Bidding Documents
for
Dedicated Freight Corridor Project
(Western Corridor, Phase 1: Rewari - Vadodara)

CIVIL, BUILDING and TRACK WORKS

Contract Package 3 (R)
for
ICB No. CT P-3 (R): Iqbalgarh – Vadodara Section

VOLUME IV Data Book (2/2)

Issued on : 3rd June 2015

Employer:
Dedicated Freight Corridor Corporation of India Ltd.
(A Government of India Enterprise)

NK Consortium
NK – JARTS – PBJ – NKI
Consulting Engineers

(3rd June 2015)

DFCC NEW DELHI

NK CONSORTIUM NJPi

BIDDING DOCUMENTS

FOR

CIVIL, BUILDING and TRACK WORKS

Contract Package 3 (R)
for
ICB No. CT P-3 (R): Iqbalgarh – Vadodara Section

SUMMARY TABLE OF CONTENTS

DFCC NEW DELHI

NK CONSORTIUM NJPi

BIDDING DOCUMENTS

FOR

CIVIL, BUILDING and TRACK WORKS

Contract Package 3 (R)
for
ICB No. CT P-3 (R): Iqbalgarh – Vadodara Section

SUMMARY TABLE OF CONTENTS

VOLUME V: (3/3)

DFCC NEW DELHI

NK CONSORTIUM NJPi

TABLE OF CONTENTS

DFCC NEW DELHI
NK CONSORTIUM NJPi

LIST OF TABLES

DFCC NEW DELHI
NK CONSORTIUM NJPi

LIST OF FIGURES

CHAPTER 1 DESIGN REPORT ON CIVIL AND TRACK WORKS

1.1 INTRODUCTION

This document reports the results of the design activities carried out by the Consultant for civil and track works and composes of the following parts:

Section 1.1:

This section concisely explains the composition of the report.

Section 1.2:

This section provides information on norms, codes and standards the design is based on.

Section 1.3:

This section clarifies the design criteria and design parameters approved by the employer to be followed by the Engineering Consultant. Engineering parameters detailing the geometric design, vertical clearances, earthwork design, and bridge clearances was established by the Engineering Consultant through Technical Working Papers in order to enable the prospective Bidders to appreciate the design criteria adopted in this Project.

Section 1.4:

This section describes the approach taken to the design for each discipline, and indicates particular design features which are important for the preparation of the bid. Also the nature, level of detail and how to interpret information shown on the drawings are explained. The quantities in the BOQ are only indicative. The Contractor is required to estimate the quantities as per his design philosophy.

Section 1.1 to 1.9 of this report covering the design aspect has been included in Volume3. Specifications and will be sent to the Contractor as a part of the bid documents.

1.1.1 The Dedicated Freight Corridor (DFC) Project

Ministry of Railways (MOR), Government of India has planned to construct a High Axle Load Dedicated Freight Corridor (DFC) covering about 3325 Km on two corridors, Eastern and Western Corridors. The Western Corridor is planned from Jawaharlal Nehru Port, Mumbai to Tughlakabad/Dadri near Delhi. The Western corridor of DFC Project covers a length of 1,483 Km (JNPT – Ahmadabad – Palanpur – Rewari – Asaoti - Dadri). Western Corridor is planned to be implemented in two Phases. The first phase envisages construction of 935 Km between Vadodara and Rewari.

The project entails construction of double-track electrified railway lines capable of handling 32.5 ton axle load, longer trains and double stack con tainers. The bridges and other structures will be designed to allow movement of 32.5 ton axle load while the track structure will be designed for 25 ton axle load operating at maximum train speed of up to 100 Km/hr.

1.2 NORMS, CODES AND STANDARDS GOVERNING THE DESIGN

The Final Location Survey (FLS), GAD of Bridges, Geotechnical Investigation Reports, Hydrological data provided by DFCCIL has been reviewed based on the following documents:

(1) Indian Railway Codes and Manuals, Indian Road Congress Codes

1) Indian Railways Permanent Way Manual (IRPWM);
2) Indian Railway Engineering Code (IREC);
3) Indian Railways Bridge Manual (IRBM)
4) Indian Railways Standard Concrete Bridge Code;
5) Guidelines and Specifications for Design of Formation for Heavy Axle Load (GE: 0014);
6) Indian Railway Manual for Long Welded Rails
7) Code of Practice for the Design of Sub-structures and Foundation of Bridges;
8) Lateral and Vertical Clearances at Underpasses for Vehicular Traffic (IRC: 54-1974);
9) Directions stipulated by Ministry of Railways via their letter no: 2006/RE/161/3 of May 19, 2005, CT/CONTR/BG/MG of Nov. 4/11, 2005, 2006/Infra/6/3 of June 23, 2008, 2000/PL-19/13 Pt. 4 of June 3, 2009, CT/DG/DFC of Dec. 8, 2009;
10) Indian Railways Schedule of Dimensions (SOD) 2004 & DFCC Draft SOD.
11) Indian Road Congress (IRC) Codes
12) Bureau of Indian Standard (IS) Codes
13) List of Design Codes to be followed, which are latest and / or over and above given by DFCCIL

(2) International Standards

1) UIC
2) JIS
3) EN
4) DIN

1.3 DESIGN CRITERIA APPROVED BY THE EMPLOYER

1.3.1 Design Principles

General

Indicative horizontal and vertical alignments of the railway are given in the Alignment Drawings as indicated in Appendix 1 [Alignment of Track ways and Work Areas] to the Employer's Requirements and listed in the Employer's Drawings.

Although the Contractor is not permitted to propose large deviations in alignment, he is responsible for reviewing the horizontal and vertical alignment with respect to his design and construction proposal within the defined Right of Way (ROW) based on the criteria herein prior to the further development of his design Works during the Design Phase.

The entire Line Tracks contained in this contract is divided in a Main Line, Connecting Lines, Loop Lines (in Yard) and Sidings for the clarification purpose of the design criteria.

The project entails construction of double-track electrified railway lines capable of handling 32.5 ton axle load, longer trains and double stack containers. The bridges, formation and other structures shall be designed to allow movement of 32.5 ton axle load while the track structure shall be designed for 25 ton axle load operating at maximum train speed of up to 100 Km/hr.

For the purposes of clarification of the design criteria, the entire Line Tracks is divided into Main Line, Connecting Lines and Loop Lines (in Yard). In addition, Secondary tracks have been defined as tracks leading away from the main lines in a station to other facilities e.g. sidings, yards and depots.

1.3.2 Geometric Criteria

In terms of Paragraph 401 of Indian Railway Permanent way Manual, the horizontal curve is the radius of a circular curve is determined by measuring the Versine on a chord of known length, from the equation,

$R = 125 \times C^2 / V$

Where,

R = Radius in meters;
C = Chord length in meters; and
V = Versine in millimeters.

The Curves can be designated by the radius in meters or by its degree. The angle subtended at the center by a chord of 30.5 meters, is the degree of the curve.

A one degree (1°) curve is thus of (360 x 30.5) / 2π = 1750 meter radius

A two degree (2°) curve has a radius of 1750 / 2 =875 meters and so on.

Curves shall be described invariably by the radius in meters [700 m for 2.5 degree, 1167 m for 1.5 degree].

The following curve parameters have been followed for this project:

(a) Minimum curve radius

(i) Main Track: 700 m (2.5 degrees)

(ii) Siding and connecting track: 438 m (4 degrees)

(iii) For reverse curves, it is preferable to maintain a radius of 875 m or more to enable application of long welded rails.

(iv) The actual radius of both the tracks shall remain same. This will be achieved by shifting the centre of the curve suitably.

(b) Minimum length of straight length between adjacent curves:

Desirable straight length between is 50m. In cases, where there is space constraint, both transitions can meet each other by suitable extending the lengths ensuring that rate of change of cant and versine along the two transitions so extended is kept the same.

However, in exceptional cases, minimum straight of at least one wagon length (20 m) be kept particularly for reverse curves or between two curves with specific approval of DFCCIL.

1) Cant

Actual cant is defined by the following formula Ca =$GV^2/127R$

Where,

Ca: Actual Cant (mm)
G: Dynamic gauge in mm (= 1750 mm)
V: Standard speed (km/hr)
R: Radius of curve (meter)

The standard speed for actual cant shall be defined by considering the maximum permissible speed (100 km/hr), speed restriction, gradient and train operation plan.

Table 1.3-1 Standard Speed by Type of Section

Type of section	Standard speed
i. General Sections	85 km/hr (equilibrium speed)
ii. Sections near station	As per train operation plan
iii. Long ascending section	

Source: The Consultant

The cant computed shall be rounded off to nearest 5 mm

- Maximum cant: 140 mm
- Maximum cant deficiency: 75 mm

- Cant Excess* (maximum): 75 mm
- Cant transition: Straight ramp
- The Cant Excess practically may be equal to actual Cant provided when the train stops or exceed 75mm in case the train operates at low speed.

2) Transition Curve

Transition curve is an easement curve, in which the change of radius is progressive throughout its length and is usually provided in a shape of a cubic parabola at each end of the circular curve. It affords a gradual increase of curvature from zero at the tangent point to the specified radius of circular arc and permits a gradual increase of super-elevation, so that the full super-elevation is attained simultaneously with the curvature of the circular arc.

(a) Type of transition curve: Cubic parabola

(b) Transition curve length is defined by the maximum of the following three values:

Standard Length

L= 0.008Ca x Vm
L= 0.008Cd x Vm
L= 0.72Ca

Where:

L:	Length of transition curve in meters
Vm:	Maximum permissible speed 100 km/hr
Ca:	Actual cant in mm
Cd:	Cant deficiency for Vm in mm

Note:

- Minimum length in exceptional case (Para 407 (3) of IRPWM)
  As an exceptional case: (a) and (b) can be reduced up to 2/3 of the standard length and (c) can be reduced up to 1/2.
- The transition length shall be rounded off to 5 meter.
- Cant Gradient: maximum 1 in 720, however, in exceptional cases it can be 1 in 360.
- There should be no change of grade in the transition curve.
- There should be no transition curve at level crossings and within 100 m of un-ballasted deck bridges.

Note: Chainage of IP and transition curves

- The Chainage of the IPs and transition curves are referential. The chainage on the plan and profile is for reference only.

3) Gradient

- Maximum gradient: 1/200 (=0.5%) [Compensated]
- Curve compensation: 70/R (%) where,

R= horizontal curve radius in metre

(a) Maximum gradient in yard

- Standard: 1/1200 (=0.083%)
  Exceptional case: 1/400 (=0.25%)
- No change of gradient in transition curve and within 30 m of any points and crossings.
- The approaches of all "Important Bridges" shall preferably be level for 100m from the abutments. If for any constraint of unavailability of adequate space, the same can be reduced up to 50m with the prior consent of the Employer.
- In case of other "Major bridges" there shall not be any change of gradient within 40m from either of the abutments. Only in very exceptional cases, like in flyovers, change of gradient on the bridge can be permitted with the prior consent of the Employer.

4) Vertical Curves

Vertical curve is applied only at the junction of the two grades where the algebraic difference in change of grade is equal to or more than 0.4%

- Minimum Radius to be 4,000 m
- Vertical curves shall not coincide with horizontal transition curves but could be coincide with circular curves.
- Vertical curves shall not coincide with point and crossing work.

5) Minimum distance between adjoining tracks

- DFC tracks: 6 m

(a) In case of Station Yards:

- A minimum distance of 6.25m shall be kept between Main Line to First Loop Line to accommodate LED based Signaling system.
- As the maximum length of TRD portal is 32 meter, which can accommodate five lines, a distance of 6.7 meter is required after five lines.

(Reference: DFCCIL Letter No. HQ/EN/WC/E&S/5/Vol-I Dated 28-0602012)

- DFC track and existing line track: 7 m (6 m in exceptional case)

Note: The tentative alignment drawings provide for minimum distance between the adjoining DFC track and existing line as 8 meters (6 m in exceptional case). However, this shall be revised to 7 meters, where ever such a distance has been indicated by the Contractor (6 m in exceptional case). The alignment shall be modified accordingly; where required.

- Extra Clearance on Curves: As per Appendix to Schedule of Dimensions (SOD). However, extra clearance up to 5 degrees has been accounted for in the above spacing requirement.

6) Station Yards

Clear Standing Room (CSR) of Loops 2x750m (1500m) at Junction Stations and staggered 750m long loops at the Crossing Stations. The CSR for the purposes of design shall be defined as the distance from fouling mark on one side to the fouling mark on the other side of the yard line.

(a) Turnouts

(i) Type of turnout

- Main tracks and auxiliary main tracks: 1 in 12 with curved thick web switch with CMS Crossing.
- Sidings: 1 in 8.5 with curved thick web switch with CMS Crossing

(ii) Technical Requirements

- Turnouts should not take off from the transition portion of the curve.
- The practice of turnouts not taking off from curves should be adopted to reduce the maintenance inputs and improve the riding quality.
- There will be no change of grades within 30 m of any points and crossings.
- Turnouts will be laid on PSC fan shaped sleepers.
- There will be no level crossings in on PSC fan shaped sleepers.
- A point and a crossing shall not coincide with a vertically curved track.

7) Level Crossings

There will be no level crossings in yards on the proposed DFC alignment.

Wherever the DFC alignment is parallel to the existing IR track and the level crossings are being extended, depending upon the classification of level crossing, category of road, necessary provision of grades, approach indicators shall be provided as per Chapter 9 of Indian Railways Permanent Way Manual.

- The type and standard of the approaches to the Level Crossing shall be similar to the existing approaches
- Suitable Height Gauges shall be provided on both sides of Level Crossing for protection against electrified tracks of DFC as per the applicable Codes
- Lighting shall be as per applicable IRS Standards

- Signages shall be as per applicable Codes and Standards
- Check rail shall be provided as per applicable IR standards. The minimum length of the check rail for square crossing shall be 2m more than the width of gate. In case of skew Level Crossing, the length of check rail shall be increased in accordance with the formula as specified in Chapter IX – Level Crossings and Gateman of Indian Railway Permanent Way Manual
- Width of surfacing between the gates shall be same as that of the width of gates
- Width of surfacing outside gate shall be tapering off to the existing carriageway width within a distance of 30m from gate.
- 15m long G.I. barbed wire fencing with RCC posts on both sides of Level Crossing on DFC side.
- Double Wall Corrugated HDPE pipes for track crossing & road crossing of cables at LC Gates shall be provided as specified in the Bid Documents.

1.3.3 Vertical Clearances

(1) Minimum height above rail level

Minimum height above rail level for a distance of 1600 mm on either side of centre of track shall be:

a) Case I: When lower track line is DFC line

Light overhead structure such as FOB etc. and for heavy overhead structure at turnouts, etc. = 8430 mm

Heavy overhead structure such as Flyover or ROBS = 8050 mm

b) Case II: When DFC tracks are crossing over IR Lines;

Vertical clearances to be observed as per IR SOD – Para 10 (iii)
- Light overhead structure such as FOB = 6250 mm
- Heavy overhead structure such as Flyover or ROBS = 5870 mm

Note:

In case IR track is nominated for Double Stack Container (DSC), vertical clearance shall be provided as per Sub-Para (1), Case I above.

On Lines proposed to be electrified on 25kV AC System, necessary provision should be made in overhead structures and overhead equipment if necessary by using longer traction overhead equipment masts to permit possible raising of the track by 275 mm in future to cater for increased ballast cushion, larger sleeper thickness and deeper rail sections. [Note (b) DFCC Draft SOD, Item 9 B) (ii) Page 4 and IR SOD Item 10 (iii) Note, Page 7]

(2) Levels

All levels shall be quoted in meters correct to three decimal places and shall be to Mean Sea Level Datum India. The rail level on a track will refer to the top of the lower rail.

(3) Clearances Required for Double Stack Containers (DSC)

The Employer has identified 29 locations of WDFC (Phase I) where DFCCIL and IR structures are crossing each other. DFCCIL has communicated through their letter no. HQ/EN/WC/E&S/5 dated September 27, 2010, that the locations where vertical clearance for DSC would be required to be provided as per the following **Table 1.3-2**. In the table referred, wherever "Yes" has been mentioned under the column "Whether Vertical Clearance for DSC Required", DFC Clearances are to be followed, and wherever the word "No" is written, vertical clearances of IR are to be followed (Paragraph 1.3.4 (1) 2) above).

Table 1.3-2 **Planned Structures on WDFC over DFC lines and Existing IR Lines**

No.	Section CPM	Location	Upper Line	Lower Line	Note	Whether Vertical Clearance for DSC Reqd.?
1.	Sec 5 BRC	Makarpura JS	DFC Main Tracks	Connecting track to Makarpura Station	DFCC / DFCC	Yes
2.	Sec 5 BRC	Makarpura JS	Connecting track to Makarpura Station	Mumbai – Vadodara M/L	-	Yes
3.	Sec 5 BRC	44K853	DFC Main Tracks	Vishvamitri – Jambusar Rd. Line	IR Narrow Gauge	No
4.	Sec 5 BRC	24K616	DFC Main Tracks	Vasad – Kathana Line		No
5.	Sec 5 BRC	7K026	DFC Main Tracks	Anand –Khambat Line		No
6.	Sec 5 BRC	23K785	DFC Main Tracks	Nadiad – Bhadran Line (IR)	IR NG line	No
7.	Sec 6 ADI	71K600	DFC Main Tracks	Ahmedabad – Botad Line (IR)	MG Line	No
8.	Sec 6/7 ADI	SBT JS near 84K100	DFC Dn. Main Tracks	Connecting Track South Yard to SanandStn.	DFCC / DFCC	Yes
9.	Sec 6/7 ADI	SBT JS near 84K100	DFC Dn. Main Tracks	ADI-Viramagam Line		Yes
10.	Sec 6/7 ADI	SBT JS near 84K100	DFC Dn. Main Tracks	Connecting Track North Yard to SanandStn.	DFCC / DFCC	Yes
11.	Sec 6/7 ADI	SBT JS near 84K100	DFC Up Main Tracks	Connecting Track South yard to SBT Jn. Yard	DFCC	Yes
12.	Sec 6/7 ADI	SBT JS near 84K100	DFC Up Main Tracks	ADI-Viramagam Line (IR)		Yes
13.	Sec 6/7 ADI	SBT JS near 84K100	DFC Up Main Tracks	Connecting track north yard towards SBT Jn. Yard	DFCC	Yes
14.	Sec 6/7 ADI	120K518	DFC Main Tracks	Kalol – Kotosan Rd. Line (IR MG)		No
15.	Sec 8 ADI	151K677	DFC Main Tracks	Mehsana – Linch – Viramgam Line (IR BG)		Yes
16.	Sec 8 ADI	151K750	DFC Main Tracks	Connecting track sub yard to Linch yard		Yes
17.	Sec 8 ADI	166K658	DFC Main Tracks	Mehsana-Ranuj Line (IR MG)		No
18.	Sec 8 ADI	229K370	DFC Main Tracks	PNU-Chadotar-Samkhiali line (IR)		Yes
19.	Sec 8 ADI	229K634	DFC Main tracks	Connecting track sub yard to Chhadotar yard	DFCC	Yes
20.	Sec 9 AII	25K422	DFC Main tracks	Marwar-PNU line		Yes
21.	Sec 12 AII	56K220	DFC Main tracks	AII-Chittaurgarh line	IR	No
22.	Sec 12 AII	56K-60K	Madar – Chittaurgarh line	DFC main tracks		Yes

Source: DFCCIL Letter no.HQ/EN/WC/E&S/5, dated 27th September 2010

(4) Track Structure for 32.5 Ton Axle Load

The Consultants understanding of the vertical clearance for track structure designed for 25 ton axle load and 32.5 tons is given in the table below.

Table 1.3-3 4Track Structure Dimension by Axle Load

Description / Axle Load	25.0 tons	32.5 tons	Remarks
Thickness of Rail (mm)	172 #2)	186 #1)	#1) UIC68Kg/m Rly. Bd. Letter 2006/Infra/6/3 of 23/6/08 #2) UIC 60Kg/m, 90 UTS conforming to T-12-2009 as per Railway Board Notice 2000/PL19/13 Pt.4, dated 3 June 2009.
Thickness of rail pad (mm)	6 #3)	10	#3) Assumed
Thickness PC Sleeper at rail seat (mm)	210	250 #4)	#4) Assumed [Sleeper Density : 1660 Sleeper/Km]
Ballast Thickness (mm)	350 #5)	350	#5) IRPWM Correction Slip 117 Para 263 (2) Dated 19th May 2009
Future Margin (mm)	275	217 #6)	#6) IR SOD Note: Item 10, and DFCC SOD Item 9B, Note (b)
Total Thickness #4)(mm)	1013	1013	

1.3.4 Track Structure

Following technical parameters in respect of track structure corresponding to 25 tonne axle load as the first stage of DFC project will be adopted:

Table 1.3-4 Technical Parameters of Track Structure

S. N	Technical Parameter	Value
1	Gauge	1676mm (BG)
2	Spacing of Tracks	
2.1	Minimum Distance: Centre to centre of DFC Tracks	6.0 Meter
2.2	Minimum distance centre to centre from existing IR to DFC Track	7.0 Meter [6 Meter in exceptional cases]
3 (a)	Rails for Main Line and Points and crossings	UIC60Kg - 1080 HH Japanese Rails
3 (b)	Rails for other than Main Line and Points and Crossings	UIC60Kg - 90UTS (with specifications conforming to specifications but not inferior to IRS : T-12-2009)
4.0	Points & Crossings – Main Line and running Loops.	Zu1-60, 1080 HH Rail, 1 in 12 curved thick web switches with weldable CMS Crossings on PSC Sleepers layout
4.1	Points & Crossings – Minor Loops and non-running lines/Sidings	Zu1-60, 1080 HH Rail, 1 in 8 1/2 curved thick web switches with weldable CMS Crossings on PSC Sleepers layout
4.2	Points & Crossings – Minor Loops and non-running lines/Sidings	Zu1-60, 1080 HH Rail, 1 in 8 1/2 curved thick web switches with weldable CMS Crossings on PSC Sleepers layout
5.0	Check Rail Clearances at Level Crossings	
5.1	Minimum	51 mm
5.2	Maximum	57 mm
6.0	Minimum depth of space for wheel flange from rail level	38 mm
7.0	Ballast Cushion below the bottom of the sleeper at the rail seat – Main Line.	350 mm.
7.1	Ballast Cushion – Loop Line & Sidings	250 mm
8.0	Sleeper	PSC Mono-block, 60 Kg with 1 in 20 cant

S. N	Technical Parameter	Value
		for the rail seat (The rail seat of PSC Sleeper will be able to cater to 68 Kg/m and 60 Kg/m rail sections by providing suitable liners.)
9.0	Sleeper Density – Main Line	1660
9.1	Sleeper Density – Loop Line & Sidings	1540
10	Fastening	Elastic Rail Clip
11	Formation Width– Embankment	a) For Double Track : 13.5 meter b) For Single Track : 7.5 meter
11.1	Formation Width– Cutting excluding side drains	a) For Double Track : 12.9 meter b) For Single Track : 6.9 meter

Source: DFCCIL and Working Papers

1.3.5 Earthwork Design

For this Contract, the "Guideline and Specification for Design of Formation for Heavy Axle Load, GE: 0014", issued by RDSO will be followed. The geometric parameters and design principles are described in terms of earthwork structure as follows:

- Formations comprises of Granular layer (Blanket) over prepared sub-grade and embankment fill (Para 3.0 Formation Components);
- Cross fall slope to be at least 1:30 or 3% with tolerance of 0.5% (Para 5.7 Geometrical requirements for the soil formation);
- Parameter of blanket thickness (45cm, 60cm, 80cm or 100cm) and sub grade (75cm or 100cm) are specified as mandatory provisions to be adopted (Para 17. Specification & Recommendations: (Mandatory));
- In the case of new construction, minimum height of embankment should not be less than one meter to ensure proper drainage, effective stress dispersal, and uniform riding qualities (para 5.1.3);
- Uniform total thickness of formation of 2m should be provided including blanket, prepared sub grade & top layer of embankment fill etc. (Table 6, Para 2. Two Layer System (Blanket & Prepared Sub-grade on Embankment Fill);
- To allow for increased width of ballast on account of super elevation, additional necessary toe wall may be provided to ensure a cess width of 900 mm (Para 5.7 Geometrical requirements for the soil formation, Top Width of Formation);
- The construction drawings including longitudinal and cross-sections based on his final design shall be prepared by the Contractor. The drawings shall be reviewed by the Consultant and accepted by the Employer.
- The slope stability analysis shall generally be in accordance with Annexure-III of RDSO GE: G-1.

The following two tables indicates the geometric parameters and design principles with regards to Earthwork Structure of DFC project.

Table 1.3-5 Geometric Parameters of Earthwork

S. No.	Parameter	Value	Reference
1-1	Formation Width		
1-1(a)	Embankment	13.5m	Cross section of Earthwork Structure (Embankment Height > 6m)
1-1(b)	Cutting	12.9 m	
1-2	Slope Gradient for Embankment	2H : 1V	Cross section of Earthwork Structure (Embankment Height > 6m)
1-3	Slope Gradient for Cut	1H : 1V	Typical Cross section of Earthwork Structure (Cut)
1-4	Thickness of Blanket	600mm	Cross section of Earthwork Structure (Embankment Height > 6m)
1-5	Thickness of Prepared Sub-grade	1,000mm (If the existing soil conditions satisfy the conditions of prepared sub-grade for embankment height up to 1.6 meter, the same shall be treated as sub-grade.)	Cross section of Earthwork (Embankment Height > 6,000) to be provided at 6 meter below FL.
1-6	Width of Berm	1,500mm (Minimum)	Cross section of Earthwork Structure (Embankment Height > 6,000)
1-7	Cross Slope at Top of Blanket	1 : 30 or 3.0% with tolerance of 0.5%	Cross section of Earthwork Structure (Embankment Height > 6,000)
1-8	Cross Slope at Top of Prepared Sub grade	1 : 30 or 3.0% with tolerance of 0.5%	Cross section of Earthwork Structure (Embankment Height > 6,000)
1-9	Cross Slope at Top of Embankment Fill	1 : 30 or 3.0% with tolerance of 0.5%	Cross section of Earthwork Structure (Embankment Height > 6,000)
1-10	Cross Slope at Berm	1 : 30 or 3.0% with tolerance of 0.5%	Cross section of Earthwork Structure (Embankment Height > 6,000)

Source: Guideline and Specification for Design of Formation for Heavy Axle Load, GE: 0014 & DFCCIL

Table 1.3-6 Design Principles of Earthwork

S. No.	Conditions	Design Principle	Reference
2-1	FL (Formation Level) is higher than GL (Ground Level) by 6 m.	Embankment structure on the natural ground consists of following layers. (i) Blanket in 600 mm (ii) Prepared Sub-grade in 1,000mm (iii) Embankment fill in remaining thickness Berm is prepared every 6m from top of blanket layer	Cross section of Earthwork Structure (Embankment Height > 6,000)
2-2	FL is higher than GL by 1.6 m – 6.0m	Embankment structure on the natural ground consists of following layers. Blanket in 600 mm Prepared Sub-grade in 1,000mm Embankment fill in remaining thickness	Typical cross section of Earthwork Structure (Embankment)
2-3	FL is higher than GL by 0.6 - 1.6m	Embankment structure with cutting work consists of following layers. Blanket in 600 mm Prepared Sub-grade in 1,000mm Natural ground requires more than Embankment fill requirement - Min. Ev2 : 30 MPa If natural ground have more than 60 MPa in Ev2, prepared sub-grade layer is not required.	Cross section of Earthwork Structure (Embankment Height = 600～1600)
2-4	FL is higher than GL 0 - 0.6m	Cut structure consists of following layers. Blanket in 600 mm	Cross section of Earthwork Structure (Embankment Height < 600)
2-5	FL is equal to or less than GL	Cut structure consists of following layers. Blanket in 600 mm	Typical cross section of Earthwork Structure (Cut)
2-6	HFL (High Flood Level) is higher than GL	Embankment structure on the natural ground consists of following layers. Blanket in 600 mm Prepared Sub-grade in 1,000mm Embankment fill in more than 1,000mm from H.F.L.	Cross section of Earthwork Structure (Flood Prone Area)

Source: Guideline and Specification for Design of Formation for Heavy Axle Load, GE: 0014 & DFCCIL

1.3.6 Drainage

For effective drainage, the following points shall be kept in view:

Top of the formation should be finished to cross slope of 1 in 30 from centre of formation to both sides in case of single/double line. However, in case of multiple lines, the cross slope should be from one end to the other towards cess/drain provided in between.

Once the top surface of the formation has been finished to proper slope and level, movement of material vehicle for transportation of ballast, sleepers etc. should be avoided as these movements will cause development of unevenness, ruts on surface which will accumulate water and weaken the formation.

At locations, where the water table is high and fill soil is fine grained, it may be desirable to provide a granular layer of about 30 cm thickness at the base, above the sub-soil across the full width of formation.

Blanket material should conform to the laid down specifications.

In the double track section, central drain between two tracks should not be provided, however between IR and DFC tracks it should be provided.

In cuttings, properly designed side drains and catch water drains should be provided.

In yard, surface drains should be generally open for ease of cleaning and inspection.

1.3.7 Bridges

The basis for the design of structure, sub-structure, foundation for major bridges, protection works for minor bridges, RUB's and ROBs, RFOs and footover bridges shall be based on relevant IRS, IRC and IS standards.

(1) Design Life and Serviceability

The design life of a structure is that period for which it is designed to fulfill its intended function when inspected and maintained in accordance with agreed procedures. The assumption of a design life for a structure or component does not necessarily mean that the structure will no longer be fit for its purpose at the end of that period. Neither will it necessarily continue to be serviceable for that length of time without adequate and regular inspection and routine maintenance.

Requirements for durability, including choice of materials and detailed requirements to achieve good durability, are given in the relevant paragraphs herein. All Design Life criteria shall be confirmed

The design life of all civil engineering structures shall be a minimum of 100 years unless otherwise specified or agreed.

Contractor is expected to submit a report demonstrating, the approach in design, construction & selection of material so as to achieve 100 years design life.

The design life of each structure, facilities and systems are defined as follows.

1) Structures of the Civil Works

The design life of all civil engineering structures of the Civil Works is considered a minimum of 100 years unless otherwise specified in the Specifications under the Contract. In case design life of proposed structures by the Contractor seems insufficient, the Employer may reject the Contractor's proposal.

2) Structures of the Building Works

The design life of all building structures of the Building Works is considered a minimum of 50 years unless otherwise specified in the Specifications under the Contract. In case design life of proposed structures by the Contractor seems insufficient, the Employer may reject the Contractor's proposal.

3) Mechanical, Electrical and Plumbing (MEP)

The design life of MEP services including water supply, drainage services and fire protection services is considered a minimum of 20 years unless otherwise specified in the Specifications under the Contract.

4) Heating, Ventilating and Air-conditioning (HVAC)

The design life of all HVAC facilities, systems and services is considered a minimum of 10 years unless otherwise specified in the Specifications under the Contract.

The Contractor is deemed to have guaranteed to the Employer that the Contractor is responsible for any significant failure and or substantial reduction in performance or quality of the Works in accordance with the Employers's Requirement, Specifications and the Conditions of Contract.

(2) Railway Design Requirements

The Contractor is responsible for design and construction of the Civil Works, the Building Works and the Track Works, and is also responsible for coordinating and cooperating with Other Contractors so that the design and installation of all components of the railway are compatible as a whole.

The design and installation of all railway operating equipment, including signals and signaling cables, the traction power electrification equipment, electrical cables, electrical and mechanical equipment, telecommunication links, etc. that are required for the railway will be undertaken by the Other Contractors.

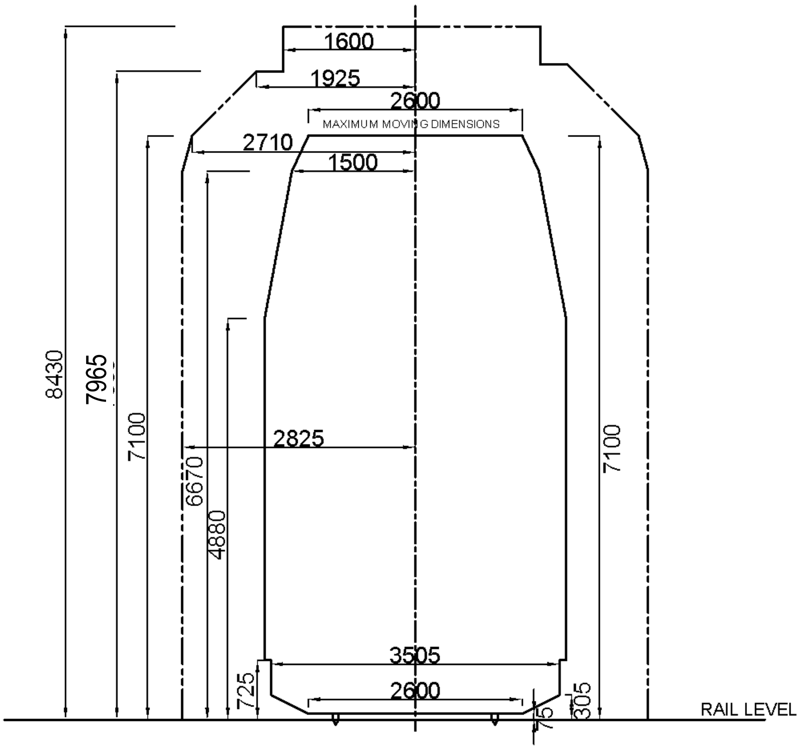
The Contractor shall design the Works taking into account of the works to be done by the Other Contractors and handover the site where the Other Contractors have to execute their works as planned and programmed during the design phase.

The extent and detail of such provisions are to be determined by the Contractor making due enquiries, during the design coordination period from the Other Contractors engaged to provide railway operating equipment as stated above.

The Contractor shall be responsible for coordinating his design and construction with the Other Contractors and with the Employer and for ensuring that the design incorporates such fixings as are required in order to avoid any necessity for the ther Contractors or the Employer to drill, weld, burn or cut any part of the structure when carrying out installations

1) MMD and Structure Gauges

The Maximum Moving Dimensions (MMD) has been calculated on the condition of wagon's static and dynamic movement for the DFC. Those dimensions are shown on the MMD and Structure Gauges Drawing as attached [Employer's Referential Drawings] to the Employer's requirements and also duplicated in Figure 1.3-1 below. The Contractor shall ensure that the proposed size and location of the Permanent Works and other Contractor's works are outside the Structure Gauge through the procedure as described in Appendix 10 [Contractor's Coordination with Others] to the Employer's Requirements.



Source: DFCCIL

Figure 1.3-1 Maximum Moving Dimension and Structure Gauges

With regard to headroom clearance, the following exceptions are added to the requirements above. Minimum height above rail level for a distance of 1,600 mm on either side of the centre of the track shall be:

Light overhead structure such as foot over bridges 8,430 mm

Heavy overhead structure such as road over bridge or flyover 8,050 mm

Heavy overhead structure at turnout etc. 8,430 mm

Note: On Lines proposed to be electrified on 25 kV AC System, necessary provision should be made in overhead structures and overhead equipment if necessary by using longer traction overhead equipment masts to permit possible raising of the track by 275 mm in future to cater for increased ballast cushion, larger sleeper thickness and deeper rail sections. [Note (b) DFCC Draft SOD, Item 9 B) (ii) Page 4 and IR SOD Item 10 (iii) Note, Page 7]

2) Vertical Clearances for RUB, ROB's and RFO's

The vertical clearance for fixed structure gauge in SOD is considered as 8.430m as is explained above.

Vertical Clearance at under passes shall between 3.6m to 5.5m depending upon the type of road as per IRC 54 - 1974 “Lateral and Vertical Clearances at Underpasses for Vehicular Traffic”.

In parallel section where Bridge is proposed for passage of vehicular/double decker, it shall have a minimum Vertical Clearance as available under the bridge of adjacent track. For bridge provided for passage of non-vehicular traffic in Detour section a min vertical clearance of 3.6 m to 4.5 m shall be provided, as per IRC 11 - 1962 “Design and Layout of Cycle Tracks” (Refer to Para 1.4.6 (1) of this report).

Suitable Height Gauges to be provided on both sides of RUBs.

3) Hydrological Design Considerations and Design of Protection Works

a) Discharge Estimation and Water Way Calculation

Estimation of design discharge is required for proper design, construction, and maintenance of bridge water ways, foundations, approaches and training works. Parameters like Vertical clearances also depend on the design discharge. RDSO Technical Monograph 50 - “Hand Book for Estimation of Design Discharge for Railway Bridges” shall be used for determining the Discharge.

b) Protection Works

All bridges with open foundations shall be protected by a well designed flooring system. The concrete floor shall be protected by curtain wall at upstream side and Drop wall at Down Stream side. Flexible apron of 1m thick shall be provided beyond curtain/ Drop walls. The Minimum depth of Drop wall shall be 3.5m. The embankment on approaches shall be protected by stone pitching and Toe wall shall be provided at the end of the embankment slope.

c) Scour Depth Calculations

For hydraulic design, most important parameters are discharge, HFL and Scour. Depth of the scour shall be calculated as from Lacey's formula.

1.3.8 Loading

(1) General

As per MOR letter no.2000/PL19/13 Pt4 of 3rd June 2009, and as per MOR letter DO No. 2006/Infra/6/3 Pt1 of 3rd December 2009, it was decided that while DFCC track would be fit for 25 tonne axle load, the substructure of bridges alone should be made suitable for 32.5 tonne axle load.

The loading standards applied to the Rail Track Structures and Rail Track Formations shall generally be in accordance with Bridge Rules [second reprinting 2008, incorporating correction slips up to 39] issued by Research Design and Standards Organization and Bridge Design Manual [1998] issued by Government of India, Ministry of Railways.

The design loading accommodating 32.5 ton axle load is further described below for the structure designs of the Civil Works under the Contract.

(2) Superimposed Dead Load

The Contractor shall propose the superimposed dead load to be applied in this Contract to the Engineer for review. The Contractor shall coordinate with the other Contractors in the early stage of the design phase and confirm the superimposed dead load with respect to the works carried out by the other Contractors. Until the time other contractor (Systems Contractor – which may take about 8 to 10 months from, the date of award of this contract), it may not be possible for the Contractor to coordinate with other Contractors in early stage of Design Phase for confirming the superimposed dead load. In such eventualities, the Contractor shall liason with the Engineer for superimposed dead loads or any other design coordination issue.

The superimposed dead load to be applied to the structures shall include, but not necessarily limited to;

Running rails;

Sleeper;

Concrete bed, if applicable;

Concrete trough (with cables inside);

Parapet;

Overhead Equipment (OHE);

Wearing Coat; and

Ballast

(3) Railway Live Loads

1) Limit State Design

As per clause no 10 of IRS concrete Bridge code, the structures shall be designed for following limit state concept:

Ultimate Limit State

Serviceability Limit State

The design of RCC elements shall be carried out by Ultimate Limit state concept as per clause no 10.3 of IRS Concrete Bridge Code.

For serviceability limit state RCC elements shall be checked for permissible crack widths as per Clause 10.2.1(a) of IRS Concrete Bridge code.

Application of the live load shall be strictly complied with the Bridge Rules and the Bridge Design Manual introduced above.

2) Nominal Loads

a) Static Loading

The nominal loading for the design of members shall comprise fully loaded locomotive(s) and wagons each having four, six and eight axles as shown in the Bridge Rules [DFC Loading (32.5t Axle Load)] .

Five (5) different combinations of the coupled locomotive(s) and wagons shall be applied to the structure so as to give the most adverse effect on the element being considered. Note that the loading due to rolling stock may be modified as such the Contractor shall confirm the finalized rolling stock with the Other Contractors prior to commencement of the Technical Design.

b) Dynamic Loading:

The Static Loading given above shall be multiplied by an appropriate dynamic factor as detailed in Clause 2.4 [Dynamic Effect] of the Bridge Rules.

c) Longitudinal Braking and Traction Loads:

Longitudinal loads from braking and traction shall be in accordance with Clause 2.8 of [Longitudinal Effects] of the Bridge Rules. Five (5) different combinations of the coupled locomotive(s) and wagons as prepared for the DFC Loading (32.5t Axle Load) shall be considered.

Traction Effort per Loco:	63t (618.03 kN), 52t (510.12 kN) or 84t (824.04 kN) depending on the combination
Braking Force of Loco Axle:	25% of Axle Load
Braking Force of Train Load:	13.4% of Train Load

d) Centrifugal load:

The centrifugal load shall be calculated in accordance with in Clause 2.5 [Forces due to Curvature and Eccentricity of Track] of the Bridge Rules.

3) Wind Loading

The bridge structure shall be designed for wind loading in accordance with Clause 2.115 [Wind Pressure Effect] of the Bridge Rules.

4) Temperature Loading

The bridge structure shall be designed for temperature loading in accordance with Clause 2.6 [Temperature Effect] of the Bridge Rules. Overall temperature and differential temperature shall be determined and applied as loading based on the variation of temperature assumed by the Contractor taking into account of all conceivable conditions on each objective structure.

5) Seismic Loading

The bridge structure shall be designed for seismic loading in accordance with

Clause 2.12 [Force and Effects due to Earthquake] of the Indian Railways Bridge Rules as issued by RDSO.

6) Other Loadings

a) Derailment Loading

Derailment Loading applied to the bridge structures shall be in accordance with Clause 2.14 [Derailment Loads] of the Bridge Rules.

c) Racking Forces

The bridge structure shall be designed for Racking Forces in accordance with Clause 2.9 [Racking Forces] of the Bridge Rules.

d) Footpath on Bridges

Consideration of the loads due to pedestrian traffic as indicated in Clause 2.3.2 [Footbridges and Footpath on Bridges] of the Bridge Rules shall be taken into account.

In addition to the above the following forces should also be considered for design of structures:

- Live Load Surcharge
- Frictional resistance for expansion bearing
- Erection Forces and their Effects
- CWR/ LWR Loads on Bridge
- Plassers Quick Relay System (PQRS)
- Earth Pressure
- Earth pressure due to Surcharge, on abutments, on return walls, on wing walls
- Earth Pressure due to Seismic Effects
- Light water pipe and other services

7) Load combinations

The load combinations are adopted as per Clause 11.2 of IRS concrete Bridge Code. Partial safety factors for ultimate limit state of collapse and for serviceability limit state for different load combinations shall be considered.

8) Load combinations for Box culvert bridges

The box culverts are subjected to earth pressure from outside, water pressure from inside, Surcharge due to earth fill, permanent way and live load in addition to dead loads and live loads.

9) Idealization of Structure:

The structures shall be idealized as plain frame/ space frame with loadings in vertical and horizontal directions where applicable. The nodes at founding level shall be idealized as spring supports considering elastic soil springs.

10) Soil Structure Interaction Modeling and Analysis Procedure:

Where the soil structure interaction is to be considered, the soil shall be idealized as a classical Winkler foundation - Beam on springs. The soil passive resistance is considered to be offered by linear elastic springs. Spring constants for the bottom raft are calculated based on modulus of sub grade reaction of the soil strata. After performing the analysis, the forces in the springs shall be compared with the allowable bearing pressure.

(4) Differential Settlement

Consideration of the forces resulting from differential settlement shall be made where the nature of the chosen foundation system and the ground conditions indicate that such a condition may arise. The effects of differential settlement between adjacent structures shall be assessed in accordance with followings;

1) Differential Settlement

Differential settlement between adjacent structures shall be evaluated and due allowance incorporated into the size of the structures and detailing of joints to ensure that the Structure Gauge is not infringed within the design life.

2) Safety against deformation and differential settlements:

The foundation should deform within acceptable limit of total and differential settlements. These acceptable limits depend on the type of structures and substrata involved and should be decided judiciously. The settlement shall not normally exceed 25mm after the end of the construction period for bridges with simply supported spans.

In case of structures sensitive to differential settlement, the tolerable settlement limit has to be fixed based on the conditions in each case.

1.3.9 Bearings

Where Elastomeric bearings are to be used, Design of bearing shall be carried out as per UIC – 772 (R).

1.3.10 Design of Road-Under-Bridges

(1) Primary Loads

In addition to the above loads, following loads due to Highway vehicles shall be considered on the base slab for the design of RUB's as per IRC 6: 2000

The design will cater for Class A / Class 70R loading as per Table 2 of IRC 6:2000. The impact forces shall be considered as per Cl: 211 of IRC-6-2000.

Live load on foot paths: Basic intensity of footpath live load is taken as 500 kg/sq. m. as per Cl: 209.1 of IRC 6-2000.

(2) Load Combination

The load combinations shall be adopted as per Clause 11.2 of IRS Concrete Bridge Code.

(3) Design Considerations

1) Clearance for Roads

The Contractor shall refer the Standard Specifications and Code of Practice published by the Indian Roads Congress and/or consult with the competent authority to maintain the appropriate clearance over the road as required accordingly.

2) Clearance for Existing Railways

With regard to the clearance over the existing IR railways, the Contractor shall comply with the provisions provided in Indian Railways Schedules of Dimensions 1676mm Gauge (BG) [Revised in 2004 including the latest amendment] published by Ministry of Railways.

3) Clarification of Design Assumptions

Stresses in partially completed structures shall be analyzed for appropriate critical conditions at various stages of the construction. Any restriction on the construction operations resulting from design assumptions shall be clearly specified on the drawings and specifications.

4) Bridge Bearings and Movement Joints

Bridge bearings and movement joints shall have a minimum design life of 50 years apart from minor components which can be replaced without complete removal and without interruption to traffic. Such components shall have a service life of 20 years.

a) Movement Joints

Movement joints and other necessary measures to control shrinkage and thermal effects shall be incorporated in the structural design so that the performance of architectural finishes or of any services are not adversely affected during normal working conditions. Movement joints shall be designed to be easily maintained and replaceable.

b) Bearings

All bearings shall be replaceable without major disruption to railway operating or to any activity underneath the bridge. Appropriate jacking points shall be provided.

5) Bearing Inspection Platform

Bearing inspection platforms shall be provided to ensure the safe access to monitor the bearing inspections for all Important and Major Bridges.

1.3.11 Deck Drainage

The rainwater run-off from bridge decks shall be collected and piped to a suitably designed storm water drainage system. This drainage system shall be easily accessible for safe inspection and routine maintenance without entering the Railway Envelope or otherwise interrupting the operation of the railway. The gaps between decks shall be suitably covered so that the rainwater will not run down from the gaps.

1.3.12 Free Board in Bridges on Parallel Section

In terms of Paragraph 313 (Freeboard) of the Indian Railways Bridge Manual 1998, it is directed that:

The freeboard from the water level of the design discharge (Q) to the formation level of the Railway embankment or the top of the guide bund including afflux shall not be less than 1m. In cases where heavy wave action is expected, freeboard shall be increased suitably.

In special circumstances, where the freeboard can be safely reduced and where adoption of the prescribed values would result in heavy expenditure and/or serious difficulties in construction, the freeboard may be relaxed at the discretion of the Chief Bridge Engineer as indicated in Table 1.3-7 below:

Table 1.3-7 Minimum Freeboard by Discharge

Discharge (Cumecs)	Minimum free board (mm)
Less than 3	600
3 to 30	750
More than 30	“No relaxation is permissible”

Source: Railway Bridge Manual

While executing works other than rebuilding a bridge or extending it for doubling purpose, the existing free board may be retained after taking measures for safety as considered necessary with the acceptance of the Engineer / Employer.

DFCCIL has communicated that, “In case of parallel alignment, the provision of free board clearance, i.e. 1m normal cases, can be relaxed to 600 mm and 750 mm depending upon the discharge, i.e. up to 3 cumecs – 600 mm and between 3 to 30 cumecs – 750 mm. But in no case, it should be less than the free board available in the existing corresponding IR Bridges if the existing freeboard is already less than 1m”.

1.4 DESIGN FEATURES

1.4.1 Alignment Design

(1) Interpretation of the information on the original design

1) Notation of Curve Parameters

The following are the definition of standardized notation for curve parameters:

TS: Point of change from tangent to spiral (= Beginning of Transition Curve)

SC: Point of change from spiral to circular (=Beginning of Circular Curve)

CS: Point of change from circular to spiral (= End of Circular Curve)

ST: Point of change from spiral to tangent (= End of Transition Curve)

2) Centerline of Alignment

Centre line is the linear path of the center of down track (line with trains running towards Delhi)

3) Geometrical Elements Table and Intersection Points (IP) of Curves

Geometrical elements table and Intersection Point (IP) of curves on the FLS drawings are correct, however its position indicated on the drawing is for reference only. Geometrical elements table, IP Coordinates, and the attached IP alignment drawings are provided as reference for centerline stakeout purposes.

4) Notation on Plan and Profiole Drawings

Proposed FL: Interprete as Formatio Level (FL) of DFC
Existing FL: Interprete as FL of existing IR lines (in parallel section

5) Information provided in Tender Document

Volume II – Annex - Employer's Requirement Drawings

Volume V - Employer's Drawings

- Detail Plan & Profile
- Curve List
- Gradient List

Break Metre List [#1)]

- Details of Horizontal Alignment
- Details of Track Layout
- Junction and Crossing (J&C) Station
- Design Reference

(2) Important Assumptions for the Preparation of the Work Quantity

1) Right of Way

ROW on the plan and profile drawings is transferred from Land Plans. The Contractor is required to confirm the consistency between the ROW indicated on FLS and on Site.

2) Coordinate System of Horizontal and Vertical Alignment

The coordinate system of the FLS alignment was based on local coordinate system, and not in a uniform system based on triangulation station benchmarks based on GPS coordinates (X, Y, Z) in terms of UTM projection on WGS-84 datum. The profile of FLS (Z value) is based on the datum of Greater Triangulation Survey Bench Marks (GTSBM) which were established by Survey of India, not Z coordinate of GPS readings.

The Consultant has integrated the FLS drawings utillizing the result of the confirmation survey of section boundaries, excluding Section boundaries at 7/8, 8/9, based on the National Coordinate System established by Survey of India. However, the accurate integration of the FLS section at section boundaries has not been not possible due to traverse and leveling errors

[#1)] When one particular location has two chaianges [either short or long] due to realignment or for any other reason, it is defined as break point [one point with two different chaianges]. The list of such break points is denoted as break list.

being not distributed by the surveyors.

The horizontal alignment was integrated on the National Coordinate System, assuming that that the azimuth direction and the the position of each planimetric feature provided from DFCCIL is correct.

The Contractor shall verify the coordinates of the alignment points of the entire alignment of the package, and confirm the consistency of the alignment on site.

In view of the above, confirmatory traverse Survey, Centre Line Survey and Topographic Survey having been included as a part of General works to be carried out by the Contractor.

3) Chainage of IP and transition curves

The Chainage of the IPs and transition curves are referential. The chainage on the plan and profile is for reference only.

4) Geotechnical Information

The geological information from CPMs was integrated and compiled as Boring Location Map and Boring Profile. (Refer to “1.2 Boring Location Map”, and “2. Boring Profile” of Data Book, Volume IV, of the Bid Document)

5) Earthwork

a) The estimated quantities of Fill/Cut to based on the Bidder’s/Contractor’s assessment of FLS in respect of the ground levels.

b) Quantity of Blanket Material: 600 mm thick blanket layer

c) Quantity of Sub-grade Material: 1000 mm thick sub-grade material

1.4.2 Topographic, Geological / Hydrological and Materials Aspects

(1) Topographical Features

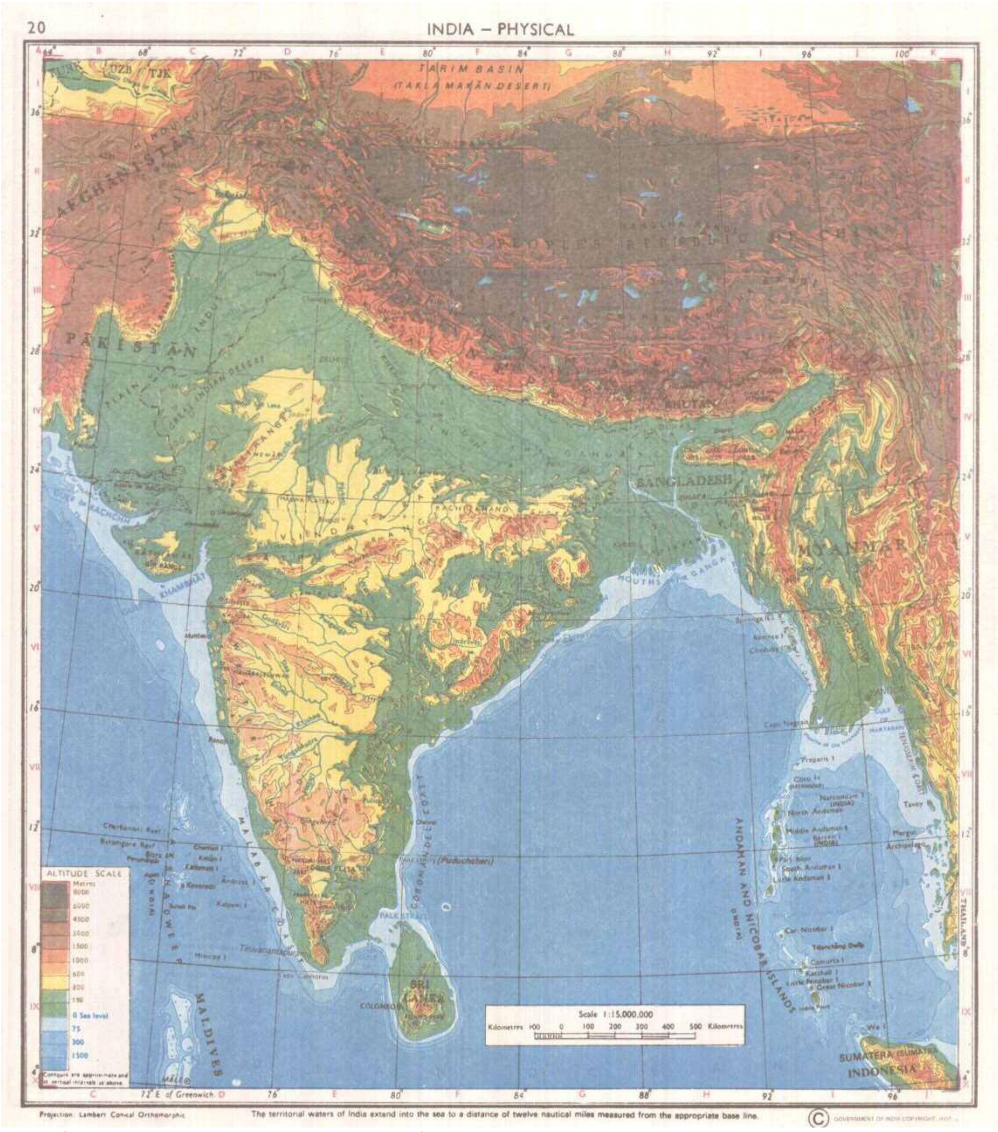
1) General

The mainland comprises four regions, namely, the great mountain zone, plains of the Ganga and the Indus, the desert region and the southern peninsula, as indicated in Figure 1.4-1.

The Himalayas comprise three almost parallel ranges interspersed with large plateaus and valleys, some of which, like the Kashmir and Kullu valleys, are fertile, extensive and of great scenic beauty. Some of the highest peaks in the world are found in these ranges. The high altitudes admit travel only to a few passes, notably the Jelep La and Nathu La on the main Indo-Tibet trade route through the Chumbi Valley, north-east of Darjeeling and Shipki La in the Satluj valley, north-east of Kalpa (Kinnaur). The mountain wall extends over a distance of about 2,400 km with a varying depth of 240 to 320 km. In the east, between India and Myanmar and India and Bangladesh, hill ranges are much lower. Garo, Khasi, Jaintia and Naga Hills, running almost east-west, join the chain to Mizo and Rkhine Hills running north-south.

The plains of the Ganga and the Indus, about 2,400 km long and 240 to 320 km broad, are formed by basins of three distinct river systems - the

Indus, the Ganga and the Brahmaputra. They are one of the world's greatest stretches of flat alluvium and also one of the most densely populated areas on the earth. Between the Yamuna at Delhi and the Bay of Bengal, nearly 1,600 km away, there is a drop of only 200 metres in elevation.



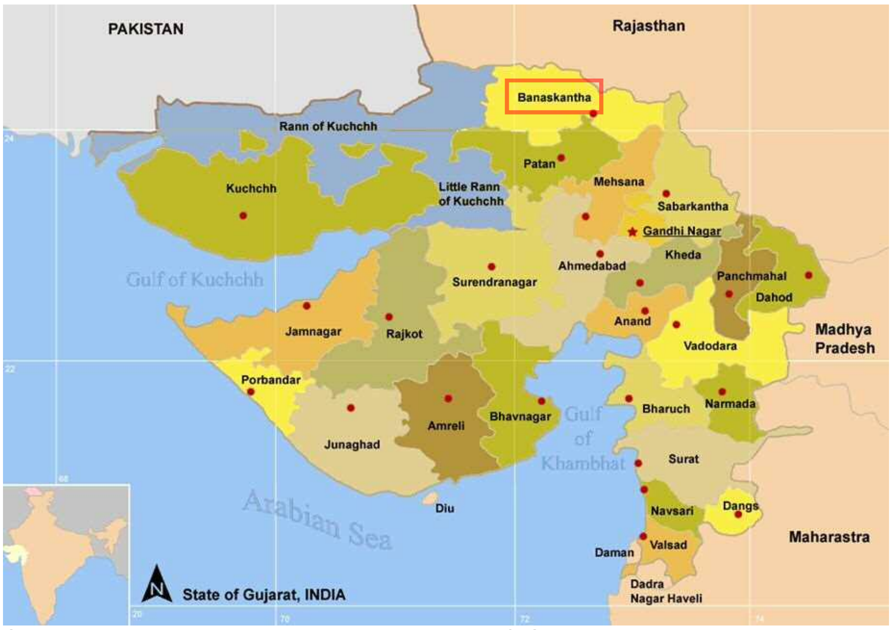
Source: The International Portal of India,
http://india.gov.in/knowindia/geological_structure.php

Figure 1.4-1 Topographical Map of India

The desert region can be divided into two parts - the great desert and the little desert. The great desert extends from the edge of the Rann of Kuchch beyond the Luni River northward. The whole of the Rajasthan-Sind frontier runs through this. The little desert extends from the Luni between Jaisalmer and Jodhpur up to the northern wastes. Between the great and the little deserts lies a zone of absolutely sterile country, consisting of rocky land cut up by limestone ridges.

The Peninsular Plateau is marked off from the plains of the Ganga and the Indus by a mass of mountain and hill ranges varying from 460 to 1,220 metres in height. Prominent among these are the Aravalli, Vindhya, Satpura, Maikala and Ajanta. The Peninsula is flanked on the one side by the Eastern Ghats where average elevation is about 610 metres and on the other by the Western Ghats where it is generally from 915 to 1,220 metres, rising in places to over 2,440 metres. Between the Western Ghats and the Arabian Sea lies a narrow coastal strip, while between Eastern Ghats and the Bay of Bengal there is a broader coastal area. The southern point of plateau is formed by the Nilgiri Hills where the Eastern and the Western Ghats meet. The Cardamom Hills lying beyond may be regarded as a continuation of the Western Ghats.

2) Gujarat State



Source: http://en.wikipedia.org/wiki/File:Map_of_Gujarat_districts.png

Figure 1.4-2 Political Boundary of Gujarat State

a) Banaskantha District

The Banaskantha District lies between 23˚35’ to 24˚43’ north latitudes and 71˚0’ to 73˚0’ east longitudes on the banks of the Banas River, in the north-western part of Gujarat. The terrain of this district can be divided into two broad physiographic sub-divisions viz., eastern hilly region and western plain region. The eastern part of the district is rugged and hilly. The region is highly elevated in the district and the altitude ranges between 100 m and 300 m above M.S.L. The region is well forested. The western region of the district is a vast level plain with an elevation of below 100 m from mean sea level. This tract is devoid of any significant vegetation and the area touching on the Rann of Kachchh is an extensive salt marsh. The general slope of the district is from north-east to south-west in which direction all the rivers flow. Banas is the principal river of the district. Other minor rivers are Umardasi, Saraswati, and Sukal. These are non-perennial. Most of the rivers of the district originate in the Aravalli Hills and are monsoon dependent.

The landscape is characterized by a subdued topography comprising a variety of depositional landforms. The transitional area between the plain and the highland is marked by a pediment zone of undulating topography, characterized by low altitude mounds and hillocks of stabalised Aeolian sands dunes. There are also small alluvial fans and cones of fluvial material brought by the rivers coming from the neighbouring highland. The central part of the plain shows mix topography of fluvial plains marked by subdued fossil dunes. The western part is almost a level ground of saline waste land with a thin veneer of sand and silt.

(Source: Ministry of Railways, DFCCIL of India Ltd., Environmental and Social Impact Mitigation Measures Study (ESIMMS) The Project For Gujarat State Final Report, October 2007)

3) Rajasthan State

a) Sirohi District

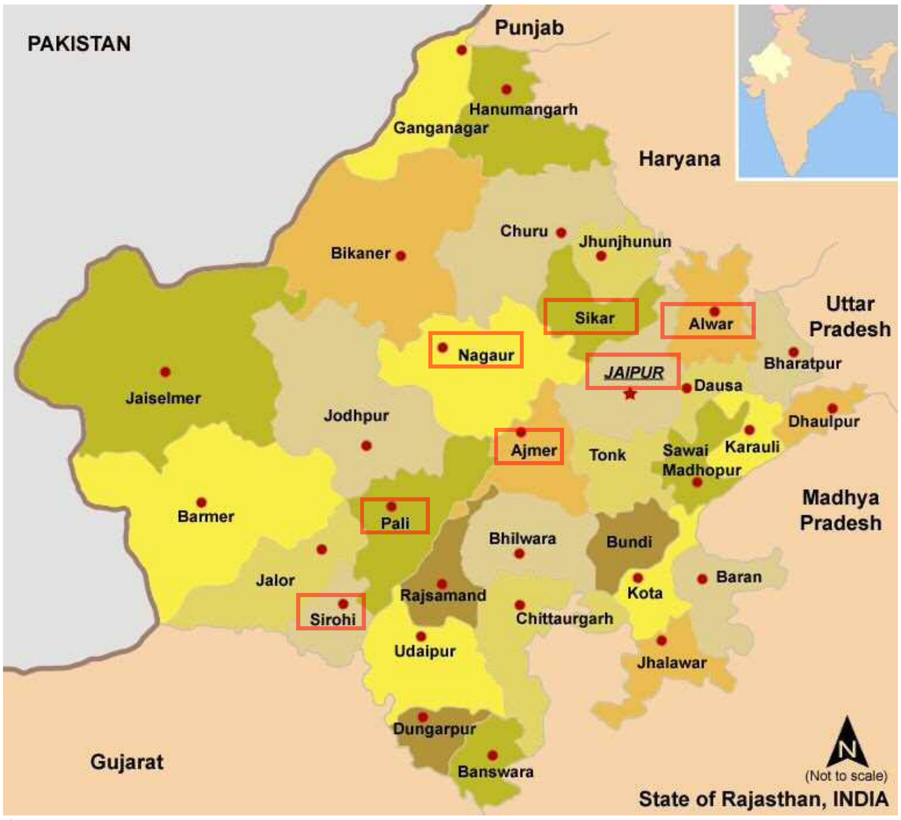
Sirohi District is in the shape of an irregular triangle, with the apex near the village of Harji in the extreme e north and the base extending west by north-west from a point where the territories of the former states of Sirohi, Idar and Danta met. It is much broken up hills and rocky ranges. The main feature is the almost isolated mountain of Abu, the highest peak of which, Guru Sikhar, rises 1,722 m above the mean sea level. The mountain is situated near the southern border. It is separated by a narrow pass from an adjacent range of narrow hills which runs in north-eastern direction almost up to Sheoganj and divides the district into two not very unequal parts. Most of the area of tehsils Reodar, Sirohi and Sheoganj lies in the western part of these hills.

b) Pali District

Pali District is situated at 180-500 m. above sea level

c) Ajmer and Nagaur District

The eastern portion of the Ajmer District is generally flat, broken only by gentle undulations, but the western parts, from north-west to south-west, are intersected by the great Aravalli Range. Many of the valleys in this region are sandy deserts, part of India's Thar Desert, with an occasional oasis of cultivation, but there are also some very fertile tracts; among these is the plain on which lies the town of Ajmer. This valley, however, is not only fortunate in possessing a noble artificial lake, but is protected by the massive walls of the Nagpathar range or Serpent rock, which forms a barrier against the sand. The only hills in the district are the Aravalli Range and its offshoots



Source: http://en.wikipedia.org/wiki/File:Map_rajasthan_dist_all_shaded.png

Figure 1.4-3 Political Boundary of Rajasthan

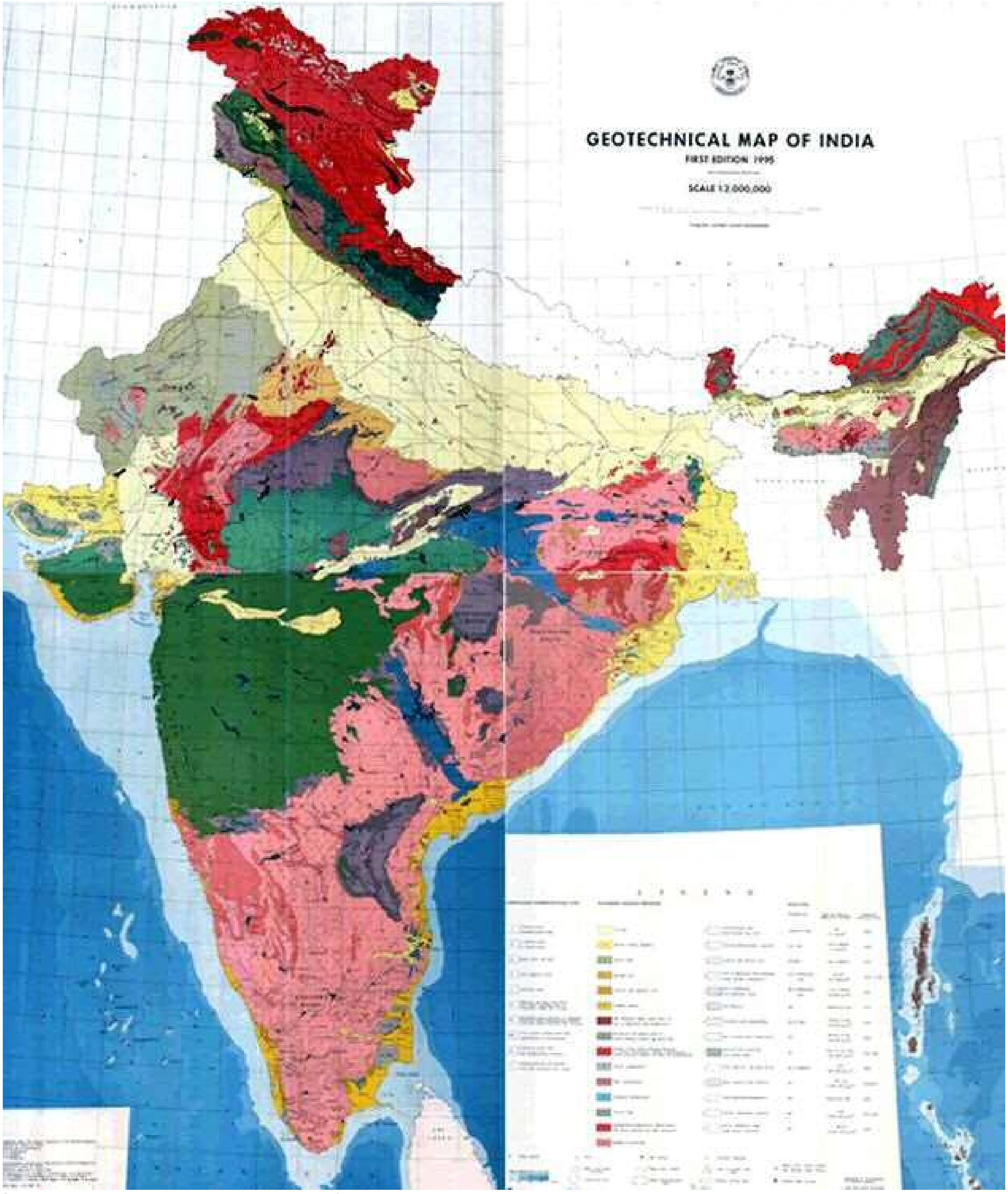
(2) Geological Conditions

1) General

The geological regions broadly follow the physical features, and may be grouped into three regions: the Himalayas and their associated group of mountains, the Indo-Ganga Plain, and the Peninsular Shield.

The Himalayan mountain belt to the north and the Naga-Lushai Mountain in the east, are the regions of mountain-building movement. Most of this area, now presenting some of the most magnificent mountain scenery in the world, was under marine conditions about 600 million years ago. In a series of mountain-building movements commencing about 70 million years ago, the sediments and the basement rocks rose to great heights. The weathering and erosive agencies worked on these to produce the relief seen today. The Indo-Ganga plains are a great alluvial tract that separates the Himalayas in the north from the Peninsula in the south.

The Peninsula is a region of relative stability and occasional seismic disturbances. Highly metamorphosed rocks of the earliest periods, dating back as far as 380 crore years, occur in the area; the rest being covered by the coastal-bearing Gondwana formations, lava flows belonging to the Deccan Trap formation and younger sediments.



Source: The International Portal of India,
http://india.gov.in/knowindia/geological_structure.php

Figure 1.4-4 Geological Map of India

2) Gujarat State

a) Banaskantha District

The oldest litho units belonging to the Delhi Supergroup of rocks occupy the eastern part of the district. These rocks are represented by the metasediments of the Todgarh/Basantgarh Formations of the Kumbhalgarh Group and Jiyapura and Reodar Formations of the Sirohi Group. The metasediments of the Kumbhalgarh Group are predominantly calcareous and are intruded by the basic intrusives of Phulad Ophiolite Suite and Sendra-Ambaji Granite and gnesises. The younger Sirohi Group is dominantly argillaceous with some calcareous bands. The Delhi Supergroup of rocks are subjected to still younger igneous activity represented in the form of Jalor Granite and rhyolite porphyry, belonging to the Malani Igneous Suite. The Mesozoic sediments are represented by the Katrol and Bhuj Formations and comprise arenaceous and argillaceous sediments in the north-western part of the district.

3) Rajastan State

a) Sirohi District

Sirohi District is broken up by hills and rocky ranges. The granite massif of Mount Abu divides the district into two portions, running from north-east to south-west. The south and south-east part of the district, which lies between Mount Abu and the main spine of the Aravallis, is mountainous and rugged, and is drained by the West Banas River. Abu Road, a station on the main Delhi-Ahmedabad rail line, lies in the valley of the West Banas.

b) Pali District

The rocks exposed in the district are pre-Delhi granites, granite, gneisses, schist and Alwar, Ajabgarh and Rialto formation of Delhi group. The major part of the district is covered by quarter- hairy sediments. The pre-Delhi group of rocks comprising Mica-schists and gneisses occupy a major part of the district.

c) Ajmer District

Ajmer is almost totally devoid of rivers, the Banas being the only stream, which can be dignified with that name, and it only touches the south-eastern boundary of the district so as to irrigate the pargana of Samur. Four small streams--the Sagarmati, Saraswati, Khari and Dai--also intersect the district. In the dry weather they are little more than brooks.
The district is divided into four subdivisions, Ajmer, Beawar, Kekri and Kishangarh, and further subdivided into six tehsils, Ajmer, Beawar, Nasirabad, Kekri, Kishangarh and Sarwar.

d) Nagaur District

The Nagaur-Ganganagar basin1 in western Rajasthan, India is an elongated, asymmetrical sedimentary basin trending NNE-SSW. Jodhpur Gp., Bilara Gp., Hanseran Evaporite Gp. and Nagaur Gp. constitute the late Proterozoic-early Cambrian sedimentary package (Marwar Super Gp.) which rests on the Rhyolytic Basement (Malani Rhyolite) dated 680Ma. The Jodhpur and Nagaur Groups are essentially clastic units whereas the intermediate Bilara Gp. is comprised of limestone and dolomite. The Hanseran Evaporite Gp. is a coeval facies equivalent of the Bilara carbonates. Presence of algal facies, stromatolites, ripple lamintes, mud-crack and mudchip conglomerates indicate shallow marine peritidal depositional environment for the Bilara carbonates. Owing to lack of characteristic faunal evidence and radiogenic dates from Bilara rocks, its correlation with globally recorded late Neoproterozoic carbonates and evaporates has been enigmatic. Combination of lithostratigraphy and chemostratigraphy can be used as a potent tool for stratigraphic correlation particularly when sections are sparsely fossiliferous. In an effort to constrain the age and to shed light on the paleoenvironment of the unmetamorphosed Bilara carbonates a detailed analysis of its carbon and oxygen isotope geochemistry was performed.

(3) Hydrological Studies and Hydraulic Design of Cross Drainage (CD) Structures

1) Hydrological Studies

The hydrological studies for the estimation of design discharge that would pass through a cross drainage structure like bridge or culvert involves following activities:

a) Drainage area delineation

The first step in designing a cross drainage structure across a river is the estimation of flood discharge of specified return period that would pass safely through the structure. In order to estimate the design runoff, the catchment area is delineated on topographic sheets up to the proposed location. Before demarcation, there is need to check the scale of the map by verifying with the known distance on the ground and the map and accordingly the maps are adjusted to true scale for catchment delineation.

b) Rainfall analysis

Regional Depth Duration Frequency (DDF) Studies

The Indian Meteorological Department (IMD) has conducted detailed rainfall studies for Luni River Basin, Central Water Commission (CWC) designated sub zone 1(a). The studies covers Depth Duration Frequency analysis of rainfall data from 142 ordinary rain gauges (ORG) stations of IMD/states and 40 self recording rain gauges (SRRG) station of IMD/railways. The design storm components have been derived in the form of 24 hours -25, 50, 100 years return period in the form of Isopluvial maps which are presented in Plates 8, 9 and 10 respectively of the report. The procedure adopted for developing these isopluvial maps are discussed in the report.

Similarly, IMD have conducted this DDF (Also known as Intensity Duration Frequency, IDF) on the basis of 12 SRRG and 130 ORG stations maintained by IMD/State and 35 SRRG stations maintained by railway in 11 bridge catchments in Sub zone -3(a) for Mahi and Sabarmati river basin. Similarly, for this zone also studies have been presented in the form of Isopluvial maps of 24 hours 25, 50 and 100 years return period in Plates 9, 10 and 11 respectively. For estimation of design discharge for the bridges having catchment less than 5000 km2 engineers in India generally use these Iso pluvial maps and select Rainfall intensity on the basis of bridge location. Since these rainfall intensities are point rainfall, therefore, a correction factor (Areal reduction factor) is applied to distribute the point rainfall uniformly across the entire catchment to maximize the estimated discharge. The area reduction factors for Luni Basin –Sub Zone 1(a) is given in Annexure-4.2 Page 41 of "Central Water Commission-Flood Estimation Report for Luni (Sub Zone-1a)". Similarly, the area reduction factors for Mahi and Sabarmati (sub zone 3 (a) have been given in Fig 11 (a) and 11(b) of the above report. For DFCC project the design rainfalls have been used from these Iso pluvial maps. The design rainfall of 24 hours duration and 50 years return period used along the project stretch is presented below.

c) Estimation of design discharge at the proposed bridge site

There are mainly three approach to estimate the design peak discharge of given return period, i.e., by (i) Statistical Analysis if we have sufficient number, at least 10-15 years annual peak observed discharge data nearby location are required for estimating design discharge corresponding to 50 years design return, (ii) catchment based Empirical formula, and (iii) both Catchment and Rainfall based Rational and Synthetic Unit Hydrograph methods. However, for very large catchment and important rivers like Mahi or Sabarmati, we should collect observed discharge data of last 15-20 years.

For this project, in absence of time series data, only Empirical, Rational and Synthetic Unit Hydrograph methods have been applied. After catchment delineation (area) and knowing rainfall intensity of given return period across the entire catchment the next step comes is the estimation of design discharge of a that return period. There are various methods which are applied to estimate maximum (peak) discharge or to develop hydrograph. Some of these methods have been used for this project and discussed briefly below.

Synthetic Unit Hydrograph

Central Water Commission (CWC), Ministry of Water Resources, Govt Of India in association with IMD and RDSO has published Flood estimation report for various river basins called **Sub Zone Reports** for the entire river basins/sub basins of India. In these reports, formula, unit hydrograph parameters, and methods for developing a Synthetic Unit Hydrograph has been given. The DFCC project passes falls in two Sub Zones , i.e., (i) from Rewari t upo Abu Road- Luni Basin Sub Zone Report (Sub zone – 1(a) and (ii) from Abu Road to Vadodara - Mahi and Sabarmati Basin Sub Zone Report (Sub zone – 3(a).

2) Hydraulic Design

After estimation of design discharge expected to pass through a bridge safely in a given return period the next step is to know the minimum waterway, i.e. minimum length of the proposed bridge required, the design HFL, i.e., the height of the bridge and the maximum scour level which, i.e., the minimum depth of foundation. These three important hydraulic parameters are determined from channel routing or hydrodynamic modeling.

Channel routing is done by applying from simple **Manning's formula** to various software (HEC RAS or MIKE 11 etc.) and following inputs are required like, (i) channel cross sections along the channel, (ii) design discharge, (iii) boundary conditions information (sub critical super critical) (iv) simulation types (steady or unsteady).

When applying simple Manning's method, the required minimum waterway is finalized on the basis of computed afflux which should be within permissible limit such as like from to 0.15-0.50 m only. The final design HFL is normal HFL (applying Manning Formula in absence of the proposed bridge) + afflux.

(4) Design Discharge for Drainage Facilities

The Contractor is required to firm up the location, type, and size of drains along the permanent way, specially for the case of parallel section, i.e., between two embankment (existing IR and new DFC), outer drains (between embankment and country side), as well as inner drains, (between two embankment).

1.4.3 Track Work Design

(1) General:

The track works shall be laid on to the prepared embankment and designed to ensure functional requirements described in the Employer's Requirements and Particular Specifications. The track design and construction has to be such so as to ensure minimum maintenance. The design and construction of track works should include but not limited to the following major activities:

- Site Survey;
- General Requirements;
- Temporary Works;
- Mechanized track laying involving laying of ballast bed, handling and spreading of rails, rail cutting & drilling, handling and laying of concrete sleepers, threading of rails to sleepers, top ballasting, tamping and lining;
- Rail welding – Flash Butt in general /Thermit welding of rail joints at isolated locations and in exceptional cases with the approval of the Engineer / Employer;
- Ultrasonic testing of rails;
- De-stressing of Long/Continuously welded rails;
- Insertion of Glued Joints and Rail Expansion Joints;
- Drainage;
- Fencing;
- Provision of Permanent Markers;
- The Final track to be constructed to predefined tolerances;
- Testing and Commissioning; and
- Maintenance of track during the defect liability period

1) Track structure

The DFCCIL currently plans to construct the track structure to cater to 25 tonne axle load using 60 kg/m HH rails procured from Japan, mono-block concrete sleepers laid at nominal 600mm spacing (1660/km) and placed on 350mm ballast cushion. This is based on best international practice for Heavy Haul railways involving movement of 25 tonne axle load rolling stock. With the current traffic projections, rail renewal will have to be carried out after 800 GMT i.e. in about 10 to 15 years (depending upon the traffic carried by various sections of WDFC. In order to allow use of heavier 68 Kg/m rail in future during the life span of the concrete sleeper, the width of the rail seat shall be such so as to accommodate 60 Kg/m rail and 68 kg/m rails by provision of suitable liners. RDSO's standard drawing for 25 tonne axle load concrete sleeper is for the track gauge of 1673 mm (RDSO drawing no. T-7008 for 136 RE Rails).

2) Planning for the construction method and procedure for track work

Construction will be mechanized. Bottom ballast will be placed initially and accurately leveled. Concrete sleepers will be lifted by suitable machines and set to the required spacing on the ballast to the correct alignment.

i) 60 Kg (1080 grade) Head Hardened Japanese Rails rolled in suitable lengths (12.5m/25m), undrilled at ends will be brought to site. Adequate precautions shall be taken during transport of rails to avoid any damage to rails [geometry and alignment and avoid excessive stress during handling]. The rails shall be subjected to prescribed checks before commencing the welding process. Before use at site, the rails shall be flash butt welded in lengths of 250 m under controlled conditions in depot by the Contractor by following all the precautions and mandatory checks as per Indian Railways Manual for Flash Butt Welding of Rails. The Employer may authorize the Engineer or deploy at its own cost, a specialist agency for checking and certification of the process and quality of welding at the Contractor's site depot.

The 250 m long rails after laying in track will also be welded by deploying Mobile Flash Butt Welding plant except in exceptional circumstances restricted to special locations apart from turnouts where Thermit welding may be deployed with the approval of the Employer/Engineer.

De-stressing will be carried out within the appropriate neutral temperature range for each section using suitable rail tensors.

3) Material survey and procurement plan for ballast and sleepers

Ballast shall conform to IR specifications issued by RDSO [IRS GE:1] with latest correction slip. It can be procured through local quarries located in the close proximity of the proposed DFCC alignment" and approved by the Engineer. Ballast may be procured through such local approved quarries located in close proximity to the new line as far as possible, or, at least close to the existing IR network, to enable its transport by road along the proposed alignment during construction and by ballast trains during operation and maintenance.

Sleepers will have to be procured through RDSO approved manufacturers.

4) Station loops, yards and depot tracks

The rails in station loop tracks, yards and depot tracks (for Other than Main Line and Points and Crossings) shall be UIC60/90UTS Rail Steel of Grade 880 will be continuously welded and laid on mono-block pre-stressed concrete sleepers at nominal 650mm spacing (1540 pcs/km.)

In Depot buildings, various non-ballasted track forms (e.g. embedded rails) will be required inside to permit rolling stock inspections and access to wheel lathes, etc.

Check rails shall be installed on curved tracks with a radius < 220m.

Turnouts from Main Line will be 1 in 12.

1 in 8 ½ turnouts shall be provided for those lines taking off from loops for sidings and from yard lines. The turnouts will have curved thick web switch rails, cast manganese crossings and laid on fan-shaped PSC bearers.

5) Performance Requirements

The main line and loop line tracks shall carry 50 to 100 GMT per annum/direction. The track structure shall be suitably tamped deploying appropriate tamping units so as to ensure the track structure requires minimal intervention between the two tamping cycles for operating 25 tonne axle load trains operating at a maximum speed of 100km/hr. The tamping cycle will be 2 years or 100 GMT of traffic; whichever is earlier.

6) Track Laying Standards

The following standards of track geometry should be achieved in floating condition measured three months after the restoring the speed to normal i.e. 100 km/hr.

Table 1.4-1 Track Laying Standards

Sl. No.	Description	Value
1	Maximum difference of any point in relation to the designed layout	a) Vertical : +/-10 mm b) Horizontal : +/-10mm
2	Gauge (with reference to 1676 mm)	a) Maximum variation over the prescribed track gauge : +3mm to 0mm b) Maximum variation in track gauge from sleeper to sleeper : 2mm c) Average track gauge (mean over 100 m length): +1.8mm to 0mm
3	Misalignment :	+/-5mm
4	Vertical Un-evenness (left & right hand rails)	+2mm to (-)1 mm
5	Maximum deviation of measured versine over its designed value on a 20 m chord (half overlapping)	+/-5mm
6	Cant/Cross Level (to be measured at every 4th sleeper)	a) Straight track and curved track: +/- 3mm b) Sleeper to sleeper variation of cant/x-level : +/- 1mm

Sl. No.	Description	Value
7	Twist (maximum value on base of 3 m)	a) Straight and circular portion of curve = +/- 1mm/m b) On transition portion of curve (over designed value) = +0.5mm/m
8	Turnouts	a) Stock rail joint (longitudinal location) : +/-15 mm b) Nose to nose of Xing in crossovers : +/- 10mm c) Flangeway clearance at the end of the switch planning : +5mm to (-) 0mm d) Switch toe opening : +1mm to (-) 0mm e) Switch toe squareness : 5 mm f) Deviation of measured versine over its designed value for switches, lead track and curved crossing (measured on 6 meter half overlapping chord) : +/-3mm
9	Sleeper laying	a) Spacing ; +/-10mm b) Sleeper perpendicularity to rail centre line (out of square) : 5 mm
10	Fishplated rail joint squareness across the track:	10 mm
11	Rail Expansion Joint	a) Gauge : +/- 1mm b) Gap at opening : +/-2mm c) Out of squareness of switch rails : +/-2mm

7) Flash Butt Welding Tolerances

Each completed joint shall be checked for straightness, alignment and finishing by using a one meter and 10 centimeter long straight edge. The permissible tolerances should conform to “Manual For Flash-butt Welding of Rails (2004) – Ministry of Railways”.

8) Testing of Flash Butt Welded (FBW) Joints

All flash butt welded joints in the plant shall be subjected to Visual inspection, Dimensional checks & Ultrasonic Testing for bond integrity. Further, sample weld joints shall be subjected to Transverse Bending Test & Detailed Metallurgical Tests in a laboratory as a Quality Assurance Measure for hardness criteria and magnetic particle inspection etc. The Test Regime of Flash Butt Welds, as given in Para 10 of Manual of FBW of rails shall be followed.

Rectification measures to improve the quality of flash butt welds to obtain the desired metallurgical properties, strength & heat-affected zone etc. at welded ends of rails shall be taken to the satisfaction of the Inspecting Agency nominated by the Employer. Complete record of all such tests shall be maintained.

9) Thermit Welding Tolerances:

The finished dimensional tolerances shall be as under and to be measured after cooling of the welded joint and should conform to 'Manual for Fusion of Welding of Rails by Alumino Thermit Welding Process 2006, Ministry of Railways", as indicated in Section 1.8.

All precautionary measures as defined in IR Standard Specifications for Fusion Welding of Rails by Alumino-Thermic Process should be followed for carrying out the Thermt Welding.

Rail joints, welded by the Contractor shall be guaranteed against failure for a period of one year from the date of commissioning of the project. The failed joints shall be replaced in accordance with clause 6.4 of the aforementioned manual.

10) Ultrasonic Testing of Rails / Welds:

Ultrasonic Testing of Rails/ Welds shall be carried out as per Manual for Ultrasonic Testing of Rails and Welds 2006, as mentioned in Section 1.8.

11) De-stressing of Continuous Welded Rail (CWR)

Neutralization of the stresses (De-stressing) in the Rails during construction shall be carried out when:

(a) The CWR track is laid at a temperature outside the range of the temperature interval for CWR track laying;

(b) It is found out that under the influence of construction activities the neutral temperature has changed and does not coincide anymore with the laying in neutral temperature;

(c) There is a necessity of construction works connected with the weakening of the ballast bed or considerable movement of the track's vertical or horizontal position and in all cases of danger of the CWR track's disruption;

(d) In any other case as required by the provisions of the LWR Manual.

1.4.4 Station Facilities Design

(1) Interpretation of the information on the original design

Curve parameters is defined and in accordance with section 1.3.2.

(2) Important Assumptions for the Preparation of the Work Quantity

1) Operational and Maintenance Facilities of the Stations

The facilities required for operation and maintenance of the project have been worked based on IR and other international standards.

Error! Reference source not found. below indicates the operational and maintenance facilities planned at the Junction and Crossing Stations along with the tentative area requirements proposed by the Consultant.

Table 1.4-2 Operation and Maintenance Facilities of the Stations

Package	CPM	Junction & Crossing Station (Mark)	Junction & Crossing Station (Name)	Chainage DFC (Km)	Buildings Location and Areas: Control Room (CTC) & Office of Regional Manager (Sqm)	Buildings Location and Areas: Crew Changing Building, (Sqm)	IMD covered area (SqM): Civil (Sqm)	IMD covered area (SqM): S & T (Sqm)	IMD covered area (SqM): OHE & PSI (Sqm)	IMD Sub Depot: Civil (Sqm)	IMD Sub Depot: S & T (Sqm)	IMD Sub Depot: OHE & PSI (Sqm)	OHE Depot WT (Sqm)	Track Machine Depot (Sqm)	Station Bldg, Offices, Resting Facilities including Verandah (Sqm)	Service Building: S & T Dept (SqM)	Service Building: Electrical Dept. (Sqm)	Service Building: Engg. Department (Sqm)	T W S (Sqm)	M M U (Sqm)	Sub-Depots for brake down/ emergency & day to day maintenance (Sqm)	Total Area (Sqm)	Misc. Work PF, path way etc. [As actual or @ 5% of area required (SqM)]	Total covered Area Required at each Station (SqM)	Open Area to be developed at each station (SqM)	SIDING: Ballast Depots/ siding 750 M long	SIDING: Hot Axle [UP] 120 m length	SIDING: Hot Axle [Dn] 120 m length	SIDING: Track M/C 120 m length	SIDING: IMD	SIDING: Track M/C Depot	SIDING: Tower Wagon Siding (35m effective length)	SIDING: Wiring Train Siding (250m)	SIDING: Accident Relief Train Siding (750m long)	SIDING: Total Length of Siding at each station	Covered Parking for Sedan Type Vehicles	Residential Buildings (Nos. of units): Type-II	Residential Buildings (Nos. of units): Type-III	Residential Buildings (Nos. of units): Type-IV	Residential Buildings (Nos. of units): Type-V	Residential Quarters for Key Men on DFCCIL & IR Stations and at other Locations (Type II) (Nos.)
3	Vadodara Sec-5	**JS1**	**Makapura**	133.001	-	120	460	410	834	-	-	-	50	200	663	120	130	150	165	100	-	3,402	85	3,487	4,176	-	Yes	Yes	D/U	Yes	Yes	Yes (U or D)	Yes	-	765	10 Veh.	4	4	2	2	8
		CS1	Vasad	168.226	-	-	-	-		125	125	64	-	-	460	120	130	150	-	-	100	1,274	48	1,322	1,617	-	-	Yes	U (Future) /D	-	-	-	-	-	240	10 Veh.	4	4	2	-	4
	Ahmedabad Sec-5	CS2	Changa	196.649	-	-	-	-		125	125	64	-	-	460	120	130	150	Future Provision	100	100	1,374	48	1,422	1,617	-	Yes	-	D (Future) /U	-	-	Yes (U or D)	-	-	275	10 Veh.	4	4	2	-	5
		CS3	Timba	57.519	-	-	-	-		125	125	64	-	-	460	120	130	150	-	-	100	1,274	48	1,322	1,617	Yes (U or D)	-	Yes	U (Future) /D	-	-	-	-	-	990	10 Veh.	4	8	2	-	4
		JS2	**Sabarmati South**	80.660	2500	-	460	410	834	-	-	-	-	-	663	120	130	150	-	100	-	5,367	183	5,550	6,239	-	-	Yes	One for D & U	Yes	-	Yes (U or D)	-	Yes	1025	10 Veh.	20	6	4	2	9
	Ahmedabad Sec-7	**JS3**	**Sabarmati North**	98.636	-	-	-	-	-	-	-	-	-	-	**663**	120	130	150	-	-	-	1,063	53	1,116	1,116	-	Yes	-	D/U	-	-	-	-	-	360	10 Veh.	20	6	4	-	6
	Ahmedabad Sec-8N	CS4	Ghumasan	17.506	-		-			125	125	64	-	-	460	120	130	150	-	-	100	1,274	48	1,322	1,617	-	-	-	U (Future) /D	-	-	-	-	-	120	10 Veh.	4	8	2	-	4
		JS4	Mahesana	58.121	-	-	-			125	125	64	-	-	663	120	130	150	-	100	-	1,477	58	1,535	1,830	-	Yes	Yes	D/U	-	-	-	-	-	480	10 Veh.	20	6	4	-	8
		CS5	Malosan	100.732	-	-	-			125	125	64	-	-	460	120	130	150	-	100	100	1,374	53	1,427	1,722	-	-	-	U (Future) /D	-	-	-	-	-	120	10 Veh.	4	8	2	-	4
	Ajmer Sec-9 (North Side)	**JS5**	**Palanpur**	12.151	-	-	460	410	834	-	-	-	-	-	663	120	130	150	-	100	-	2,867	58	2,925	3,614	-	Yes	Yes	D/U	Yes	-	Yes (U or D)	-	-	515	10 Veh.	20	6	4	-	8
		Station	**Chadotar**	1.278	-	-	-	-	-	-	-	-	-	-	460	-	-	150	-	-	-	610	31	641	641	-	-	-	-	-	-	-	-	-	-	2 Veh.	4	4	2		1
	Residential Quarters (Type II) for KEY MEN at IR Stations and at Other Locations as detailed below																																								23
	Total Nos. of Residential Quarters (Type II) for KEY MEN at DFCCIL Stations, IR Stations and at Other Locations																																								**84**

ABBREVIATIONS for SIDING - D: DOWN U : UP

Note : The number of various types of Residential Buildings as identified above at individual Stations are tentative and may change during the design stage keeping the total number of respective type of residential buildings unchanged

Abbreviations:

OHE	Over Head Equipment
PSI	Power Supply Installation
TWS	Tower Wagon Shed
IMD	Integrated Maintenance Depot
CTC	Centralized Train Control
ESM	Elect. Signal Maintenance
PWI	PW Inspector (Senior Section Engg.)
TI	Traffic Inspector
MMU	Machine Maintenance Unit

	Location of Key Men Quarters at IR Stations and Other Locations	**Nos.**
1	Jhulasan Railway Station of IR	1
2	Dangaw Railway Station of IR	1
3	Ambliyasan Railway Station of IR	2
4	Jagudan Railway Station of IR	3
5	Mehsana Railway Station of IR	2
6	Unjha Railway Station of IR	2
7	Kamli Railway Station of IR	3
8	Sidhpur Railway Station of IR	1
9	Dharewada Railway Station of IR	1
10	Chapi Railway Station of IR	1
11	Umardashi Railway Station of IR	1
12	Palanpur Railway Station of IR	2
13	Chitrasani Railway Station of IR	2
14	Jethi Railway Station of IR	1
	Total	23

1.4.5 Railway Bridge Design

(1) Classifications of Bridges

There are six types of bridges planned in this Project. The bridges are defined based on their span/location as per the provisions of Indian Railways Bridge Manual, as follows:

S.N	Type	Definition
1	Important bridge	Having a linear waterway of 300 meters or a total waterway area of 1,000 m2 or more. Classifications may also depend on considerations of depth of waterway, extent of river training works and maintenance.
2	Railway Flyover (RFO)	Railway bridge over other railways.
3	Major bridge	Having either a total linear waterway of 18.3 meters (60ft) or more or they have a clear opening of 12.2 meters (40 ft) or more in any one span.
4	Minor bridge	Bridges that do not fall into the above categories.
5	Road over bridge (ROB)	Road bridges going over railways.
6	Road under bridge (RUB)	Box culverts, set under railways, used by motorized/non-motorized vehicles and pedestrians.

Source: Indian Railway Bridge Manual

(2) Vertical and Horizontal Clearances:

Vertical and Horizontal Clearances are as per geometric design parameters defined in sections 1.3.2, 1.3.3 and 1.3.7 of this document and attached Technical Working Papers.

The technical specifications for design of bridges structures have been covered seperately in the Technical Specifications.

Survey and Alignment, GL and FL are based on the survey and alignment setting carried out by the Employer. This will require verification by the Contractor to ensure correctness of its designs.

1.4.6 RFO/ROB/RUB Design

(1) Vertical Clearances of Bridges

As per IR Bridge manual, IRC 54-1974, IRC 5 -1998, and MOR Letter No. 2007/Infra/6/8 Pt. II of July 29, 2010.

1) For RFO and ROB

DFC crossing IR track	6,525 mm
DFC crossing DFC track	8,705 mm

2) For RUB

National Highways	5.5 m
State Highways	5.0 m
Village Road	3.6 to 4.5 m

(2) Design of RC Box Culverts

1) Review of Standard Design for RC Box Culverts

In the Standard Design for RC Box Culverts approved by DFCCIL, the following design criteria are used.

- IRS Bridge Rules incorporating CS No. 33
- IRS Concrete Bridge Code incorporating CS No. 7
- IRS Bridge Sub-structure and Foundation Code incorporating CS No. 22

This design is suitable for DFC Loading (32.5 ton axle load) with PSC sleepers. Load condition includes the live load, earth pressure and longitudinal forces due to braking and traction considering the wind load etc. as per relevant codes.

The Consultant has made a confirmation of standard design by carrying out the calculation for 1x1.2mx1.2m Box Culvert in case of 1m fill. It is concluded that the calculation carried out by the Consultant was comparable with the result of the Standard Design.

2) Calculation for Non-Standard-Design RC Box Culverts

Reviewing the GADs prepared by CPM, the Consultant found out that there were many GADs of RC Box Culverts which are not conforming to the Standard Design. In addition to the calculations for RC Box Culvert Standard Design, the Consultant has carried out calculations for various sizes of the majority of non-standard-design RC Box Culverts as given in Table 1.4-3 below. The Contractor should carry out the standardization of sizes and undertake their design as per his design philosophy.

Table 1.4-3 Non-Standard-Design RC Box Culvert Classified by the Consultant

S.NO	SIZE		FILL(m)	S.NO	SIZE		FILL(m)
	W(m)	H(m)			W(m)	H(m)	
1	2.0	1.2	1.0	17	5.0	3.0	1.0
2	2.0	2.0	1.0	18	5.0	5.0	1.0
3	2.0	3.0	1.0	19	6.0	2.0	1.0
4	3.0	2.0	1.0	20	6.0	5.6	1.0
5	3.0	3.0	1.0	21	6.0	5.6	2.0
6	3.2	5.6	0.0	22	6.0	5.6	3.0
7	4.0	2.0	1.0	23	6.0	5.6	4.0
8	3.2	5.6	0.0	24	6.0	5.6	5.0
9	4.0	2.0	1.0	25	6.0	5.6	6.8
10	4.0	3.0	0.0	26	6.1	5.0	1.0
11	4.0	5.6	1.0	27	7.5	5.5	1.0
12	4.0	5.6	2.0	28	9.2	5.0	1.0
13	4.0	5.6	3.0	29	9.3	5.0	1.0
14	4.0	5.6	4.0	30	9.3	5.5	1.0
15	4.0	5.6	5.0	31	10.5	5.5	1.0
16	4.0	5.6	6.0				

Source: Analysis by the Consultant

(3) Important Assumptions for the Preparation of the Work Quantity

The sizes of Box Bridges have been standardized and are indicated on the Employer's Drawings.

1.4.7 Review of Level Crossings

The design of the level crossing shall be carried out in accordance with codes and stipiulations indicated on Chapter 9 Level Crossing and Gateman of Indian Railway Permanent Way Manual.

The following criterion has been adopted for deciding grade separator/provision of RUB or subways in lieu of existing level crossings on the parallel section:

- Level Crossings falling on National and State Highways;
- Rail Level of (a) existing IR Level Crossing, and (b) the rail level of proposed DFC alignment [In case of level difference more than that can be accommodated as per the permissible road gradient];
- TVU more than 50,000 based on the traffic census and data of which has been provided via DFCCIL;
- Where ever the HFL of nearby bridge is higher than the existing rail level;
- Level crossing falling in DFC yard limits have either been relocated or converted to RUB/ROB;
- Existing Level crossings in IR yards where DFCC track is passing close by; and
- Wherever the formation height permits, the existing level crossings have diverted through RUB/Sub-ways.

1.5 SUBSURFACE INVESTIGATION

(1) Number of Subsurface Investigation

1) General

Approximately 529 bore holes were driven at depth up to 30m at major bridge location and up to 12m at minor bridge locations. However, due to the site condition, depth of drilling work ranging from 6m to 35m was carried out at the location shown in Borehole Location Map of the Data Book.

Table 1.5-1 Summary of Subsurface Investigation in Package – 3 of Phase-1

Type of Structure	Total Number of Structure (nos.)	Total Number of Subsurface Investigation (structure nos.)	Total Number of Subsurface Investigation (boring nos.)	Average Boring Depth (m)
Important Bridge	5	9	36	24.9
Major Bridge	105	60	123	27.5
Rail Fly Over	16	4	7	30.0
Minor Bridge	341	129	148	17.6
RUB	313	104	126	17.2
ROB	7	1	1	12.0
FOB	2	0	0	0.0
Track Crossing	32	0	0	0.0
Pedestal Underpass	20	0	0	0.0
Level crossing	0	0	0	0.0
Embankment	0	88	88	17.0
Minor Bridge For Roads	2	0	0	0.0
Total	843	395	529	20.4
Total Length (m)		296,816		
Frequency of Subsurface Investigation (m/nos.)		751		

Source: Analysis by the Consultant

According to "Guidelines and Specifications for Design of Formation for Heavy Axle Load Report No, RDSO/2007/GE: 0014, RDSO, November 2009" the frequency of subsoil exploration as reproduced and explained as below.

4.4.3 c) Detailed subsoil exploration is necessary to check stability of structures against failure and to predict anticipated settlement. Bores are made along alignment normally at 200 m to 300m apart in case of uniform type of soil and closely spaced in critical zones."

In the "Working Paper No.11 Evaluation Method for Determining Necessity of Ground Improvement", the Consultant recommended following frequency of geotechnical investigation.

Although Geotechnical Investigations were carried out at various bridge sites, the geo-technical investigations were not carried out for Formation as per intervals in Table 2 of Working Paper No. 11 reproduced below. The Contractor may carry out additional geotechnical investigations based on the engineering judgment of the Contractor, subject to approval by the Engineer/Employer.

Table 1.5-2 General Standard Frequency of Geotechnical Investigation for Earthwork

DFCC NEW DELHI NK CONSORTIUM NJPi

Plateau Large Plain (Uniform Layer)	Narrow Plain (Normal Layer)	Valley (Irregular Layer)
500m	200m	50m

In addition to above, subject to approval by the Engineer/Employer, the Contractor may apply the Static Cone Penetration Test to identify the locations where ground improvement required at shallower than 1.5m from the ground surface all along the alignment.

At the locations where geotechnical investigation was not carried out, neighboring geotechnical investigation results were utilized where soil condition were relatively uniform, however, It considered necessary that additional geotechnical investigations is required as per the site conditions and importance of structures.

2) CPM Vadodara

In Vadodara, the total number of 78 subsurface investigations out of 233 structures was carried out. In addition to this 34 subsurface investigations for embankment were also carried out.

Table 1.5-3 Summary of Subsurface Investigation in Vadodara

Type of Structure	Total Number of Structure (nos.)	Total Number of Subsurface Investigation (structure nos.)	Total Number of Subsurface Investigation (boring nos.)	Average Boring Depth (m)
Important Bridge	1	5	2	30.0
Major Bridge	46	20	40	28.7
Rail Fly Over	6	3	6	30.0
Minor Bridge	74	14	18	20.0
RUB	103	36	36	12.0
ROB	1	0	0	0.0
FOB	0	0	0	0.0
Track Crossing	0	0	0	0.0
Pedestal Underpass	0	0	0	0.0
Level crossing	0	0	0	0.0
Embankment	0	34	34	15.2
Minor Bridge For Roads	2	0	0	0.0
Total	233	112	136	19.8
Total Length (m)		74,334		
Frequency of Subsurface Investigation (m/nos.)		664		

Source: Analysis by the Consultant

3) CPM Ahmedabad

In Ahmedabad, the total number of 217 subsurface investigations out of 558 structures was carried out. In addition to this 45 subsurface investigations for embankment were also carried out.

Table 1.5-4 Summary of Subsurface Investigation in Ahmedabad

Type of Structure	Total Number of Structure (nos.)	Total Number of Subsurface Investigation (structure nos.)	Total Number of Subsurface Investigation (boring nos.)	Average Boring Depth (m)
Important Bridge	3	3	27	27.0
Major Bridge	56	37	73	28.3
Rail Fly Over	10	1	1	30.0
Minor Bridge	243	107	122	17.6
RUB	200	68	90	19.3
ROB	6	1	1	12.0
FOB	0	0	0	0.0
Track Crossing	23	0	0	0.0
Pedestal Underpass	17	0	0	0.0
Level crossing	0	0	0	0.0
Embankment	0	45	45	19.6
Minor Bridge For Roads	0	0	0	0.0
Total	558	262	359	21.2
Total Length (m)		204,705		
Frequency of Subsurface Investigation (m/nos.)		781		

Source: Analysis by the Consultant

6) CPM Ajmer

In Ajmer, total number of 12 subsurface investigations out of 52 structures was carried out. In addition to this 9 subsurface investigations for embankment were also carried out.

Table 1.5-5 Summary of Subsurface Investigation in Ajmer

Type of Structure	Total Number of Structure (nos.)	Total Number of Subsurface Investigation (structure nos.)	Total Number of Subsurface Investigation (boring nos.)	Average Boring Depth (m)
Important Bridge	1	1	7	15.5
Major Bridge	3	3	10	17.0
Rail Fly Over	0	0	0	0.0
Minor Bridge	24	8	8	12.0
RUB	10	0	0	0.0
ROB	0	0	0	0.0
FOB	2	0	0	0.0
Track Crossing	9	0	0	0.0
Pedestal Underpass	3	0	0	0.0
Level crossing	0	0	0	0.0
Embankment	0	9	9	11.2
Minor Bridge For Roads	0	0	0	
Total	52	21	34	14.0
Total Length (m)		17,777		
Frequency of Subsurface Investigation (m/nos.)		847		

Source: Analysis by the Consultant

(2) Standard Penetration Test (SPT)

The Standard Penetration Test (SPT) was carried out in soil or decomposed rock formation in the boreholes at 1.5m intervals basically, in order to determine the consistency of fine grained soil or densities of coarse grained soil. This test was carried out in accordance to IS: 2131.

1) Sand

As per the SPT results, it turns out that the ground surface can be classified to be loose to medium in relative dense sand, and is uniformly distributed.

DFCC NEW DELHI
NKC CONSORTIUM NJPI

Table 1.5-6 Summary of N-Value of Sand at Top Layer

State of Sand [1)]		Observed N- Value at Top Layer (boring nos.)					
Relative Density	N-Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9	Total
very loose	< 4	0	0	0	0	0	0
loose	4 - 10	24	28	4	15	7	78
medium	10 - 30	57	5	11	13	23	109
dense	30 - 50	0	0	0	0	0	0
very dense	> 50	0	0	0	0	0	0
n.a.	-	0	0	0	0	1	1
Total		81	33	15	28	31	188
1) Terzaghi-Peck, 1948							

Source: Analysis by The Consultant

2) Clay

In sections of various CPMs, clay is distributed uniformly at the ground surface. As a whole, medium, stiff, very stiff and hard clay is found to be uniformly distributed. The states of the clay in the sections of CPMs are as follows:

Table 1.5-7 Summary of N-Value of Clay at Top Layer

State of Clay [1)]		Observed N- Value at Top Layer (boring nos.)					
Consistency	N-Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9	Total
very soft	< 2	0	0	0	0	0	0
soft	2 - 4	0	1	0	0	0	1
medium	4 - 8	5	42	1	10	1	59
stiff	8 - 15	31	64	15	120	1	231
very stiff	15 - 30	17	6	4	19	0	46
hard	> 30	2	0	0	0	0	2
n.a.	-	0	0	1	0	1	2
Total		55	113	21	149	3	341
1) Terzaghi-Peck, 1948							

Source: Analysis by the Consultant

(3) Ground Water Table Measurement

Ground water table in bore hole was recorded at the locations of boring. The summary is reproduced below.

Table 1.5-8 Summary of Ground Water Table Measurement

Ground Water Table (m)	Measured Ground Water Table (boring nos.)					
	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9	Total
0-5	28	104	27	0	0	159
5-10	40	24	8	0	0	72
10-15	13	0	0	0	0	13
15-20	15	0	0	0	0	15
20-25	9	0	0	0	0	9
25-30	13	0	0	0	0	13
30-35	4	0	0	0	0	4
35-40	11	0	0	0	0	11
40-45	3	0	0	0	0	3
45-50	0	0	0	0	0	0
>50	0	0	0	0	0	0
N.A.	0	18	1	177	34	230
Total	136	146	36	177	34	529

Source: Analysis by The Consultant

1.5.2 Laboratory Test

Laboratory tests were performed on selected soil samples to determine their significant engineering characteristics and properties. The testing program was formulated with emphasis on obtaining the compressibility and shear strength characteristics of the undisturbed sample as required for an engineering study of foundation conditions.

The specification was prepared for the laboratory tests aimed to clarify and confirm the engineering properties of the drilling core sample and soil materials samples. The laboratory tests were performed according to generally approved and standardized testing methods as per Indian Standard practices.

Following reviews were carried out based on the test result of the sample extracted in the shallowest position except soil classification.

(1) Test item

Laboratory test is mainly classified into three, physical property test, mechanical property test and chemical property test.

The following laboratory tests were carried out.

Table 1.5-9 Summary of Laboratory Test Item

Test Item		CPM			Reference
		Vadodara	Ahmedabad	Ajmer	
Physical Property	Sieve Analysis	yes	yes	yes	IS:2720
	Liquid and Plastic Limits	yes	yes	yes	IS:2720
	Specific Gravity	yes	yes	yes	IS:2720
	Free Swell Index	yes	yes	yes	IS:2720
	Bulk Density	yes	yes	yes	IS:2720
	Moisture Content	yes	yes	yes	IS:2720
Mechanical Property	Box Shear Test	yes	yes	yes	IS:2720
	Triaxial Shear Test	yes	yes	yes	IS:2720
	Consolidation Test	no	yes	no	IS:2720
	Unconfined Compression Test	no	yes	no	IS:2720
Chemical Property	Chemical Analysis for Water	yes	yes	yes	IS:2720
	Chemical Analysis for Soil	yes	yes	yes	IS:2720

Source: Analysis by the Consultant

(2) Physical Property

1) Soil Classification

By using sieve analysis and liquid and plastic limits test results, soil classification was carried out, as summarized in

Table 1.5-11. Among these results, soil classification was carried out by the Consultant in Vadodara, Ahmedabad and Ajmer

As a whole, majority of soil is classified as SM in top layer and SM in bottom layer. The majority of soil classifications in the section of CPMs are as follows:

Vadodara : Top Layer: SM, Bottom Layer: SM

Ahmedabad : Top Layer: CL & CI, Bottom Layer: CL & CL-ML

Ajmer : Top Layer: SP-SM & SM, Bottom Layer: SM & SR

Soil Classification System of Bureau of Indian Standard is presented in Table 1.5-10

Results of soil classification of soil groups are shown in Table 1.5-11.

Table 1.5-10 Soil Classification System of Bureau of Indian Standard (BIS)

Description			Group Symbol	Laboratory criteria			Notes
				Fines (%)	Grading	Plasticity	
Coarse grained soils: Fine particles (size smaller than 75 micron) less than 50%	Gravels (particles larger than 4.75mm) more than 50% of coarse fraction	Well graded gravels, sandy gravels, with little or no fines	GW	0 - 5	Cu > 4 1 < Cc < 3		A dual symbol, if fines are 5 – 12 %. Dual symbols, if above A-line and 4 < PI < 7
		Poorly graded gravels, sandy gravels, with little or no fines	GP	0 - 5	Not satisfying GW requirements		
		Silty gravels, silty sandy gravels	GM	> 12		Below A- line or PI < 4	
		Clayey gravels, clayey sandy gravels	GC	> 12		Above A- line and PI > 7	
	Sands particles more than 50% of coarse fraction (size above 75 micron)	Well graded sands, sandy soils, with little or no fines	SW	0 - 5	Cu > 6 1 < Cc < 3		
		Poorly graded sands/,sandy soils, with little or no fines	SP	0 - 5	Not satisfying SW requirements		
		Silty sands	SM	> 12		Below A- line or PI < 4	
		Clayey sands	SC	> 12		Above A- line and PI > 7	
Fine grained soils particles (size less than 75 micron) more than 50%	Silts and clays (Liquid Limit <35)	Inorganic silts , silty or clayey fine sands, with slight plasticity	ML	Plasticity Index less than 4			
		Inorganic clays, silty clays, sandy clays of low plasticity	CL	Plasticity Index more than 7			
		Inorganic silt and clay of low plasticity	CL-ML	Plasticity Index between 4 and 7			
	Silts and clays (Liquid limit 35-50)	Inorganic silts , clayey silt with medium plasticity	MI	Below A-line of Plasticity Chart			
		Inorganic clays, silty clays of medium plasticity	CI	Above A- line of Plasticity Chart			
	Silts and clays (Liquid limit > 50)	Inorganic silts of high plasticity	MH	Below A-line of Plasticity Chart			
		Inorganic clays of high plasticity	CH	Above A- line of Plasticity Chart			

Source: Guide Line for Earthwork in Railway Project, GE: G-1, RDSO

Table 1.5-11 Summary of Soil Classification

Soil Group	Soil Classification Results (boring nos.)											
	Sec.5		Sec.6		Sec.7		Sec.8N		Sec.9		Total	
	Top Layer	Bottom Layer	Top Layer	Bottom Layer	Top Layer	Bottom Layer	Top Layer	Bottom Layer	Top Layer	Bottom Layer	Top Layer	Bottom Layer
GW	0	0	0	0	0	0	0	0	0	0	0	0
GP	0	0	0	0	0	0	0	0	0	0	0	0
GP-GM	0	0	0	0	0	0	0	0	0	0	0	0
GW-GM	0	0	0	0	0	0	0	0	0	0	0	0
GM	0	0	0	0	0	0	0	0	0	0	0	0
GM-GC	0	0	0	0	0	0	0	0	0	0	0	0
GC	0	2	0	0	0	0	0	0	1	0	1	2
SW	0	0	0	5	0	1	0	0	0	0	0	6
SW-SM	0	0	4	22	1	11	0	0	0	0	5	33
SP	0	0	0	0	3	0	0	1	5	6	8	7
SP-SM	0	0	10	2	0	0	22	23	14	5	46	30
SM	71	73	19	39	7	3	5	0	11	9	113	124
SM-SC	0	2	0	0	0	0	0	0	0	0	0	2
SC	10	14	0	1	4	6	1	3	0	1	15	25
ML	5	5	4	5	5	3	0	0	1	0	15	13
OL	0	0	0	0	0	0	0	0	0	0	0	0
CL-ML	7	4	1	3	0	0	0	85	0	0	8	92
CL	18	25	35	19	2	1	149	65	1	0	205	110
MI	0	0	22	12	1	1	0	0	0	0	23	13
OI	0	0	0	0	0	0	0	0	0	0	0	0
CI	25	11	45	38	12	9	0	0	0	0	82	58
CI-CH	0	0	0	0	0	0	0	0	0	0	0	0
MH	0	0	0	0	0	0	0	0	0	0	0	0
OH	0	0	0	0	0	0	0	0	0	0	0	0
CH	0	0	6	0	0	0	0	0	0	0	6	0
WR[1)]	0	0	0	0	0	0	0	0	0	2	0	2
SR[2)]	0	0	0	0	0	0	0	0	0	8	0	8
SDR[3)]	0	0	0	0	0	0	0	0	0	0	0	0
HR[4)]	0	0	0	0	0	0	0	0	0	2	0	2
n.a.	0	0	0	0	1	1	0	0	1	1	2	2
Total	136	136	146	146	36	36	177	177	34	34	529	529

Source: The Consultant

Note: 1) WR: Weathered Rock

2) SR: Soft Rock

3) SDR: Soft Disintegrated Rock

4) HR: Hard Rock

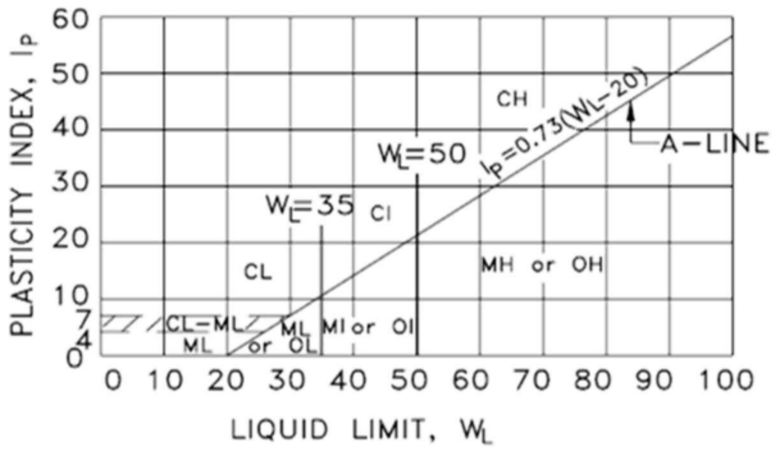
2) Liquid and Plastic Limit

Compressibility becomes large as Liquid Limit (LL) is large. Plasticity is defined as follows.

LL < 35% : Low Plasticity

LL 35 – 50% : Medium Plasticity

LL > 50% : High Plasticity



PLASTICITY CHART

Source: RDSO, Guide Line for Earthwork in Railway Project, GE: G-1

Figure 1.5-1 Plasticity Chart

There is no soil equivalent to High Plasticity, most of soils are classified as Medium Plasticity, and Low Plasticity as a result of an examination.

Table 1.5-12 Summary of Liquid and Plastic Limit

Liquid Limit (LL) (boring nos.)						Plastic Limit (PL) (boring nos.)					
Value (%)	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9	Value (%)	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=20	0	0	0	0	13	<=5	75	0	0	0	31
20 - 25	38	0	0	0	17	5 - 10	0	0	0	0	0
25 - 30	56	20	0	123	1	10 - 15	3	1	0	0	0
30 - 35	20	27	16	30	1	15 - 20	40	59	21	81	1
35 - 40	11	63	8	0	2	> 20	18	72	7	72	2
40 - 45	10	14	3	0	0	n.a.	0	14	8	24	0
> 45	1	10	1	0	0	-	-	-	-	-	-
n.a.	0	12	8	24	0	-	-	-	-	-	-
Total	136	146	36	177	34	Total	136	146	36	177	34
Max. Value	46.0	56.0	46.0	31.8	38.0	Max. Value	25.0	31.0	29.0	21.9	12.0
Min. Value	22.0	27.6	32.0	26.5	18.0	Min. Value	0.0	15.0	16.0	17.0	0.0

Source: Analysis by the Consultant

3) Specific Gravity

Specific Gravity changes due to mineral composition in the soil, so the difference of specific gravity appears local distribution of minerals.

It is considered that the relatively uniform soil is distributed in Ajmer section because specific gravity is distributed in narrow range, and various soils are distributed in Vadodara & Ahmedabad because specific gravity is distributed in wide range.

Table 1.5-13 Summary of Specific Gravity

Specific Gravity (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<= 2.50	1	0	0	0	0
2.5 - 2.55	5	2	0	0	0
2.55 - 2.6	19	3	0	0	0
2.6 - 2.65	74	43	18	0	9
2.65 - 2.7	37	66	15	0	17
> 2.7	0	5	0	0	0
-	0	27	3	177	8
Total	136	146	36	177	34
Max. Value	2.70	2.71	2.69	-	2.68
Min. Value	2.49	2.53	2.61	-	2.61

Source: Analysis by the Consultant

4) Free Swell Index

In IS 2720, Free Swell Index is defined as follows.

Table 1.5-14 Free Swell Index Test

D FS (%)	DEGREE OF EXPANSIVENESS
< 20	LOW
20 –35	MODERATE
35 –50	HIGH
>50	VERY HIGH

Source: RDSO, A Booklet on Geotechnical Testing for Railway Engineers Laboratory and Field Test

Although Free Swell Index is not considered as the parameter of ground improvement in RDSO Guideline GE0014, treatment such as replacement for high and very high will be required due to site condition.

Table 1.5-15 Summary of Free Swell Index

Free Swell Index (boring nos.)					
Value(%)	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=20	84	63	14	0	32
20 - 35	36	39	15	0	0
35 - 50	15	3	0	0	0
> 50	1	0	0	0	0
n.a.	0	41	7	177	2
Total	136	146	36	177	34
Max. Value	52.00	44.00	26.00	-	15.00
Min. Value	0.00	10.00	5.00	-	0.00

Source: Analysis by the Consultant

5) Bulk Density

Similar to Specific Gravity, it is considered that the relatively uniform soil is distributed in Ajmer because Bulk Density is distributed in narrow range, and various soils are distributed in Vadodara & Ahemdabad because it is distributed in wide range.

Table 1.5-16 Summary of Bulk Density

Bulk Density (B.D.) (boring nos.)					
Value (t/m3)	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=1.7	1	0	0	0	2
1.7 - 1.8	38	16	5	0	6
1.8 - 1.9	62	67	17	0	14
1.9 - 2.0	30	26	13	0	2
2.0 - 2.1	4	13	0	0	2
> 2.1	1	0	0	0	0
n.a.	0	24	1	177	8
Total	136	146	36	177	34
Max. Value	2.13	2.10	1.99	-	2.04
Min. Value	1.64	1.78	1.78	-	1.69

Source: Analysis by the Consultant

6) Natural Moisture Content

Except for Ajmer, there is a wide variation in a result of natural moisture

DFCC NEW DELHI

NK CONSORTIUM NJPI

content. Most of the cases, natural moisture content is lower than 30%, high natural moisture content soil are found in Ahmedabad section.

Table 1.5-17 Summary of Natural Moisture Content

Natural Moisture Content (M.C.) (boring nos.)					
Value (%)	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=5	1	0	0	0	0
5 - 10	30	0	0	0	24
10 - 15	64	2	2	0	1
15 - 20	32	15	8	0	0
20 - 25	8	75	25	0	1
> 25	1	30	0	0	0
n.a.	0	24	1	177	8
Total	136	146	36	177	34
Max. Value	29.00	29.00	25.00	-	25.00
Min. Value	5.00	15.00	14.00	-	5.00

Source: The Consultant

(3) Mechanical Property

1) Un-Confined Compression Test

Un-Confined Compression Test was carried out for a few cases in the section of CPM Ahmedabad. There is a wide variation in value of qu, shows various soils are distributed in Ahemdabad.

Table 1.5-18 Summary of Un-Confined Compression Test

Un-Confined Compression Test (boring nos.)					
Value, C (kg/cm^2)	Sec. 5	Sec. 6	Sec. 7	Sec. 8	Sec. 9
<= 0.5	0	27	4	0	0
0.5 - 1.0	0	58	16	0	0
1.0 - 2.0	0	19	6	0	0
2.0 - 3.0	0	6	0	0	0
> 3.0	0	0	0	0	0
n.a.	136	36	10	177	34
Total	136	146	36	177	34

Source: Analysis by the Consultant

DFCC NEW DELHI
NK CONSORTIUM NJPi

2) Box Shear Test

C and ϕ (fai) obtained by the Box Shear Test are used for slope stability analysis, retaining wall design, Safe bearing capacity of open foundation and Load bearing capacity of pile/well foundation. According to the test result, it turns out that the soil having 25 to 30 in ϕ is widely distributed.

Table 1.5-19 Summary of Box Shear Test

Box Shear Test (boring nos.)											
Value, C kg/cm^2	Sec. 5	Sec. 6	Sec. 7	Sec. 8	Sec. 9	Value, ϕ (degree)	Sec. 5	Sec. 6	Sec. 7	Sec. 8	Sec. 9
<= 0.5	74	11	5	0	24	<=25	0	0	0	0	0
0.5 - 1.0	0	0	0	0	0	25 - 30	69	6	2	0	24
1.0 - 1.5	0	0	0	0	0	30 - 35	5	5	3	0	0
> 1.5	0	0	0	0	0	> 35	0	0	0	0	0
n.a.	62	135	31	177	10	n.a.	62	135	31	177	10
Total	136	146	36	177	34	Total	136	146	36	177	34

Source: Analysis by the Consultant

3) Triaxial Shear Test

Similar to Box Share Test, C and ϕ obtained by the Triaxial Shear Test are used for slope stability analysis, Safe bearing capacity of open foundation and Load bearing capacity of pile/well foundation. It turns out that the soil having less than 15 in ϕ is distributed mostly in Ahmedabad.

Table 1.5-20 Summary of Triaxial Shear Test

Triaxial Shear Test (boring nos.)											
Value, C (kg/cm^2)	Sec. 5	Sec. 6	Sec. 7	Sec. 8	Sec. 9	Value, ϕ (degree)	Sec. 5	Sec. 6	Sec. 7	Sec. 8	Sec. 9
<= 0.25	61	13	3	0	2	<=15	17	111	26	0	0
0.25 - 0.5	1	52	9	0	0	15 - 20	26	0	4	0	2
0.5 - 1.0	0	35	16	0	0	> 20	19	0	0	0	0
1.0 - 2.0	0	11	2	0	0	n.a.	74	35	6	177	32
> 2.0	0	0	0	0	0	-	-	-	-	-	-
n.a.	74	35	6	177	32	-	-	-	-	-	-
Total	136	146	36	177	34	Total	136	146	36	177	34

Source: Analysis by the Consultant

(4) Consolidation Test

Consolidation Test was conducted only in the section of CPM Ahmadabad only. Compression Index becomes larger for high plasticity clay. According to test result, C_C shows less than 0.3 in most of the cases.

DFCC ★ NEW DELHI ★
NK CONSORTIUM NJPI

Table 1.5-21 Summary of Consolidation Test

Consolidation Test (boring nos.)					
Value, Cc	Sec. 5	Sec. 6	Sec. 7	Sec. 8	Sec. 9
<= 0.1	0	14	2	0	0
0.1 - 0.2	0	94	27	0	0
0.2 - 0.3	0	3	0	0	0
> 0.3	0	0	0	0	0
n.a.	136	35	7	177	34
Total	136	146	36	177	34

Source: Analysis by the Consultant

DFCC NEW DELHI

NK CONSORTIUM NJPi

(4) Chemical Property

The chemical properties of the particular soil affect the following:

- durability of structures by degradation of concrete and corrosion of steel materials,
- ground improvement measures for soft ground, and
- type of vegetation to be adopted for and slope protection.

1) Water

Chemical test results of water are shown in the following table below. The permissible limits are shown in blue colour and values exceeding the permissible limit, shown in yellow colour.

Table 1.5-22 Summary of Chemical Property of Water

pH (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=6	0	0	0	0	0
6-7	0	1	0	0	0
7-8	95	7	0	0	12
8-9	2	0	0	0	18
9-10	0	0	0	0	2
>10	0	0	0	0	2
n.a.	39	138	36	177	0
Total	136	146	36	177	34

Chlorides as Cl (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=0.006	62	1	0	0	0
0.006 - 0.007	7	0	0	0	0
0.007 - 0.008	8	0	0	0	0
0.008 - 0.009	10	0	0	0	0
0.009 - 0.2	10	7	0	0	34
> 0.2	0	0	0	0	0
n.a.	39	138	36	177	0
Total	136	146	36	177	34

Sulphate (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<0.01	83	1	0	0	3
0.01 - 0.02	14	0	0	0	0
0.02 - 0.03	0	7	0	0	1
0.03 - 0.04	0	0	0	0	30
>0.04	0	0	0	0	0
n.a.	39	138	36	177	0
Total	136	146	36	177	34

Organic Matter (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
< = 0.05	0	0	0	0	0
0.005 - 0.01	0	0	0	0	0
0.01 - 0.02	0	0	0	0	34
>0.02	0	0	0	0	0
n.a.	136	146	36	177	0
Total	136	146	36	177	34

Inogranic Matter (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<0.05	0	0	0	0	3
0.05 - 0.1	0	0	0	0	0
0.1 - 0.2	0	0	0	0	1
0.2 - 0.3	0	0	0	0	30
>0.3	0	0	0	0	0
n.a.	136	146	36	177	0
Total	136	146	36	177	34

Acidity (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
< 1	0	0	0	0	0
1 - 2	0	0	0	0	0
2 - 3	0	0	0	0	4
3 - 4	0	0	0	0	16
4 - 5	0	0	0	0	14
>5	0	0	0	0	0
n.a.	136	146	36	177	0
Total	136	146	36	177	34

Alkalinity (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<= 10	0	0	0	0	0
10 - 15	0	0	0	0	1
15 - 20	0	0	0	0	5
20 - 25	0	0	0	0	28
>25	0	0	0	0	0
n.a.	136	146	36	177	0
Total	136	146	36	177	34

Source: Information from DFCCIL compiled by the Consultant

2) Soil

Chemical test results of soil are shown below. According to IS-2720, soil having pH value equal to 7 is classified as neutral, less than 7 as acidic, more than 7 as alkaline.

Table 1.5-23 Summary of Chemical Property of Soil

pH (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=6	0	0	0	0	0
6-7	0	1	0	0	0
7-8	5	35	0	138	15
8-9	108	49	11	39	12
9-10	21	0	15	0	0
>10	2	0	0	0	0
n.a.	0	61	10	0	7
Total	136	146	36	177	34

Carbonate (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<= 0.005	40	0	0	0	27
0.005 - 0.01	60	0	0	0	0
0.01 - 0.03	36	0	0	0	0
0.03 - 0.05	0	0	0	0	0
0.05 - 0.08	0	0	0	0	0
> 0.08	0	0	0	0	0
n.a.	0	0	0	0	7
Total	136	0	0	0	34

Chlorides as Cl (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=0.002	0	21	26	0	0
0.002 - 0.004	0	0	0	0	0
0.004 - 0.006	1	0	0	23	0
0.006 - 0.008	103	0	0	31	19
0.008 - 0.01	32	0	0	13	8
> 0.01	0	57	0	110	0
n.a.	0	68	10	0	7
Total	136	146	36	177	34

Sulphate as SO_3 (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
0 - 0.008	136	0	0	0	27
0.008 - 0.01	0	0	0	0	0
> 0.01	0	21	0	177	0
n.a.	0	125	36	0	7
Total	136	146	36	177	34

Nitrate (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=0.006	43	0	0	0	2
0.006 - 0.007	0	0	0	0	4
0.007 - 0.008	6	0	0	0	17
0.008 - 0.009	87	0	0	0	4
0.009 - 0.01	0	0	0	0	0
> 0.01	0	0	0	0	0
n.a.	0	146	36	177	7
Total	136	146	36	177	34

Salinity (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=0.01	2	0	0	0	2
0.01 - 0.02	66	0	0	0	21
0.02 - 0.03	51	0	0	0	4
0.03 - 0.04	10	0	0	0	0
> 0.04	7	0	0	0	0
n.a.	0	146	36	177	7
Total	136	146	36	177	34

SO_4 (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=0.01	0	0	0	0	0
0.01 - 0.02	0	0	2	0	0
0.02 - 0.03	0	4	9	0	0
0.03 - 0.04	0	38	15	0	0
> 0.04	0	15	0	0	0
n.a.	136	89	10	177	34
Total	136	146	36	177	34

Organic Matter (boring nos.)					
Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9
<=2	11	0	0	0	0
2 - 3	86	0	0	0	0
3 - 4	32	0	0	0	0
4 -5	4	0	0	0	0
> 5	3	0	0	0	0
n.a.	0	146	36	177	34
Total	136	146	36	177	34

Source: Information from DFCCIL compiled by the Consultant

1.5.3 Black Cotton Soil Distribution

In India, black cotton soil having high swelling property is found in about one fifth of land area, mainly in Midwest. According to the paper titled "Black Cotton Soil of India" written by D. Mohan and R.K. Bhandari in 1978, the characteristic of the black cotton soil in India is shown as follows.

Atterberg Limit

Liquid Limit (wL) : 46 - 97%

Plasticity Index (Ip) : 21- 63%

Shrinkage Limit : 7 - 30%

Grain Size Distribution

Clay : 32 - 70%

Silt : 17 - 43%

Sand : 1 - 26%

Gravel : 0 - 8%

Organic Matter Content : 0.4 - 2.4%

As per the test results, the soil equivalent to the black cotton soil is assumed to be distributed following location.

It is necessary to revise above mentioned BCS definition, following BCS distribution and countermeasure based on the latest evaluation.

Table 1.5-24 Summary of Assumed BCS Distribtion

CPM	Section	Proposed Ground Improvement Area		
		Chainage, km		Length m
		From	To	
Ahmedabad	Section - 6	31.444	32.145	701
		35.629	36.419	790
		46.400	46.640	240
Total				1,731

The following remedies are suggested incase black cotton soil is encountered by the Contractor during the course of GT investigations:

- Treating the top layer of the soil with quick lime so as to reduce the harmful effects of the black cotton soil
- Providing a blanket of graded inverted filter at top of the embankment
- Consolidation of black cotton soil at optimum moisture content
- Provision of bituminous carpet or similar other intercepting material like polythene sheets etc. so as to intercept the surface water getting into formation
- To provide the drainage conditions of the formation at surface and sub-surface level.

1.5.4 Ground Improvement

In the "Guidelines and Specification for Design of Formation for Heavy Axle Load, GE: 0014", the evaluation parameters for ground improvement are described as follows.

1) Ground Improvement Method -

Field tests are required to be conducted on sub-soil strata, such as Plate Load Test for determination of elastic modulus at second loading (EV2), Standard Penetration Test to determine N-value, and Unconfined Compression Test or Vane Shear Test to determine unconfined compressive strength or undrained cohesion, Cu. If values of these test parameters, as specified in following para are not achieved then ground improvement is required.

2) For ground soil/ sub-strata layers with low bearing capacities, assessed by following evaluation parameters:

- Ev2 value less than 20 MPa, (Optional) or

- Undrained cohesion (Cu) < 25 kPa, or

- N-value (determined from Standard Penetration Test (SPT) < 5, shall be required ground improvement.

According to following SPT result, there are some location where required ground improvement.

However, these tests were not carried out shallower than 1.5m from the ground surface. Therefore, the Consultant recommends applying the Static Cone Penetration Test to identify the locations where ground improvement is required at shallower than 1.5m from the ground surface as per Working Paper No.011.

The proposed areas where ground improvement is required are as follows:

Table 1.5-25 Summary of Ground Improvement Requirement in Sand Layer

Ground Improvement		Observed N- Value at Top Layer (boring nos.)					
Requirement	N-Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9	Total
Required	< 5	0	1	0	0	0	1
Not Required	> = 5	81	32	15	28	30	186
n.a.	-	0	0	0	0	1	1
Total		81	33	15	28	31	188

Source: information from DFCCIL compiled by the Consultant

Table 1.5-26 Summary of Ground Improvement Requirement in Clay Layer

Ground Improvement		Observed N- Value at Top Layer (boring nos.)					
Requirement	N-Value	Sec. 5	Sec. 6	Sec. 7	Sec. 8N	Sec. 9	Total
Required	< 5	0	9	0	0	0	9
Not Required	> = 5	55	104	20	149	2	330
n.a.	-	0	0	1	0	1	2
Total		55	113	21	149	3	341

Table 1.5-27 Proposed Areas of Ground Improvement

CPM	Section	Proposed Ground Improvement Area					
		Chainage, km		Length	Width	Depth	Volume
		From	To	m	m	m	m^3
Ahmedabad	Section - 6	29.890	32.145	2,255	50	2	225,500
		33.360	33.990	630	40	2	50,400
		34.625	36.420	1,795	45	2	161,550
Total				4,680			437,450

It is necessary to revise above mentioned soft ground distribution and countermeasure based on the latest evaluation.

Refer to Databook for details of actual boring logs.

1.5.5 Availability of Embankment Fill Material

Geological Investigation Reports provided from CPMs included information on physical property such as soil classification and mechanical property of soil along the Project alignment, but did not include the CBR value which is required for soil selection of blanket, prepared-subgrade and embankment fill materials.

The Contractor shall procure the materials suitable for sub-grade and embankment fill after carrying out the necessary tests required as per specifications, and confirming their suitability..

It is proposed that the Contractor may apply the relationship between “Soil Classification”, and “Range of CBR Value” as primary selection methods of suitable soil for prepared subgrade and embankment fill materials in Working Paper No.012.

The relationship between “Soil Classification” and “Range of CBR Value” would be applied for rough guideance only for the selection of suitable soil for blanket, prepared-subgrade and embankment fill materials.

1.6 DESIGN OF RC BOX FOR DFC PHASE-1

1.6.1 Design Criteria

The criterion adopted in the standard design are based on the following design criteria, specifications, and assumptions:

- IRS Bridge Rules incorporating CS No. 33
- IRS Concrete Bridge Code incorporating CS No. 7
- IRS Bridge Sub-structure and Foundation Code incorporating CS No. 22
- DFC Loading (32.5 tonne axle load) with PCS sleepers
- Fe 500 grade steel conforming to IS 1786: 1985 for reinforcement.
- Length of lap provided shall be greater than 25 φ + 150mm in tension and 20 φ + 150 mm in compression
- Preparation of bed below the Culvert shall be based on actual site conditions to achieve the necessary Safe Bearing Capacity.
- Backfill material should be as per cl. 7.5 of the IRS Bridge Sub-structure and Foundation Code
- All RCC surfaces should be painted with Bitumen or Coal Tar of approved quality @1.464 kg/m2
- Clear cover to main reinforcement shall be 50mm
- Depth and size of foundation, return walls, levels of upstream and downstream shall be decided based on site conditions
- Tolerances shall be followed as per the IRS Concrete Bridge Code
- M30 grade of concrete shall be used for severe exposure conditions. For very severe exposure higher grades of concrete may be used.
- Bed slope should be kept a minimum of 1 in 100
- For intermediate span or fill depths, immediately higher values can be adopted
- M-25 grade of concrete shall be used for plain-cement concrete (PCC)
- Ballast cushion shall be minimum of 300mm and maximum of 400mm

DFCC NEW DELHI
NK CONSORTIUM NJPI

1.6.2 Design Load Condition for the Cast-in-situ Single Cell Box Culvert.

The design load condition for the cast-in-situ single cell box culvert standard design are stipulated as follows:

Dimensions of the Box - The dimensions of the box refers to the clear inner dimensions. The height of box includes 150mm thick wearing coat provided inside the box

Fill Depth - It is the height of fill from the bottom of the sleepers to the top of the box fill is inclusive of depth of ballast and depth of soil fill as per Clause 2.4.2.1, Note 1 of IRS Concrte Bridge Code (CBC)

SIDL: Weight of Ballast, Rails and Sleepers is increased by 20% for design. Ballast depth of 300mm and 400mm is considered for design

Live Load: The live load and longitudinal forces due to braking and traction is taken from IRS Bridge Rules. For spans up to 20m, braking forces are less than tractive forces. Longitudinal forces are not considered for fill depths exceeding 1m. Designs are applicable only for PSC sleepers.

Curvature: The design is done for a 1 degree curve, for a maximum speed of 125 kmph as per as per the Revised Draft Loading Standards and Design Criteria for Bridges, letter No. HQ/EN/Bridge Design dated 28 Feb. 2008. The cant provided in the curves is 110 mm. The maximum additional vertical reaction due to curvature is 15% of the live load.

Wind load: The wind load acts only on the live load since the box structure is buried. The over-turning moment due to wind is resisted by vertical reactions on the wheels, one upward and the other downward. The increase in vertical reaction due to downward force is only considered in design since uplift is not an issue in box culverts

Coefficient of Earth pressure: The extreme values of coefficient of earth pressure used for design are 0.25 and 0.6

Modelling of supports - The supports are modelled as a series of springs. The spring stiffness is calculated by taking a deflection of 25mm under a load of 100kN/m2 to represent soil of poor bearing capacity and 25mm deflection under 1000kN/m2 to represent soil of very good bearing capacity

Grade of concrete and steel: The minimum grade of concrete for box culvert as per Table 4(b), Clause 5.4.4 of IRS Concrete Bridge Code, Correction Slip CS-8 dt. 15-Feb-2006 is M25 for RCC under 'Very Severe' environmental condition. M30 is adopted for design Fe 500 grade steel conforming to IS 1786: 1985 shall be used

1.6.3 Load Condition and Load Combination:

Types of Load and Load combination using to design the RCC Box for DFC are shown in the following table.

Table 1.6-1 Types of Load

Load Case	Description of the Load Case
LOAD 11 SLF_WT	Self Weight of the box
LOAD 21 BALLAST_RAIL	Weight of Ballast, Sleeper and Rail. Calculated value is increased by 20%
LOAD 22 SIDL_SOIL_DRY	Weight of Overburden Soil, Dry condition
LOAD 23 SIDL_SOIL_SAT	Weight of Overburden Soil, Saturated condition
LOAD 31 BM-LL	Live Load: EUDL for Bending Moment
LOAD 32 BM-CDA	Live Load: CDA for Bending Moment
LOAD 33 SF-LL	Live Load: EUDL for Shear Force
LOAD 34 SF-CDA	Live Load: CDA for Shear Force
LOAD 41 CURV-BM	Vertical Reaction due to Curvature for calculation of BM
LOAD 42 CURV-SF	Vertical Reaction due to Curvature for calculation of SF
LOAD 51 LONG	Longitudinal Forces (Braking/ Traction), not considered for fill depth > 1 m
LOAD 61 WL	Vertical reaction due to Wind acting on Rolling Stock
LOAD 711 EP-SYM-MIN-DRY	Earth Pressure, Symmetric on both sides, Minimum value, Dry Soil
LOAD 712 EP-SYM-MIN-SAT	Earth Pressure, Symmetric on both sides, Minimum value, Saturated Soil
LOAD 713 EP-SYM-MAX-DRY	Earth Pressure, Symmetric on both sides, Maximum value, Dry Soil
LOAD 714 EP-SYM-MAX-SAT	Earth Pressure, Symmetric on both sides, Maximum value, Saturated Soil
LOAD 715 EP-RIGHT-MAX-DRY	Earth Pressure, Min on Left, Max on Right, Dry Soil
LOAD 716 EP-RIGHT-MAX-SAT	Earth Pressure, Min on Left, Max on Right, Saturated Soil
LOAD 717 EP-LEFT-MAX-DRY	Earth Pressure, Max on Left, Min on Right, Dry Soil
LOAD 718 EP-LEFT-MAX-SAT	Earth Pressure, Max on Left, Min on Right, Saturated Soil
LOAD 811 SUR-SYM-DL-MIN	DL Surcharge, Symmetric on both sides, Minimum coefficient
LOAD 812 SUR-SYM-LL-MIN	LL Surcharge, Symmetric on both sides, Minimum coefficient
LOAD 813 SUR-SYM-DL-MAX	DL Surcharge, Symmetric on both sides, Maximum coefficient
LOAD 814 SUR-SYM-LL-MAX	LL Surcharge, Symmetric on both sides, Maximum coefficient
LOAD 815 SUR-RIGHT-DL+LL-MAX	Min DL surcharge on Left, Max DL + LL surcharge on Right
LOAD 816 SUR-LEFT-DL+LL-MAX	Max DL + LL surcharge on Left, Min DL surcharge on Right
LOAD 817 SUR-RIGHT-DL-MAX	Min DL surcharge on Left, Max DL surcharge on Right
LOAD 818 SUR-LEFT-DL-MAX	Max DL surcharge on Left, Min DL surcharge on Right

Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

Table 1.6-2 Load Combination (1)

LOAD CASE	101	102	201	202	103	104	203	204
	Without Wind		With Wind		Without Wind		With Wind	
	Dry	Saturated	Dry	Saturated	Dry	Saturated	Dry	Saturated
LOAD 11 SLF_WT	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
LOAD 21 BALLAST_RAIL	2	2	2	2	2	2	2	2
LOAD 22 SIDL_SOIL_DRY	2	0	2	0	2	0	2	0
LOAD 23 SIDL_SOIL_SAT	0	2	0	2	0	2	0	2
LOAD 31 BM-LL	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 32 BM-CDA	2	2	1.75	1.75	0	0	0	0
LOAD 33 SF-LL	0	0	0	0	0	0	0	0
LOAD 34 SF-CDA	0	0	0	0	0	0	0	0
LOAD 41 CURV-BM	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 43 CURV-SF	0	0	0	0	0	0	0	0
LOAD 51 LONG	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 61 WL	0	0	1.25	1.25	0	0	1.25	1.25
LOAD 711 EP-LEFTMIN-DRY	1.7	0	1.7	0	1.7	0	1.7	0
LOAD 721 EP-LEFTMIN-SAT	0	1.7	0	1.7	0	1.7	0	1.7
LOAD 731 EP-LEFTMAX-DRY	0	0	0	0	0	0	0	0
LOAD 741 EP-LEFTMAX-SAT	0	0	0	0	0	0	0	0
LOAD 712 EP-RIGHTMIN-DRY	1.7	0	1.7	0	1.7	0	1.7	0
LOAD 722 EP-RIGHTMIN-SAT	0	1.7	0	1.7	0	1.7	0	1.7
LOAD 732 EP-RIGHTMAX-DRY	0	0	0	0	0	0	0	0
LOAD 742 EP-RIGHTMAX-SAT	0	0	0	0	0	0	0	0
LOAD 811 SUR-LEFTMIN-DL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 821 SUR-LEFTMIN-LL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 831 SUR-LEFTMAX-DL	0	0	0	0	0	0	0	0
LOAD 841 SUR-LEFTMAX-LL	0	0	0	0	0	0	0	0
LOAD 812 SUR-RIGHTMIN-DL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 822 SUR-RIGHTMIN-LL	1.7	1.7	1.7	1.7	0	0	0	0
LOAD 832 SUR-RIGHTMAX-DL	0	0	0	0	0	0	0	0
LOAD 842 SUR-RIGHTMAX-LL	0	0	0	0	0	0	0	0

Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

Table 1.6-3 Load Combination (2)

LOAD CASE	105	106	205	206	107	108	207	208
	Without Wind		With Wind		Without Wind		With Wind	
	Dry	Saturated	Dry	Saturated	Dry	Saturated	Dry	Saturated
LOAD 11 SLF_WT	1.4	1.4			1.4	1.4		
LOAD 21 BALLAST_RAIL	2	2			2	2		
LOAD 22 SIDL_SOIL_DRY	2	0			2	0		
LOAD 23 SIDL_SOIL_SAT	0	2			0	2		
LOAD 31 BM-LL	0	0			0	0		
LOAD 32 BM-CDA	0	0			0	0		
LOAD 33 SF-LL	0	0			0	0		
LOAD 34 SF-CDA	0	0			0	0		
LOAD 41 CURV-BM	0	0			0	0		
LOAD 42 CURV-SF	0	0			0	0		
LOAD 51 LONG	0	0			0	0		
LOAD 61 WL	0	0			0	0		
LOAD 711 EP-LEFTMIN-DRY	0	0			0	0		
LOAD 721 EP-LEFTMIN-SAT	0	0			0	0		
LOAD 731 EP-LEFTMAX-DRY	1.7	0			1.7	0		
LOAD 741 EP-LEFTMAX-SAT	0	1.7			0	1.7		
LOAD 712 EP-RIGHTMIN-DRY	0	0			1.7	0		
LOAD 722 EP-RIGHTMIN-SAT	0	0			0	1.7		
LOAD 732 EP-RIGHTMAX-DRY	1.7	0			0	0		
LOAD 742 EP-RIGHTMAX-SAT	0	1.7			0	0		
LOAD 811 SUR-LEFTMIN-DL	0	0			0	0		
LOAD 821 SUR-LEFTMIN-LL	0	0			0	0		
LOAD 831 SUR-LEFTMAX-DL	1.7	1.7			1.7	1.7		
LOAD 841 SUR-LEFTMAX-LL	0	0			0	0		
LOAD 812 SUR-RIGHTMIN-DL	0	0			1.7	1.7		
LOAD 822 SUR-RIGHTMIN-LL	0	0			0	0		
LOAD 832 SUR-RIGHTMAX-DL	1.7	1.7			0	0		
LOAD 842 SUR-RIGHTMAX-LL	0	0			0	0		

Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

Table 1.6-4 Load Combination (3)

LOAD CASE	109	110	209	210	111	112	211	212
	Without Wind		With Wind		Without Wind		With Wind	
	Dry	Saturated	Dry	Saturated	Dry	Saturated	Dry	Saturated
LOAD 11 SLF_WT	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
LOAD 21 BALLAST_RAIL	2	2	2	2	2	2	2	2
LOAD 22 SIDL_SOIL_DRY	2	0	2	0	2	0	2	0
LOAD 23 SIDL_SOIL_SAT	0	2	0	2	0	2	0	2
LOAD 31 BM-LL	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 32 BM-CDA	2	2	1.75	1.75	0	0	0	0
LOAD 33 SF-LL	0	0	0	0	0	0	0	0
LOAD 34 SF-CDA	0	0	0	0	0	0	0	0
LOAD 41 CURV-BM	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 42 CURV-SF	2	2	1.75	1.75	0	0	0	0
LOAD 51 LONG	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 61 WL	0	0	1.25	1.25	0	0	1.25	1.25
LOAD 711 EP-LEFTMIN-DRY	0	0	0	0	0	0	0	0
LOAD 721 EP-LEFTMIN-SAT	0	0	0	0	0	0	0	0
LOAD 731 EP-LEFTMAX-DRY	1.7	0	1.7	0	1.7	0	1.7	0
LOAD 741 EP-LEFTMAX-SAT	0	1.7	0	1.7	0	1.7	0	1.7
LOAD 712 EP-RIGHTMIN-DRY	0	0	0	0	0	0	0	0
LOAD 722 EP-RIGHTMIN-SAT	0	0	0	0	0	0	0	0
LOAD 732 EP-RIGHTMAX-DRY	1.7	0	1.7	0	1.7	0	1.7	0
LOAD 742 EP-RIGHTMAX-SAT	0	1.7	0	1.7	0	1.7	0	1.7
LOAD 811 SUR-LEFTMIN-DL	0	0	0	0	0	0	0	0
LOAD 821 SUR-LEFTMIN-LL	0	0	0	0	0	0	0	0
LOAD 831 SUR-LEFTMAX-DL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 841 SUR-LEFTMAX-LL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 812 SUR-RIGHTMIN-DL	0	0	0	0	0	0	0	0
LOAD 822 SUR-RIGHTMIN-LL	0	0	0	0	0	0	0	0
LOAD 832 SUR-RIGHTMAX-DL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 842 SUR-RIGHTMAX-LL	1.7	1.7	1.7	1.7	0	0	0	0

Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

DFCC NEW DELHI

NK CONSORTIUM NJPi

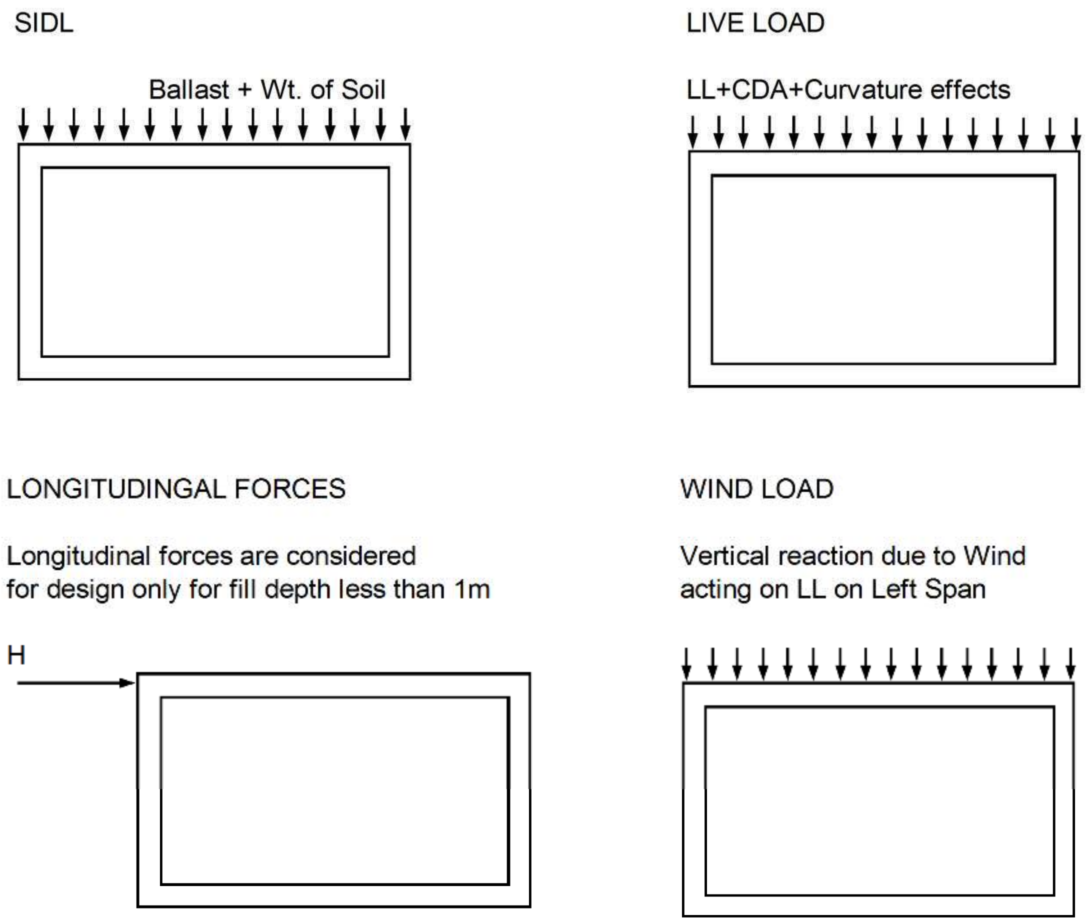
Table 1.6-5 Load Combination (4)

LOAD CASE	113	114	213	214	115	116	215	216
	Without Wind		With Wind		Without Wind		With Wind	
	Dry	Saturated	Dry	Saturated	Dry	Saturated	Dry	Saturated
LOAD 11 SLF_WT	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
LOAD 21 BALLAST_RAIL	2	2	2	2	2	2	2	2
LOAD 22 SIDL_SOIL_DRY	2	0	2	0	2	0	2	0
LOAD 23 SIDL_SOIL_SAT	0	2	0	2	0	2	0	2
LOAD 31 BM-LL	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 32 BM-CDA	2	2	1.75	1.75	0	0	0	0
LOAD 33 SF-LL	0	0	0	0	0	0	0	0
LOAD 34 SF-CDA	0	0	0	0	0	0	0	0
LOAD 41 CURV-BM	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 42 CURV-SF	2	2	1.75	1.75	0	0	0	0
LOAD 51 LONG	2	2	1.75	1.75	2	2	1.75	1.75
LOAD 61 WL	0	0	1.25	1.25	0	0	1.25	1.25
LOAD 711 EP-LEFTMIN-DRY	0	0	0	0	0	0	0	0
LOAD 721 EP-LEFTMIN-SAT	0	0	0	0	0	0	0	0
LOAD 731 EP-LEFTMAX-DRY	1.7	0	1.7	0	1.7	0	1.7	0
LOAD 741 EP-LEFTMAX-SAT	0	1.7	0	1.7	0	1.7	0	1.7
LOAD 712 EP-RIGHTMIN-DRY	1.7	0	1.7	0	1.7	0	1.7	0
LOAD 722 EP-RIGHTMIN-SAT	0	1.7	0	1.7	0	1.7	0	1.7
LOAD 732 EP-RIGHTMAX-DRY	0	0	0	0	0	0	0	0
LOAD 742 EP-RIGHTMAX-SAT	0	0	0	0	0	0	0	0
LOAD 811 SUR-LEFTMIN-DL	0	0	0	0	0	0	0	0
LOAD 821 SUR-LEFTMIN-LL	0	0	0	0	0	0	0	0
LOAD 831 SUR-LEFTMAX-DL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 841 SUR-LEFTMAX-LL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 812 SUR-RIGHTMIN-DL	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
LOAD 822 SUR-RIGHTMIN-LL	1.7	1.7	1.7	1.7	0	0	0	0
LOAD 832 SUR-RIGHTMAX-DL	0	0	0	0	0	0	0	0
LOAD 842 SUR-RIGHTMAX-LL	0	0	0	0	0	0	0	0

Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

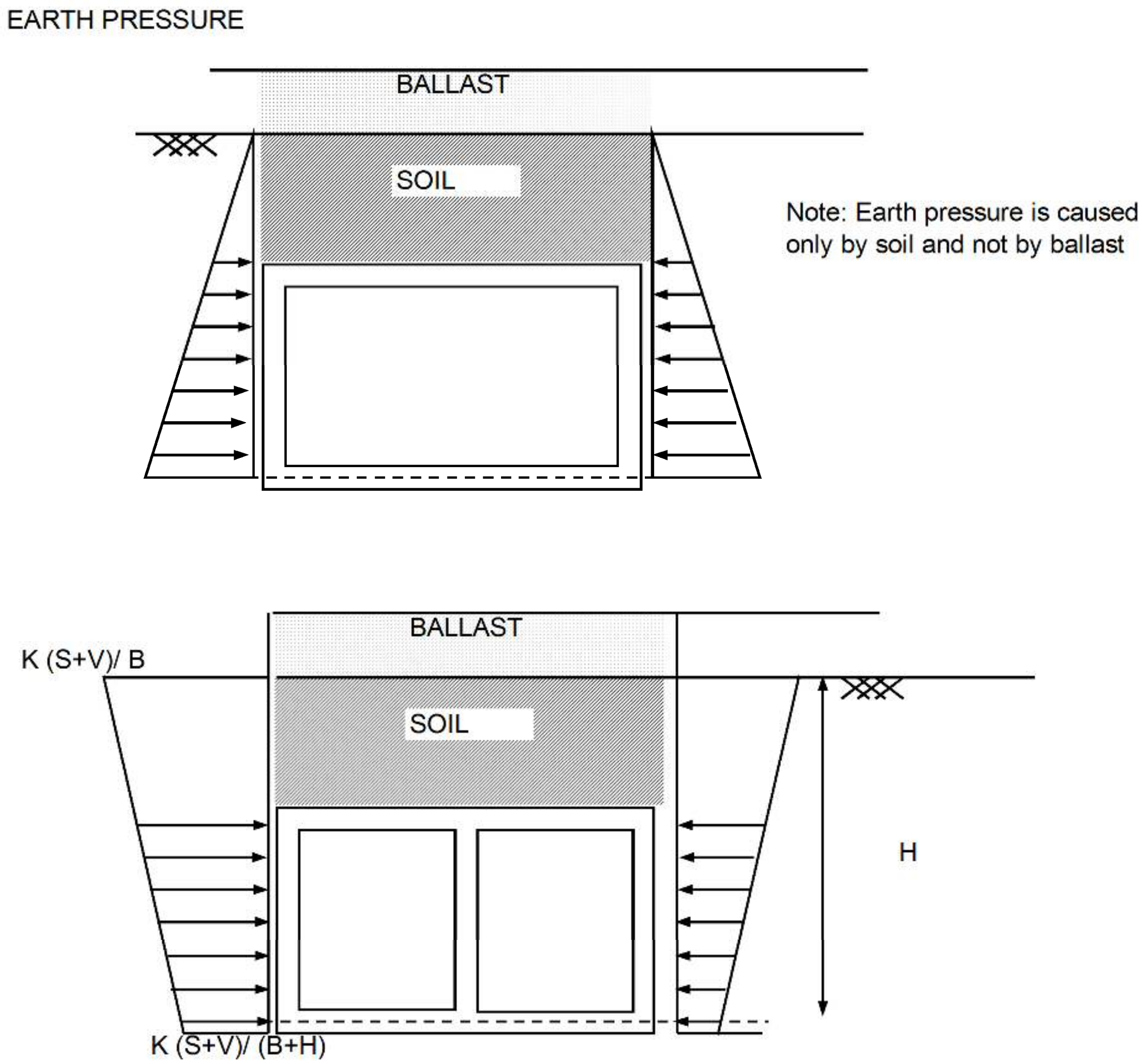
1.6.4 Schematic representation of loads

Schematic representation of loads is shown as follows:



Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

Figure 1.6-1 Schematic Representation of Loads (1)

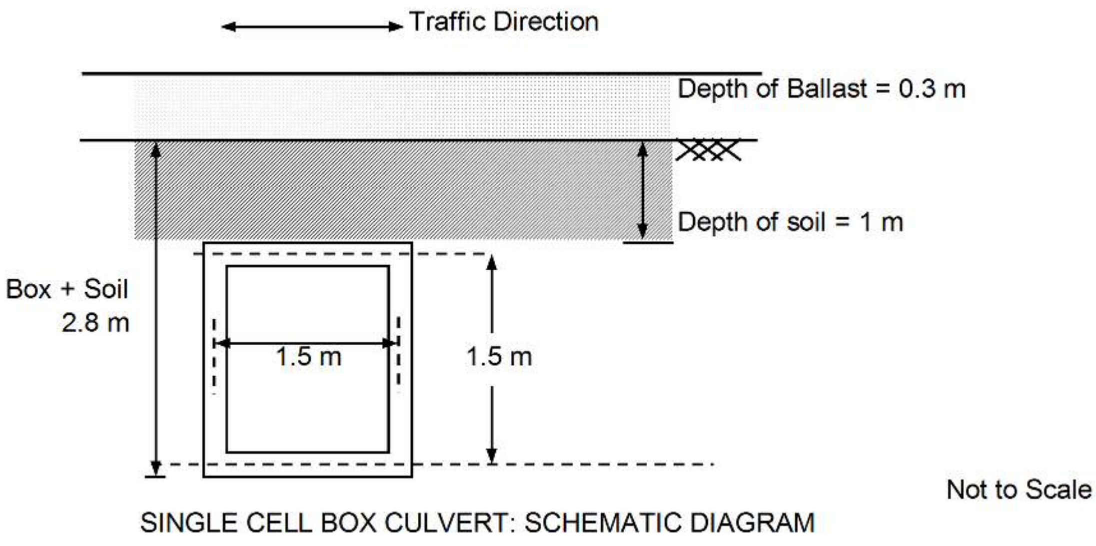


Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

Figure 1.6-2 Schematic Representation of Loads (2)

1.6.5 Confirmation of Standard Design in case of 1x1.2mx1.2m Box Culvert with 1 m fill.

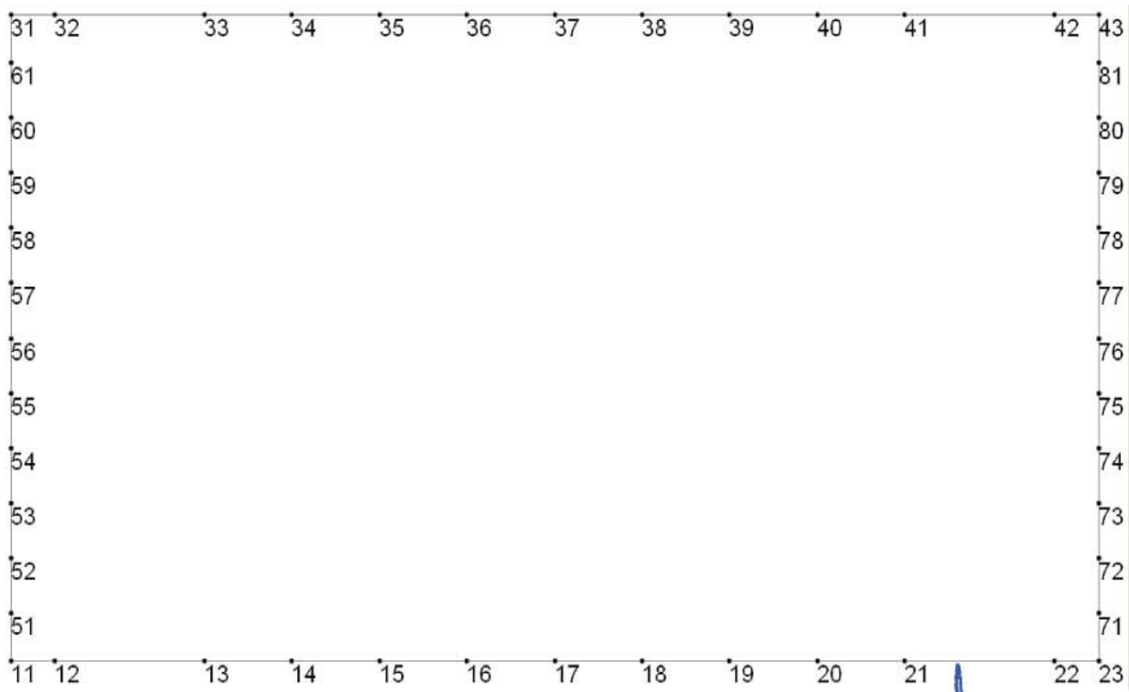
The Consultant has carried out the confirmation of Standard Design in case of 1x1.2mx1.2m Box Culvert with 1 m fill shown as follows:



Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

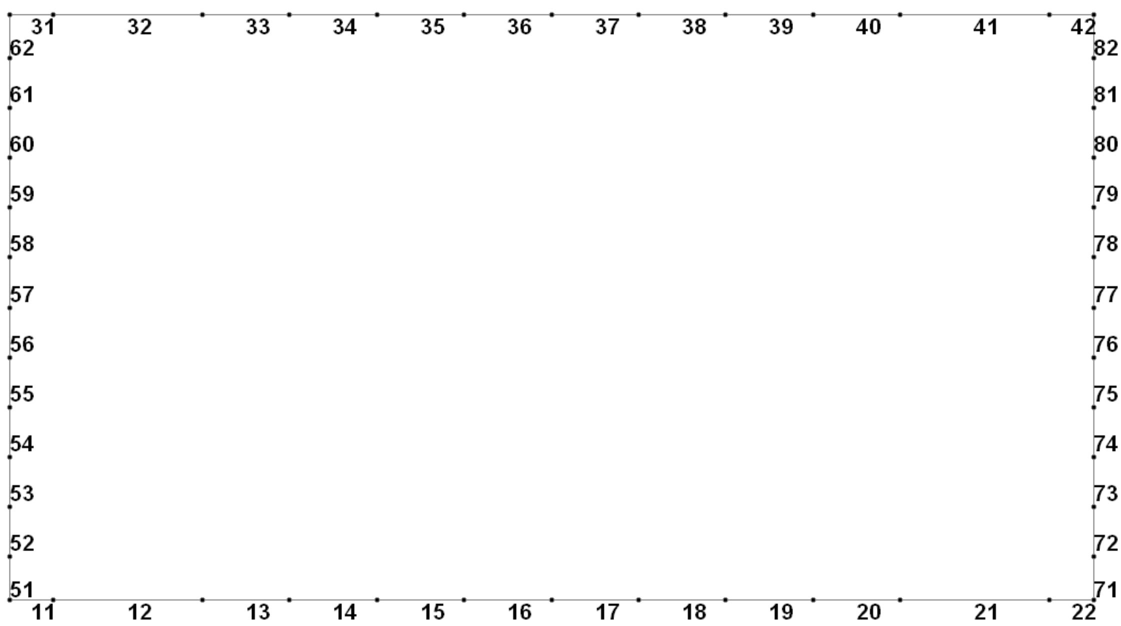
Figure 1.6-3 Hypothetical Configuration of 1x1.2mx1.2m Box Culvert with 1 m fill

The structural modeling was conceived as follows:



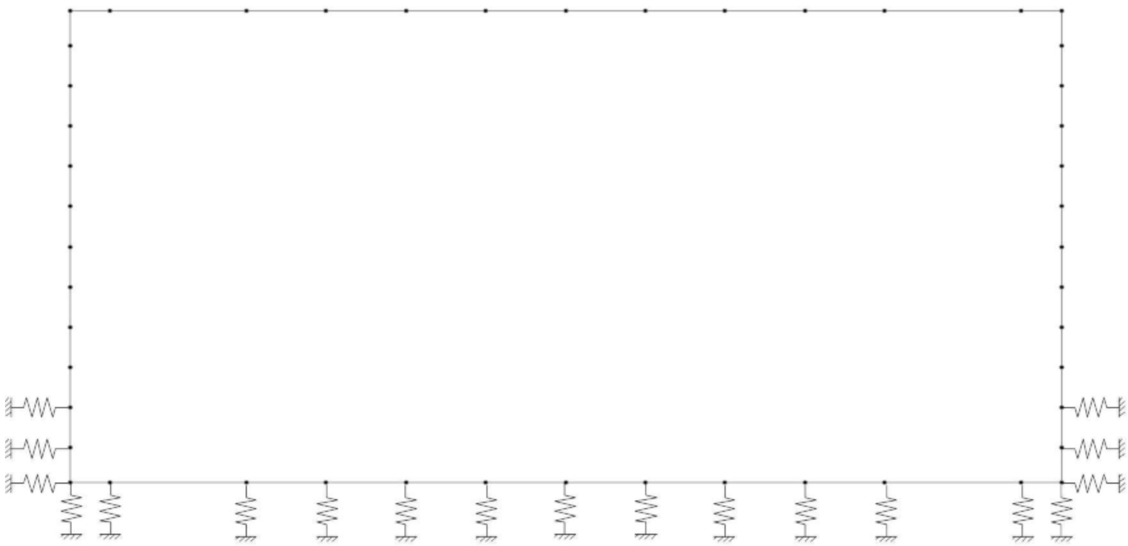
Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

Figure 1.6-4 Structural Model (node numbers) for Analysis of 1x1.2mx1.2m Box Culvert



Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

Figure 1.6-5 Member Incidences Model for Analysis of 1x1.2mx1.2m Box Culvert



Source: Design Note for Single Cell Box Culvert (Fill height 1.0m)

Figure 1.6-6 Spring Support Model for Analysis of 1x1.2mx1.2m Box Culvert

Table 1.6-6 Input data for structural analysis by STAAD for Analysis non-standard-design RCC Box of 1x1.2mx1.2m Box Culvert with 1 m fill

Inner Dimensions		
Width	1.2	m
Depth	1.2	m
Top Flange Thickness	0.3	m
Bottom Flange Thickness	0.3	m
Wall Thickness	0.3	m
Haunch Size		
Length	0.15	m
Depth	0.15	m
Centre-line distances		
Width = 1.2 + 0.3	1.5	m
Depth = 1.2 + 0.3	1.5	m
Total Fill Depth	1.3	m
Depth of Ballast	0.3	m
Max. Depth of Ballast	0.4	m
Depth of Soil = 1.3 - 0.3	1	m
Depth of Soil + Height of Structure = 1 + 1.2 + 0.3 + 0.3	2.8	m
Density of Ballast (Based on Design Basis Note RP002)	18.8	kN/m3
Density of Dry Soil	18	kN/m3
Density of Saturated Soil	20	kN/m3
SBC of Soil (assumed value)	100	kN/m2
Factor of Safety for Soil	1	
Concrete Grade fck	M 30	
Young's Modulus E = 5000 sqrt(30)	27386	N/mm2
SELF WEIGHT		
Self weight of Box calculated by STAAD		
SIDL		
Ballast Load = 18.8 kN/m3 × 1m × (0.4+0.25) m	12.22	kN/m
Weight of Rail (4 × 0.7 kN/m over 2.7 m sleeper)	1.04	kN/m
Number of Sleepers per m width	1.66	per m
Weight of sleepers @ 3.2 kN per sleeper = 3.2 × 1.66	5.312	kN/m
Weight of sleepers (of 2.7m length) for 1m strip	2	kN/m
Dry Soil Wt. = Dry Density 18 × 1m × 1 m	18	kN/m
Saturated Soil Wt. = Saturated Density 20 × 1m × 1 m	20	kN/m

LIVE LOAD

Span	P for BM	P for SF
1	461	462
1.5	520	520
2	550	550
2.5	570	625
3	580	735
3.5	600	810
4	675	870
4.5	735	925
5	810	1020
5.5	910	1100
6	995	1170
6.5	1060	1250
7	1125	1325
7.5	1185	1400
8	1240	1475

C/c span	1.5	m
Load for BM and SF is interpolated from the Table		
Load for BM	520	kN
Load for SF	520	kN

CDA = 0.15+8/(6+1.5), subject to a maximum of 1	1.000	
CDA Coeff. (2 - d/0.9) for 1.3 m fill	0.810	
This value is reduced from 0.5 to zero from fill height of 0.9m to 3m		
CDA modified for 1.3 m fill = 1 × 0.5 × 0.81	0.405	
Live Load for BM, 300mm Ballast = 520 kN / 1.5 m	346.67	kN/m
Live Load for SF, 300mm Ballast = 520 kN / 1.5 m	346.7	kN/m
Width of dispersion of live load - not to exceed c/c of tracks, i.e., 6m		
Sleeper Length	2.7	m
Dispersion length in Fill (2V: 1H)	1.3	m
Total width of dispersion = 2.7 + 1.3	4.0	m
Live Load for BM over 1m strip = 346.67 / 4	86.7	kN/m
Live Load for SF over 1m strip = 346.67 / 4	86.7	kN/m

CURVATURE

Vertical Reaction due to 1º curve	15	%
Effect of Curvature for BM = (15/100)×86.7	13.01	kN/m
Effect of Curvature for BM = (15/100)×86.7	13.01	kN/m

LONGITUDINAL FORCE: Not considered for Depth of Fill > 1m

Span	Tractive force kN
1.5	105
2	210
2.5	210
3	210
3.5	245
4	310
4.5	310
5	310
5.5	310
6	310
6.5	330
7	330
7.5	330
8	410

Tractive force for 1.5 m span 105 kN

Width of dispersion of tractive force (assumed)	3	m
Longitudinal forces considered since fill depth <= 1m		
Tractive force over 1m strip = 105 / 3	35	kN
Note: Braking force is less than Tractive force for spans < 20m		

WIND LOAD

Limiting value of wind pressure when bridge is loaded	1.5	kN/m2
Exposed height of moving load = 7.1 - 0.6 m	6.5	m
Load per m = 1.5 kN/m2 × 6.5 m	9.75	kN/m
This load is applied at h / 2 = 6.5 / 2 + 0.6	3.85	m
Moment = 9.75 kN/m × 3.85 m	37.54	kN-m per m length
Vertical Reaction on each rail = 37.5375 / 1.676 m	22.48	kN/m
This load is distributed by sleepers		
Length over which downward reaction is distributed = 4 m / 2	2	m
Vertical Reaction over 1m strip = 22.48 kN/m / 2 m	12	kN/m

MINIMUM EARTH PRESSURE

Minimum Coeff. of earth pressure	0.25	
Minimum Earth Pressure : Dry = 0.25 × 18 × 2.8	12.60	kN/m
Minimum Earth Pressure : Saturated = 0.25 × 20 × 2.8	14.00	kN/m

MAXIMUM EARTH PRESSURE

Maximum Coeff. of earth pressure	0.6	
Maximum Earth Pressure k □ h : Dry	30.24	kN/m
Maximum Earth Pressure k □ h : Saturated	33.60	kN/m

EARTH PRESSURE DUE TO DEAD LOAD SURCHARGE

Invariably, h < (L - B) for box culvert		
S - Live load Surcharge per m length	176	kN/m
V - Dead load Surcharge - Ballast + Sleeper	53.74	kN/m
Width of dispersion at formation level	3	m
MAXIMUM EP		
Ka V / B	10.75	kN/m
Ka V / (B + h)	5.56	kN/m
MINIMUM EP		
Ka V / B	4.48	kN/m
Ka V / (B + h)	2.32	kN/m

EARTH PRESSURE DUE TO LIVE LOAD SURCHARGE

MAXIMUM EP		
Ka S / B	35.20	kN/m
Ka S / (B + h)	18.21	kN/m
MINIMUM EP		
Ka S / B	14.67	kN/m
Ka S / (B + h)	7.59	kN/m

DESIGN OF TOP AND BOTTOM SLAB

Overall depth of the slab D	300	mm
Depth in the haunch region = 300+50	350	mm
Effective cover to reinforcement	75	mm

Grade of concrete used fck =	M 30	
The top and bottom slab is designed symmetrically.		

Design of Slab at the face of the Wall

Hogging Moment	48.86	kN-m
Sagging Moment	28.9	kN-m
Shear	285.33	kN

Design for Flexure

The design for flexure is done as per cl. 15.4.2.2.1 of CBC

Area of 12mm dia. at 110mm c/c, Fe 500 grade steel =	1028	mm^2
Lever arm = z		

$$\frac{z}{d} = 1 - \frac{1.1\, fy\, Ast}{fck\, b\, d}$$

Effective depth of the haunch at the face of the wall	275	mm
z / d = 1 – (1.1×500×1028.1575957203)/(30×1000×275) =	0.931	(limited to 0.95)
MuR = 0.87 fy Ast z = 0.87×500 × 1028.1575957203 × 0.931×275	115	kN-m>Demand
Minimum % of steel (cl. 15.9.4.1 of CBC) for slab	0.2	%
Minimum As for the slab (0.2% of 300 mm tk., 1m width)	600	mm^2
Min. As based on Shear (cl. 15.4.3.2.3 of CBC) = V / 2 (0.87 fy)	328	mm^2

The actual area of steel provided is greater than the minimum required.

Design for Shear

Shear resistance is calculated as per cl. 15.4.3 of CBC

Shear stress v = V / b d = 285.33 × 1000 / 1000 × 275	1.038	N/mm^2
As per cl. 15.4.3.1 of CBC, v should not exceed 0.75 sqrt(fck) or 4.75 N/mm2, whichever is less.	4.107919	N/mm^2

Shear Capacity

$$v_c = \frac{0.27}{1.25}\left(\frac{100\, As}{b\, d} f_{ck}\right)^{1/3}$$

p = 100 As / b d = 100×1028.1575957203 / 1000×275	0.374	%
vc = (0.27/1.25)×(0.374 × 30 ^ (1/3)	0.484	N/mm^2

Shear capacity is enhanced by a factor ‘s’ based on the following expression

s = $(500/d)^{1/4}$ or 0.7, which ever is greater (cl. 15.4.3.3 of CBC)

s = (500/275) ^ 0.25 =	1.161	
Since v > vc, stirrups need to be provided		
Hooked links are provided as stirrups. Bar diameter	10	mm
Spacing along the length	150	mm
Spacing along the barrel	110	mm

$$Asv > \frac{b\, s_v\left(\tau + 0.4 - s\tau c\right)}{0.87\, f_{sv}}$$

Note: Maximum value of fsv = 415 N/mm2

DFCC NEW DELHI

NK CONSORTIUM NJPI

As > 1000×150 (1.038+0.4-1.161×0.484) / (0.87×415) =	365	mm^2 per m
As per leg = 365 / (1000 / 110)	40.2	mm^2

Hence, 10mm dia. hooked links are provided at the above mentioned spacing

Design of Slab at Midspan

Hogging Moment	0	kN-m
Sagging Moment	61.97	kN-m
Shear	100	kN

Design for Flexure

The design for flexure is done as per cl. 15.4.2.2.1 of CBC

12mm diameter bars are provided at 110mm centres

Area of Fe 500 grade steel provided =	1028.158	mm^2

Lever arm = z

$$\frac{z}{d} = 1 - \frac{1.1 fy\, Ast}{fck\, b\, d}$$

Effective depth of the slab	225	mm
z / d = 1 – (1.1×500×1028.1575957203)/(30×1000×225) =	0.916	(limited to 0.95)
MuR = 0.87 fy Ast z = 0.87×500 × 1028.1575957203 × 0.916×225	92	kN-m>Demand
Minimum % of steel (cl. 15.9.4.1 of CBC) for slab	0.2	%
Minimum As for the slab (0.2%)	600	mm^2
Min. As based on Shear (cl. 15.4.3.2.3 of CBC) = V / 2 (0.87 fy)	115	mm^2

The actual area of steel provided is greater than the minimum required.

DESIGN OF WALLS

Wall thickness at face of slab = 300 + 50	350	mm
Effective depth	275	mm
Maximum Moment	77.09	kN-m
Corresponding Axial Load	333.45	kN
0.1 fck b D = 0.1×25×1000×300	900	kN

As per cl. 15.4.2.1.2 of the IRS Concrete Bridge Code (CBC), the axial load in beams can be ignored if the axial load is less than 0.1 fck times the cross sectional area.

Minimum reinforcement for walls is 0.2% on each face

Area of Fe 500 grade steel provided =	1028.158	mm^2
z / d = 1 – (1.1×500×1028.1575957203)/(30×1000×275) =	0.931	(limited to 0.95)
MuR = 0.87 fy Ast z = 0.87×500 × 1028.1575957203 × 0.931×275	115	kN-m, > Demand

Distribution Steel

Minimum % of distribution steel = 0.12% of concrete area

As = 0.12/100 ×1000 × 300	360	mm^2

10mm diameter bars are provided at 125mm centres

BASE PRESSURE

Self Weight

Volume of concrete per m length	1.8	m^3
Weight of box = 1.845 × 25 kN/m3	46	kN/m
Weight per m length = 46.125 / (1.2 + 2 × 0.3)	25.6	kN/m^2

SIDL

Ballast + Rail + Sleepers (increased by 20%)	18.3	kN/m^2
Overburden saturated soil	20	kN/m^2

Live Load

LL + Curvature + Vertical reaction due to wind	146.82	kN/m^2

Load factors for SLS
1.0 for DL, LL and 1.2 for SIDL

Base pressure = 1×25.6 + 1.2×18.312 + 1×146.82	218.4	kN/m^2

Minimum SBC required is 220 kN/m^2

Table 1.6-7 Input data for structural analysis by STAAD for Analysis non-standard-design RCC Box of 1x10.5x5.5 with 1 m fill

Inner Dimensions		
Width	10.5	m
Depth	5.5	m
Top Flange Thickness	1.60	m
Bottom Flange Thickness	1.60	m
Wall Thickness	1.40	m
Haunch Size		
Length	0.9	m
Depth	0.3	m
Centre-line distances		
Width = 10.5 + 1.4	11.9	m
Depth = 5.5 + 1.6	7.1	m
Total Fill Depth	1.3	m
Depth of Ballast	0.3	m
Max. Depth of Ballast	0.4	m
Depth of Soil = 1.3 - 0.3	1	m
Depth of Soil + Height of Structure = 1 + 5.5 + 1.6 + 1.6	9.7	m
Density of Ballast (Based on Design Basis Note RP002)	18.8	kN/m3
Density of Dry Soil	18	kN/m3
Density of Saturated Soil	20	kN/m3
SBC of Soil (assumed value)	100	kN/m2
Factor of Safety for Soil	1	
Concrete Grade fck	M 30	
Young's Modulus E = 5000 sqrt(30)	27386	N/mm2
SELF WEIGHT		
Self weight of Box calculated by STAAD		
SIDL		
Ballast Load = 18.8 kN/m3 × 1m × (0.4+0.25) m	12.22	kN/m
Weight of Rail (4 × 0.7 kN/m over 2.7 m sleeper)	1.04	kN/m
Number of Sleepers per m width	1.66	per m
Weight of sleepers @ 3.2 kN per sleeper = 3.2 × 1.66	5.312	kN/m
Weight of sleepers (of 2.7m length) for 1m strip	2	kN/m
Dry Soil Wt. = Dry Density 18 × 1m × 1 m	18	kN/m
Saturated Soil Wt. = Saturated Density 20 × 1m × 1 m	20	kN/m

LIVE LOAD

Span	P for BM	P for SF
1	461	462
1.5	520	520
2	550	550
2.5	570	625
3	580	735
3.5	600	810
4	675	870
4.5	735	925
5	810	1020
5.5	910	1100
6	995	1170
6.5	1060	1250
7	1125	1325
7.5	1185	1400
8	1240	1475
8.5	1335	1621
9	1400	1672
9.5	1459	1718
10	1511	1760
11	1688	1848
12	1760	1960

C/c span	11.9	m
Load for BM and SF is interpolated from the Table		
Load for BM	1752.8	kN
Load for SF	1911.5	kN

CDA = 0.15+8/(6+11.9), subject to a maximum of 1	0.597	
CDA Coeff. (2 - d/0.9) for 1.3 m fill	0.810	
This value is reduced from 0.5 to zero from fill height of 0.9m to 3m		
CDA modified for 1.3 m fill = 0.597 × 0.5 × 0.81	0.242	
Live Load for BM, 300mm Ballast = 1752.8 kN / 11.9 m	147.29	kN/m
Live Load for SF, 300mm Ballast = 1911.5 kN / 11.9 m	160.6	kN/m
Width of dispersion of live load - not to exceed c/c of tracks, i.e., 6m		
Sleeper Length	2.7	m
Dispersion length in Fill (2V: 1H)	1.3	m
Total width of dispersion = 2.7 + 1.3	4.0	m
Live Load for BM over 1m strip = 147.29 / 4	36.8	kN/m
Live Load for SF over 1m strip = 160.63 / 4	40.2	kN/m

CURVATURE

Vertical Reaction due to 1° curve	15	%
Effect of Curvature for BM = (15/100)×36.8	5.52	kN/m
Effect of Curvature for BM = (15/100)×40.2	6.03	kN/m

LONGITUDINAL FORCE: Not considered for Depth of Fill > 1m

Span	Tractive force kN
1.5	105
2	210
2.5	210
3	210
3.5	245
4	310
4.5	310
5	310
5.5	310
6	310
6.5	330
7	330
7.5	330
8	410
8.5	410
9	410
9.5	412
10	490
11	490
12	515

Tractive force for 11.9 m span	515	kN
Width of dispersion of tractive force (assumed)	3	m
Longitudinal forces considered since fill depth <= 1m		
Tractive force over 1m strip = 515 / 3	171.7	kN
Note: Braking force is less than Tractive force for spans < 20m		

WIND LOAD

Limiting value of wind pressure when bridge is loaded	1.5	kN/m2
Exposed height of moving load = 7.1 - 0.6 m	6.5	m
Load per m = 1.5 kN/m2 × 6.5 m	9.75	kN/m
This load is applied at h / 2 = 6.5 / 2 + 0.6	3.85	m
Moment = 9.75 kN/m × 3.85 m	37.54	kN-m per m length
Vertical Reaction on each rail = 37.5375 / 1.676 m	22.48	kN/m
This load is distributed by sleepers		
Length over which downward reaction is distributed = 4 m / 2	2	m
Vertical Reaction over 1m strip = 22.48 kN/m / 2 m	12	kN/m

MINIMUM EARTH PRESSURE

Minimum Coeff. of earth pressure	0.25	
Minimum Earth Pressure : Dry = 0.25 × 18 × 9.7	43.65	kN/m
Minimum Earth Pressure : Saturated = 0.25 × 20 × 9.7	48.50	kN/m

MAXIMUM EARTH PRESSURE

Maximum Coeff. of earth pressure	0.6	
Maximum Earth Pressure k □ h : Dry	104.76	kN/m
Maximum Earth Pressure k □ h : Saturated	116.40	kN/m

EARTH PRESSURE DUE TO DEAD LOAD SURCHARGE

Invariably, h < (L - B) for box culvert		
S - Live load Surcharge per m length	176	kN/m
V - Dead load Surcharge - Ballast + Sleeper	53.74	kN/m
Width of dispersion at formation level	3	m
MAXIMUM EP		
Ka V / B	10.75	kN/m
Ka V / (B + h)	2.54	kN/m
MINIMUM EP		
Ka V / B	4.48	kN/m
Ka V / (B + h)	1.06	kN/m

EARTH PRESSURE DUE TO LIVE LOAD SURCHARGE

MAXIMUM EP		
Ka S / B	35.20	kN/m
Ka S / (B + h)	8.31	kN/m
MINIMUM EP		
Ka S / B	14.67	kN/m
Ka S / (B + h)	3.46	kN/m

DESIGN OF TOP AND BOTTOM SLAB

Overall depth of the slab D	1600	mm
Depth in the haunch region = 1600+300	1900	mm
Effective cover to reinforcement	75	mm
Grade of concrete used fck =	M 30	

The top and bottom slab is designed symmetrically.

Design of Slab at the face of the Wall

Hogging Moment	2406.77	kN-m
Sagging Moment	59.8	kN-m
Shear	1916.77	kN

Design for Flexure

The design for flexure is done as per cl. 15.4.2.2.1 of CBC

Area of 32mm dia. at 150mm c/c, Fe 500 grade steel =	5362	mm^2

Lever arm = z

$$\frac{z}{d} = 1 - \frac{1.1\,fy\,Ast}{fck\,b\,d}$$

Effective depth of the haunch at the face of the wall	1825	mm
z / d = 1 – (1.1×500×5361.65146212658)/(30×1000×1825) =	0.946	(limited to 0.95)
MuR = 0.87 fy Ast z = 0.87×500 × 5361.65146212658 × 0.946×1825	4027	kN-m > Demand
Minimum % of steel (cl. 15.9.4.1 of CBC) for slab	0.2	%
Minimum As for the slab (0.2% of 1600 mm tk., 1m width)	3200	mm^2
Min. As based on Shear (cl. 15.4.3.2.3 of CBC) = V / 2 (0.87 fy)	2203	mm^2

The actual area of steel provided is greater than the minimum required.

Design for Shear

Shear resistance is calculated as per cl. 15.4.3 of CBC		
Shear stress v = V / b d = 1916.77 × 1000 / 1000 × 1825	1.05	N/mm^2
As per cl. 15.4.3.1 of CBC, v should not exceed 0.75 sqrt(fck) or 4.75 N/mm2, whichever is less.	4.107919	N/mm^2

Shear Capacity

$$v_c = \frac{0.27}{1.25}\left(\frac{100\,As}{b\,d} f_{ck}\right)^{1/3}$$

p = 100 As / b d = 100×5361.65146212658 / 1000×1825	0.294	%
vc = (0.27/1.25)×(0.294 × 30 ^ (1/3)	0.446	N/mm^2

Shear capacity is enhanced by a factor 's' based on the following expression		
s = $(500/d)^{1/4}$ or 0.7, which ever is greater (cl. 15.4.3.3 of CBC)		
s = (500/1825) ^ 0.25 =	0.723	
Since v > vc, stirrups need to be provided		
Hooked links are provided as stirrups. Bar diameter	10	mm
Spacing along the length	150	mm
Spacing along the barrel	150	mm

$$Asv > \frac{b\,s_v\left(\tau + 0.4 - s\tau c\right)}{0.87\,f_{sv}}$$

Note: Maximum value of fsv = 415 N/mm2

As > 1000×150 (1.05+0.4-0.723×0.446) / (0.87×415) =	470	mm^2 per m
As per leg = 470 / (1000 / 150)	70.5	mm^2
Hence, 10mm dia. hooked links are provided at the above mentioned spacing		

Design of Slab at Midspan

Hogging Moment	0	kN-m
Sagging Moment	3035.96	kN-m
Shear	100	kN

Design for Flexure

The design for flexure is done as per cl. 15.4.2.2.1 of CBC		
32mm diameter bars are provided at 150mm centres		
Area of Fe 500 grade steel provided =	5361.651	mm^2
Lever arm = z		

$$\frac{z}{d} = 1 - \frac{1.1\,fy\,Ast}{fck\,b\,d}$$

Effective depth of the slab	1525	mm
		(limited to
z / d = 1 – (1.1×500×5361.65146212658)/(30×1000×1525) =	0.936	0.95)
MuR = 0.87 fy Ast z = 0.87×500 × 5361.65146212658 × 0.936×1525	3328	kN-m>Demand
Minimum % of steel (cl. 15.9.4.1 of CBC) for slab	0.2	%

Minimum As for the slab (0.2%)	3200	mm^2
Min. As based on Shear (cl. 15.4.3.2.3 of CBC) = V / 2 (0.87 fy)	115	mm^2

The actual area of steel provided is greater than the minimum required.

DESIGN OF WALLS

Wall thickness at face of slab = 1400 + 100	1500	mm
Effective depth	1425	mm
Maximum Moment	3077.48	kN-m
Corresponding Axial Load	1810.85	kN
0.1 fck b D = 0.1×25×1000×1400	4200	kN

As per cl. 15.4.2.1.2 of the IRS Concrete Bridge Code (CBC), the axial load in beams can be ignored if the axial load is less than 0.1 fck times the cross sectional area.

Minimum reinforcement for walls is 0.2% on each face

Area of Fe 500 grade steel provided =	5361.651	mm^2
z / d = 1 – (1.1×500×5361.65146212658)/(30×1000×1425) =	0.931	(limited to 0.95)
MuR = 0.87 fy Ast z = 0.87×500 × 5361.65146212658 × 0.931×1425	3094	kN-m
		> Demand

Distribution Steel

Minimum % of distribution steel = 0.12% of concrete area

As = 0.12/100 ×1000 × 1400	1920	mm^2

16mm diameter bars are provided at 100mm centres

BASE PRESSURE

Self Weight

Volume of concrete per m length	58.5	m^3
Weight of box = 58.5 × 25 kN/m3	1463	kN/m
Weight per m length = 1462.5 / (10.5 + 2 × 1.4)	110	kN/m^2

SIDL

Ballast + Rail + Sleepers (increased by 20%)	18.3	kN/m^2
Overburden saturated soil	20	kN/m^2

Live Load

LL + Curvature + Vertical reaction due to wind	67.96	kN/m^2

Load factors for SLS

1.0 for DL, LL and 1.2 for SIDL

Base pressure = 1×110 + 1.2×18.312 + 1×67.96	223.9	kN/m^2

Minimum SBC required is 225 kN/m^2

In case the SBC is found to be less than 225 kN/m^2, necessary ground improvement shall be carried out by the Contractor

1.7 MATERIAL INFORMATION

1.7.1 Requirement of Earthwork Material Specified in GE: 0014, RDSO

(1) Subsoil, Embankment and Track Subgrade

The following properties are ideal and poor soils for earthwork.

1) Ideal Soil

- High bearing capacity (BC) in reference to static loads, minor settlement
- High BC in reference to dynamic loads, due to unequal grain size, high structural resistance, and good consolidation
- Elasticity
- Stable as regards erosion
- High water permeability
- Filter criteria w.r.t ballast layer above and sub soil below
- Cost effectiveness in supply and construction

2) Poor Soil

- Non- cohesive and loose
- Cohesive, soft to semi solid mixed soil with various content of sand, silt, clay and water.
- Contain solid rocks of irregular size, solid rocks with cohesive weathering elements.

(2) Blanket

Specifications of the material for blanket layer over prepared sub-grade should be such that it is well-graded sandy gravel layer of adequate hardness. Particles size gradation curve should be more or less within Enveloping Curves of blanket material as shown in Fig. 9 below & Grading Percentages within the range given in Table-5 below and should also have following criteria satisfied :

i) Cu > 7 and Cc between 1 and 3.

ii) Fines (passing 75 microns) : 3% to 10%.

iii) Los Angeles Abrasion value < 35%.

iv) Minimum required Soaked CBR value 25% of the blanket material compacted at 100% of MDD

In exceptional cases on technical and economic considerations, LAA value may be relaxed upto 40% by Pr CE on Open Line & CAO/C in construction projects.

v) Filter Criteria should be satisfied with prepared subgrade/subgrade layer just below blanket layer, as given below :

Criteria–1: D15 (blanket) < 5 x D85 (sub-grade)

Criteria–2: D15 (blanket) > 4 to5 D15 (sub-grade)

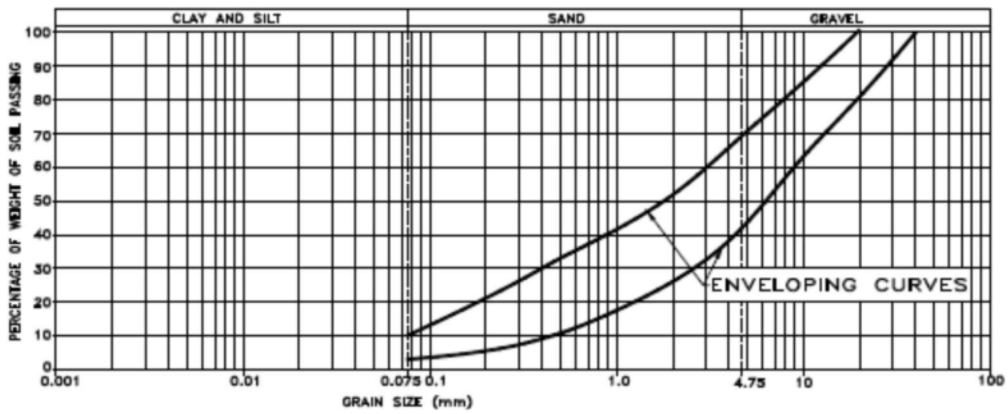
Criteria–3: D50 (blanket) < 25 x D50 (sub-grade)

Filter Criteria is optional, at present. This can be adopted with the experienced gained of its compliance for different types of soils with blanket.

Table 1.7-1 Grading Percentage of Blanket Material

S.no.	IS Sieve Size	**percent passing** (by weight)
1.	40 mm	100
2.	20 mm	80 – 100
3.	10 mm	63 – 85
4.	4.75 mm	42 – 68
5.	2 mm	27 – 52
6.	600 micron	13 – 35
7.	425 micron	10 – 32
8.	212 micron	6 – 22
9.	75 micron	3 - 10

Source: RDSO, GE:0014



Source: RDSO, GE:0014

Figure 1.7-1 Enveloping Curves for Blanket Material

1.7.2 Ballast

(1) Basic Quality

Ballast should be hard durable and as far as possible auger along edge/corners, free from weather portions of parent rock, organic impurities and inorganic residues.

(2) Particle Shape

Ballast should be cubical in shape as far as possible. Individual pieces should not be flaky and should have generally flat faces with not more than two rounded/sub rounded faces.

(3) Mode of Manufacture defined in IRS-GE-1, RDSO

Ballast shall be machine crushed.

1.7.3 Summary Table:

Following Table shows requirement of earthwork and ballast material.

Table 1.7-2 Summary of Requirement of earthwork and ballast material

Layer	Raw Materials								Compacted Layer			
	Maximum Size	Fine Content	Uniformity Coefficient, Cu	Coefficient of Curvature, Cc	CBR	Aggregate Impact Value (AIV)	Abrasion Value	Water Absorption	Thickness		Compaction, % of MDD (Maximum Dry Deisity)	Deformation Modulus, EV2
									Total	One Layer		
Ballast	65 mm					Max. 20%	Max. 30%	Max. 1%	350 mm	350 mm		
Blanket	40 mm	Fines (passing 75 microns) 3-10%	> 7	1 – 3	>=25%		<35%		600mm	250 mm	100%	120 Mpa
Prepared Sub-Grade	–	Fines (passing 75 microns) 12%-50% (SQ2), or <12% (SQ3)	>= 2		>=8%				1,000mm	300 mm	98%	60 Mpa
Embankment Fill	200 mm	Fines (passing 75 microns) 12%-50% (SQ2), or <12% (SQ3)	>= 2		>=5%				–	300 mm	97%	30 Mpa

Source: The Consultant

1.7.4 Procurement Procedure

(1) Related Authority

The following organizations are generally to be involved in sourcing of earthwork materials. This is only for guidance of the Contractor. The materials required for the project shall be arranged by the Contractor using his own resources..

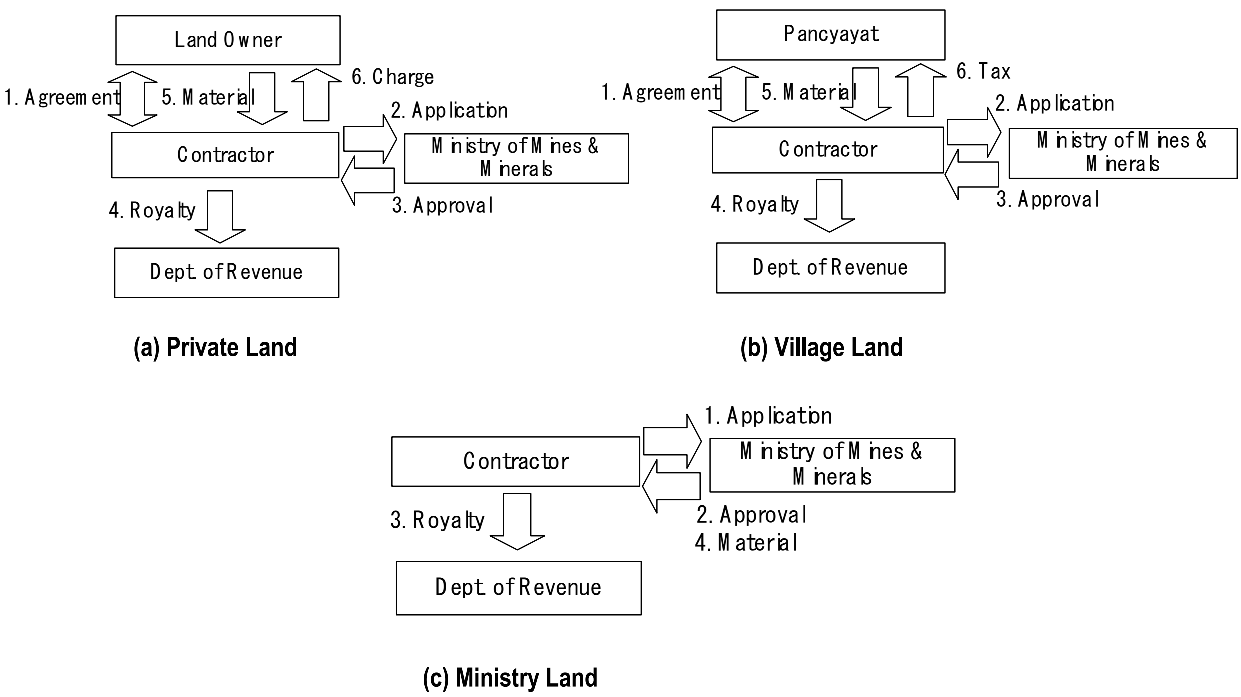
Table 1.7-3 Related Authority

No.	Name	Role	Reference
1.	Ministry of Mines & Minerals	Give approval regarding Borrow area detail (Location, Depth & Area etc.)	Every state has Ministry office
2.	Department of Revenue	Collect Royalty	Every state has Ministry office
3.	Panchayat	Collect Tax	If land related to the panchayat property
4.	Others	Traffic Police Regional Transport Office (RTO) etc.	Traffic police & RTO handle the issue related to the over loading & timing of Vehicle Entry in Area etc.

Source: Investigation by The Consultant

(2) Purchase Procedure

Most of the earthwork materials will have to be sourced by the Contractor from the private land, indicative methodology for arranging earthwork materials from various land owners is given in flow diagram below:.



Source: The Consultant

Figure 1.7-2 Procurement Procedure for Borrow Material

1.7.5 Indicative List of Related Authorities

Following table lists the authorities related to the purchase of earthwork and ballast materials.

Table 1.7-4 Indicative List of Related Authority

CPM	Name	Address
Vadodara	1. Ministry of Mines & Minerals	Dept. of Geology & Ministry of Mines & Mineral 7th floor Kuber Bhavan, Vadodra Distt. Vadodra
	2. Revenue dept.	Dept. of Revenue Kuber Bhavan, Vadodra Distt. Vadodra
Ahmedabad	1. Ministry of Mines & Minerals	Dept. Of Geology & Ministry of Mines & Minerals Bahumali Building, Lal Darwaza, Ahemdabad Distt. Ahmedabad
	2. Revenue dept.	Dept. Of Revenue Bahumali Building Lal Darwaza Ahemdabad Distt. Ahmedabad
Ajmer	1. Ministry of Mines & Minerals	**Banaskantha office:** Dept. Of Geology & Ministry of Mines & Minerals Palanpur distt. Banaskantha
	2. Revenue dept.	**Banaskantha office:** Dept. Of Revenue Palanpur distt. Banaskantha
Ajmer & Jaipur (Rajasthan)	1.Ministry of Mines & Minerals	**(Head Quarter) Rajasthan State** 1.Directorate, Department of Mines & Geology, Shastri Circle, Udaipur (Raj) - 313001 E-Mail: adg@dmg-raj.org **Alwar office:** Dept. of Mines & Geology Khanij Bhawan Mevati Nagar, Alwar **Sikar office:** Dept. of Mines & Geology Khanij Bhawan , Jhujnu by pass Sikar **Nagaur office:** Dept. of Mines & Geology Khanij Bhawan , Opposite Nagaur stadium, Nagaur **Jaipur office:** Dept. of Mines & Geology Khanij Bhawan , Tilak Marg Udhyog Bhawan Parisar , Jaipur **Ajmer office:** Dept. of Mines & Geology Khanij Bhawan , Near R.P.S.C, Jaipur Road , Ajmer **Pali office:** Dept. of Mines & Geology Khanij Bhawan , Sojat City, Sojat **Sirohi office:** Dept. of Mines & Geology Khanij Bhawan , Opposite main post office, Tin batti choraha Sirohi
	2. Revenue Dept.	**Alwar office:** Dept. of Revenue, Alwar Distt.Alwar **Sikar office:** Dept. of Revenue, sikar Distt. Sikar **Nagaur office:** Dept. of Revenue, Nagaur Distt. Nagaur **Jaipur office:** Dept. of Revenue, Jaipur Distt. Jaipur **Ajmer office:** Dept. of Revenue, Ajmer Distt. Ajmer **Pali office:** Dept. of Revenue , sojat Distt. Sojat **Sirohi office:** Dept. of Revenue, Sirohi Distt. Sirohi

Source: Information compiled by the The Consultant

DFCC NEW DELHI

NK CONSORTIUM NJPi

1.8 CODES, MANUALS AND SPECIFICATIONS FOR THE DESIGN AND CONSTRUCTION OF WDFC PROJECT

The list of technical standards, codes, and manual made available by DFCCIL tabulated as follows:

Apart from the basic data, technical specifications and specific requirements listed in the Employer's Requirement, all items of works shall be governed by the latest versions of the following Codes, Specifications as revised/corrected/amended (with latest correction slip) up to the time of bid submission.

The Contractor is requested to arrange the following codes/manuals for reference during the design stage.

No.	Reference Authority	Description of Code/Manual
1	Indian Railway Standard Codes and specifications (IRS)	1. Indian Railway Bridge rules, specifying the loads for Design of Superstructure and substructure of Bridges. 2. IRS Specifications for Steel Bridges Code 3. IRS : Welded Bridge Code for steel bridge girders 4. Indian Railway Schedule of Dimensions, to be consulted with approval of employer where provisions in DFC schedule of dimensions do not cover the particular situation. 5. Draft DFC Schedule of Dimensions 6. Indian Railway Code for Practice of Plan/Reinforced and Pre-stressed concrete for general / bridge construction (Concrete Bridge Code) 7. Indian Railway Bridge Manual 8. Indian Railway Manual of Instruction on Long Welded Rails 9. IR Manual for Flash Butt Welding of Rails 10. IR Standards Specification for Fusion Welding of Rails Alumino -Thermic Process. 11. IRS T 29 2000 Cast manganese Steel Crossings. 12. IRS T 39 1985 Pretressed Concrete Sleepers. 13. IRS GE 1 June 2004 Ballast specification. 14. IRS T 1966 Fish Plates and Fish Bolts. 15. IRS Fabrication and Erection of Steel Girder Bridges & Locomotive Turn Tables (BI-1979) 16. RDSO/M&C/RP-194/94 – Wiper seal & dust seal. 17. Indian Railways Permanent Way Manual. 18. Indian Railways Works Manual. 19. IRS Standard Code of Practice for the design of Sub-structure & Foundations. 20. IRS: Manual on the design and construction of well and pile foundation. 21. Guidelines for earthwork in railway projects: Guideline No. GE:G-1, July, 2003 22. Guidelines and Specifications for Design of Formation for Heavy Axle Load - Report No. RDSO/2007/GE : 0014 23. Report No. RDSO/2007/GE: 0011: Guidelines for blanket layer provision on track formation with emphasis on heavy axle load train operation. 24. Report No. GE: R-50: Transitional System on approaches of bridges issued by RDSO. 25. RDSO Specification No. GE: IRS-2 (Final): Specification for mechanically produced blanketing material for railway formation including guidelines for laying. 26. Indian Railway – Engineering Code.

No.	Reference Authority	Description of Code/Manual
2	Indian Roads Congress Codes and Specifications	27. IRC:5 Standard Specifications and Codes of Practice for Road Bridges Section – I – General features of design. 28. IRC:6 Standard Specifications and Codes of Practice for Road Bridges – Section – II – Loads and Stresses. 29. IRC:18 Design Criteria for Pre-stress Concrete Road Bridges (Post-tensioned concrete). 30. IRC:21 Standard Specifications and Codes of Practice for Road Bridges – Section III Cement concrete (Plain & reinforced) 31. IRC:22 Standard Specifications and Codes of Practice for Road Bridges – Section VI Composite Construction. 32. IRC:24 Standard Specifications and Codes of Practice for Road Bridges – Section V Steel Road Bridges. 33. IRC:83 (Part-III) Standard Specifications and Codes of Practice for Road Bridges – Section – IX – Bearings Part -III. Pot, POT cum PTFE Pin and Metallic Guide Bearings 34. IRC:78 Sub-structure for Road Bridges. 35. IRC:87 Design and erection of false work for road bridges. 36. Specifications for Road and Bridge Works issued by Ministry of Road Transport & Highways. (MORTH).
3	Indian Standard Specifications – Bridges & General	37. IS:2062-1992 Steel for General Structural Purposes – Specifications (Fourth Revision) 38. IS:8500-1991 Structural steel – Micro alloyed (Medium and high strength qualities – specification (first Revision) 39. IS:1024-1999 Use of Welding in Bridges and Structures subject to Dynamic Loading – code of Practice – 2nd Revision (Reaffirmed 1998) 40. IS: 1261-1959 Seam Welding in Mild Steel (Reaffirmed 1998) 41. IS: 1367 Technical Supply conditions for Threaded steel fasteners. 42. IS:9595-1996 Metal Arc welding of Carbon and Carbon Manganese Steels – Recommendations (First Revision). 43. IS: 3502-1994 Steel Chequered Plates – Specifications (2nd Revision). 44. IS:7205-1974 Safety Code for erection of Structural Steel Work (Fifth Reprint July, 2001). 45. IS:7215-1974 Tolerances for Fabrication of Steel Structures (Reaffirmed 1995, Sixth Reprint July, 1997) 46. IS: 814-1991 Covered Electrodes of Manual Metal Are Welding (Fifth Revision) 47. IS:1323-1982 Oxy-acctylene Welding for Structural Work in Mild Steel (Second Revision) 48. IS:1786-1985 High Strength Deformed Steel Bars & Wires for Concrete Reinforcement (Third Revision). 49. IS:432-1982 (Part-I) Mild Steel, Medium Tensile Steel Bars and Hard Drawn. 50. IS:432-1982 (Part-II) Mild Steel, Medium Tensile Steel Bars and Hard Drawn. 51. IS:875-1987 (Part 3) Code of Practice for Design Loads (Other than Earthquakes) for Buildings and Structures – Wind Loads (Second Revision) 52. IS:1893-2002 (Part – I) – Criteria for Earthquake Resistant Design of Structures : Part – I – General Provisions and Buildings (Fifth Revisions) 53. IS:1161-1998 Steel Tubes for Structural Purposes – Specifications

No.	Reference Authority	Description of Code/Manual
		(Fourth Revisions)
		54. IS:8629-1977 (Parts I to III) Protection of Iron and Steel Structures from Atmospheric Corrosion (Reaffirmed 2002).
		55. IS:3757-1985 High Strength Bolts.
		56. IS:6623-1985 High Strength Nuts.
		57. IS:1148-1982 Specification for hot rolled rivet bars (upto 40mm dia) for structural purposes (third revisions)
		58. IS:1149-1982 High tensile steel rivet bars for structural purposes (third revision)
		59. IS: 1030 Grade 280-520W- Cast Steel.
		60. IS: 6911 Stainless Steel.
		61. IS: 1363- (all 3 parts) Hexagon head bolts, screws and nuts of product grade C.
		62. IS: 1929 Hot forged steel rivets for hot closing (12 to 36 mm dia).
		63. IS: 57 Red lead for paints and other purposes.
		64. IS: 75 Linseed oil, raw and refined.
		65. IS : 77 Linseed oil, boiled for paints
		66. IS: 102 Ready mixed paints, brushing, red lead, non-settling priming.
		67. IS: 123 Ready mixed paints, brushing, finishing, semi-gloss, for general purposes to Indian Colours etc.
		68. IS: 2339 Aluminum paints for general purposes, in dual container.
		69. IS: 280 Mild steel wire for general engineering purposes.
		70. IS: 456 Plain and reinforced concrete.
		71. IS: 1182 Radiographic examination of butt joints in steel plates.
		72. IS: 2595 Radiographic testing.
		73. IS: 383 Coarse and fine aggregate from natural sources for concrete.
		74. IS: 2386 (all 8 parts) Tests for aggregates for concrete
		75. IS: 3025 (all 49 parts) – Methods of sampling and test for water and waste water.
		76. IS: 1791 Batch type concrete mixers.
		77. IS: 4634 Methods of testing performance of batch type concrete mixers.
		78. IS: 6925 Methods of test for determination of water soluble chlorides in concrete admixtures.
		79. IS: 9103 Admixtures for concrete.
		80. IS: 516 Method of test for strength of concrete.
		81. IS: 4031 (all 15 parts) – Physical tests for hydraulic cement.
		82. IS: 5513 Vicat apparatus.
		83. IS: 10080 Vibration machine for casting standard cement mortar cubes.
		84. IS: 10262 Concrete mix design.
		85. IS: 1343 Pre-stressed concrete.
		86. IS: 975 (all 5 parts) – Design loads (other than earthquakes) for buildings and structures.
		87. IS: 2720 (all 41 parts) – method of tests for soil.
		88. IS: 800 General construction in steel.
		89. IS: 786 Conversion factors and conversion tables.
		90. IS: 6639 Hexagonal bolts for steel structures.
		91. IS: 104 Ready mixed paint, brushing, zinc chrome, priming.
		92. IS: 2074 Ready mixed paint, air drying, red oxide-zinc chrome.
		93. IS: 1852 Rolling and cutting tolerances for hot rolled steel products.
		94. IS: 1270 Metric steel tape measure.
		95. IS: 487 Brush, paint and varnish.
		96. IS: 3400 (all 22 parts) – Methods of tests for vulcanized rubbers.

No.	Reference Authority	Description of Code/Manual
		97. IS: 1915 Steel bridge code.
		98. IS: 3085 Method of test for permeability of cement mortar and concrete.
		99. IS: 7320 Concrete slump test apparatus.
		100. IS: 5515 Compaction factor apparatus.
		101. IS: 6586 Metal spraying for protection of iron steel.
		102. IS: 5666 Etch primer.
		103. IS: 3955 Design and construction of well foundations.
		104. SP 6, 7, 16, 21,22,23,24,34,36, 52,60,70.
		105. IS: 2911 Design and construction of pile foundation
		106. IS: 5624 Foundation bolts.
		107. IS: 8112 43 Grade OPC.
		108. IS: 4326 Earthquake resistant design and construction of buildings.
		109. IS: 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces.
		110. IS: 34 White lead for paints.
		111. IS: 887 Animal tallow.
		112. IS: 816 Metal arc welding for general construction in mild steel.
		113. IS: 819 Resistance spot welding for light assemblies in mild steel.
		114. IS: 1024 Welding in bridges and structures subject to dynamic loading.
		115. IS: 1261 Seam welding in mild steel.
		116. IS: 4081 Safety code for blasting and related drilling operations.
		117. IS: 3764 Safety code for excavation work.
		118. IS: 7293 Safety code for working with construction machinery.
		119. IS: 817 Training and testing of metal arc welders.
		120. IS: 1200 (all relevant parts) – Method of measurement of building and civil engineering works.
		121. IS: 14268 Prestressing Strands
		122. IS: 2911 Code of practice for design and construction of pile Foundations (all parts)
		123. IS: 269 Indian Standard Specifications for Ordinary & Low Heat Portland Cement.
		124. IS: 432 Indian Standard Specifications for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire.
		125. IS: 4082 Recommendations of stacking and storage of construction materials at site.
		126. IS: 1199 Indian Standard Specifications for Method of Sampling and analysis of concrete.
		127. IS: 2502 Code of practice for bending and fixing of Bars for concrete reinforcement.
		128. IS: 2722 Indian Standard Specifications for Portable Swing Weight batches for concrete (Single and Double Bucket type)
		129. IS: 2751 Code of Practice for Welding of Mild Steel Bars used for reinforced concrete construction.
		130. IS: 4926 Indian Standard Specifications for ready Mixed concrete
		131. IS:3764 -1992 Code of safety for excavation work.
		132. IS:4081-1986 Safety code for Blasting and related drilling operations.
		133. IS:7293-1974 Safety code for working with construction machinery.
		134. IS:3696-1987 (Part - I) Safety code for scaffolds and Ladders (Part I - Scaffolds)
		135. IS:3696-1987 (Part - II) Safety code for Scaffolds and Ladders (Part II - Ladders)
		136. IS:3016-1965 Code of practice for Fire precaution in welding and cutting operations.

No.	Reference Authority	Description of Code/Manual
		137. IS: 7293-1974 Safety code for working with construction machinery. 138. IS: 14881-2001 Method for Blast Vibration Monitoring – Guidelines. 139. IS: 2911 (all Parts) Code of Practice for Design and Construction of Pile Foundations. 140. IS: 1493 Design of Bored and Cast in Situ Piles Founded in Rock.- Guide lines 141. IS: 1785 Part 1 High Tensile Steel Wire. 142. IS:1080-1985 Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell) 143. IS:1498-1970 Classification and identification of soils for general engineering purposes 144. IS:1725-1982 Specification for soil based blocks used in general building construction 145. IS:1888-1982 Method of Load Test on Soils 146. IS:1892-1979 Code of practice for subsurface investigations for foundations 147. IS:1904-1986 Code of practice for design and construction of foundations in soils: general requirements 148. IS:2131-1981 Method for Standard Penetration Test for Soils 149. IS:2132-1986 Code of practice for thin walled tube sampling of soils 150. IS:2809-1972 Glossary of Terms and Symbols Relating to Soil Engineering 151. IS:2810-1979 Glossary of terms relating to soil dynamics. 152. IS:2974-1982 Part I : Code of Practice for Design and Construction of Machine Foundations - Part I : Foundation for Reciprocating Type Machines. 153. IS:4091-1979 Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles
4	Indian standard Specifications - Soil	154. IS:2720-1983 Part 1 : preparation of Dry soil sample for Various test 155. IS:2720-1973 Part 2 : Methods of test for soils: Part 2 Determination of water content 156. IS:2720-1980 Part 3 : Sec 1 : Methods of test for soils: Part 3 Determination of specific gravity Section 1 fine grained soils 157. IS:2720-1980 Part III : Sec 2 : Test for Soils - Part III : Determination of Specific Gravity - Section 2 : Fine, Medium and Coarse Grained Soils 158. IS:2720-1985 Part 4 : Methods of Test for Soils - Part 4 : Grain Size Analysis 159. IS:2720-1985 Part 5 Method of Test for Soils - Part 5 : Determination of Liquid and Plastic Limit 160. IS:2720-1972 Part 6 Methods of test for soils: Part 6 Determination of shrinkage factors 161. IS:2720-1980 Part 7 Determination of water content drt density relation using light compaction 162. IS:2720-1983 Part 8 Determination of water content drt density relation using Heavy compaction 163. IS:2720-1991 Part 10 Methods of test for soils: Part 10 Determination of unconfined compressive strength 164. IS:2720-1993 Part 11 Methods of test for soils: Part 11 Determination of the Shear Strength Parameters of a specimen tested in inconsolidated, indrained triaxial compression without the measurement of pore water pressure 165. IS:2720-1981 Part 12 Methods of test for soils: Part 12 Determination of shear strength parameters of soil from consolidated undrained triaxial compression test with measurement of

No.	Reference Authority	Description of Code/Manual
		pore water pressure 166. IS:2720-1986 Part 13 Methods of Test for Soils - Part 13 : Direct Shear Test 167. IS:2720-1983 Part 14 Methods of Test for Soils - Part 14 : Determination of Density Index (Relative Density) of Cohesionless Soils 168. IS:2720-1965 Part 15 Methods of Test for Soils - Part XV : Determination of Consolidation Properties 169. IS:2720-1987 Part 16 Laboratory determination of CBR 170. IS:2720-1992 Part 20 Methods of test for soils: Part 20 Determination of linear shrinkage 171. IS:2720-1977 Part 21 Determination of total soluble solids 172. IS:2720-1972 Part 22 Methods of test for soils: Part 22 Determination of organic matter 173. IS:2720-1976 Part 23 Methods of test for soils: Part 23 Determination of calcium carbonate 174. IS:2720-1976 Part 24 Methods of Test for Soils - Part XXIV : Determination of Cation Exchange Capacity 175. IS:2720-1982 Part 25 Methods of test for soils: Part 25 Determination silica sesquioxide ratio 176. IS: 2720-1987 Part 26 Determination of pH value of soil 177. IS: 2720-1977 Part 27 Methods of test for soils: Part 27 Determination of total soluble sulphates 178. IS:2720-1974 Part 28 Methods of test for soils: Part 28 Determination of dry density of soils inplace, by the sand replacement method 179. IS:2720-1975 Part 29 Determination of dry density of soil in place by the core cuter Method 180. IS:2720-1980 Part 30 Methods of test for soils: Part 30 Laboratory vane shear test 181. IS:2720-1987 Part 36 Methods of test for soils: Part 36 Laboratory determination of permeability of granular soils (constant head) 182. IS:2720-1976 Part 37 Methods of test for soils: Part 37 Determination of sand equivalent values of soils and fine aggregates 183. IS:2720-1977 Part 40 Determination of Free soil index of Soils
5	Other International Codes	184. EN1990-2002 (Eurocode - Basis of Structural Design) – (For Safety, comfort deformation including twist and deflection) 185. EN1991-2-2003 (Eurocode 1 - Action on Structures, part 2 – Traffic Loads on Bridges)-(Natural frequency range and Loading for fatigue estimation) 186. EN1992-1:2004 (Eurocode 2 - Design of Concrete Structures, Part 1-General Rules and Rules for Buildings) 187. EN1992-1-1:2004 (Eurocode 3 - Design of Steel Structures, Part 1-1 -1 General Rules) - (Classification of cross sections). 188. EN1993-1-8:2002 (Eurocode 3 – Design of Steel Structures, Part 1 - 8 Design of Joints) – (Classification of HSFG Bolts). 189. EN1993 – 1-9:2002 (Eurocode 3 – Design of Steel Structures, Part 1-9 Fatigue Strength of Steel Structures). 190. EN1993-2:2004 (Eurocode 3 – Design of Steel Structures, Part 2 – Steel Bridges) - (Requirements for fatigue assessment, Road and Rail Bridges). 191. EN1994-2:2003 (Eurocode 4 – Design of Composite Steel & Concrete Structures, Part 2 – Rules for Bridges) – (Width of effective flange, shear connectors).

NK CONSORTIUM NJPI

NEW DELHI

No.	Reference Authority	Description of Code/Manual
6	UIC Codes	192. UIC 774 – 3R Forces due to LWR. 193. UIC-772R: Bearings of rail bridges. 194. UIC 774-3R Track/Bridge interaction
7	BS Codes	195. BS – 3784 Grade "A" Specifications for Poly tetrafluroethylene 196. BS-5350: Standard Method of test of adhesives, Part C9, Floating roller peel test. 197. BS-5400 Part – 1 General Statement. 198. BS-5400 Part – 2 Specifications for loads. 199. BS-5400 Part – 3 Code of Practice for Steel Bridges. 200. BS-5400 Part – 5 Code of Practice for composite Bridges. 201. BS-5400 Part- 9 Bridge Bearings. 202. BS-5400 Part-10 Code of Practice for Fatigue. 203. BS-1449, 3484, 1134, 5296.
	NOTE: 1. The above list is only for guidance of the Contractor is by no means exhaustive. All IS IRC and IRS Codes with latest correction slips pertaining to the work shall be applicable. 2. Where the drawings and specifications described for the work is in general terms and not in complete detail, it shall be understood that only the best general practice is to prevail, materials and workmanship of the best quality are to be employed and the instructions of the Engineer are to be complied with.	

The Consultant has provided a softcopy of the following codes/manuals in Portable Document Format (PDF), compiled in a DVD disk.

Subject	Description
Bridges	**Bridge Manual 1998 with Correction Slips 13 to 19**
	Bridge Rules 2008 with correction Slips 40 to 42
	Code of Practice for the Design of Sub-Structures and Foundation of Bridges 2003 with Correction Slip 23 to 29
	Code of Practice for Plain, Reinforced & Pre-stressed Concrete for General Bridge Construction 2003 with Correction Slip 8 to 12
	Standard Specification for Fabrication and Erection of Steel Girder Bridges and locomotive Turn-tables (2008)
	Manual of the Design and Construction of Well and Pile Foundations (1985) with Correction Slip 1 to 2
	Code of Practice for the Design of Steel or wrought Iron Bridges for Carrying Rail, Road or Pedestrian Traffic (2003)
	Code of Practice for Metal Arc Welding in Structural Steel Bridges Carrying Rail, Rail-cum-Road or Pedestrian Traffic – Welded Bridge Code (1989)
Earth Work	**Guidelines and Specifications for Design of Formation for heavy axle Load RDSO/2007/GE: 0014 (2009)**
	Guidelines for Earth Work in Railway Projects GE: G-1 (2003)
Track	**Manual for Flash Butt Welding of Rails (2004)**
	Manual for Fusion Welding of Rails by Alumino-Thermic Process (2006)
	Manual for Glued Insulated Rail Joints (1998)
	Indian Railway Permanent Way Manual with Correction Slips 100 to 120 (2004)
	Schedule of Dimensions 1676 mm Gauge, addendum and Correction Slips 1 to 3 (2004)
	Track Machine Manual (2009)
	Manual for Ultrasonic Testing of Rails and Correction Slips 1 to 4 and Correction Slip of Jan 2008 (2006)
	Manual of Instructions for Long Welded Rails and Correction Slips 10 to 13 (1996)

Subject	Description
	Track Manual Volume I (1994) and Track Manual Volume II (1989)
	Specifications for Track Ballast IRS-GE-1 (2004)
	Rail Specifications IRS – T12-2009
Others	**Engineering Code with Correction Slip 42 (2009)**
	Draft Business Plan for DFCCIL (2010)