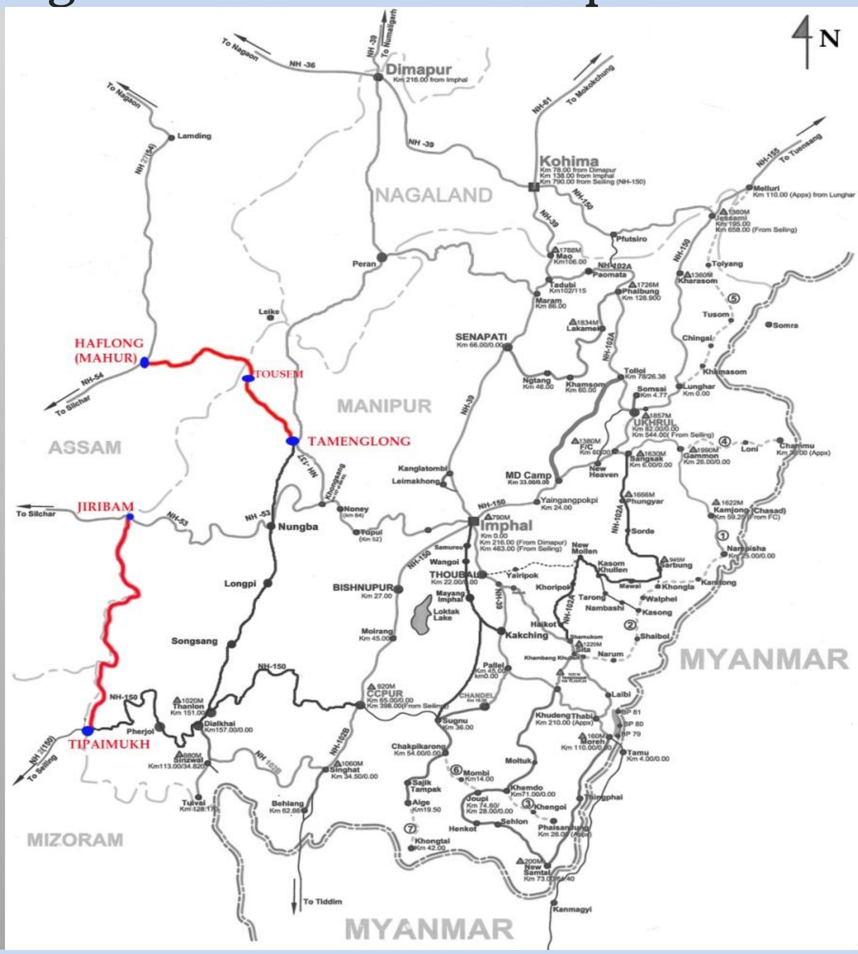
NATIONAL HIGHWAY INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

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



DRAFT DETAILED PROJECT REPORT
VOL-II DESIGN REPORT
PKG-4
PHELONG-AZURAM SECTION
(FROM KM 30+800 TO KM 41+450) LENGTH-10.65KM

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

FINAL DESIGN REPORT

1.0 HIGHWAY & STRUCTURE DESIGN

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

Table 6.1: Draft Design Standards

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

1.1 Geometric Design

1.1.1 General

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

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

1.1.2 Design Speed

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

The ruling design speed corresponding to the type of terrain as per IRC:SP 79-2018, are as follows:

Table 6.2: Design Speed Standards

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

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

1.1.3 Levels of Service (LOS)

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

Table 6.3: Standards for Level of Service

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

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

1.1.4 Cross Sectional Elements

1.1.4.1 Roadway Width for Multilane Highways

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

Table 6.4: Road Cross Section

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

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

1.1.4.2 Lane Width

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

1.1.4.3 Shoulders

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

1.1.4.4 Pavement Camber (Cross-fall)

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

Table 6.5: Provision for Cross-fall

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

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

1.1.4.5 Embankment Slopes

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

1.1.5 Typical Cross-sections

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

1.1.6 Horizontal Alignment

1.1.6.1 General

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

1.1.6.2 Sight Distances

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

Table 6.6: Sight Stopping Distance Criteria

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

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

1.1.6.3 Horizontal Curve

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

Table 6.7: Horizontal Radii Criteria

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

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

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

Table 6.8: Adopted Horizontal Radii

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

1.1.6.4 Transition (Spiral) Curves

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

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

1.1.6.5 Super-elevation

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

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

1.1.7 Vertical Alignment

1.1.7.1 General

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

1.1.7.2 Gradients

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

Table 6.9 : Vertical Gradient

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

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

1.1.7.3 Vertical Curves

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

L = K x A,

Where L = Length of vertical curve in metres;

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

Summit or Crest Curves

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

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

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

Valley or Sag Curves

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

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

1.2 Bridges and Cross Drainage Structures

1.2.1 General

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

1.2.1.1 Bridges and Culvert

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

1.3 Hydrological and Hydraulic Investigations

Hydrological Data

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

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

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

1.4 Hydrological Design Methodology

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

The following assumptions have been made during peak discharge calculation:

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

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

1.4.1.1 Assessment of Peak Discharge

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

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

Dickens Method

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

Q = CM (0.75)

Where,

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

M Is the catchment area in sq.km and

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

14-19, in Madhya Pradesh; and

32, in Western Ghats.

Area – Velocity Method (Manning's Formula)

Q = A x V

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

Where, Q = the discharge in cumecs ;

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

V = Velocity in m/sec;

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

P = Wetted perimeter of the stream in m.;

S = Bed slope of the stream; and

n = Rugosity Co-efficient.

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

1.4.1.2 Hydraulic Analysis for Design HFL

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

1.4.1.3 Afflux Calculation

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

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

Where, h = Afflux in meters;

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

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

and

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

1.4.1.4 Scour Depth Calculation

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

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

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

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

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

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

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

1.4.1.5 Maximum Depth of Scour for Design of Foundation

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

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

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

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

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

1.4.1.6 Additional Balancing Culvert on Main Carriage Way

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

1.4.1.7 Pipe Culvert

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

1.4.1.8 Various Codes and Publication to be adopted

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

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

1.4.1.9 Design Live Load

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

1.4.1.10 Vertical Load

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

1.4.1.11 Longitudinal Forces

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

1.4.1.12 Seismic Zone

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

1.4.1.13 Condition of Exposure

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

1.4.1.14 Grade of Concrete

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

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

1.5 Miscellaneous

1.5.1 Road Signs

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

1.5.2 Road Markings

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

1.5.3 Traffic Barriers

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

1.5.4 River Training work

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

2.0 PAVEMENT DESIGN

2.1 General

2.1.1 Objectives

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

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

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

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

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

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

2.1.2 Scope

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

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

2.2 Analysis Of Data For Pavement Design

2.2.1 General

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

2.2.2 Pavement Condition Study Data

Preliminary pavement condition survey was carried out on the entire length of Morvan-jawad road, before starting the actual deflection studies using Benkelman beam. The stretches of the existing road pavement were subdivided into sub-stretches based on the type and extent of cracking, rutting and other pavement distress as per the IRC Guidelines, IRC : 81 - 1997. The sub-stretches with uniform pavement condition which could be strengthened by suitable overlays were identified in order to carry out Benkelman beam rebound deflection studies.
Based on the analysis of pavement condition studies, the road corridors and the different sections there-of have been sub-divided into set of sub- stretches with fairly uniform characteristics. These have been re-grouped into the following four categories for the purpose of proposing the different types of pavement improvement programmers.
Sub-stretches for strengthening of the existing pavement by suitable Overlays
Sub-stretches for widening of carriageway including shoulders, using pavement layers as per "Design of New Pavements"
Sub-stretches for the construction of new pavement layers starting from the subgrade, as per "Design of New Pavements" on the stretches needing

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

2.2.3 Classified Traffic Volume Data

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

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

2.2.3.2 Traffic Growth Rate

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

2.2.5 Design C.S.A. Values

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

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

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

2.3.2 Calculation of VDF

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

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

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

2.3.3 Computation of design traffic

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

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

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

Where

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

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

r = Annual growth rate of commercial vehicles, %

x = Design life in years

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

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

1.6 PAVEMENT DESIGN OF PROJECT ROAD

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

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

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

1.7 Average Annual Daily Traffic and it Composition

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

Table 1.4: Annual Average Daily Traffic (AADT)

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

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

Traffic growth rate during the design life in percentage

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

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

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

Vehicle Damage Factor

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

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

Hence, The Adopted VDF is 2.5.

Cumulative Mean Standard Axles (CMSA)

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

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

Adopted MSA is 20 as per IRC SP 73:2018

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

1.4. PAVEMENT DESIGN

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

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

Table 1.5

Homogenous Section (Km)			CBR (%)	MSA	Adopted Pavement Composition (mm)			
From	To	Length (in Km)		Adopted	BC	DBM	WWM	GSB
30+800	41+450	10.650	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

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

Index

Index table:

1.0 Design Report

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

1.1 Introduction:-

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

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

1.2 Reference documents :-

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

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

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

1.4 Loads:-

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

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

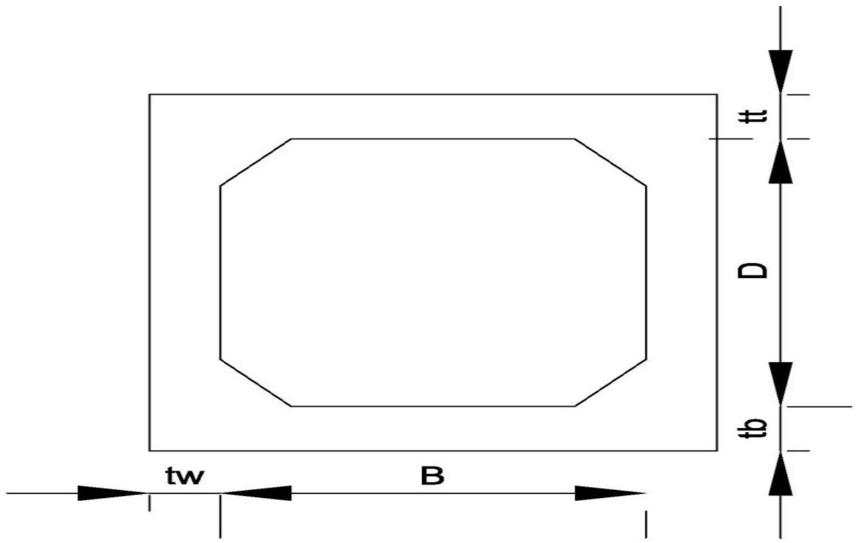
1.5 Load combinations

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

1.6 Material properties

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

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



2.1 Dimensions of Box

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

SIDL (Top Slab)

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

2.2 Basic Parameters

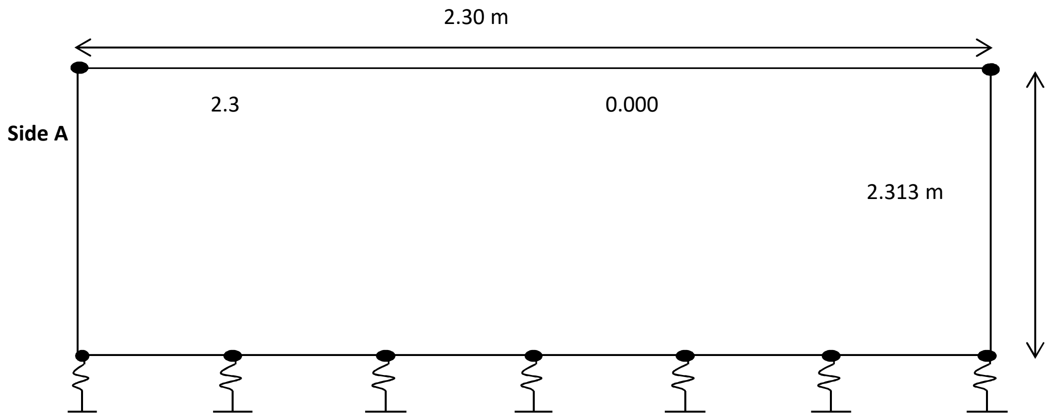
Coefficient of Active Earth Pressure	=	0.279	
Earth Pressure at rest K_0 = (1-sinf) =	=	0.5	
Factor of Earthpressure/Active earthpres:	=	1.793	
Saturated Density of fill	=	20	kN/m^3
Submerged Density of fill	=	10	kN/m^3
Dry Density of fill	=	20	kN/m^3
Density of Concrete	=	25	kN/m^3
Live Load Surcharge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

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

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

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



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

3.1 Earth Pressure and Live Load Calculation

1) a Earth Pressure (Normal Condition)

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

1) b Fluid Pressure

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

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

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

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

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

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

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

Live Load Surcharge = 5.651 kN/m

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

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

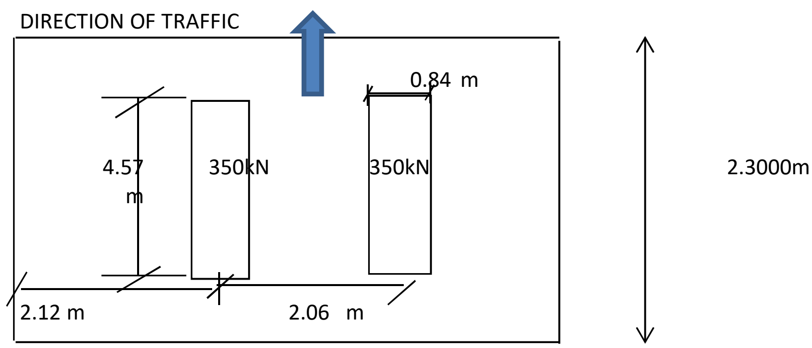
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 13.75 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



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

153.17 KN/m

352.3 KN

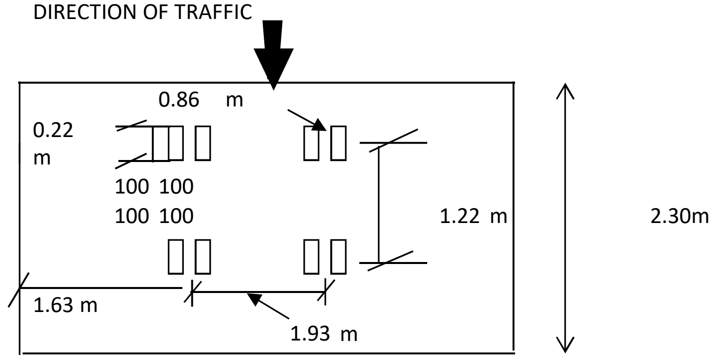
Effective width of Loading

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

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

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

B) 40T Boggie Load at Mid Span



Total Load = 400kN

Effective width of Loading

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

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

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

C) 40T Boggie Load at Support

Effective width of Loading

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

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

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

D) 70R Track at Support

Effective width of Loading

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

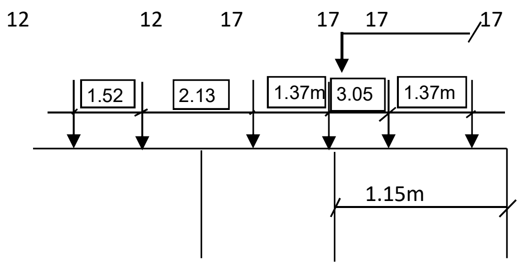
2.06<2.49 ***Therefore overlapping due to load dispersion occurs***

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

Increase due to impact = 42.08 kN/m^2

Say **42.10** kN/m^2

F) 70R Wheel Case 1

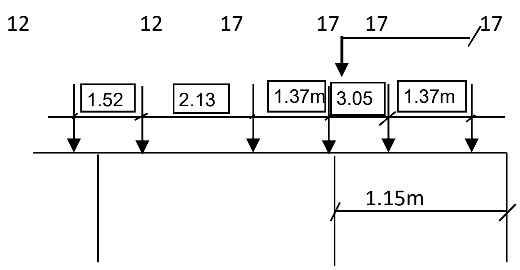


0.86m 1.93m 0.86m

Width along span = 0.970m

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

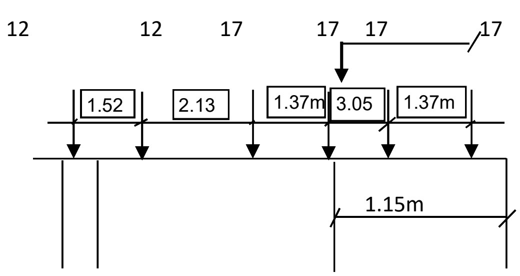
F) 70R Wheel Case 2



Width along span = 0.970m

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

G) 70R Wheel Case 3

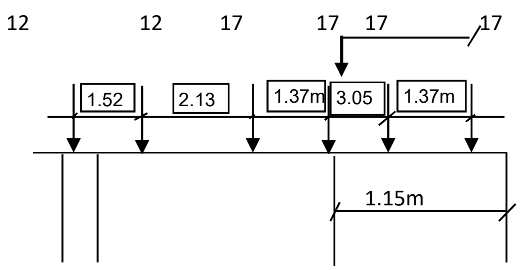


Width along span = 0.970m

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

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

H) 70R Wheel Case 4



Width along span = 0.970m

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

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

3.2 Temperature load calculation

Effective Bridge Temperature

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

Effect of temperature gradient

The box has been checked for temperature differential.

$F = E_c\, aDt\, A$

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

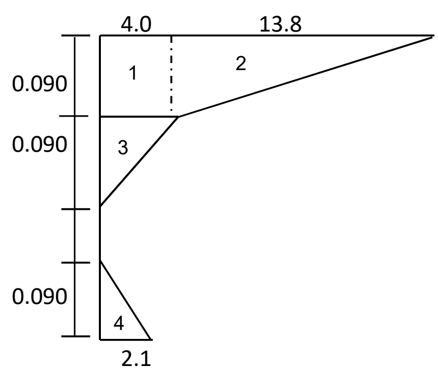
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 300 mm

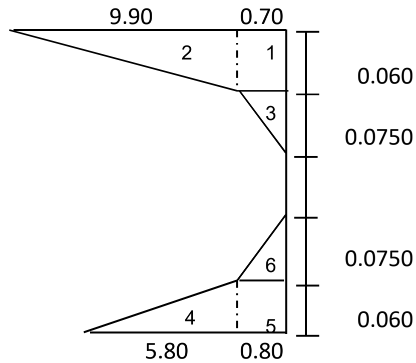
EFFECT OF TEMPERATURE RISE



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

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

EFFECT OF TEMPERATURE FALL



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

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	0.00	1.00	0.00
iii) Impact due to floating bodies			
Seismic Effect			
a) During Service	0.00	0.00	1.50
b) During Construction	0.00	0.00	0.75
Hydraulic Loads (Accompanying Load):			
Water Current Forces	1.00	1.00	1.00
Wave Pressure	1.00	1.00	1.00
Hydrodynamic Effect	0.00	0.00	1.00
Buoyancy	0.15	0.15	0.15

Serviceability Limit State

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

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

Combination for Base Pressure and Design of Foundation

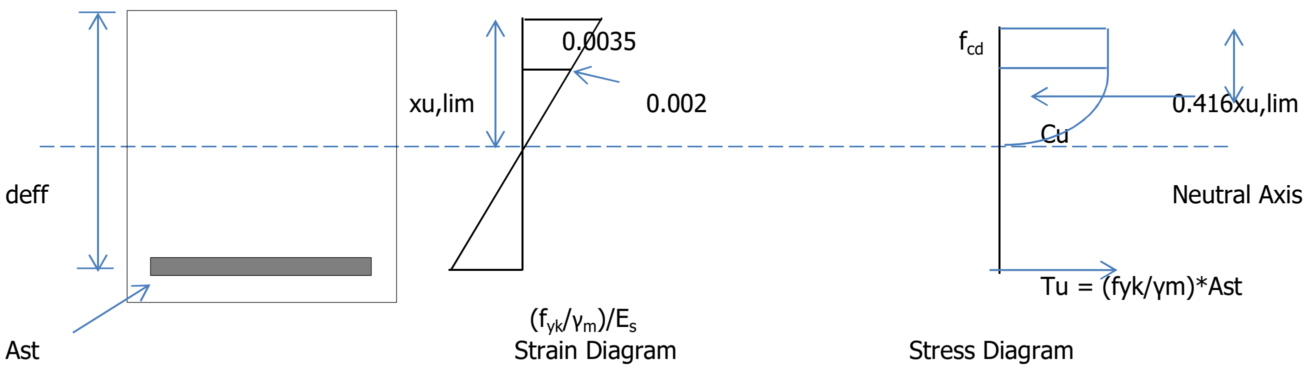
Table 3.4, Annex B, IRC:6-2014

Also refer IRC Amendment dated 28th July, 2012

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

	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

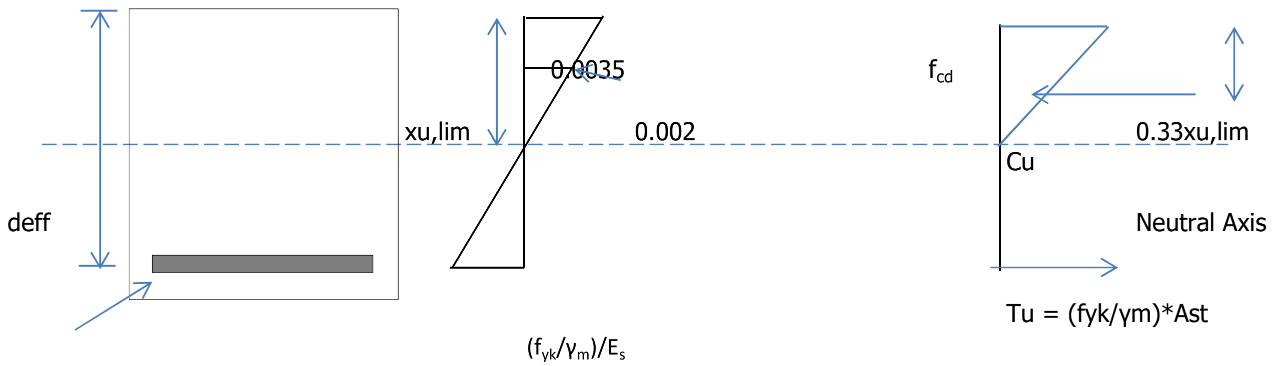
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

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		

5.1.2 Verification for serviceability limit state for top slab



Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

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

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

Cu = 1/2*fcd*b*xu
= 0.5 *fcd*b*xu
Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain
cg of compression block from top = 0.33 xu
Tu = fyd*Ast
$R_{sls} = M_{u,sls}/bd^2$ = 0.5fcd*(xu/d)*(1-0.33*xu/d)

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

Here R_{sls} is in MPa

Calculation of Reinforcement

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

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

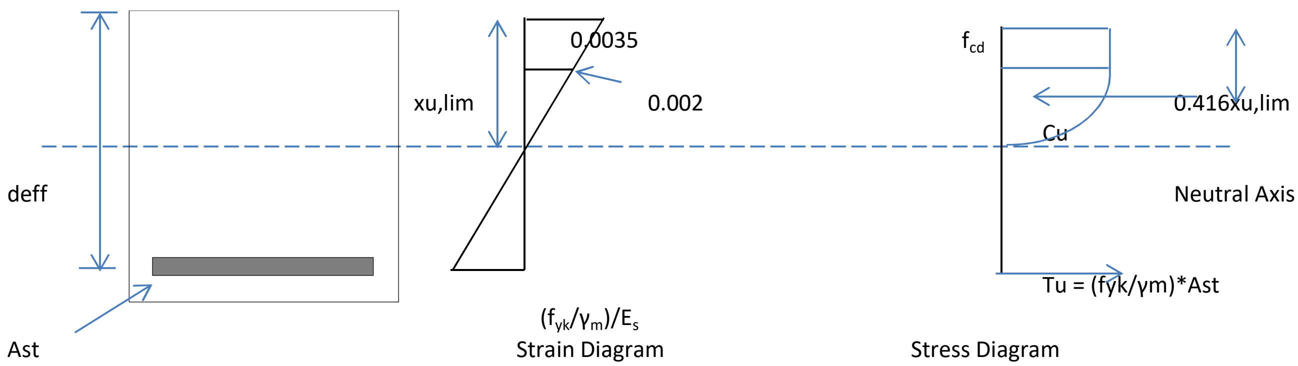
Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	42.0		15.0	33		10
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	242.0		242.0	243.0		243.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}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

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

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

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

5.2.1 Verification of structural strength for bottom slab



ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 325 mm

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

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

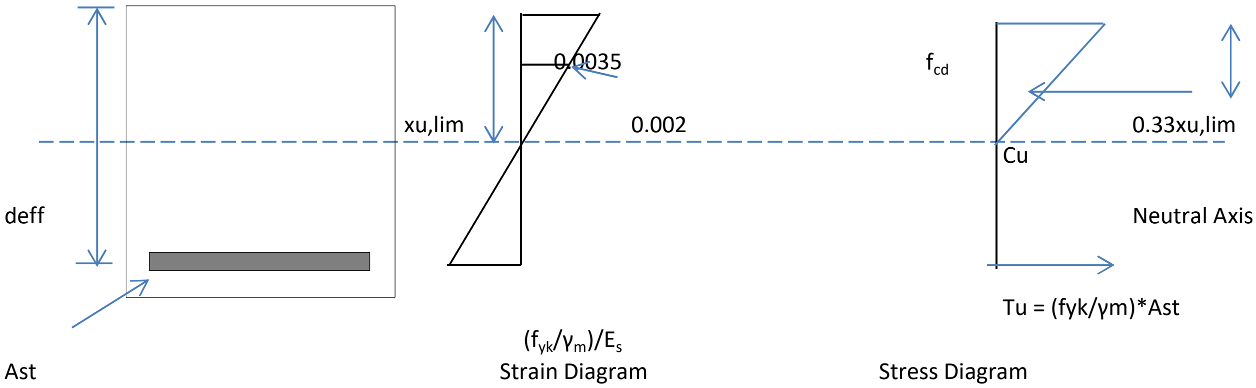
Moment on the section	**Bottom End support**			**Top Mid Span**		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	86.0		80.0	65.0		58.0
b	1000		1000	1000		1000
D	325		325	325		325
c	75		75	40		40
d	232.0		232.0	268.0		268.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}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

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

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

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

5.2.2 Verification for serviceability limit state for bottom slab



SERVICEABILITY LIMIT STATE

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

As per clause 12.2.1, IRC:112-2011

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

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

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

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 325 mm

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

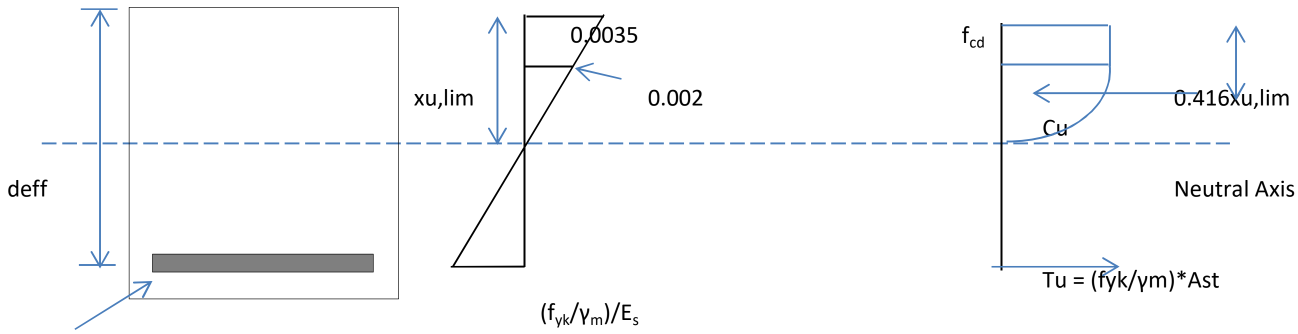
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 2 x 2	Date & Rev.	0

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

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

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

5.3.1 Verification of structural strength for outer wall



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

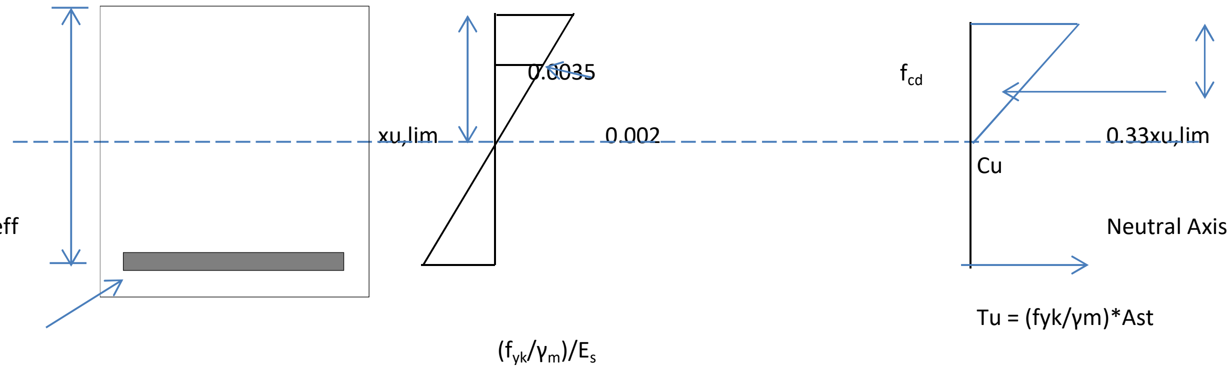
Here R_{lim} is in MPa

Calculation of Reinforcement

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

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

5.3.2 Verification for serviceability limit state for outer wall



Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

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

As per clause 12.2.1, IRC:112-2011

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

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

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

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 300 mm

Clear cover = 75

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

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

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

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

6.0 Summary of provided Reinforcement

Provided Reinforcement

Top Slab

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

Index

1.0 Design Report

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

1.1 Introduction:-

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

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

1.2 Reference documents :-

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

1.3 Assumptions:-

The following assumptions have been taken while designing the Box.

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

1.4 Loads:-

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

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

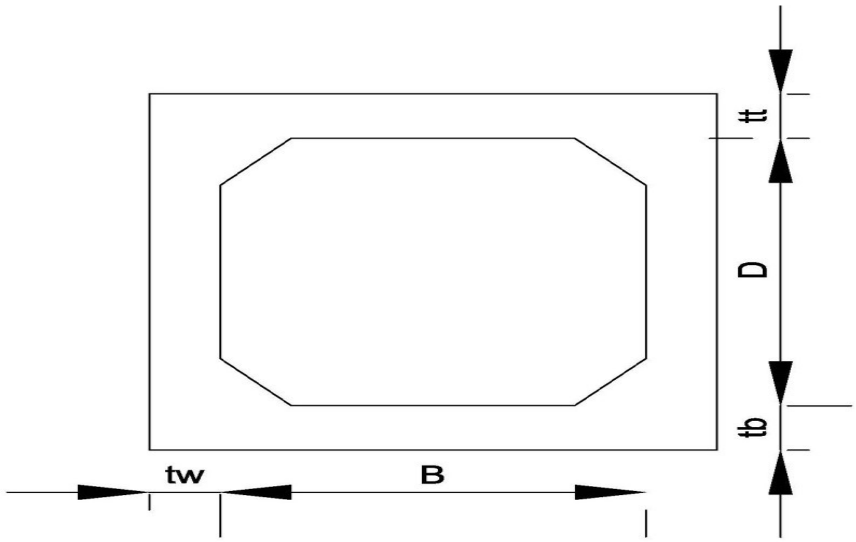
1.5 Load combinations

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

1.6 Material properties

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

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



2.1 Dimensions of Box

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

SIDL (Top Slab)

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

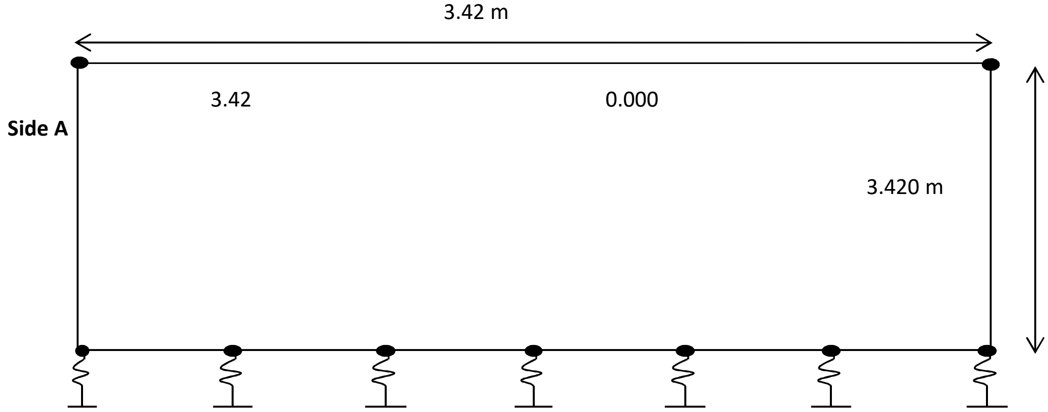
2.2 Basic Parameters

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

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

2.3 Idealised Structure for Staad Analysis

(Analysis is done for 1m Strip)



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

3.1 Earth Pressure and Live Load Calculation

1) a Earth Pressure (Normal Condition)

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

1) b Fluid Pressure

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

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

Earth Pressure	Height
2.69	0.21
46.43	3.630 m

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

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

2) a Live Load Surcharge (Normal Condition)

Live Load Surcharge = 6.696 kN/m

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

Live Load Surcharge = 5.651 kN/m

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

Live Load Surcharge = 15.348 kN/m

2) d Live Load Surcharge at rest

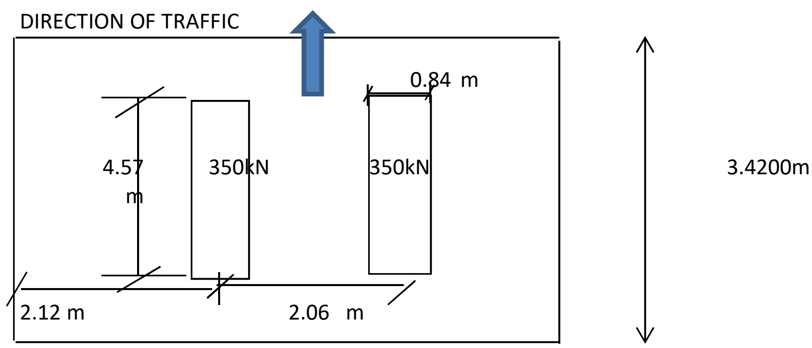
Live Load Surcharge = 12.000 kN/m

2) e Load due to water on Bottom Slab

Uniform Load = 24.95 kN/m^2

3) Live Load on Top Slab

A) 70R Track at Mid Span



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

Effective width of Loading

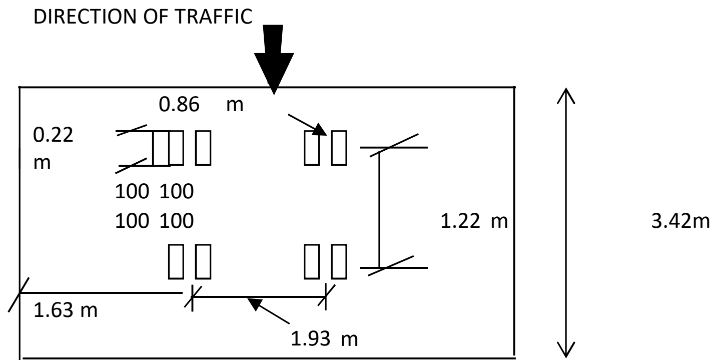
a	=	1.71 m
b1	=	0.99 m
b/lo	=	3.51
a	=	2.60
beff	=	3.21 m

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

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

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

B) 40T Boggie Load at Mid Span



Total Load = 400kN

<u>Effective width of Loading</u>

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

<u>Effective width of Loading</u>

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

<u>Effective width of Loading</u>

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

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

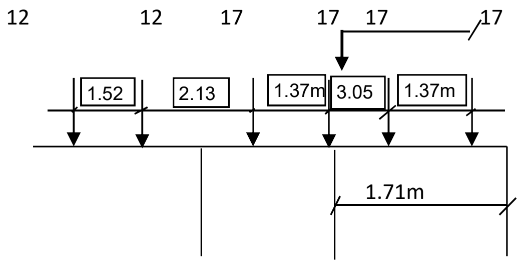
Effective width	=	5.27 m
Width along span	=	3.420 m
Load Intensity	=	29.07 kN/m^2

	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

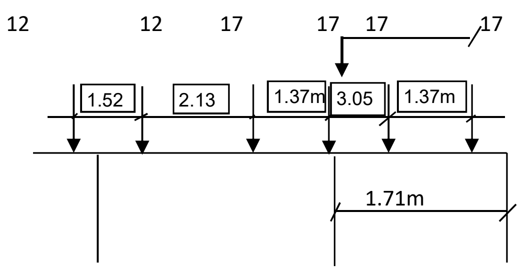


0.86m 1.93m 0.86m

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

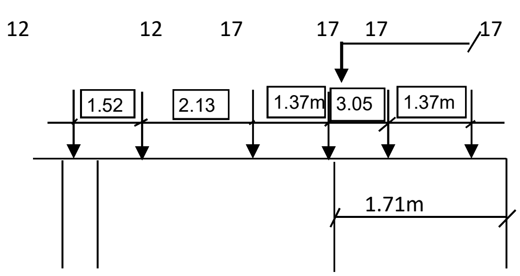
F) 70R Wheel Case 2



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



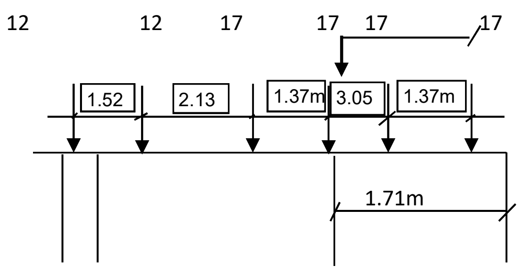
Width along span = 1.210m

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

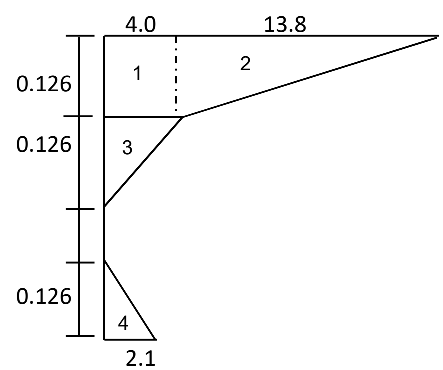
a = Coefficient of Thermal expansion = 1.20E-05 /^{o}C (as per IRC:6)

Dt = Temperature differential

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

Average thickness of Deck slab = 420 mm

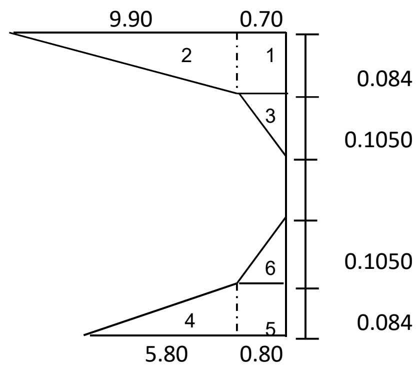
EFFECT OF TEMPERATURE RISE



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	0.042 m from bottom	-0.168
				SF =	67.77	M =	8.039

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

EFFECT OF TEMPERATURE FALL



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

3.3 Summary of factored moments

Grade of Concrete = M30

Grade of Steel = Fe500

Summary of factored moments

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

4.0 Partial Safety Factors

Material Parameters

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

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

Partial Safety Factor for Materials

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

Partial Safety Factor for Loads

Ultimate Limit State

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

Also refer IRC Amendment dated 28th July, 2012

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

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

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

Serviceability Limit State

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

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

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

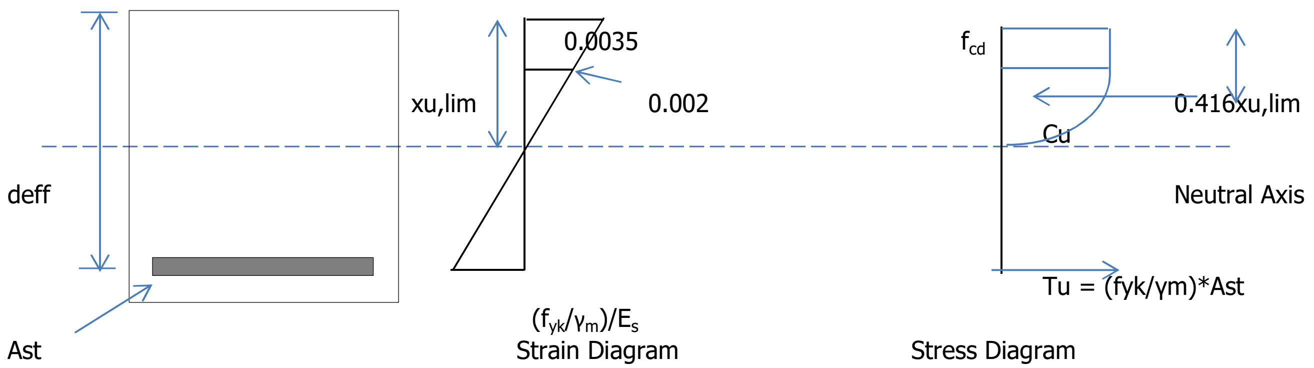
Combination for Base Pressure and Design of Foundation

Table 3.4, Annex B, IRC:6-2014
Also refer IRC Amendment dated 28th July, 2012

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

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

5.1.1 Verification of structural strength for top slab



ULTIMATE LIMIT STATE

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa

E_c = 31000 MPa

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

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

Clear cover = 50

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

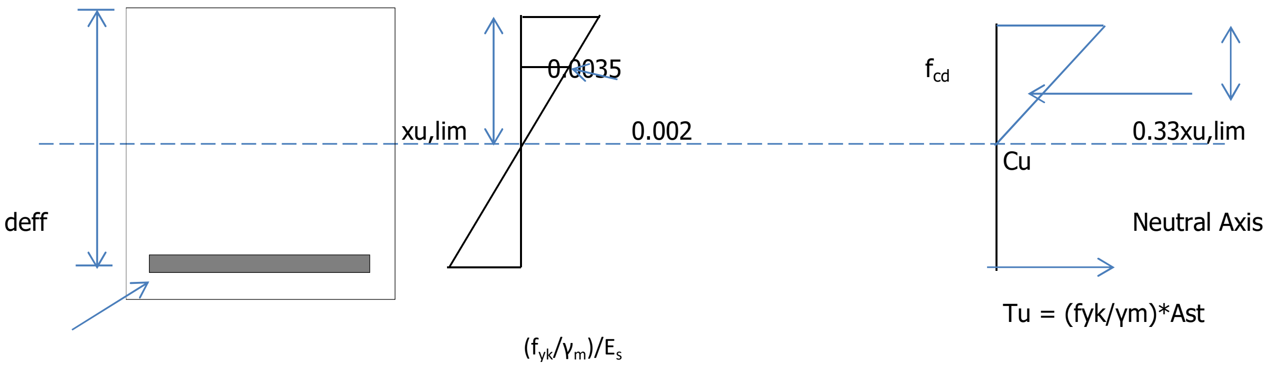
Moment on the section	**Top slab Top End support**			**Top slab Bottom Mid Span**		
	Basic Comb			Basic Comb		
Actual moment (KNm)	80.0			70.0		
b	1000			1000		
D	420			420		
c	50			50		
d	352.0			353.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
$xu_{,lim}/d$	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$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

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

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

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

5.1.2 Verification for serviceability limit state for top slab



Ast Strain Diagram Stress Diagram

SERVICEABILITY LIMIT STATE

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

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

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

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

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

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

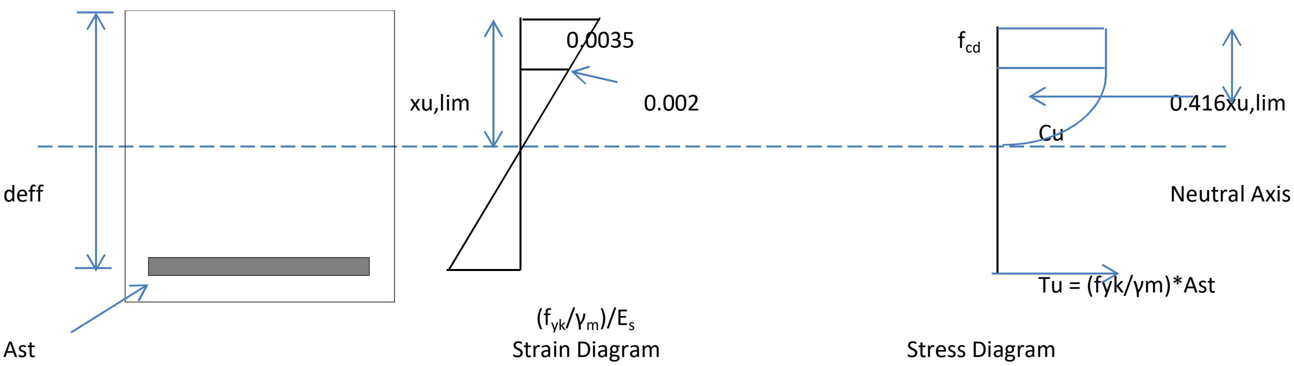
	Project	0	Designed by:	KB
	Client	0	Checked by:	0
	Job Name	RCC BOX OF SIZE 1 x 3 x 3	Date & Rev.	0

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

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

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

5.2.1 Verification of structural strength for bottom slab



<u>ULTIMATE LIMIT STATE</u>

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b	=	1000	mm			
Depth of section D	=	420	mm			
Clear cover at bott.	=	75		Clear cover at top	=	40

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

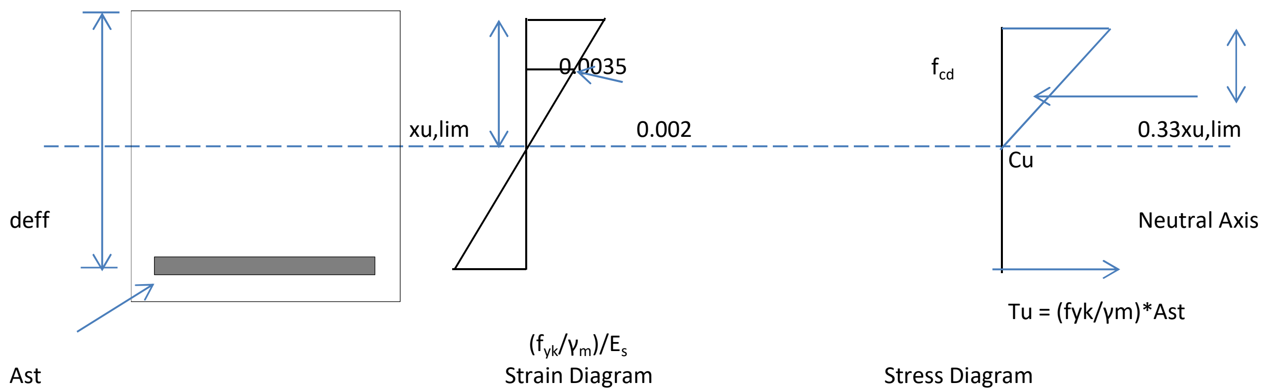
Moment on the section	Bottom End support			Top Mid Span		
	Combination (1)		Combination (2)	Combination (1)		Combination (2)
Actual moment (KNm)	130.0		107.0	111.0		93.0
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}	13.40		13.40	13.40		13.40
f_{Yd}	435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

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

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

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

5.2.2 Verification for serviceability limit state for bottom slab



SERVICEABILITY LIMIT STATE

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

As per clause 12.2.1, IRC:112-2011

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

As per clause 12.2.2, IRC:112-2011

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

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

Cu = 1/2*fcd*b*xu
= 0.5 *fcd*b*xu   Refer Chaper 5 of Reinfroced Concrete
cg of compression block from top = 0.33 xu   Limit State Design by Ashok K. Jain
Tu = fyd*Ast

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm
Depth of section d = 420 mm
Clear cover at bott. = 75   Clear cover at top = 40

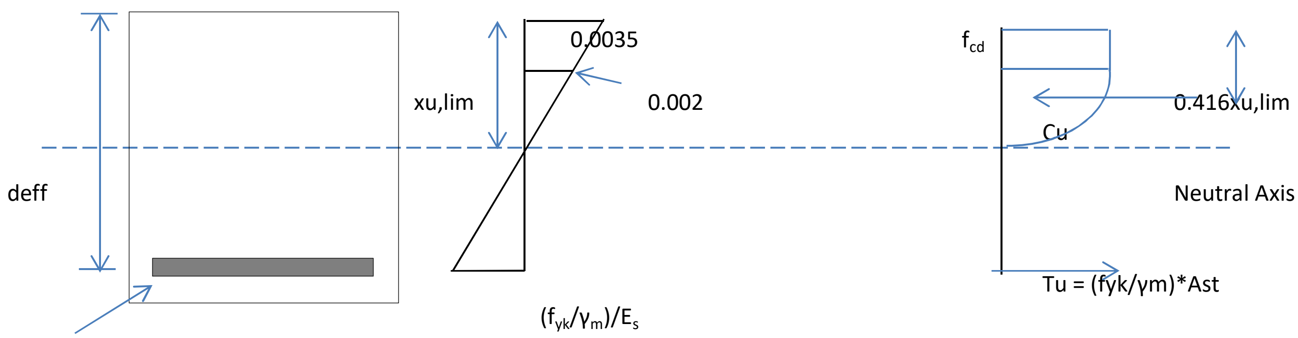
Moment on the section	**Bottom End support**			**Top Mid Span**		
	For Rare Combination		For Quasi-Perma. Combination	For Rare Combination		For Quasi-Perma. Combination
Actual moment (KNm)	91.0		28.0	77		24
b	1000		1000	1000		1000
D	420		420	420		420
c	75		75	40		40
d	327.0		327.0	363.0		363.0
f_{cd}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

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

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

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

5.3.1 Verification of structural strength for outer wall



Ast Strain Diagram Stress Diagram

ULTIMATE LIMIT STATE

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

As per clause 6.4.2.8, IRC:112-2011

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

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

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

E_c = 31000 MPa

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

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

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

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

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

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

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

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 420 mm

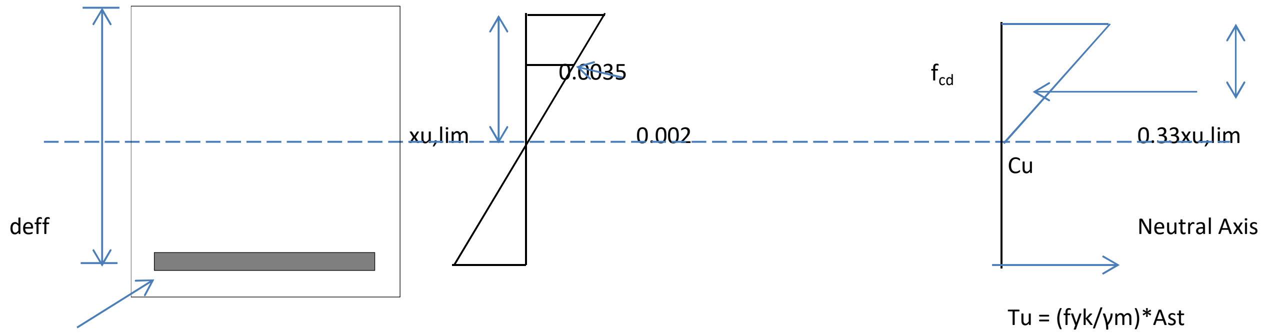
Clear cover = 75

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

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

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

5.3.2 Verification for serviceability limit state for outer wall



Ast

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

Strain Diagram

Stress Diagram

SERVICEABILITY LIMIT STATE

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

As per clause 12.2.1, IRC:112-2011

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

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

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

As per clause 12.2.2, IRC:112-2011

Grade of steel f_Y = 500 N/mm^2

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

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

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

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = 1/2*fcd*b*xu

= 0.5 *fcd*b*xu

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

cg of compression block from top = 0.33 xu

Tu = fyd*Ast

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

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

Here R_{sls} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section d = 420 mm

Clear cover = 75

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

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

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

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

6.0 Summary of provided Reinforcement

Provided Reinforcement

Top Slab

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

Bottom Slab

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

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

Outer Wall

At outer face of top end

Area of Steel Provided = 1508.0 mm^2/m

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

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

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

At inner face of top end

Area of Steel Required = 488.9 mm^2/m

Area of Steel Provided = 523.6 mm^2/m

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

At outer face of bottom end

Area of Steel Provided = 1508.0 mm^2/m

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

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

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

At inner face of bottom end

Area of Steel Provided = 523.6 mm^2/m

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

Shear Reinforcement

Bottom Slab

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

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

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

Top Slab

Req. Reinforcement = 264 mm^2/m

Provided Reinforcement =

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

Bottom Slab

Req. Reinforcement = 271.3 mm^2/m

Provided Reinforcement =

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

Outer Wall

Req. Reinforcement = 244.4 mm^2/m

Provided Reinforcement =

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

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

7.0 Base Pressure

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

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

Bearing capacity = 100 KN/sqm

DESIGN OF BREAST WALL & RETAINING WALL

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

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

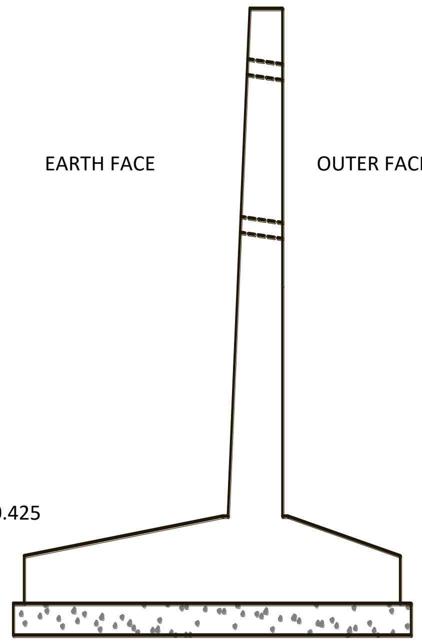
INDEX

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

Design Input:

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

Design Length of Wall	=	1.000	m
Levels			
FRL	=	100.000	m (Assumed)
Wall shaft top level	=	100.000	m
Ground level/LBL/MSL	=	95.000	m (Assumed)
Foundation level	=	93.000	
Shaft bottom level	=	93.550	m
Coeff. Of Friction μ	=	0.500	
FRL - FND LVL. H	=	7.000	m
SBC of soil-Normal Case	=	220.000	kN/m2
Permissible FOS against Sliding	=	1.500	Normal Case
Permissible FOS against Overturning	=	2.000	Normal Case
Wall			
Thickness of Wall shaft at Top	=	0.300	m
Thickness of Wall shaft at Bottom	=	0.700	m
Foundation			
Total Width of Footing	=	4.600	m
Width of Toe Slab	=	1.500	m
Width of Heel Slab	=	2.400	m
Thickness of Toe slab at tip	=	0.300	m
Thickness of Toe slab near shaft	=	0.550	m
Thickness of heel slab at tip	=	0.300	m
Thickness of heel slab near shaft	=	0.550	m
Depth of Footing below GL	=	2.000	m



Material Specification			
Concrete Grade	=	30	M
Characteristic Compressive Strength of Concrete,fck	=	30.00	Mpa at 28 days
Design Compressive strength of Concrete, fcd	=	13.400	Mpa at 28 (0.67/1.5 * fck)
Tensile strength of concrete , fctm	=	2.50	Mpa
Strain at reaching Characteistic Strength, 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 Retaining Wall for height 5 m from G.L	Date & Rev.	-

Load Factors (As per IRC:6-2014)

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

-Refer Table 3.2 of IRC:6-2014

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

Table 3.3 Partial Safety Factor For Verification of Servicibilty Limit State

-Refer Table 3.3 of IRC:6-2014

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

Table 3.4 Partial Safety Factor For Design of Foundation

-Refer Table 3.4 of IRC:6-2014

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

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

VOLUME CALCULATION

C.G. Of Footing	=	2.3	m
C.G. Of shaft from toe tip	=	1.85	m
Distance between c.g. Of shaft and footing =		0.45	m

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

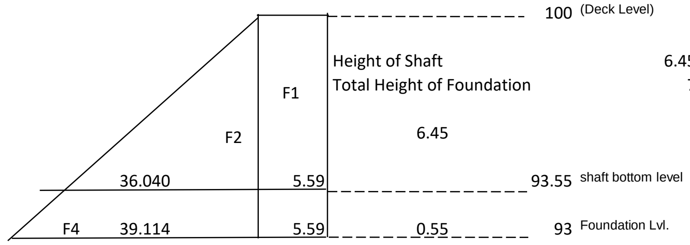
Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Retaining Wall for height 5 m from G.L*	*Date & Rev.*	-

Earth Pressure : Normal Dry Case

Properties of backfill material :

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

Assuming



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

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

@ RL 93 m (at Foundation Level)

Due to Live Load Surcharge

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

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

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

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

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

Intensity for triangular portion (At Foundation level)

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

Force Due To Fluid Pressure

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

Intensity for triangular portion (At Shaft bottom level)

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

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

Intensity for triangular portion (At Foundation level)

= 4.8 x 7 = 33.600 kN/m^2

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

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

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

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

Force due to passive @ Foundation, F

= 0.5 x 229.486 x 2 x 1 = 229.486 KN

Moment due to passive @ Foundation, M

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

Summary of Moment and Horizontal Force

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

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

Stability Check of Foundation

Foundation Lvl = 93.000 m

Properties of Footing Base:

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

Normal Dry Case

For SBC Calculation **For Equilibrium Calculation**

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

Load Factor	Vertical Load(P) kN.	Long. Ecc. (eL2) @ Toe (m)	ML@toe = PxeL2 (kNm)
1.000	80.625	-1.763	-142.169
1.000	315.6	-3.304	-1042.724
1.000	25.8	-2.067	-53.320
1.000	47.25	-0.742	-35.082
1.000	0	-1.5	0.000
1.000	25.5	-3.240	-82.620
1.000	15.9375	-0.850	-13.547
1.000	7.5625	-1.85	-13.991
	518.275		-1383.453

For Safe Bearing Capacity Calculation :

load factor

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

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

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

Check Against Sliding:

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

Check Against Overturning

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

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

Design of Foundation

Foundation Lvl = 93.000 m

Properties of Footing Base:

A = 4.600 m^2

ZL = 3.527 m^3

ZT = 0.767 m^3

Normal Dry Case

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

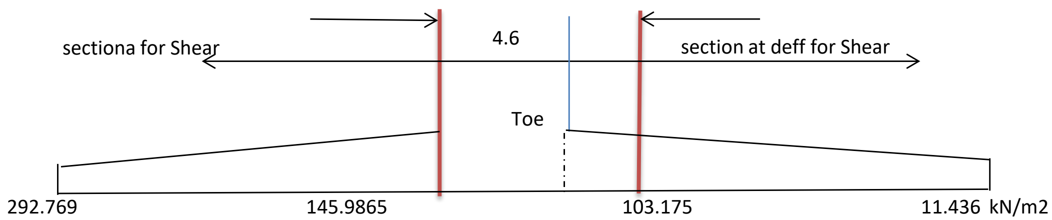
		load factor					
Moment due to active earth pressure	=	1.500	x	402.4800684	=	603.720	kNm
Moment due to Live load surcharge	=	1.200	x	136.8980	=	164.278	kNm
						767.998	

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

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

Normal Dry Case

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



Normal Dry Case

Heel Slab - Moment Calculation

Average Base Pressure for Design of Heel Slab	=	219.38 kN/m2												
Upward moment due to Base pressure	=	631.81 kNm/m												
	factor			VOL										
Downward moment due to backfill	=	1.350	x	15.78	/	1	x	20	x	1.2	=	511.272	kNm/m	
Downward moment due to self weight of Heel	=	1.35	x	1.02	/	1	x	25	x	1.040	=	35.802	kNm/m	
Net Moment at face of shaft	=	631.81	-511.27	-35.80		84.73	kNm/m	OK						

Heel Slab - Shear Calculation at Face of Wall

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

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

Average Base Pressure for Design of Toe Slab													
	=	57.31	kN/m2										
Upward moment due to Base pressure	=	64.47	kNm/m										
Downward moment due to self weight of Toe	=	1.35	x	0.6375	/	1	x	25	x	0.650	=	13.985	kNm/m
Net Moment at face of shaft	=	64.47		-13.985	=	50.483	kNm/m	OK					

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

Toe Slab - Shear Calculation at deff from Face of Wall

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

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

Design Input :

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

Project	-	Designed by:	KB
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

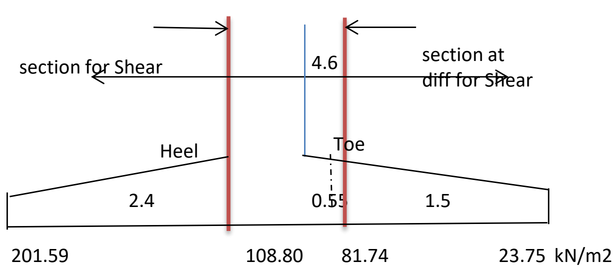
Normal Dry Case

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

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)	=	$\frac{\sigma sc - k_t f_{ct\,eff} (1 + \alpha_e \rho_{p\,eff})}{\rho_p\, eff}$	/ Es		
tensile stress in steel, ,σsc	=	97.018	113.889	N/mm2	
Kt	=	0.500	0.500		
Tensile strength of concrete = fct eff = fctm	=	2.500	2.500	N/mm2	319.12
αe = Es/Ecm	=	6.452	6.452		
(εsm - εcm)	=	-0.001	-0.0010		
Crack width , Wk=Sr max (εsm - εcm)	=	**0.000**	**0.000**		
Check	=	**SAFE**	**SAFE**		

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

Calculation of Forces For Design of Wall

Wall bottom level = 93.55 m

Normal Dry Case

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

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

Total Horizontal Force = 217.59 KN

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

Total Moment due to Horizontal Force = 580.105 kNm

Summary of Forces:

P	108.844	KN
ML	589.539	kNm
FL	217.594	KN

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

Design of Wall:

Grade of Concrete = 30.00 M 30

fck = 30.00 N/mm2

fcd = 13.40 N/mm2

Grade of steel 500.00 Fe

fy = 500.00 N/mm2

fyd = 434.78 N/mm2

Es = 200000.00 N/mm2

Cross section of Wall:

Thickness of Wall (B) = 0.7 m

Depth of Wall (D) = 1 m

Area of Concrete (Ac) = 0.7 m2

Clear Cover to earth faces = 75 mm

Clear Cover to non earth faces = 40 mm

Maximum Dia of Vertical Reinf. = 16 mm

Dia of Horizontal Reinf. = 12 mm

Summary of Design Forces:

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

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = 108.84 kN

0.1 fcd Ac

= 0.1 13.4 700000

= 938000 N

= 938.0 kN

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

PART 1: LONGITUDINAL MOMENT : VERTICAL REINFORCEMENT ON EARTH FACE

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

Check For Depth of Wall :

Mult = 0.167 x fck x b x d^2

= 589.54 kNm/m

b = 1000 mm

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

(dreq) 343.03 mm

Total Depth Required (Dreq) = 426.03 mm

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

Effective depth provided(deff) = 617 mm

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

Minimum Longitudinal Reinforcement in wall on each face

=

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

Ast min = 840 mm2/m

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

Area of Steel Required:

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

= 0.0038

Ast_{req} = 2660.74 mm2/m

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

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

Percentage of steel = 0.374 %

Check for Moment of Resistance of Section due to Steel

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

= 380.60 mm

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

= 105.38 mm

OK

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

z = d - 0.416 x X

= 573.16 mm

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

MR = fyd . Ast . Z

= 652324195.0

= 6.52E+08 Nmm /m

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

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

LONGITUDINAL REINFORCEMENT ON NON EARTH FACE

Minimum Longitudinal Reinforcement in wall on each face

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

Ast min = 840 mm2/m

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

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

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

= 0.001 x 7.00E+05 = 700.00

Minimum Horizontal Reinf. provided 890.0 mm2 per meter

Min dia of bar = 0.25 x 16 = 4 mm

or 8 mm

Maximum Spacing between bars <= 300 mm/cc

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

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

SLS CHECK OF WALL

Foundation Lvl = 93.55 m

Creep Coeff (¢ = 1.2 For Dry atmosperic condition

Ecm = 31000

Es = 200000 N/mm2

Eceff = Ecm / (1 + ø) = 14090.90909

Modular Ratio (m) = Es/ Eceff = 14.19

Normal Dry Case

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

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

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

Summary of Forces:

P	80.625	KN
ML	414.841	kNm
FL	145.063	KN

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

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

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

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

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

Stability Check Summary

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

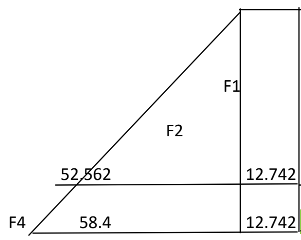
Reinforcement summary

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

Earth Pressure : Normal Dry Case

Properties of backfill material :

c	=	0					
ϕ	=	**30**	degree	0.524	radians	0.866	
θ	=	87.11	degree	1.520	radians	0.050	
θ1	=	90	degree	1.571	radians	0.000	
β	=	26.5	degree	0.462512252	radians	0.895	
δ	=	**20**	degree	0.349	radians	0.940	
Kah	=	0.279	active component				
Kph	=	5.737	Passive component				
γ	=	20	kN/m3				
Equivalent Live Load Surcharge height	=	1.2	m				
Assuming				100	(Deck Level)		
			Height of Shaft	6.45	m		6.45
			Total Height of Foundation	7	m		7
				6.45			
				93.55	shaft bottom level		
			0.55	93	Foundation Lvl.		



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

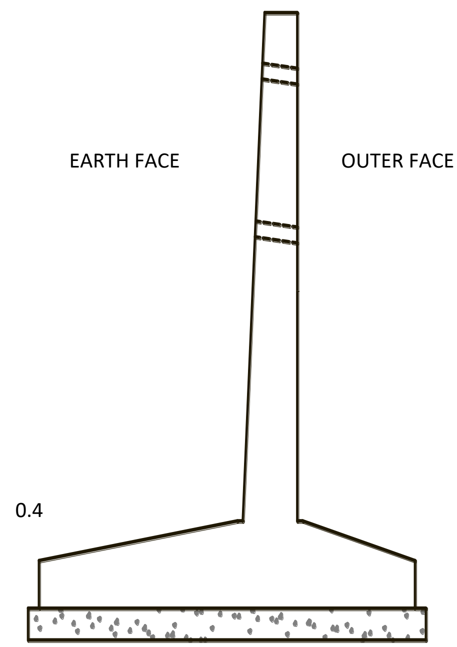
INDEX

	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

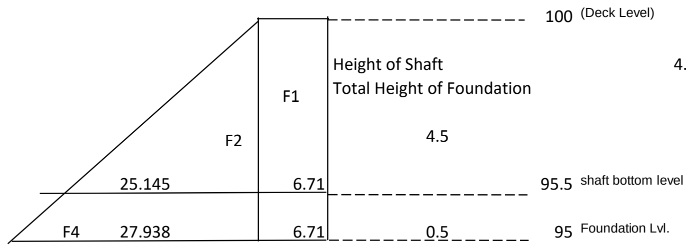
Project	-	*Designed by:*	*KB*
Client	-	*Checked by:*	-
Job Name	*Design of Breast Wall for height 3 m from G.L*	*Date & Rev.*	-

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



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

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

@ RL 95 m (at Foundation Level)

Due to Live Load Surcharge

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

Due to Active Earth Pressure

Intensity for triangular portion (At Shaft bottom level)

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

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

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

Intensity for triangular portion (At Foundation level)

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

Force Due To Fluid Pressure

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

Intensity for triangular portion (At Shaft bottom level)

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

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 m²

ZL = 2.220 m³

ZT = 0.608 m³

Normal Dry Case

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

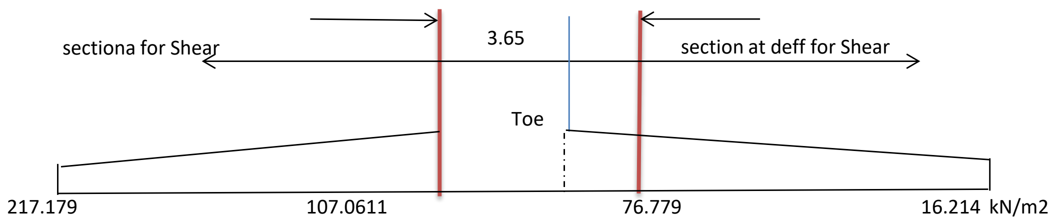
		load factor					
Moment due to active earth pressure	=	1.500	x	146.6764098	=	220.015	kNm
Moment due to Live load surcharge	=	1.200	x	83.8151	=	100.578	kNm
						320.593	

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

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

Normal Dry Case

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



Normal Dry Case

Heel Slab - Moment Calculation

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

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

Heel Slab - Shear Calculation at Face of Wall

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

Toe Slab - Moment Calculation

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

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

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

Toe Slab - Shear Calculation at deff from Face of Wall

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

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

Design Input :

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

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

Flexural Reinforcement Calculation:

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

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

Shear Reinforcement Calculation:

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

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

SLS CHECK OF FOUNDATION

Foundation Lvl = 95.000 m

Properties of Footing Base:

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

Creep Coeff = 1.2 For Dry atmosperic condition

Ecm = 31000 N/mm2

Es = 200000 N/mm2

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

Modular Ratio (m) = Es/ Eceff = 14.19

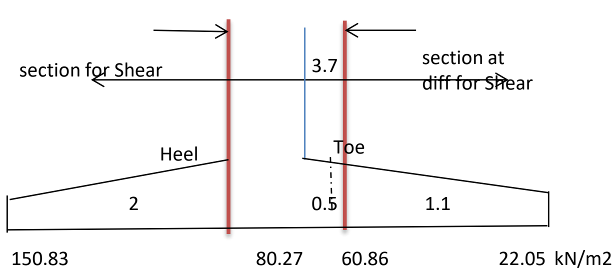
Normal Dry Case

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

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

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

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



Normal Dry Case

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

Heel Slab - Moment Calculation

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

Toe Slab - Moment Calculation

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

		Heel Slab	Toe Slab	
Working bending moment, M	=	29.06	19.62	kNm/m
Dx	=	1.00	1.00	m
Dy	=	0.55	0.55	m
Section Modulus (ZL) of uncracked sectio	=	0.05	0.05	m3
Bending Stress (M/ZL)	=	0.576	0.389	N/mm2
Tensile stress of concrete , fctm	=	2.500	2.500	N/mm2
Cracked or Uncracked Section	=	Uncracked	Uncracked	
Section properties of Cracked section:				
Note: Stresses under Service load are usually within Linear Elastic Range hence such analysis involved use of Modulus ratio.				
Clear Cover, c	=	75.000	75.000	
Maximum dia used, f	=	12.000	12.000	
Effective Depth deff (dy)	=	419.000	419.000	mm
Ast provided	=	628.240	628.240	mm2/m
Percentage of steel , pt	=	0.0022	0.0023	
k=sqrt{ 2 pt *m + (pt*m)^2 } - pt* m	=	0.221	0.226	
Depth of neutral axis from extreme Compression face (yc = k * dy)	=	92.472	94.512	mm
Depth of neutral axis from extreme tension face (yt = dy-yc)	=	326.528	324.488	mm
Depth of neutral axis from c.g. Of tension steel (ys)	=	245.528	243.488	mm
Cracked moment of Inertia (Icr)	=	Dx *(k * dy)^3/3 + m Ast * (dy - k * dy)^2		

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

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)	=	$\dfrac{\sigma sc - k_t f_{ct\,eff} (1 + \alpha_e \, p_{p\,eff})}{p_p\,eff}$	/ Es		
tensile stress in steel, ,σsc	=	113.835	76.872	N/mm2	
Kt	=	0.500	0.500		
Tensile strength of concrete = fct eff = fctm	=	2.500	2.500	N/mm2	424.9
αe = Es/Ecm	=	6.452	6.452		
(εsm - εcm)	=	-0.002	-0.0017		
Crack width , Wk=Sr max (εsm - εcm)	=	**0.000**	**0.000**		
Check	=	**SAFE**	**SAFE**		

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

Calculation of Forces For Design of Wall

Wall bottom level = 95.5 m

Normal Dry Case

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

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

Total Horizontal Force = 121.07 KN

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

Total Moment due to Horizontal Force = 326.637 kNm

Summary of Forces:

P	64.547	KN
ML	330.276	kNm
FL	121.071	KN

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

Design of Wall:

Grade of Concrete = 30.00 M 30

fck = 30.00 N/mm2

fcd = 13.40 N/mm2

Grade of steel 500.00 Fe

fy = 500.00 N/mm2

fyd = 434.78 N/mm2

Es = 200000.00 N/mm2

Cross section of Wall:

Thickness of Wall (B) = 0.55 m

Depth of Wall (D) = 1 m

Area of Concrete (Ac) = 0.55 m2

Clear Cover to earth faces = 75 mm

Clear Cover to non earth faces = 40 mm

Maximum Dia of Vertical Reinf. = 16 mm

Dia of Horizontal Reinf. = 12 mm

Summary of Design Forces:

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

As per Clause 7.6.4.1 of IRC:112-2011

Ultimate axial force (Pu) = 64.55 kN

0.1 fcd Ac

= 0.1 13.4 550000

= 737000 N

= 737.0 kN

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

PART 1: LONGITUDINAL MOMENT : VERTICAL REINFORCEMENT ON EARTH FACE

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

Check For Depth of Wall :

Mult = 0.167 x fck x b x d^2

= 330.28 kNm/m

b = 1000 mm

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

(dreq) 256.76 mm

Total Depth Required (Dreq) = 339.76 mm

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

Effective depth provided(deff) = 467 mm

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

Minimum Longitudinal Reinforcement in wall on each face

=

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

Ast min = 660 mm2/m

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

Area of Steel Required:

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

= 0.0037

Ast_{req} = 2041.14 mm2/m

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

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

Percentage of steel = 0.381 %

Check for Moment of Resistance of Section due to Steel

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

= 288.07 mm

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

= 84.30 mm

OK

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

z = d - 0.416 x X

= 431.93 mm

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

MR = fyd . Ast . Z

= 393268377.6

= 3.93E+08 Nmm /m

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

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

LONGITUDINAL REINFORCEMENT ON NON EARTH FACE

Minimum Longitudinal Reinforcement in wall on each face

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

Ast min = 660 mm2/m

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

PART 3 : HORIZONTAL REINFORCEMENT CALCULATION

Horizontal Reinforcement for wall

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

= 0.001 x 5.50E+05 = 550.00

Minimum Horizontal Reinf. provided 712.0 mm2 per meter

Min dia of bar = 0.25 x 16 = 4 mm

or 8 mm

Maximum Spacing between bars <= 300 mm/cc

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

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

SLS CHECK OF WALL

Foundation Lvl = 95.5 m

Creep Coeff (¢ = 1.2 For Dry atmosperic condition

Ecm = 31000

Es = 200000 N/mm2

Eceff = Ecm / (1 + ø) = 14090.90909

Modular Ratio (m) = Es/ Eceff = 14.19

Normal Dry Case

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

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

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

Summary of Forces:

P	47.813	KN
ML	163.935	kNm
FL	80.714	KN

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

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

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

Check For Crack Width			
Crack width , Wk	=	Sr max (εsm - εcm)	
Above Formula For Calculation of Sr max is applicable if the spacing between the reinf. is less or equal to 5*(c+ϕ/2)			
5*(c+ϕ/2)	=	415.000	mm
Provided Spacing	=	160.000	mm
Check for Applicability of Formula	=	OK	
Maximum crack spacing , $S_{r\,max}$	=	3.4 c +	0.425 k1 k2 ϕ / $p_{p\,eff}$
K1	=	0.700	for deformed b
K2	=	0.500	for bending
depth of neutral axis , yc	=	167.664	mm
$\Sigma_{r\,eff}$ = As/Ac eff	=	, where Ac,eff =effective area of concrete in tension surrounding the reinf.	
hc eff = Min of 2.5 (Dy - dy) ,Dy - yc/3 , Dy/2	=	207.500	mm
Ac, eff = Dx * hc,eff	=	207500.000	mm
$\Sigma_{r\,eff}$ = As/Ac eff	=	0.010	
Maximum crack spacing , $S_{r\,max}$	=	490.825	mm
(ε_{sm} - ε_{cm})	=	σsc - kt fct eff (1 + αe r r eff) / r r eff	/ Es
tensile stress in steel, ,σsc	=	172.295	N/mm2
Kt	=	0.500	
Tensile strength of concrete = fct eff = fctm	=	2.500	N/mm2
αe = Es/Ecm	=	6.452	
(εsm - εcm)	=	0.00020	
Crack width , Wk=Sr max (εsm - εcm)	=	**0.099**	
Check	=	**SAFE**	

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

Stability Check Summary

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

Reinforcement summary

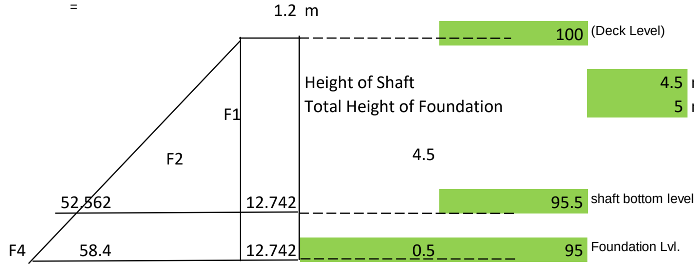
Type of reinforcement	Area of steel required	Area of steel provided						
Straight Portion of Shaft								
Vertical steel at earth face	2041	16	mm bar @	150	mm c/c (i.e.)	2094	mm2	OK
		12	mm bar @	150	mm c/c (i.e.)			
Vertical steel at non-earth face	660	12	mm bar @	150	mm c/c (i.e.)	754	mm2	OK
Distribution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

Earth Pressure : Normal Dry Case

Properties of backfill material :

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

Assuming



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

HORIZONTAL ALIGNMENT REPORT

Horizontal Alignment Report

S.No.	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Start Direction	End Direction	Incurve
1	Line	30800	30823.197	23.197			N89° 52' 30.29"W				
2	Spiral-Curve-Spiral	30823.197	30843.197	20		31.623m		11.4592 (d)	N89° 52' 30.29"W	N78° 24' 57.33"W	Incurve
3	Spiral-Curve-Spiral	30843.197	30873.534	30.337	50.000m			34.7635 (d)	N78° 24' 57.33"W	N43° 39' 08.70"W	
4	Spiral-Curve-Spiral	30873.534	30893.534	20		31.623m		11.4592 (d)	N43° 39' 08.70"W	N32° 11' 35.74"W	Outcurve
5	Line	30893.534	30979.782	86.248			N32° 11' 35.74"W				
6	Spiral-Curve-Spiral	30979.782	30999.782	20		31.623m		11.4592 (d)	N32° 11' 35.74"W	N43° 39' 08.70"W	Incurve
7	Spiral-Curve-Spiral	30999.782	31053.851	54.07	50.000m			61.9592 (d)	N43° 39' 08.70"W	S74° 23' 18.26"W	
8	Spiral-Curve-Spiral	31053.851	31073.851	20		31.623m		11.4592 (d)	S74° 23' 18.26"W	S62° 55' 45.29"W	Outcurve
9	Line	31073.851	31089.017	15.165			S62° 55' 45.29"W				
10	Spiral-Curve-Spiral	31089.017	31119.017	30		47.434m		11.4592 (d)	S62° 55' 45.29"W	S74° 23' 18.26"W	Incurve
11	Spiral-Curve-Spiral	31119.017	31142.564	23.548	75.000m			17.9890 (d)	S74° 23' 18.26"W	N87° 37' 21.35"W	
12	Spiral-Curve-Spiral	31142.564	31172.564	30		47.434m		11.4592 (d)	N87° 37' 21.35"W	N76° 09' 48.39"W	Outcurve
13	Line	31172.564	31276.174	103.609			N76° 09' 48.39"W				
14	Spiral-Curve-Spiral	31276.174	31296.174	20		44.721m		5.7296 (d)	N76° 09' 48.39"W	N70° 26' 01.91"W	Incurve
15	Spiral-Curve-Spiral	31296.174	31316.559	20.386	100.000m			11.6802 (d)	N70° 26' 01.91"W	N58° 45' 13.29"W	
16	Spiral-Curve-Spiral	31316.559	31336.559	20		44.721m		5.7296 (d)	N58° 45' 13.29"W	N53° 01' 26.81"W	Outcurve
17	Line	31336.559	31340.237	3.678			N53° 01' 26.81"W				
18	Spiral-Curve-Spiral	31340.237	31370.237	30		47.434m		11.4592 (d)	N53° 01' 26.81"W	N41° 33' 53.85"W	Incurve
19	Spiral-Curve-Spiral	31370.237	31423.246	53.009	75.000m			40.4958 (d)	N41° 33' 53.85"W	N1° 04' 08.91"W	
20	Spiral-Curve-Spiral	31423.246	31433.246	10		27.386m		3.8197 (d)	N1° 04' 08.91"W	N2° 45' 02.07"E	Outcurve
21	Line	31433.246	31439.258	6.012			N2° 45' 02.07"E				
22	Spiral-Curve-Spiral	31439.258	31459.258	20		31.623m		11.4592 (d)	N2° 45' 02.07"E	N8° 42' 30.89"W	Incurve
23	Spiral-Curve-Spiral	31459.258	31499.606	40.348	50.000m			46.2357 (d)	N8° 42' 30.89"W	N54° 56' 39.34"W	
24	Spiral-Curve-Spiral	31499.606	31519.606	20		31.623m		11.4592 (d)	N54° 56' 39.34"W	N66° 24' 12.30"W	Outcurve
25	Line	31519.606	31539.129	19.523			N66° 24' 12.30"W				
26	Spiral-Curve-Spiral	31539.129	31559.129	20		63.246m		2.8648 (d)	N66° 24' 12.30"W	N63° 32' 19.06"W	Incurve
27	Spiral-Curve-Spiral	31559.129	31669.662	110.532	200.000m			31.6652 (d)	N63° 32' 19.06"W	N31° 52' 24.50"W	
28	Spiral-Curve-Spiral	31669.662	31689.662	20		63.246m		2.8648 (d)	N31° 52' 24.50"W	N29° 00' 31.26"W	Outcurve
29	Line	31689.662	31983.321	293.659			N29° 00' 31.26"W				
30	Spiral-Curve-Spiral	31983.321	32003.321	20		24.495m		19.0986 (d)	N29° 00' 31.26"W	N48° 06' 26.19"W	Incurve
31	Spiral-Curve-Spiral	32003.321	32073.275	69.955	30.000m			133.6034 (d)	N48° 06' 26.19"W	S1° 42' 38.61"E	
32	Spiral-Curve-Spiral	32073.275	32093.275	20		24.495m		19.0986 (d)	S1° 42' 38.61"E	S20° 48' 33.54"E	Outcurve
33	Line	32093.275	32302.322	209.047			S20° 48' 33.54"E				
34	Spiral-Curve-Spiral	32302.322	32322.322	20		54.772m		3.8197 (d)	S20° 48' 33.54"E	S16° 59' 22.56"E	Incurve
35	Spiral-Curve-Spiral	32322.322	32381.006	58.685	150.000m			22.4159 (d)	S16° 59' 22.56"E	S5° 25' 34.53"W	
36	Spiral-Curve-Spiral	32381.006	32401.006	20		54.772m		3.8197 (d)	S5° 25' 34.53"W	S9° 14' 45.52"W	Outcurve
37	Line	32401.006	32695.709	294.703			S9° 14' 45.52"W				
38	Spiral-Curve-Spiral	32695.709	32725.709	30		67.082m		5.7296 (d)	S9° 14' 45.52"W	S14° 58' 32.00"W	Incurve
39	Spiral-Curve-Spiral	32725.709	32786.193	60.484	150.000m			23.1033 (d)	S14° 58' 32.00"W	S38° 04' 43.82"W	
40	Spiral-Curve-Spiral	32786.193	32816.193	30		67.082m		5.7296 (d)	S38° 04' 43.82"W	S43° 48' 30.30"W	Outcurve
41	Line	32816.193	33034.692	218.499			S43° 48' 30.30"W				

Horizontal Alignment Report											
S.No.	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Start Direction	End Direction	Incurve
42	Spiral-Curve-Spiral	33034.692	33054.692	20		40.000m		7.1620 (d)	S43° 48' 30.30"W	S50° 58' 13.40"W	Incurve
43	Spiral-Curve-Spiral	33054.692	33095.037	40.345	80.000m			28.8948 (d)	S50° 58' 13.40"W	S79° 51' 54.52"W	
44	Spiral-Curve-Spiral	33095.037	33115.037	20		40.000m		7.1620 (d)	S79° 51' 54.52"W	S87° 01' 37.62"W	Outcurve
45	Line	33115.037	33328.854	213.817			S87° 01' 37.62"W				
46	Spiral-Curve-Spiral	33328.854	33348.854	20		70.711m		2.2918 (d)	S87° 01' 37.62"W	S84° 44' 07.03"W	Incurve
47	Spiral-Curve-Spiral	33348.854	33404.04	55.186	250.000m			12.6478 (d)	S84° 44' 07.03"W	S72° 05' 14.93"W	
48	Spiral-Curve-Spiral	33404.04	33424.04	20		70.711m		2.2918 (d)	S72° 05' 14.93"W	S69° 47' 44.34"W	Outcurve
49	Line	33424.04	33482.575	58.535			S69° 47' 44.34"W				
50	Spiral-Curve-Spiral	33482.575	33502.575	20		48.990m		4.7746 (d)	S69° 47' 44.34"W	S65° 01' 15.61"W	Incurve
51	Spiral-Curve-Spiral	33502.575	33509.957	7.382	120.000m			3.5245 (d)	S65° 01' 15.61"W	S61° 29' 47.57"W	
52	Spiral-Curve-Spiral	33509.957	33529.957	20		48.990m		4.7746 (d)	S61° 29' 47.57"W	S56° 43' 18.84"W	Outcurve
53	Line	33529.957	33666.413	136.456			S56° 43' 18.84"W				
54	Spiral-Curve-Spiral	33666.413	33696.413	30		38.730m		17.1887 (d)	S56° 43' 18.84"W	S39° 31' 59.39"W	Incurve
55	Spiral-Curve-Spiral	33696.413	33724.414	28.001	50.000m			32.0866 (d)	S39° 31' 59.39"W	S7° 26' 47.50"W	
56	Spiral-Curve-Spiral	33724.414	33754.414	30		38.730m		17.1887 (d)	S7° 26' 47.50"W	S9° 44' 31.94"E	Outcurve
57	Line	33754.414	33793.054	38.64			S9° 44' 31.94"E				
58	Spiral-Curve-Spiral	33793.054	33813.054	20		44.721m		5.7296 (d)	S9° 44' 31.94"E	S4° 00' 45.46"E	Incurve
59	Spiral-Curve-Spiral	33813.054	33870.792	57.739	100.000m			33.0818 (d)	S4° 00' 45.46"E	S29° 04' 09.17"W	
60	Spiral-Curve-Spiral	33870.792	33890.792	20		44.721m		5.7296 (d)	S29° 04' 09.17"W	S34° 47' 55.65"W	Outcurve
61	Line	33890.792	33953.095	62.303			S34° 47' 55.65"W				
62	Spiral-Curve-Spiral	33953.095	33973.095	20		50.000m		4.5837 (d)	S34° 47' 55.65"W	S30° 12' 54.47"W	Incurve
63	Spiral-Curve-Spiral	33973.095	33985.62	12.525	125.000m			5.7409 (d)	S30° 12' 54.47"W	S24° 28' 27.29"W	
64	Spiral-Curve-Spiral	33985.62	34005.62	20		50.000m		4.5837 (d)	S24° 28' 27.29"W	S19° 53' 26.11"W	Outcurve
65	Line	34005.62	34145.445	139.825			S19° 53' 26.11"W				
66	Spiral-Curve-Spiral	34145.445	34165.445	20		31.623m		11.4592 (d)	S19° 53' 26.11"W	S8° 25' 53.15"W	Incurve
67	Spiral-Curve-Spiral	34165.445	34218.74	53.295	50.000m			61.0717 (d)	S8° 25' 53.15"W	S52° 38' 24.83"E	
68	Spiral-Curve-Spiral	34218.74	34238.74	20		31.623m		11.4592 (d)	S52° 38' 24.83"E	S64° 05' 57.79"E	Outcurve
69	Line	34238.74	34343.496	104.756			S64° 05' 57.79"E				
70	Spiral-Curve-Spiral	34343.496	34363.496	20		24.495m		19.0986 (d)	S64° 05' 57.79"E	S45° 00' 02.86"E	Incurve
71	Spiral-Curve-Spiral	34363.496	34368.798	5.302	30.000m			10.1260 (d)	S45° 00' 02.86"E	S34° 52' 29.39"E	
72	Spiral-Curve-Spiral	34368.798	34388.798	20		24.495m		19.0986 (d)	S34° 52' 29.39"E	S15° 46' 34.45"E	Outcurve
73	Line	34388.798	34426.406	37.608			S15° 46' 34.45"E				
74	Spiral-Curve-Spiral	34426.406	34446.406	20		31.623m		11.4592 (d)	S15° 46' 34.45"E	S27° 14' 07.41"E	Incurve
75	Spiral-Curve-Spiral	34446.406	34461.791	15.386	50.000m			17.6306 (d)	S27° 14' 07.41"E	S44° 51' 57.63"E	
76	Spiral-Curve-Spiral	34461.791	34481.791	20		31.623m		11.4592 (d)	S44° 51' 57.63"E	S56° 19' 30.60"E	Outcurve
77	Line	34481.791	34491.072	9.28			S56° 19' 30.60"E				
78	Spiral-Curve-Spiral	34491.072	34506.072	15		21.213m		14.3239 (d)	S56° 19' 30.60"E	S42° 00' 04.39"E	Incurve
79	Spiral-Curve-Spiral	34506.072	34567.886	61.815	30.000m			118.0572 (d)	S42° 00' 04.39"E	S76° 03' 21.43"W	
80	Spiral-Curve-Spiral	34567.886	34582.886	15		21.213m		14.3239 (d)	S76° 03' 21.43"W	N89° 37' 12.37"W	Outcurve
81	Line	34582.886	34655.907	73.021			N89° 37' 12.37"W				
82	Spiral-Curve-Spiral	34655.907	34665.907	10		22.361m		5.7296 (d)	N89° 37' 12.37"W	N83° 53' 25.89"W	Incurve

Horizontal Alignment Report											
S.No.	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Start Direction	End Direction	Incurve
83	Spiral-Curve-Spiral	34665.907	34673.352	7.445	50.000m			8.5317 (d)	N83° 53' 25.89"W	N75° 21' 31.66"W	
84	Spiral-Curve-Spiral	34673.352	34683.352	10		22.361m		5.7296 (d)	N75° 21' 31.66"W	N69° 37' 45.17"W	Outcurve
85	Line	34683.352	34692.782	9.43			N69° 37' 45.17"W				
86	Spiral-Curve-Spiral	34692.782	34702.782	10		22.361m		5.7296 (d)	N69° 37' 45.17"W	N75° 21' 31.66"W	Incurve
87	Spiral-Curve-Spiral	34702.782	34726.076	23.294	50.000m			26.6932 (d)	N75° 21' 31.66"W	S77° 56' 52.84"W	
88	Spiral-Curve-Spiral	34726.076	34736.076	10		22.361m		5.7296 (d)	S77° 56' 52.84"W	S72° 13' 06.36"W	Outcurve
89	Line	34736.076	34950.046	213.97			S72° 13' 06.36"W				
90	Spiral-Curve-Spiral	34950.046	34975.046	25		43.301m		9.5493 (d)	S72° 13' 06.36"W	S62° 40' 08.89"W	Incurve
91	Spiral-Curve-Spiral	34975.046	35015.69	40.644	75.000m			31.0498 (d)	S62° 40' 08.89"W	S31° 37' 09.60"W	
92	Spiral-Curve-Spiral	35015.69	35040.69	25		43.301m		9.5493 (d)	S31° 37' 09.60"W	S22° 04' 12.13"W	Outcurve
93	Line	35040.69	35098.527	57.837			S22° 04' 12.13"W				
94	Spiral-Curve-Spiral	35098.527	35123.527	25		43.301m		9.5493 (d)	S22° 04' 12.13"W	S12° 31' 14.66"W	Incurve
95	Spiral-Curve-Spiral	35123.527	35129.267	5.74	75.000m			4.3850 (d)	S12° 31' 14.66"W	S8° 08' 08.82"W	
96	Spiral-Curve-Spiral	35129.267	35154.267	25		43.301m		9.5493 (d)	S8° 08' 08.82"W	S1° 24' 48.65"E	Outcurve
97	Line	35154.267	35381.48	227.213			S1° 24' 48.65"E				
98	Spiral-Curve-Spiral	35381.48	35411.48	30		67.082m		5.7296 (d)	S1° 51' 27.56"E	S7° 35' 14.04"E	Incurve
99	Spiral-Curve-Spiral	35411.48	35510.631	99.151	150.000m			37.8728 (d)	S7° 35' 14.04"E	S45° 27' 36.08"E	
100	Spiral-Curve-Spiral	35510.631	35540.631	30		67.082m		5.7296 (d)	S45° 27' 36.08"E	S51° 11' 22.56"E	Outcurve
101	Line	35540.631	35719.972	179.341			S51° 11' 22.56"E				
102	Spiral-Curve-Spiral	35719.972	35739.972	20		24.495m		19.0986 (d)	S51° 11' 22.56"E	S32° 05' 27.62"E	Incurve
103	Spiral-Curve-Spiral	35739.972	35803.129	63.156	30.000m			120.6195 (d)	S32° 05' 27.62"E	S88° 31' 42.61"W	
104	Spiral-Curve-Spiral	35803.129	35823.129	20		24.495m		19.0986 (d)	S88° 31' 42.61"W	N72° 22' 22.45"W	Outcurve
105	Line	35823.129	35825.445	2.316			N72° 22' 22.45"W				
106	Spiral-Curve-Spiral	35825.445	35845.445	20		38.730m		7.6394 (d)	N72° 22' 22.45"W	N80° 00' 44.42"W	Incurve
107	Spiral-Curve-Spiral	35845.445	35907.88	62.435	75.000m			47.6970 (d)	N80° 00' 44.42"W	S52° 17' 26.53"W	
108	Spiral-Curve-Spiral	35907.88	35927.88	20		38.730m		7.6394 (d)	S52° 17' 26.53"W	S44° 39' 04.55"W	Outcurve
109	Line	35927.88	35971.648	43.768			S44° 39' 04.55"W				
110	Spiral-Curve-Spiral	35971.648	36001.648	30		54.772m		8.5944 (d)	S44° 39' 04.55"W	S53° 14' 44.27"W	Incurve
111	Spiral-Curve-Spiral	36001.648	36058.809	57.161	100.000m			32.7506 (d)	S53° 14' 44.27"W	S85° 59' 46.47"W	
112	Spiral-Curve-Spiral	36058.809	36088.809	30		54.772m		8.5944 (d)	S85° 59' 46.47"W	N85° 24' 33.81"W	Outcurve
113	Line	36088.809	36248.073	159.265			N85° 24' 33.81"W				
114	Spiral-Curve-Spiral	36248.073	36278.073	30		54.772m		8.5944 (d)	N85° 24' 33.81"W	S85° 59' 46.47"W	Incurve
115	Spiral-Curve-Spiral	36278.073	36433.219	155.145	100.000m			88.8917 (d)	S85° 59' 46.47"W	S2° 53' 43.67"E	
116	Spiral-Curve-Spiral	36433.219	36463.219	30		54.772m		8.5944 (d)	S2° 53' 43.67"E	S11° 29' 23.39"E	Outcurve
117	Line	36463.219	36480.536	17.317			S11° 29' 23.39"E				
118	Spiral-Curve-Spiral	36480.536	36510.536	30		67.082m		5.7296 (d)	S11° 29' 23.39"E	S5° 45' 36.91"E	Incurve
119	Spiral-Curve-Spiral	36510.536	36586.968	76.432	150.000m			29.1950 (d)	S5° 45' 36.91"E	S23° 26' 04.99"W	
120	Spiral-Curve-Spiral	36586.968	36616.968	30		67.082m		5.7296 (d)	S23° 26' 04.99"W	S29° 09' 51.47"W	Outcurve
121	Line	36616.968	36618.524	1.556			S29° 09' 51.47"W				
122	Spiral-Curve-Spiral	36618.524	36648.524	30		67.082m		5.7296 (d)	S29° 09' 51.47"W	S23° 26' 04.99"W	Incurve
123	Spiral-Curve-Spiral	36648.524	36806.959	158.435	150.000m			60.5178 (d)	S23° 26' 04.99"W	S37° 04' 59.00"E	

Horizontal Alignment Report											
S.No.	**Type**	**Start Station**	**End Station**	**Length**	**Radius**	**A**	**Direction**	**Delta angle**	**Start Direction**	**End Direction**	**Incurve**
124	Spiral-Curve-Spiral	36806.959	36836.959	30		67.082m		5.7296 (d)	S37° 04' 59.00"E	S42° 48' 45.49"E	Outcurve
125	Line	36836.959	37118.804	281.844			S42° 48' 45.49"E				
126	Spiral-Curve-Spiral	37118.804	37148.804	30		36.742m		19.0986 (d)	S42° 48' 45.49"E	S23° 42' 50.55"E	Incurve
127	Spiral-Curve-Spiral	37148.804	37218.291	69.487	45.000m			88.4739 (d)	S23° 42' 50.55"E	S64° 45' 35.32"W	
128	Spiral-Curve-Spiral	37218.291	37248.291	30		36.742m		19.0986 (d)	S64° 45' 35.32"W	S83° 51' 30.25"W	Outcurve
129	Line	37248.291	37259.142	10.851			S83° 51' 30.25"W				
130	Spiral-Curve-Spiral	37259.142	37289.142	30		47.434m		11.4592 (d)	S83° 51' 30.25"W	N84° 40' 56.78"W	Incurve
131	Spiral-Curve-Spiral	37289.142	37328.31	39.168	75.000m			29.9221 (d)	N84° 40' 56.78"W	N54° 45' 37.23"W	
132	Spiral-Curve-Spiral	37328.31	37358.31	30		47.434m		11.4592 (d)	N54° 45' 37.23"W	N43° 18' 04.27"W	Outcurve
133	Line	37358.31	37411.052	52.742			N43° 18' 04.27"W				
134	Spiral-Curve-Spiral	37411.052	37441.052	30		36.742m		19.0986 (d)	N43° 18' 04.27"W	N62° 23' 59.20"W	Incurve
135	Spiral-Curve-Spiral	37441.052	37459.101	18.05	45.000m			22.9815 (d)	N62° 23' 59.20"W	N85° 22' 52.49"W	
136	Spiral-Curve-Spiral	37459.101	37489.101	30		36.742m		19.0986 (d)	N85° 22' 52.49"W	S75° 31' 12.57"W	Outcurve
137	Line	37489.101	37632.166	143.065			S75° 31' 12.57"W				
138	Spiral-Curve-Spiral	37632.166	37652.166	20		30.000m		12.7324 (d)	S75° 31' 12.57"W	S62° 47' 15.95"W	Incurve
139	Spiral-Curve-Spiral	37652.166	37708.547	56.381	45.000m			71.7862 (d)	S62° 47' 15.95"W	S8° 59' 54.21"E	
140	Spiral-Curve-Spiral	37708.547	37728.547	20		30.000m		12.7324 (d)	S8° 59' 54.21"E	S21° 43' 50.83"E	Outcurve
141	Line	37728.547	37839.141	110.594			S21° 43' 50.83"E				
142	Spiral-Curve-Spiral	37839.141	37859.141	20		24.495m		19.0986 (d)	S21° 43' 50.83"E	S2° 37' 55.90"E	Incurve
143	Spiral-Curve-Spiral	37859.141	37902.368	43.227	30.000m			82.5584 (d)	S2° 37' 55.90"E	S79° 55' 34.42"W	
144	Spiral-Curve-Spiral	37902.368	37922.368	20		24.495m		19.0986 (d)	S79° 55' 34.42"W	N80° 58' 30.64"W	Outcurve
145	Line	37922.368	37929.65	7.282			N80° 58' 30.64"W				
146	Spiral-Curve-Spiral	37929.65	37949.65	20		24.495m		19.0986 (d)	N80° 58' 30.64"W	S79° 55' 34.42"W	Incurve
147	Spiral-Curve-Spiral	37949.65	37972.426	22.776	30.000m			43.4987 (d)	S79° 55' 34.42"W	S36° 25' 39.18"W	
148	Spiral-Curve-Spiral	37972.426	37992.426	20		24.495m		19.0986 (d)	S36° 25' 39.18"W	S17° 19' 44.25"W	Outcurve
149	Line	37992.426	38247.638	255.212			S17° 19' 44.25"W				
150	Spiral-Curve-Spiral	38247.638	38287.638	40		63.246m		11.4592 (d)	S17° 19' 44.25"W	S5° 52' 11.29"W	Incurve
151	Spiral-Curve-Spiral	38287.638	38300.016	12.378	100.000m			7.0921 (d)	S5° 52' 11.29"W	S1° 13' 20.13"E	
152	Spiral-Curve-Spiral	38300.016	38340.016	40		63.246m		11.4592 (d)	S1° 13' 20.13"E	S12° 40' 53.09"E	Outcurve
153	Line	38340.016	38382.372	42.356			S12° 40' 53.09"E				
154	Spiral-Curve-Spiral	38382.372	38402.372	20		63.246m		2.8648 (d)	S12° 40' 53.09"E	S15° 32' 46.33"E	Incurve
155	Spiral-Curve-Spiral	38402.372	38548.285	145.913	200.000m			41.8011 (d)	S15° 32' 46.33"E	S57° 20' 50.24"E	
156	Spiral-Curve-Spiral	38548.285	38568.285	20		63.246m		2.8648 (d)	S57° 20' 50.24"E	S60° 12' 43.48"E	Outcurve
157	Line	38568.285	38748.185	179.901			S60° 12' 43.48"E				
158	Spiral-Curve-Spiral	38748.185	38778.185	30		30.000m		28.6479 (d)	S60° 12' 43.48"E	S31° 33' 51.08"E	Incurve
159	Spiral-Curve-Spiral	38778.185	38828.618	50.432	30.000m			96.3182 (d)	S31° 33' 51.08"E	S64° 45' 14.43"W	
160	Spiral-Curve-Spiral	38828.618	38858.618	30		30.000m		28.6479 (d)	S64° 45' 14.43"W	N86° 35' 53.17"W	Outcurve
161	Line	38858.618	38867.517	8.899			N86° 35' 53.17"W				
162	Spiral-Curve-Spiral	38867.517	38897.517	30		54.772m		8.5944 (d)	N86° 35' 53.17"W	S84° 48' 27.11"W	Incurve
163	Spiral-Curve-Spiral	38897.517	38933.711	36.195	100.000m			20.7380 (d)	S84° 48' 27.11"W	S64° 04' 10.21"W	
164	Spiral-Curve-Spiral	38933.711	38963.711	30		54.772m		8.5944 (d)	S64° 04' 10.21"W	S55° 28' 30.49"W	Outcurve

Horizontal Alignment Report											
S.No.	Type	Start Station	End Station	Length	Radius	A	Direction	Delta angle	Start Direction	End Direction	Incurve
165	Line	38963.711	38989.362	25.651			S55° 28' 30.49"W				
166	Spiral-Curve-Spiral	38989.362	39019.362	30		77.460m		4.2972 (d)	S55° 28' 30.49"W	S51° 10' 40.63"W	Incurve
167	Spiral-Curve-Spiral	39019.362	39133.592	114.23	200.000m			32.7245 (d)	S51° 10' 40.63"W	S18° 27' 12.35"W	
168	Spiral-Curve-Spiral	39133.592	39163.592	30		77.460m		4.2972 (d)	S18° 27' 12.35"W	S14° 09' 22.49"W	Outcurve
169	Line	39163.592	39176.146	12.554			S14° 09' 22.49"W				
170	Spiral-Curve-Spiral	39176.146	39216.146	40		126.491m		2.8648 (d)	S14° 09' 22.49"W	S11° 17' 29.25"W	Incurve
171	Spiral-Curve-Spiral	39216.146	39403.549	187.403	400.000m			26.8435 (d)	S11° 17' 29.25"W	S15° 33' 07.42"E	
172	Spiral-Curve-Spiral	39403.549	39443.549	40		126.491m		2.8648 (d)	S15° 33' 07.42"E	S18° 25' 00.66"E	Outcurve
173	Line	39443.549	39537.189	93.64			S18° 25' 00.66"E				
174	Spiral-Curve-Spiral	39537.189	39567.189	30		47.434m		11.4592 (d)	S18° 25' 00.66"E	S6° 57' 27.70"E	Incurve
175	Spiral-Curve-Spiral	39567.189	39694.396	127.208	75.000m			97.1795 (d)	S6° 57' 27.70"E	N89° 46' 41.58"W	
176	Spiral-Curve-Spiral	39694.396	39724.396	30		47.434m		11.4592 (d)	N89° 46' 41.58"W	N78° 19' 08.62"W	Outcurve
177	Line	39724.396	39783.896	59.5			N78° 19' 08.62"W				
178	Spiral-Curve-Spiral	39783.896	39813.896	30		67.082m		5.7296 (d)	N78° 19' 08.62"W	N84° 02' 55.10"W	Incurve
179	Spiral-Curve-Spiral	39813.896	39944.96	131.064	150.000m			50.0629 (d)	N84° 02' 55.10"W	S45° 53' 18.34"W	
180	Spiral-Curve-Spiral	39944.96	39974.96	30		67.082m		5.7296 (d)	S45° 53' 18.34"W	S40° 09' 31.86"W	Outcurve
181	Line	39974.96	40255.21	280.25			S40° 09' 31.86"W				
182	Spiral-Curve-Spiral	40255.21	40285.21	30		77.460m		4.2972 (d)	S40° 09' 31.86"W	S35° 51' 42.00"W	Incurve
183	Spiral-Curve-Spiral	40285.21	40450.76	165.55	200.000m			47.4265 (d)	S35° 51' 42.00"W	S11° 33' 53.28"E	
184	Spiral-Curve-Spiral	40450.76	40480.76	30		77.460m		4.2972 (d)	S11° 33' 53.28"E	S15° 51' 43.14"E	Outcurve
185	Line	40480.76	40640.409	159.649			S15° 51' 43.14"E				
186	Spiral-Curve-Spiral	40640.409	40670.409	30		67.082m		5.7296 (d)	S15° 51' 43.14"E	S10° 07' 56.66"E	Incurve
187	Spiral-Curve-Spiral	40670.409	40800.049	129.64	150.000m			49.5189 (d)	S10° 07' 56.66"E	S39° 23' 11.22"W	
188	Spiral-Curve-Spiral	40800.049	40830.049	30		67.082m		5.7296 (d)	S39° 23' 11.22"W	S45° 06' 57.70"W	Outcurve
189	Line	40830.049	40903.628	73.579			S45° 06' 57.70"W				
190	Spiral-Curve-Spiral	40903.628	40933.628	30		67.082m		5.7296 (d)	S45° 06' 57.70"W	S39° 23' 11.22"W	Incurve
191	Spiral-Curve-Spiral	40933.628	41052.936	119.308	150.000m			45.5722 (d)	S39° 23' 11.22"W	S6° 11' 08.65"E	
192	Spiral-Curve-Spiral	41052.936	41082.936	30		67.082m		5.7296 (d)	S6° 11' 08.65"E	S11° 54' 55.13"E	Outcurve
193	Line	41082.936	41161.313	78.377			S11° 54' 55.13"E				
194	Spiral-Curve-Spiral	41161.313	41191.313	30		47.434m		11.4592 (d)	S11° 54' 55.13"E	S0° 27' 22.17"E	Incurve
195	Spiral-Curve-Spiral	41191.313	41373.006	181.693	75.000m			138.8036 (d)	S0° 27' 22.17"E	N41° 39' 09.38"W	
196	Spiral-Curve-Spiral	41373.006	41403.006	30		47.434m		11.4592 (d)	N41° 39' 09.38"W	N30° 11' 36.42"W	Outcurve
197	Line	41403.006	41450	46.994			N30° 11' 36.42"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 Curve Length	K Value	Curve Radius
1	26248.516m	530.036m	5.99%	6.00%	0.01%	Sag	Symmetric Parabola	300.000m	22383.349	2238334.901m
2	30900.625m	809.182m	6.00%							
3	30904.348m	809.924m		7.00%						
4	32998.668m	977.470m	7.00%	-3.70%	11.70%	Crest	Symmetric Parabola	640.855m	54.756	5475.605m
5	34015.510m	939.808m	-3.70%	3.81%	7.51%	Sag	Symmetric Parabola	200.000m	26.62	2661.979m
6	34583.882m	961.459m	3.81%	-3.70%	7.51%	Crest	Symmetric Parabola	200.000m	26.645	2664.460m
7	35227.688m	937.659m	-3.70%							
8	35230.111m	938.003m		3.48%						
9	36538.337m	983.530m	3.48%	-5.38%	8.86%	Crest	Symmetric Parabola	300.000m	33.853	3385.343m
10	38024.479m	903.551m	-5.38%	6.91%	13.29%	Sag	Symmetric Parabola	300.000m	22.57	2256.988m
11	38850.107m	968.862m	6.91%	-3.91%	11.82%	Crest	Symmetric Parabola	400.000m	33.836	3383.621m
12	40008.723m	923.546m	-3.91%	4.62%	8.53%	Sag	Symmetric Parabola	200.000m	23.45	2345.028m
13	40662.909m	953.752m	4.62%	-6.86%	11.48%	Crest	Symmetric Parabola	200.000m	17.421	1742.113m
14	42033.969m	859.658m	-6.86%							

PCL COORDINATES

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
30800	2,774,425.0660m	545,570.2886m	N89° 52' 30.29"W
30825	2,774,425.1214m	545,545.2886m	N89° 46' 55.20"W
30850	2,774,428.3039m	545,520.6233m	N70° 37' 14.82"W
30875	2,774,442.0317m	545,500.0408m	N42° 02' 03.96"W
30900	2,774,462.5778m	545,485.8544m	N32° 11' 35.74"W
30925	2,774,483.7342m	545,472.5349m	N32° 11' 35.74"W
30950	2,774,504.8905m	545,459.2155m	N32° 11' 35.74"W
30975	2,774,526.0469m	545,445.8961m	N32° 11' 35.74"W
31000	2,774,546.4003m	545,431.4594m	N43° 54' 08.64"W
31025	2,774,559.4277m	545,410.4267m	N72° 33' 01.04"W
31050	2,774,560.7768m	545,385.7231m	S78° 48' 06.55"W
31075	2,774,551.4798m	545,362.6120m	S62° 55' 45.29"W
31100	2,774,540.1903m	545,340.3069m	S64° 27' 54.78"W
31125	2,774,531.8998m	545,316.7959m	S78° 57' 33.75"W
31150	2,774,531.2220m	545,291.9165m	N82° 38' 45.70"W
31175	2,774,536.3683m	545,267.4667m	N76° 09' 48.39"W
31200	2,774,542.3472m	545,243.1921m	N76° 09' 48.39"W
31225	2,774,548.3260m	545,218.9176m	N76° 09' 48.39"W
31250	2,774,554.3048m	545,194.6430m	N76° 09' 48.39"W
31275	2,774,560.2836m	545,170.3685m	N76° 09' 48.39"W
31300	2,774,567.3396m	545,146.4080m	N68° 14' 29.40"W
31325	2,774,579.3567m	545,124.5542m	N54° 56' 17.01"W
31350	2,774,594.3449m	545,104.5474m	N51° 48' 37.81"W
31375	2,774,611.6450m	545,086.5889m	N37° 55' 34.57"W
31400	2,774,633.5393m	545,074.7620m	N18° 49' 39.64"W
31425	2,774,658.0982m	545,070.7487m	N0° 09' 12.18"E
31450	2,774,683.0800m	545,071.6174m	N0° 33' 17.93"W
31475	2,774,707.2376m	545,066.1628m	N26° 44' 50.36"W
31500	2,774,725.8892m	545,049.9084m	N55° 23' 26.79"W
31525	2,774,737.0158m	545,027.5665m	N66° 24' 12.30"W
31550	2,774,747.0721m	545,004.6785m	N65° 33' 25.46"W
31575	2,774,758.6088m	544,982.5162m	N58° 59' 31.24"W
31600	2,774,772.7917m	544,961.9485m	N51° 49' 48.14"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
31625	2,774,789.4283m	544,943.3094m	N44° 40' 05.04"W
31650	2,774,808.2588m	544,926.8900m	N37° 30' 21.94"W
31675	2,774,828.9862m	544,912.9409m	N30° 32' 53.63"W
31700	2,774,850.7853m	544,900.7030m	N29° 00' 31.26"W
31725	2,774,872.6489m	544,888.5795m	N29° 00' 31.26"W
31750	2,774,894.5126m	544,876.4559m	N29° 00' 31.26"W
31775	2,774,916.3762m	544,864.3324m	N29° 00' 31.26"W
31800	2,774,938.2399m	544,852.2088m	N29° 00' 31.26"W
31825	2,774,960.1036m	544,840.0853m	N29° 00' 31.26"W
31850	2,774,981.9672m	544,827.9617m	N29° 00' 31.26"W
31875	2,775,003.8309m	544,815.8382m	N29° 00' 31.26"W
31900	2,775,025.6945m	544,803.7146m	N29° 00' 31.26"W
31925	2,775,047.5582m	544,791.5911m	N29° 00' 31.26"W
31950	2,775,069.4218m	544,779.4675m	N29° 00' 31.26"W
31975	2,775,091.2855m	544,767.3439m	N29° 00' 31.26"W
32000	2,775,112.4483m	544,754.1408m	N42° 17' 30.50"W
32025	2,775,122.4577m	544,732.0127m	N89° 30' 42.50"W
32050	2,775,112.8197m	544,709.7245m	S42° 44' 30.16"W
32075	2,775,089.8416m	544,701.8700m	S4° 51' 45.85"E
32100	2,775,066.0052m	544,709.1253m	S20° 48' 33.54"E
32125	2,775,042.6360m	544,718.0068m	S20° 48' 33.54"E
32150	2,775,019.2668m	544,726.8882m	S20° 48' 33.54"E
32175	2,774,995.8976m	544,735.7697m	S20° 48' 33.54"E
32200	2,774,972.5284m	544,744.6512m	S20° 48' 33.54"E
32225	2,774,949.1592m	544,753.5327m	S20° 48' 33.54"E
32250	2,774,925.7900m	544,762.4141m	S20° 48' 33.54"E
32275	2,774,902.4208m	544,771.2956m	S20° 48' 33.54"E
32300	2,774,879.0516m	544,780.1771m	S20° 48' 33.54"E
32325	2,774,855.4682m	544,788.4483m	S15° 57' 59.91"E
32350	2,774,830.9721m	544,793.2951m	S6° 25' 02.44"E
32375	2,774,806.0112m	544,794.0109m	S3° 07' 55.03"W
32400	2,774,781.2126m	544,790.9509m	S9° 14' 10.69"W
32425	2,774,756.5374m	544,786.9342m	S9° 14' 45.52"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
32450	2,774,731.8622m	544,782.9173m	S9° 14' 45.52"W
32475	2,774,707.1870m	544,778.9005m	S9° 14' 45.52"W
32500	2,774,682.5118m	544,774.8837m	S9° 14' 45.52"W
32525	2,774,657.8366m	544,770.8668m	S9° 14' 45.52"W
32550	2,774,633.1614m	544,766.8500m	S9° 14' 45.52"W
32575	2,774,608.4862m	544,762.8332m	S9° 14' 45.52"W
32600	2,774,583.8110m	544,758.8164m	S9° 14' 45.52"W
32625	2,774,559.1358m	544,754.7995m	S9° 14' 45.52"W
32650	2,774,534.4606m	544,750.7827m	S9° 14' 45.52"W
32675	2,774,509.7854m	544,746.7659m	S9° 14' 45.52"W
32700	2,774,485.1107m	544,742.7461m	S9° 21' 47.50"W
32725	2,774,460.6108m	544,737.8184m	S14° 42' 28.58"W
32750	2,774,437.0690m	544,729.4913m	S24° 15' 14.53"W
32775	2,774,415.2349m	544,717.3742m	S33° 48' 12.00"W
32800	2,774,395.6487m	544,701.8755m	S42° 08' 20.63"W
32825	2,774,377.4993m	544,684.6838m	S43° 48' 30.30"W
32850	2,774,359.4579m	544,667.3775m	S43° 48' 30.30"W
32875	2,774,341.4164m	544,650.0713m	S43° 48' 30.30"W
32900	2,774,323.3750m	544,632.7651m	S43° 48' 30.30"W
32925	2,774,305.3335m	544,615.4588m	S43° 48' 30.30"W
32950	2,774,287.2920m	544,598.1526m	S43° 48' 30.30"W
32975	2,774,269.2506m	544,580.8464m	S43° 48' 30.30"W
33000	2,774,251.2091m	544,563.5401m	S43° 48' 30.30"W
33025	2,774,233.1676m	544,546.2339m	S43° 48' 30.30"W
33050	2,774,215.3907m	544,528.6638m	S48° 00' 15.37"W
33075	2,774,201.6791m	544,507.8793m	S65° 30' 54.21"W
33100	2,774,194.9991m	544,483.8919m	S82° 58' 43.96"W
33125	2,774,193.3493m	544,458.9514m	S87° 01' 37.62"W
33150	2,774,192.0527m	544,433.9850m	S87° 01' 37.62"W
33175	2,774,190.7562m	544,409.0187m	S87° 01' 37.62"W
33200	2,774,189.4596m	544,384.0523m	S87° 01' 37.62"W
33225	2,774,188.1630m	544,359.0859m	S87° 01' 37.62"W
33250	2,774,186.8664m	544,334.1196m	S87° 01' 37.62"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
33275	2,774,185.5698m	544,309.1532m	S87° 01' 37.62"W
33300	2,774,184.2733m	544,284.1869m	S87° 01' 37.62"W
33325	2,774,182.9767m	544,259.2205m	S87° 01' 37.62"W
33350	2,774,181.3656m	544,234.2747m	S84° 28' 21.24"W
33375	2,774,177.7184m	544,209.5527m	S78° 44' 34.76"W
33400	2,774,171.6214m	544,185.3184m	S73° 00' 48.28"W
33425	2,774,163.4223m	544,161.7050m	S69° 47' 44.34"W
33450	2,774,154.7881m	544,138.2433m	S69° 47' 44.34"W
33475	2,774,146.1538m	544,114.7816m	S69° 47' 44.34"W
33500	2,774,137.1773m	544,091.4533m	S66° 10' 17.00"W
33525	2,774,125.0035m	544,069.6521m	S57° 00' 54.63"W
33550	2,774,111.2930m	544,048.7471m	S56° 43' 18.84"W
33575	2,774,097.5754m	544,027.8466m	S56° 43' 18.84"W
33600	2,774,083.8578m	544,006.9462m	S56° 43' 18.84"W
33625	2,774,070.1402m	543,986.0458m	S56° 43' 18.84"W
33650	2,774,056.4226m	543,965.1453m	S56° 43' 18.84"W
33675	2,774,042.6465m	543,944.2840m	S55° 18' 48.96"W
33700	2,774,025.7652m	543,926.0216m	S35° 25' 21.53"W
33725	2,774,002.6834m	543,917.1156m	S6° 46' 52.75"W
33750	2,773,977.8101m	543,918.5439m	S9° 22' 12.50"E
33775	2,773,953.1690m	543,922.7649m	S9° 44' 31.94"E
33800	2,773,928.5249m	543,926.9677m	S9° 03' 03.77"E
33825	2,773,903.6325m	543,928.6672m	S2° 49' 55.69"W
33850	2,773,879.0759m	543,924.3398m	S17° 09' 21.89"W
33875	2,773,856.3501m	543,914.0769m	S31° 13' 35.15"W
33900	2,773,835.6389m	543,900.0824m	S34° 47' 55.65"W
33925	2,773,815.1099m	543,885.8150m	S34° 47' 55.65"W
33950	2,773,794.5808m	543,871.5476m	S34° 47' 55.65"W
33975	2,773,773.6690m	543,857.8663m	S29° 20' 31.48"W
34000	2,773,750.8688m	543,847.6833m	S20° 15' 09.04"W
34025	2,773,727.3643m	543,839.1666m	S19° 53' 26.11"W
34050	2,773,703.8557m	543,830.6609m	S19° 53' 26.11"W
34075	2,773,680.3471m	543,822.1553m	S19° 53' 26.11"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
34100	2,773,656.8385m	543,813.6497m	S19° 53' 26.11"W
34125	2,773,633.3299m	543,805.1441m	S19° 53' 26.11"W
34150	2,773,609.8160m	543,796.6533m	S19° 17' 46.21"W
34175	2,773,585.3926m	543,792.1690m	S2° 31' 04.51"E
34200	2,773,561.7134m	543,799.3370m	S31° 09' 56.91"E
34225	2,773,544.3349m	543,816.9582m	S58° 41' 27.76"E
34250	2,773,533.0313m	543,839.2473m	S64° 05' 57.79"E
34275	2,773,522.1110m	543,861.7361m	S64° 05' 57.79"E
34300	2,773,511.1908m	543,884.2249m	S64° 05' 57.79"E
34325	2,773,500.2705m	543,906.7137m	S64° 05' 57.79"E
34350	2,773,489.2818m	543,929.1685m	S62° 04' 46.83"E
34375	2,773,472.1208m	543,946.6365m	S24° 51' 59.38"E
34400	2,773,448.2939m	543,954.1250m	S15° 46' 34.45"E
34425	2,773,424.2357m	543,960.9221m	S15° 46' 34.45"E
34450	2,773,400.9406m	543,969.7579m	S31° 21' 14.92"E
34475	2,773,383.3416m	543,987.2362m	S55° 00' 13.91"E
34500	2,773,369.2210m	544,007.8600m	S51° 15' 01.10"E
34525	2,773,348.0697m	544,019.8467m	S5° 51' 02.54"E
34550	2,773,324.9782m	544,012.3338m	S41° 53' 44.80"W
34575	2,773,314.8794m	543,990.2013m	S86° 25' 14.15"W
34600	2,773,314.8635m	543,965.2044m	N89° 37' 12.37"W
34625	2,773,315.0293m	543,940.2049m	N89° 37' 12.37"W
34650	2,773,315.1951m	543,915.2055m	N89° 37' 12.37"W
34675	2,773,317.4144m	543,890.4068m	N73° 37' 34.14"W
34700	2,773,325.8152m	543,866.8647m	N72° 36' 50.78"W
34725	2,773,327.3211m	543,842.1685m	S79° 10' 53.48"W
34750	2,773,320.1219m	543,818.2406m	S72° 13' 06.36"W
34775	2,773,312.4872m	543,794.4349m	S72° 13' 06.36"W
34800	2,773,304.8525m	543,770.6292m	S72° 13' 06.36"W
34825	2,773,297.2177m	543,746.8235m	S72° 13' 06.36"W
34850	2,773,289.5830m	543,723.0178m	S72° 13' 06.36"W
34875	2,773,281.9483m	543,699.2121m	S72° 13' 06.36"W
34900	2,773,274.3136m	543,675.4064m	S72° 13' 06.36"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
34925	2,773,266.6788m	543,651.6007m	S72° 13' 06.36"W
34950	2,773,259.0441m	543,627.7951m	S72° 13' 06.36"W
34975	2,773,250.1177m	543,604.4758m	S62° 42' 15.37"W
35000	2,773,235.1957m	543,584.5618m	S43° 36' 20.55"W
35025	2,773,214.6115m	543,570.5622m	S25° 49' 53.01"W
35050	2,773,191.5786m	543,560.8532m	S22° 04' 12.13"W
35075	2,773,168.4105m	543,551.4597m	S22° 04' 12.13"W
35100	2,773,145.2422m	543,542.0664m	S22° 02' 12.84"W
35125	2,773,121.5417m	543,534.2315m	S11° 23' 44.66"W
35150	2,773,096.6457m	543,532.6387m	S1° 08' 07.05"E
35175	2,773,071.6532m	543,533.2485m	S1° 24' 48.65"E
35200	2,773,046.6608m	543,533.8652m	S1° 24' 48.65"E
35225	2,773,021.6684m	543,534.4819m	S1° 24' 48.65"E
35230	2,773,016.1142m	543,534.6144m	S1° 51' 27.56"E
35255	2,772,991.1273m	543,535.4248m	S1° 51' 27.56"E
35280	2,772,966.1405m	543,536.2352m	S1° 51' 27.56"E
35305	2,772,941.1536m	543,537.0457m	S1° 51' 27.56"E
35330	2,772,916.1668m	543,537.8561m	S1° 51' 27.56"E
35355	2,772,891.1799m	543,538.6665m	S1° 51' 27.56"E
35380	2,772,866.1930m	543,539.4769m	S1° 51' 27.56"E
35405	2,772,841.2307m	543,540.7685m	S5° 22' 45.33"E
35430	2,772,816.6314m	543,545.0660m	S14° 39' 40.34"E
35455	2,772,793.0834m	543,553.3752m	S24° 12' 37.81"E
35480	2,772,771.2400m	543,565.4757m	S33° 45' 35.27"E
35505	2,772,751.7068m	543,581.0323m	S43° 18' 32.74"E
35530	2,772,734.8180m	543,599.4420m	S50° 28' 12.32"E
35555	2,772,719.1148m	543,618.8945m	S51° 11' 22.56"E
35580	2,772,703.4462m	543,638.3751m	S51° 11' 22.56"E
35605	2,772,687.7776m	543,657.8558m	S51° 11' 22.56"E
35630	2,772,672.1089m	543,677.3364m	S51° 11' 22.56"E
35655	2,772,656.4403m	543,696.8170m	S51° 11' 22.56"E
35680	2,772,640.7717m	543,716.2976m	S51° 11' 22.56"E
35705	2,772,625.1030m	543,735.7782m	S51° 11' 22.56"E

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
35730	2,772,609.2207m	543,755.0778m	S46° 23' 18.87"E
35755	2,772,587.4411m	543,766.0068m	S3° 23' 25.58"E
35780	2,772,564.6935m	543,757.5096m	S44° 21' 21.76"W
35805	2,772,555.6853m	543,734.9587m	N88° 03' 52.84"W
35830	2,772,561.6359m	543,710.7600m	N72° 46' 09.04"W
35855	2,772,566.5202m	543,686.3182m	N87° 18' 42.83"W
35880	2,772,563.5474m	543,661.6120m	S73° 35' 22.23"W
35905	2,772,552.6545m	543,639.2383m	S54° 29' 27.30"W
35930	2,772,535.8502m	543,620.7743m	S44° 39' 04.55"W
35955	2,772,518.0653m	543,603.2046m	S44° 39' 04.55"W
35980	2,772,500.3031m	543,585.6119m	S45° 19' 02.62"W
36005	2,772,484.0200m	543,566.6841m	S55° 09' 58.38"W
36030	2,772,472.4401m	543,544.6011m	S69° 29' 24.58"W
36055	2,772,466.6836m	543,520.3398m	S83° 48' 50.79"W
36080	2,772,466.5811m	543,495.3733m	N86° 09' 01.17"W
36105	2,772,468.5441m	543,470.4506m	N85° 24' 33.81"W
36130	2,772,470.5450m	543,445.5308m	N85° 24' 33.81"W
36155	2,772,472.5459m	543,420.6110m	N85° 24' 33.81"W
36180	2,772,474.5468m	543,395.6912m	N85° 24' 33.81"W
36205	2,772,476.5477m	543,370.7714m	N85° 24' 33.81"W
36230	2,772,478.5486m	543,345.8516m	N85° 24' 33.81"W
36255	2,772,480.5311m	543,320.9304m	N85° 52' 03.25"W
36280	2,772,480.7449m	543,295.9593m	S84° 53' 32.21"W
36305	2,772,475.4459m	543,271.5939m	S70° 34' 06.01"W
36330	2,772,464.2835m	543,249.2970m	S56° 14' 39.81"W
36355	2,772,447.9518m	543,230.4548m	S41° 55' 13.60"W
36380	2,772,427.4662m	543,216.2389m	S27° 35' 47.40"W
36405	2,772,404.1004m	543,207.5332m	S13° 16' 21.20"W
36430	2,772,379.3071m	543,204.8790m	S1° 03' 05.00"E
36455	2,772,354.5194m	543,207.8778m	S10° 50' 41.40"E
36480	2,772,330.0144m	543,212.8274m	S11° 29' 23.39"E
36505	2,772,305.4180m	543,217.2738m	S7° 40' 46.95"E
36530	2,772,280.4827m	543,218.6181m	S1° 40' 28.16"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
36555	2,772,255.6696m	543,215.8133m	S11° 13' 25.62"W
36580	2,772,231.6657m	543,208.9310m	S20° 46' 23.09"W
36605	2,772,209.0343m	543,198.3536m	S28° 15' 08.73"W
36630	2,772,187.1459m	543,186.2753m	S28° 19' 33.30"W
36655	2,772,164.5410m	543,175.6400m	S20° 57' 40.22"W
36680	2,772,140.5598m	543,168.6789m	S11° 24' 42.75"W
36705	2,772,115.7561m	543,165.7927m	S1° 51' 45.29"W
36730	2,772,090.8173m	543,167.0613m	S7° 41' 12.18"E
36755	2,772,066.4345m	543,172.4496m	S17° 14' 09.65"E
36780	2,772,043.2834m	543,181.8082m	S26° 47' 07.12"E
36805	2,772,022.0057m	543,194.8779m	S36° 20' 04.58"E
36830	2,772,002.8842m	543,210.9633m	S42° 30' 15.46"E
36855	2,771,984.5362m	543,227.9442m	S42° 48' 45.49"E
36880	2,771,966.1967m	543,244.9343m	S42° 48' 45.49"E
36905	2,771,947.8572m	543,261.9243m	S42° 48' 45.49"E
36930	2,771,929.5177m	543,278.9144m	S42° 48' 45.49"E
36955	2,771,911.1782m	543,295.9045m	S42° 48' 45.49"E
36980	2,771,892.8387m	543,312.8946m	S42° 48' 45.49"E
37005	2,771,874.4992m	543,329.8846m	S42° 48' 45.49"E
37030	2,771,856.1597m	543,346.8747m	S42° 48' 45.49"E
37055	2,771,837.8202m	543,363.8648m	S42° 48' 45.49"E
37080	2,771,819.4807m	543,380.8549m	S42° 48' 45.49"E
37105	2,771,801.1412m	543,397.8449m	S42° 48' 45.49"E
37130	2,771,782.6857m	543,414.7063m	S40° 09' 08.85"E
37155	2,771,761.1770m	543,427.0569m	S15° 49' 28.66"E
37180	2,771,736.4973m	543,427.0178m	S16° 00' 22.90"W
37205	2,771,715.5499m	543,413.9681m	S47° 50' 14.46"W
37230	2,771,704.4441m	543,391.8840m	S76° 45' 32.06"W
37255	2,771,701.0221m	543,367.1361m	S83° 51' 30.25"W
37280	2,771,699.0175m	543,342.2271m	S89° 23' 52.42"W
37305	2,771,702.4870m	543,317.5782m	N72° 34' 03.21"W
37330	2,771,713.7770m	543,295.4022m	N53° 30' 19.25"W
37355	2,771,730.7575m	543,277.0995m	N43° 26' 26.34"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
37380	2,771,748.9496m	543,259.9517m	N43° 18' 04.27"W
37405	2,771,767.1436m	543,242.8059m	N43° 18' 04.27"W
37430	2,771,784.7379m	543,225.0726m	N50° 55' 12.21"W
37455	2,771,795.3301m	543,202.7437m	N80° 09' 32.63"W
37480	2,771,793.8152m	543,177.9582m	S77° 16' 40.86"W
37505	2,771,787.6545m	543,153.7299m	S75° 31' 12.57"W
37530	2,771,781.4035m	543,129.5240m	S75° 31' 12.57"W
37555	2,771,775.1525m	543,105.3181m	S75° 31' 12.57"W
37580	2,771,768.9015m	543,081.1122m	S75° 31' 12.57"W
37605	2,771,762.6506m	543,056.9063m	S75° 31' 12.57"W
37630	2,771,756.3996m	543,032.7004m	S75° 31' 12.57"W
37655	2,771,748.0781m	543,009.2251m	S59° 10' 46.28"W
37680	2,771,730.1062m	542,992.3106m	S27° 20' 54.72"W
37705	2,771,705.9162m	542,987.4185m	S4° 28' 56.84"E
37730	2,771,682.0112m	542,994.3698m	S21° 43' 50.83"E
37755	2,771,658.7878m	543,003.6260m	S21° 43' 50.83"E
37780	2,771,635.5645m	543,012.8821m	S21° 43' 50.83"E
37805	2,771,612.3411m	543,022.1383m	S21° 43' 50.83"E
37830	2,771,589.1178m	543,031.3944m	S21° 43' 50.83"E
37855	2,771,565.5501m	543,039.5988m	S9° 43' 18.74"E
37880	2,771,541.9188m	543,033.9795m	S37° 12' 21.38"W
37905	2,771,530.1706m	543,012.7256m	S84° 37' 18.24"W
37930	2,771,532.6441m	542,987.9159m	N80° 58' 51.67"W
37955	2,771,532.1153m	542,963.2252m	S69° 42' 32.18"W
37980	2,771,515.2506m	542,945.6980m	S24° 42' 05.00"W
38005	2,771,491.5635m	542,937.7495m	S17° 19' 44.25"W
38030	2,771,467.6982m	542,930.3031m	S17° 19' 44.25"W
38055	2,771,443.8330m	542,922.8567m	S17° 19' 44.25"W
38080	2,771,419.9677m	542,915.4102m	S17° 19' 44.25"W
38105	2,771,396.1024m	542,907.9638m	S17° 19' 44.25"W
38130	2,771,372.2372m	542,900.5174m	S17° 19' 44.25"W
38155	2,771,348.3719m	542,893.0709m	S17° 19' 44.25"W
38180	2,771,324.5067m	542,885.6245m	S17° 19' 44.25"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
38205	2,771,300.6414m	542,878.1781m	S17° 19' 44.25"W
38230	2,771,276.7761m	542,870.7316m	S17° 19' 44.25"W
38255	2,771,252.9060m	542,863.3011m	S16° 56' 26.86"W
38280	2,771,228.6784m	542,857.2017m	S9° 49' 41.75"W
38305	2,771,203.7764m	542,855.8733m	S3° 53' 59.82"E
38330	2,771,179.0834m	542,859.6421m	S11° 57' 46.50"E
38355	2,771,154.6842m	542,865.0894m	S12° 40' 53.09"E
38380	2,771,130.2940m	542,870.5777m	S12° 40' 53.09"E
38405	2,771,106.0187m	542,876.5340m	S16° 17' 57.06"E
38430	2,771,082.5238m	542,885.0299m	S23° 27' 40.16"E
38455	2,771,060.2715m	542,896.3886m	S30° 37' 23.26"E
38480	2,771,039.6090m	542,910.4330m	S37° 47' 06.36"E
38505	2,771,020.8586m	542,926.9440m	S44° 56' 49.46"E
38530	2,771,004.3131m	542,945.6638m	S52° 06' 32.57"E
38555	2,770,990.2197m	542,966.2938m	S58° 56' 53.05"E
38580	2,770,977.7155m	542,987.9414m	S60° 12' 43.48"E
38605	2,770,965.2957m	543,009.6382m	S60° 12' 43.48"E
38630	2,770,952.8759m	543,031.3349m	S60° 12' 43.48"E
38655	2,770,940.4562m	543,053.0317m	S60° 12' 43.48"E
38680	2,770,928.0364m	543,074.7285m	S60° 12' 43.48"E
38705	2,770,915.6166m	543,096.4252m	S60° 12' 43.48"E
38730	2,770,903.1968m	543,118.1220m	S60° 12' 43.48"E
38755	2,770,890.7264m	543,139.7892m	S58° 44' 02.06"E
38780	2,770,873.7907m	543,157.7598m	S28° 05' 55.13"E
38805	2,770,849.5738m	543,159.5490m	S19° 38' 52.21"W
38830	2,770,831.9654m	543,142.8275m	S67° 20' 00.54"W
38855	2,770,829.1539m	543,118.2040m	N87° 00' 52.78"W
38880	2,770,830.5207m	543,093.2420m	N88° 05' 10.37"W
38905	2,770,829.2138m	543,068.3199m	S80° 31' 11.54"W
38930	2,770,822.0726m	543,044.4294m	S66° 11' 45.34"W
38955	2,770,809.6881m	543,022.7505m	S56° 11' 59.29"W
38980	2,770,795.5493m	543,002.1328m	S55° 28' 30.49"W
39005	2,770,781.2931m	542,981.5965m	S54° 18' 27.00"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
39030	2,770,765.7460m	542,962.0352m	S48° 07' 49.34"W
39055	2,770,747.9415m	542,944.5085m	S40° 58' 06.24"W
39080	2,770,728.0907m	542,929.3384m	S33° 48' 23.13"W
39105	2,770,706.5035m	542,916.7615m	S26° 38' 40.03"W
39130	2,770,683.5167m	542,906.9741m	S19° 28' 56.93"W
39155	2,770,659.5572m	542,899.8651m	S14° 30' 31.42"W
39180	2,770,635.3206m	542,893.7345m	S14° 07' 46.74"W
39205	2,770,611.0207m	542,887.8628m	S12° 39' 55.99"W
39230	2,770,586.4890m	542,883.0657m	S9° 18' 25.20"W
39255	2,770,561.7079m	542,879.7960m	S5° 43' 33.65"W
39280	2,770,536.7709m	542,878.0804m	S2° 08' 42.10"W
39305	2,770,511.7754m	542,877.9257m	S1° 26' 09.45"E
39330	2,770,486.8191m	542,879.3326m	S5° 01' 01.00"E
39355	2,770,461.9994m	542,882.2954m	S8° 35' 52.55"E
39380	2,770,437.4132m	542,886.8027m	S12° 10' 44.10"E
39405	2,770,413.1565m	542,892.8368m	S15° 45' 22.08"E
39430	2,770,389.2645m	542,900.1909m	S18° 05' 17.38"E
39455	2,770,365.5368m	542,908.0645m	S18° 25' 00.66"E
39480	2,770,341.8172m	542,915.9627m	S18° 25' 00.66"E
39505	2,770,318.0976m	542,923.8609m	S18° 25' 00.66"E
39530	2,770,294.3780m	542,931.7591m	S18° 25' 00.66"E
39555	2,770,270.5347m	542,939.2575m	S14° 22' 39.50"E
39580	2,770,245.7902m	542,942.0389m	S2° 49' 45.63"W
39605	2,770,221.4843m	542,936.7044m	S21° 55' 40.57"W
39630	2,770,200.2617m	542,923.7108m	S41° 01' 35.50"W
39655	2,770,184.4586m	542,904.4884m	S60° 07' 30.44"W
39680	2,770,175.8149m	542,881.1535m	S79° 13' 25.37"W
39705	2,770,175.1942m	542,856.2657m	N83° 06' 33.35"W
39730	2,770,179.7240m	542,831.6874m	N78° 19' 08.62"W
39755	2,770,184.7855m	542,807.2051m	N78° 19' 08.62"W
39780	2,770,189.8470m	542,782.7229m	N78° 19' 08.62"W
39805	2,770,194.5667m	542,758.1752m	N81° 09' 15.91"W
39830	2,770,196.5326m	542,733.2799m	S89° 48' 00.36"W

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
39855	2,770,194.3672m	542,708.4029m	S80° 15' 02.90"W
39880	2,770,188.1049m	542,684.2298m	S70° 42' 05.43"W
39905	2,770,177.9192m	542,661.4306m	S61° 09' 07.96"W
39930	2,770,164.0922m	542,640.6370m	S51° 36' 10.49"W
39955	2,770,147.0330m	542,622.3982m	S42° 41' 43.00"W
39980	2,770,128.1194m	542,606.0529m	S40° 09' 31.86"W
40005	2,770,109.0129m	542,589.9302m	S40° 09' 31.86"W
40030	2,770,089.9065m	542,573.8074m	S40° 09' 31.86"W
40055	2,770,070.8000m	542,557.6847m	S40° 09' 31.86"W
40080	2,770,051.6935m	542,541.5620m	S40° 09' 31.86"W
40105	2,770,032.5870m	542,525.4393m	S40° 09' 31.86"W
40130	2,770,013.4805m	542,509.3165m	S40° 09' 31.86"W
40155	2,769,994.3740m	542,493.1938m	S40° 09' 31.86"W
40180	2,769,975.2675m	542,477.0711m	S40° 09' 31.86"W
40205	2,769,956.1611m	542,460.9484m	S40° 09' 31.86"W
40230	2,769,937.0546m	542,444.8256m	S40° 09' 31.86"W
40255	2,769,917.9481m	542,428.7029m	S40° 09' 31.86"W
40280	2,769,898.5737m	542,412.9077m	S37° 13' 28.93"W
40305	2,769,877.8038m	542,399.0222m	S30° 11' 32.47"W
40330	2,769,855.4667m	542,387.8311m	S23° 01' 49.37"W
40355	2,769,831.9087m	542,379.5121m	S15° 52' 06.27"W
40380	2,769,807.4973m	542,374.1952m	S8° 42' 23.17"W
40405	2,769,782.6134m	542,371.9632m	S1° 32' 40.07"W
40430	2,769,757.6455m	542,372.8511m	S5° 37' 03.03"E
40455	2,769,732.9826m	542,376.8428m	S12° 41' 37.11"E
40480	2,769,708.8123m	542,383.2170m	S15° 51' 33.21"E
40505	2,769,684.7643m	542,390.0500m	S15° 51' 43.14"E
40530	2,769,660.7162m	542,396.8831m	S15° 51' 43.14"E
40555	2,769,636.6681m	542,403.7161m	S15° 51' 43.14"E
40580	2,769,612.6200m	542,410.5491m	S15° 51' 43.14"E
40605	2,769,588.5720m	542,417.3821m	S15° 51' 43.14"E
40630	2,769,564.5239m	542,424.2152m	S15° 51' 43.14"E
40655	2,769,540.4452m	542,430.9373m	S14° 30' 23.66"E

Proposed Centre Line Cordinates

Station	Northing	Easting	Tangential Direction
40680	2,769,515.9204m	542,435.6747m	S6° 28' 07.62"E
40705	2,769,490.9602m	542,436.4130m	S3° 04' 49.85"W
40730	2,769,466.2234m	542,433.0002m	S12° 37' 47.32"W
40755	2,769,442.3956m	542,425.5309m	S22° 10' 44.79"W
40780	2,769,420.1371m	542,414.2123m	S31° 43' 42.25"W
40805	2,769,400.0618m	542,399.3612m	S41° 07' 17.88"W
40830	2,769,382.0162m	542,382.0671m	S45° 06' 57.65"W
40855	2,769,364.3744m	542,364.3536m	S45° 06' 57.70"W
40880	2,769,346.7325m	542,346.6402m	S45° 06' 57.70"W
40905	2,769,329.0906m	542,328.9268m	S45° 06' 14.55"W
40930	2,769,310.9789m	542,311.7037m	S40° 41' 18.31"W
40955	2,769,290.7751m	542,297.0282m	S31° 13' 22.49"W
40980	2,769,268.4176m	542,285.9064m	S21° 40' 25.02"W
41005	2,769,244.5248m	542,278.6477m	S12° 07' 27.56"W
41030	2,769,219.7589m	542,275.4533m	S2° 34' 30.09"W
41055	2,769,194.8061m	542,276.4114m	S6° 56' 49.71"E
41080	2,769,170.1989m	542,280.7800m	S11° 51' 37.62"E
41105	2,769,145.7374m	542,285.9407m	S11° 54' 55.13"E
41130	2,769,121.2760m	542,291.1023m	S11° 54' 55.13"E
41155	2,769,096.8147m	542,296.2640m	S11° 54' 55.13"E
41180	2,769,072.2646m	542,300.9505m	S7° 28' 08.47"E
41205	2,769,047.3689m	542,300.6482m	S10° 00' 00.30"W
41230	2,769,023.9190m	542,292.3214m	S29° 05' 55.24"W
41255	2,769,004.4843m	542,276.7802m	S48° 11' 50.17"W
41280	2,768,991.2043m	542,255.7356m	S67° 17' 45.11"W
41305	2,768,985.5411m	542,231.5042m	S86° 23' 40.05"W
41330	2,768,988.1179m	542,206.7535m	N74° 30' 25.02"W
41355	2,768,998.6512m	542,184.2084m	N55° 24' 30.08"W
41380	2,769,015.9658m	542,166.3306m	N36° 55' 57.14"W
41405	2,769,037.0934m	542,152.9947m	N30° 11' 36.42"W
41430	2,769,058.7017m	542,140.4217m	N30° 11' 36.42"W
41455	2,769,080.3100m	542,127.8486m	N30° 11' 36.42"W