20400	2,771,781.5192m	547,850.0136m	S54° 25' 34.06"W
20425	2,771,766.9754m	547,829.6795m	S54° 25' 34.06"W
20450	2,771,752.4316m	547,809.3453m	S54° 25' 34.06"W
20475	2,771,737.8877m	547,789.0111m	S54° 25' 34.06"W
20500	2,771,723.3439m	547,768.6770m	S54° 25' 34.06"W