GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

2018/Proj./KMRCL/DBR/30/10 New Delhi, dated 20.08.2018

Managing Director,
Kolkata Metro Rail Corporation Ltd.,
Munshi Premchand Sarani,
HRBC Office Complex,
4th & 5th Floor, Kolkata-700 021

Sub: Design Basis Report for viaduct of East West Metro Corridor, Kolkata.
Ref: KMRCL's letter No. KMRCL/DPP/577/2018 dated 03.08.2018

The Design Basis Report (DBR) for viaduct (Revision-R2, August-2018), for Standard Gauge (1435mm) of East-West Metro Corridor project, Kolkata has been examined in consultation with RDSO and approval of Railway Board is hereby conveyed.

Accordingly, approved copy of DBR is enclosed.

Encl: As above

20-08-2018
(Ruth Changsan)
Director/MTP
Railway Board
☎ 011-23097061

Copy to: **Executive Director/UTHS**, RDSO, Manak Nagar, Lucknow w.r.t RDSO's letter No. UTHS/53/KMRCL/Civil dated 07.08.2018

KMRC

KOLKATA METRO RAIL CORPORATION LIMITED

(A Govt. of India Undertaking)

KOLKATA EAST-WEST METRO PROJECT



DESIGN BASIS REPORT FOR VIADUCT

(Revision – R2)

August 2018

Project Directorate
Approved on
20/8/18
Railway Board

KOLKATA METRO RAIL CORPORATION LIMITED
'KMRCL BHAWAN', 2nd& 3rd Floor,
Munshi Premchand Sarani,
KOLKATA – 700 021

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Project Director
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1. INTRODUCTION

1.1. Brief Presentation of The Project

East West Metro Corridor of Kolkata is being executed by Kolkata Metro Rail Corporation [KMRCL]. The Corridor is 16.67 km long having 10 Km. as underground and 5.79 km as elevated with Depot at Central Park in Salt Lake, Kolkata. There are 6 Underground and 6 Elevated Stations. Track is of Standard Gauge [1435 mm]. There is no At Grade Station.

1.2. Geometrical Design Feature

As per SOD, minimum curvature for elevated section 120m.

Spacing of tracks for elevated section is 4200 mm. Maximum gradient in mid-section is 4% with grade compensation @0.04% per degree of curvature.

1.3. Scope of DBR

This Design Basis Report is being submitted highlighting the design methodology of the project. All design works, cost estimates and BOQ calculations have been performed taking into consideration this Design Basis Report.

2. Proposed Structural System of Viaduct

2.1. Superstructure system

Superstructure is normally simply supported prestressed segmental box girder [8.2m wide]. In a stretch at Duttabad [11 spans], 3 span continuous, 2 span continuous and simply supported steel composite box girder have been used for superstructure.

2.2. Emergency Walkway

Walkway on the viaduct is provided for the evacuation of the passengers in safe condition. The minimum width of walkway is 550 mm.

2.3. Bearing

Elastomeric bearings/POT-PTFE Bearings are adopted which is placed underneath box girder for transfer of vertical force & shear key (protruding above the pier head) for transfer of in plane forces. Spherical bearings have been used for Duttabad viaduct [11

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spans of composite steel box girder].

2.4. Substructure system

The viaduct Superstructure is supported on single cast in-situ RCC circular piers with hammerhead pier cap.

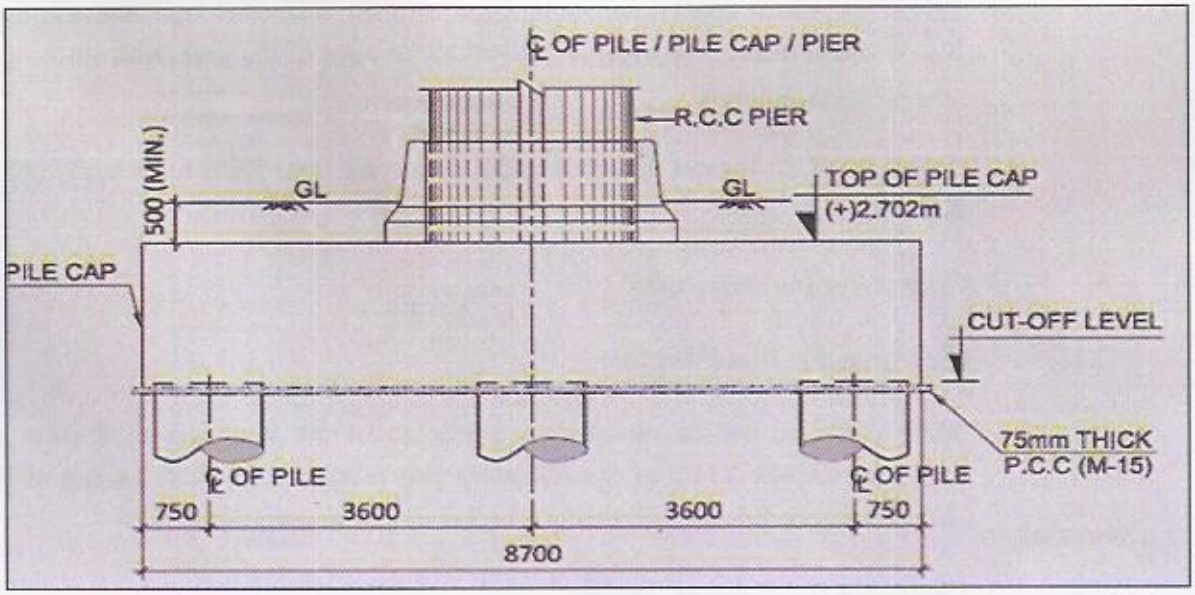
The shape of the pier follows the flow of forces. For the standard spans, the pier gradually widens at the top to support the bearing under the box webs.

Cantilever piers have been designed for specific eccentricities at the specific locations.

To prevent the direct collision of vehicle to pier, a New Jersey shaped crash barrier of 1.0 m height above existing road is provided all around the pier.

2.5. Foundation system

The entire stretch of viaduct is supported on suitable dia. bored cast-in-situ vertical piles. The typical arrangement is as under.

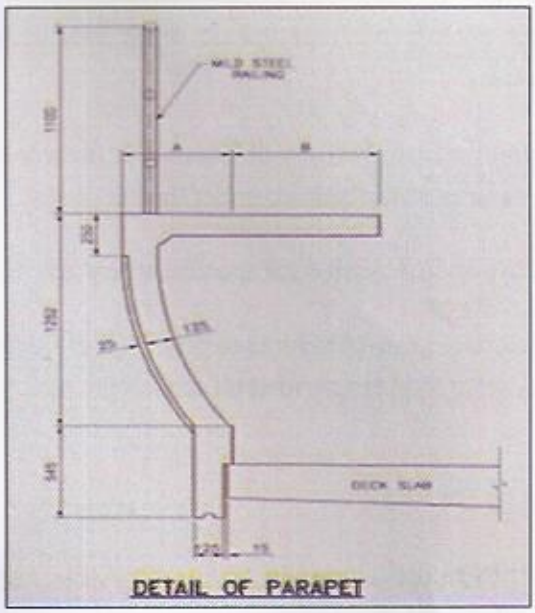


TYPICAL SECTION OF PILE/PILE-CAP

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2.6. Parapets



DETAIL OF PARAPET

Parapet is precast counter balancing type 3m long segmental type with minimum M30 R.C.C construction. The same is stitched to the edge of the deck with stitching beam of size 250mmx 400mm.

The width of the Parapet (effective width) is varying from 550m to 750mm as per SOD of KMRCL.

3. Clearances for Structures

3.1. Clearance for Road Traffic:

Minimum 5.5m vertical clearance available at 0.475m from pier shaft outer line. This conforms to para 2.11.2 of Specifications and Standards for Four Laning of Highways Through Public Private Partnership – Indian Road Congress 2009.

3.2. Clearance for Railway Traffic:

Railway traffic is not crossing the alignment of East West Metro Corridor of Kolkata. However, if it comes in future it will be as per Indian Railway Schedule of Dimensions.

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3.3. Clearances for Metro Traffic:

There is no Metro Traffic Crossing the alignment in the Viaduct. However, if it comes in the future then the clearances per the SOD of relevant Metro will be maintained.

4. Structural Materials and Properties

4.1. Cement:

Cement used is 43/53 grade OPC conforming to IS: 8112 as laid down in clause 4.1 of IRSCBC.

4.2. Concrete:

4.2.1. Density:

24/25 kN/m^3 for PSC and RCC based on reinforcement percentage, 23 kN/m^3 for plain cement concrete (IS:875 part 1).

4.2.2. Young's Modulus:

As per Clause 5.2.2.1 of IRS CBC.

4.2.3. Modular ratio:

Modular ratio shall be as per clause 5.2.6 of IRS CBC.

4.2.4. Minimum grade of concrete for structural elements:

Minimum Grade of Concrete used for various structural elements conform to IRS CBC: 1997, clause 5.4 The Grade of concrete used in Viaduct with moderate exposure condition considered are as under.

PSC – M45

RCC – M35

PCC – M30

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4.2.5. Thermal Expansion Coefficient:

e = 11.7 x 10 $^{-6}$/degree C (Clause 2.6.2 of IRS Bridge Rules) for steel and reinforced concrete.

4.2.6. Poisson's ratio:

Poisson's ratio for all concrete is taken as 0.15.

4.3. Reinforcing steel:

Only Thermo-Mechanically Treated (TMT) reinforcement bars of grade Fe 500 (min) conforming to IS: 1786 have been used. Kolkata in Zone – III of Seismic Activities and rebar used have with elongation of 14.5% as laid down in IS:1786. This is as per Clause 4.5 of IRS Concrete Bridge Code.

4.4. Pre-stressing Hardware

4.4.1. Pre-stressing steel for tendons

4.4.1.1. Pre- stressing steel conforming to IS: 14268, Class 2 low relaxation uncoated stress relieved strands.

4.4.1.2. Characteristics Strength:

Permanent pre-stressing cables consisting of 12/19 nos. of 15.2 mm nominal dia. 7 ply class-2 strands as per IS:14268-1995 has been used. The design is based on the following strand properties.

Nominal diameter of each strand = 15.2 mm

Nominal area of strand = 140 sq.mm

Breaking Strength of Strands = 260.7 kN

Ultimate Tensile strength = 189.94 Kg/sq.mm

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4.5. Pre-stressing Units:

4.5.1. Jacking Force:

Jacking Force (maximum initial pre-stressing force) as per clause 16.8.1 of IRS-CBC.

Jacking force taken is 195.5 kN which is 75% of the Breaking Strength.

4.5.2. Prestress Losses:

As per Clause 16.8.2 and 16.8.3 of IRS CBC.

4.5.3. Sheathing:

As per Clause 7.2.6.4.2 of IRS CBC.

4.5.4. Anchorages:

As per Clause 7.2.6.4.3 and Clause 16.8.3.4 of IRS CBC.

4.6. Structural steel for steel and composite bridges

4.6.1. Steel conform to IS: 2062 & IRC: 24-2010.

4.6.2. Fabrications have been done as per provisions of IRS B1 (Fabrication Code)

4.6.3. Design of steel structures have done as per IRS Steel Bridge Code & BS 5400-3:2000.

4.6.4. Steel-concrete Composite structures have designed in accordance with BS:5400 Part1 & Part3.

4.6.5. The fabrication done as per approved QAP by RDSO. The supervision of the steel girder fabrication was done by the 3rd Party Inspection.

Submerged arc welding not done as the welding lines are not straight due to curved girders. All welds are done as MIG welding. No field welding has been done.

4.7. Structural steel for Miscellaneous Use:

4.7.1. Design have done as per IS:800.

4.7.2. Hollow steel sections for structural used as per IS:4923

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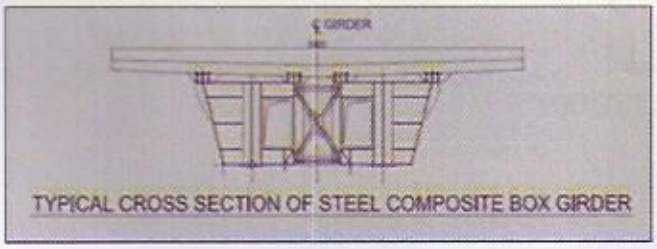
4.7.3. Steel tubes for structural purpose as per IS:1161

4.7.4. Steel for General Structural purpose as per IS:2062

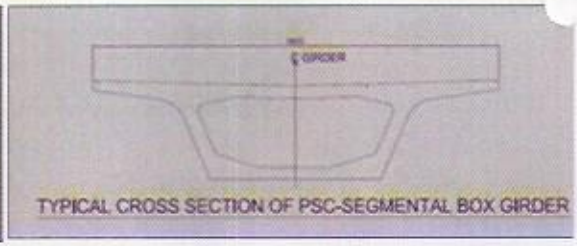
4.7.5. Stainless Steel was not used at Viaduct of Kolkata East-West metro.

5. LOADS

5.1. DEAD LOAD (DL):



TYPICAL CROSS SECTION OF STEEL COMPOSITE BOX GIRDER



TYPICAL CROSS SECTION OF PSC-SEGMENTAL BOX GIRDER

Dead load i.e. self-weight of girder has been calculated based on the actual cross section and unit weight of materials that are structural components of viaduct and permanent in nature.

5.2. SUPER IMPOSED DEAD LOAD (SIDL):

Superimposed dead loads includes all the weights of materials on the structure that are not structural elements but are permanent. It includes weight of track form plinth/ rails/ fasteners/ cables/ parapet/ hand-rail /3rd rail and assembly/ cable trough/ Signaling equipment etc. and have been considered in the design as per the site conditions.

Breakup of Super Imposed Deck Load:

1.	Wt. of Plinth [M35 Grade of Conc.]	=	3.5 MT/m (approx)
2.	Wt. of Rail & fastening	=	0.565 MT/m
3.	Wt. of Parapet	=	2.1 MT/m
4.	Wt. of Railway	=	0.08 MT/m

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5.	Wt. of Cable Trough	=	0.5 MT/m
6.	Wt. of 3rd Rail & Pedestal	=	0.275 MT/m
	Total Wt.	=	7.02 MT/m
	Say SIDL	=	**7.5 MT/m**

Above SIDLs are fixed in nature and are not likely to vary significantly during the life of the structure.

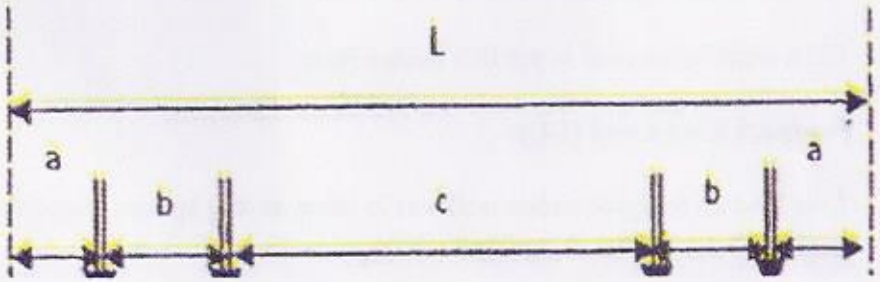
5.3. Shrinkage and creep:

Cl.5.2.3 and 5.2.4 of IRS Concrete Bridge Code has been used to select relevant values of shrinkage & creep including its variation with time.

5.4. LIVE LOAD (LL)

Railway Vehicular Load

Loading envelop chosen is as per the Rolling Stock adopted by KMRCL. The axle load adopted by KMRCL is 16MT which has been used for design of the Viaduct with following load configuration.



All axle loads = 16 tons

Maximum number of successive cars = 6

Where,

L = 21300 (Length of a car)

a = 2150 (overhang)

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b = 2300 (Wheel base in a bogie)

c = 12400 (Distance between Axle-2 and Axle-3 in the car)

Maximum number of axles will be loaded on the superstructure to arrive at maximum longitudinal force, maximum shear and maximum BM.

It shall be insured that live load coming on structure is within loading envelope decided by KMRCL.

It shall be also ensured that loads other than passenger trains like track machines, cranes etc. which may come on this structure should be within loading envelope decided by KMRCL. Further KMRCL shall also take into account any future rolling stock with higher capacity or higher occupation density for the same.

In case of maximum shear force, bending moment and longitudinal forces critical cases shall be considered.

Since both the tracks will be supported by single box girder, hence superstructure, bearing and substructure will be checked for one track loaded condition as well as both tracks loaded conditions

5.5. Coefficient of Dynamic Augment (CDA):

CDA shall be adopted as per IRS Bridge Rules.

5.6. Footpath Live Load (LL):

Live load on footpath and/or walkway is taken as 490 kg/sqm including dynamic effect as per cl: 2.3.2.1 of IRS Bridge Rules 2008.

5.7. Braking and Traction: (BR/TR)

Breaking and Tractive forces shall be as per Modern Rolling stock characteristic duly approved by KMRCL.

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Since both the tracks are supported on the single girder, hence tractive force of one track and braking of another track will be taken to produce worst condition of loading.

There is no deck having more than two tracks. It shall be ensured by KMRCL in service that trains on both the tracks are not moving in the same directions. Same shall be

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incorporated in Operating manual of KMRCL.

For longitudinal forces, provision of Clause 2.8.4 of IRS: Bridge Rule shall be followed, when the bridge carries more than one track on single superstructure.

As per Clause 2.8.5 of IRS Bridge Rules, when considering seismic forces, in traverse/longitudinal seismic condition, only 50% of gross tractive effort/breaking force will be considered.

Dispersion of longitudinl forces is not allowed as per Clause 2.8.3.4 of IRS Bridge Rules.

5.8. Centrifugal Force (CF):

The horizontal force due to centrifugal force is taken as per Cl. 2.5.3 of IRS Bridge Rules.

$C = (WV^2)/127R$

C	=	Horizontal effect in Ton/m run of span
W	=	Equivalent Distributed Live Load in Ton/m run
V	=	Maxm. Speed in Km/Hr.
R	=	Radius of curvature in m

For example: at pier Location

V	=	Maxm. Speed in = 80 Km/Hr.
R	=	445m
W	=	256 MT (Say, both 25m Span is loaded with both track)
C	=	29 MT

5.9. Gradient Effect:

As per design profile of the alignment.

5.10. Wind Load (WL):

The wind load shall be calculated as per Clause 2.11 of IRS-Bridge Rules and IS: 875 (Part 3).

As per clause 2.11 of IRS bridge Rules and IS: 875 (Part 3)

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Design Wind Speed $Vz = Vb \times K1 \times K2 \times K3$

Where,

Vb	=	50 m/sec [Basic Wind Speed for Kolkata]
K1	=	1.1 [Probability Factor (Risk Co-efficient)] [For Return Period of 120 Years]
K2	=	0.98, Factor for Terrain, Ht. & Structure size [Terrain Cat. – 2 & Class B]
K3	=	1.0factor for Topography [Site Slope is <30)
Vz	=	53.9 m/sec

Design Wind Pressure $Pz = 0.6 \times Vz2 = 1743.126$ N/m2

5.11. Seismic Load (EQ):

"Seismic Code for Earthquake Resistance Design for Railway Bridges" shall be followed. Load combination and ductile detailing aspects are in accordance with this code

5.12. Temperature Effect:

Clause 2.6 of IRS Bridge Rules shall be followed.

5.12.1. Overall temperature (OT) shall be as per Clause 215.2 of IRC:6

5.12.2. Differential Temperature (DT) shall be as per IRC:6

5.12.3. Temperature gradient shall be as per Clause 215 of IRC:6

5.13. Differential Settlement:

Differential Settlement between two adjacent viaduct piers:

i) 12mm for Long Term Settlement;

ii) 6 mm [50% of long term] for Short Term Settlement;

Differential settlement has been considered only in the design of continuous structures.

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5.14. Vehicle collision load on piers:

a. Vehicle collision load on piers shall be as per Clause 222 of IRC:6.

b. Rules specifying the loads for design of super-structure and sub-structure of bridges and for assessment of the strength of existing bridges should be done as per IRS: Bridge Rules.

5.15. Buffer Load:

Assumptions for Buffer:

- Assume Train is un-braked when entering into the Station;
- Assume no additional drive force due to rotating motors;
- Assume 100% effective mass;
- Buffer Load = 700 kN
- Train Load = 3840 kN, i.e. Buffer load is 18.2% of Train load

Here Buffer load has not been considered separately, but 18% Tractive force has been considered. All buffers are of friction type and are designed for the fully loaded train mass.

5.16. Long Welded Rail (LWR) Forces:

Guidelines vide BS Report no. 119 "RDSO Guidelines for carrying out Rail-Structure Interaction studies on Metro System (Version-2)" shall be followed.

5.17. Racking forces:

As per IRS Bridge Rules, the horizontal lateral loading due to racking has been considered in the form of a uniformly distributed load of 4 KN/m per track acting at the top of rail head without impact.

5.18. Vibration Effect:

The fundamental vibration period calculation is performed according to the expression given in Annex D of the Cl. 219.5 of IRC:6:2014

The expression is: T = 2. 0Sq.rt [(D)/(1000F)]

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D = Appropriate dead load of the superstructure & live load in KN.

F = Horizontal force in KN.

5.19. Forces on parapets:

The Parapets have been designed for footpath load as per the Codal Provision of IS 456: 2000 and to resist horizontal force & a vertical force of 1.5 kN/m applied simultaneously at the top of the Parapet as per Cl. 2.10 of IRS-Bridge Rules 200

5.20. Derailment Load:

Sacramento derailment criteria has been used for Box-girders. This criterion corresponds to the application of 40% of each wt. = 0.4 x 640 kN = 256 kN

Applied horizontally as a 3m long i.e. 85.33 kN/m horizontal force.

5.21. Erection Forces:

Analysis at Construction Stage:

To check the distortion & deflection of girder due to self-wt.& green conc. of construction stage, one 3D analysis has been done for simply supported span with actual radius of curvature.

Load Consideration:

DL (S.W. of girder + wt. of green conc.) + cons. L.L.

6. Load Combinations:

In each of SLS & ULS cases 5 basic load combination groups, according to the IRS-CBC, second revision, 1997 table 12 modified to the contents of letter no. DMRC/Corp/20/Design/312/2005 dated 13 Sep 2005 considered.

Load combinations are given below:

a) ULS (Ultimate Limit State) Load combinations:

i. 1.35DL+1.15/0.87(*) PR+1.35SIDL+1.5LL

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ii. 1.35DL+1.15/0.87(*) PR +1.35SIDL+1.6SLL

iii. 1.35DL+1.15/0.87(*) PR +1.35SIDL+1.6SLT

iv. 1.35DL+1.15/0.87(*) PR +1.35SIDL+1.5LL+1.25SLL

v. 1.35DL+1.15/0.87(*) PR +1.35SIDL+1.5LL+1.25SLT

vi. 1.35DL+1.15/0.87(*) PR +1.35SIDL+1.75DRL

(*) 1.15/0.87 according to IRS CBC art. 11.3.3, when the pre-stressing PR increases the section capacity vs. shear then PR is multiplied by 0.87. When the pre-stressing PR decreases the section capacity vs. shear then PR is multiplied by 1.15.

b) SLS (Serviceability Limit State) Load combinations:

i. 1.0DL+1.0SC+1.0PR+1.0DS+1.2SIDL+1.1LL

ii. 1.0DL+1.0SC+1.0PR+1.2SIDL+1.0SLL

iii. 1.0DL+1.0SC+1.0PR+1.2SIDL+1.0SLT

iv. 1.0DL+1.0SC+1.0PR+1.2SIDL+1.0LL+1.0SLL

v. 1.0DL+1.0SC+1.0PR+1.2SIDL+1.0LL+1.0SLT

vi. 1.0DL+1.0SC+1.0PR+1.2SIDL+1.0OT+0.8DT+1.0LL

vii. 1.0DL+1.0SC+1.0PR+1.0SIDL+1.0DRL

Load combination has been modified for Duttabad Viaduct (part of East-West Metro-11 spans) on Dec.'2014, based on IRS Concrete bridge code to the extent by the contents of Addendum & Corrigendum slip no. 13 dated 25 Nov 2010.

Load combinations are given below:

a) ULS (Ultimate Limit State) Load combinations:

i. 1.25DL+2.0SIDL+1.75LL

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ii. 1.25DL+2.0SIDL+1.4LL+1.5LWR

iii. 1.25DL+2.0SIDL+1.4LL(50%)+1.25SLL

iv. 1.25DL+2.0SIDL+1.4LL(50%)+1.25SLT

v. 1.25DL+2.0SIDL+1.4LL(50%)+1.25SLV+

vi. 1.25DL+2.0SIDL+1.4LL(50%)+1.25SLV-

vii. 1.25DL+2.0SIDL+1.4LL+1.25 WLT

viii. 1.25DL+2.0SIDL+1.4LL+1.0DRL

b) SLS (Serviceability Limit State) Load combinations:

i. 1.0DL+1.2SIDL+1.1LL

ii. 1.0DL+1.2SIDL+1.0LL+1.0LWR

iii. 1.0DL+1.2SIDL+1.0LL(50%)+1.0SLL

iv. 1.0DL+1.2SIDL+1.0LL(50%)+1.0SLT

v. 1.0DL+1.2SIDL+1.0LL(50%)+1.0SLV+

vi. 1.0DL+1.2SIDL+1.0LL(50%)+1.0SLV-

vii. 1.0DL+1.2SIDL+1.0LL+1.0 WLT

viii. 1.0DL+1.2SIDL+1.0LL+(1.0/1.75) DRL



The superstructure/bearing, sub-structure and foundation will be checked for one track loaded condition as well as both track loaded condition, for single span and both spans loaded conditions, as the case may be.

Design of viaduct shall be done in accordance with the construction methodology/construction sequence to be adopted during execution.

7. DESIGN PARAMETERS:

7.1. Units for design: [t],[m],[mm],[KN],[KN/m2],[Mpa], [Degree C],[rad]

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7.2. ULS check: As per IRS Concrete Bridge Code.

7.3. SLS check: As per IRS Concrete Bridge Code.

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7.3.1. Crack Width:

Crack width in reinforced concrete members has been checked for SLS combination -1. Crack width calculation as per clause 15.9.8.2 of IRS CBC. Crack width have not exceeded the admissible value based on the exposure conditions given in Clause 10.2.1 of IRS CBC.

For crack control in columns, Clause 15.6.7 of IRS CBC has been modified to the extent that actual axial load has been considered to act simultaneously.

7.4. Fatigue check:

Fatigue phenomenon needs to be analyzed only for those structural elements that are subjected to repetition of significant stress variation (under traffic load). Thus, generally the fatigue needs to be regarded only for deck structural part.

7.4.1. RCC and PSC structures

Fatigue check for prestressed concrete (PC) structures does not need to be performed as long as the whole section (from top to bottom fiber) remains under compression under SLS.

Fatigue check for RC structures does not need to be performed unless a RC main structure member (i.e. the deck) supports the traffic.

Requirements of the IRS-CBC, cl.13.4 has been followed for reinforcement bar welding:

Lap welding & welding in part of deck slab subjected to concentrated loads shall not be allowed.

7.4.2. Steel Structures

Fatigue check has been based on Appendix G(revised) Addendum to Correction Slip No 18, IRS Steel Bridge Code.

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Here, the girders were built up-welded section.

As per Table 9.2 detail category = 100N/mm2 (Appendix G - IRS SBC)

Partial Safety factor (gft) = 1.0 & gmf = 1.15

Allowable stress = 100/(1x1.15) = 86.96 N/mm2

As per Cl. 12.5 Appendix G - IRS SBC, the effective stress range has been calculated.

7.5. Durability:

7.5.1. Provisions of clause 5.4 of IRS CBC shall be followed to meet durability requirements.

7.5.2. Cover to reinforcement shall be in accordance with Clause 15.9.2 of IRS CBC

7.6. Design Life:

Design life for main structural system 120 yrs.

7.7. Drainage:

The top of soffit slab will be profiled so as to collect the runoff water at two points by providing a cross slope of 2.5%.

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8. DESIGN METHODOLOGY

8.1. Bearing System

8.1.1. Elastomeric bearings shall be designed in accordance with EN 1337 Part-1 and Part-3.

8.1.2. POT-PTFE bearing has been designed as per IRC:83-Part III.

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8.1.3. Spherical Bearings have been used in the Duttabad Viaduct (part of East-West Metro) as per IRC:83-2014(Part-IV) due to limitation of space on pedestal and more longevity than Pot-PTFE Bearing.

8.1.4. Replaceability of Bearings:

Accessibility and replacement of each part of bearing are of paramount importance as the design life of bearings is shorter than that of the structure. Keeping in view the above cited criteria, all the bearings and pier caps have been detailed for replacement of bearings in the future. The end diaphragms have been designed to facilitate the operations of jacks during maintenance as per IRS-CBC.

8.1.5. Seismic restrainer has been provided.

8.2. Pier cap and pier

8.2.1. For designing the pier cap as corbel, the provisions of Clause 17.2.3 of IRS CBC should be followed.

8.2.2. In case of shear span to effective depth ratio being more than 0.6 pier cap will be designed as flexural member.

8.2.3. The effective length of a cantilever pier for the purpose of slenderness ratio calculation will be taken as per IRS CBC.

8.3. Foundation

8.3.1. IS: 2911 has been followed for design of foundation.

Pile and pile cap design including pile load testing have considered based on IRS Concrete Bridge Code & IS: 2911.

8.3.2. Soil Structure Analysis:

Soil stiffness for lateral loads have been taken from IS:2911 (Part 1/sec2 Appendix C). Unconfined compressive strength has been calculated from the results from the

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Geotechnical Investigation Report. Subsoil parameters have taken from Geotechnical Investigation Report.

9. PROJECT SPECIFIC ADDITIONAL INFORMATION/DETAILS (IFANY)

Any other Codes & special publication have not required in this report.

10. DESIGN CODES AND STANDARDS

The IRS Codes have been followed in principle. If provisions were not available in IRS, the order of preference have been followed, unless specified otherwise:

For railway loading related issues:

i) UIC Codes

ii) Euro Codes

iii) Any other code, which covers railway loading.

For other Design/ detailing related issues:

i) IRC

ii) IS

iii) Euro Code

iv) BS Code

List of various codes and standards has been used at various stages of works;

IRS Codes (With Latest Versions)

IRS Bridge Rules

IRS Concrete Bridge Code

IRS Bridge substructure & Foundation Code

IRS Steel Bridge Code

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IRS Fabrication Code (B I)

IRS Welded Bridge Code

IRC CODES (WITH LATEST VERSIONS)

IRC:5	Standard Specification & Code of Practice for Road Bridges–General Features of Designs
IRC: 6	Standard Specification & Code of Practice for Road Bridges- Loads and Stresses
IRC: 18	Design Criteria for Pre-Stressed Concrete Road Bridges (Post Tensioned Concrete)
IRC: 22	Specification & Code of Practice for Road Bridges, SectionV1 – Composite Construction for Road Bridges
IRC: 24	Standard Specification & Code of Practices for Road Bridges, Section V-Steel Road Bridges
IRC: 78	Standard Specification & Code of Practice for Road Bridges —Section Foundations & Sub-Structure
IRC: 83(I)	Standard Specification & Code of Practice for Road Bridges, Part-1 Metallic Bearings
IRC:83(II)	Standard Specification & Code of Practice for Road Bridges, Part-11 Elastomeric Bearings
IRC: 83 (III)	Standard Specification & Code of Practice for Road Bridges, Part III POT, POT-cum PTTE, Pin and Metallic Guide Bearings
IRC: 83 (IV)	Standard Specification & Code of Practice for Road Bridges, Part IV Spherical and Cylindrical Bearings.
IRC: 112	Code of practice for Concrete Bridges
1RC-SP-7	Guidelines for Design and Construction of Pre-cast Pre-Tensioned Girders for bridges

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IS Codes (With Latest Versions)

IS: 269	Specs for Ordinal), and Low Head Portland cement
IS: 383	Specs for coarse and fine aggregates from natural sources for concrete
IS: 432	Specs for Mild steel and medium tensile steel bars (Part 1)
ID: 456	Plain and reinforced concrete code of practice
IS: 800	Code of practice for General Construction Steel
IS: 875	Code of Practice for Design Loads Part 1, 2 3, 4& 5 (Other than Earthquake)
IS: 1080	Design and construction of shallow foundations in soils (other than raft ring and shell)
IS: 1343	Code of practice for Pre-stressed concrete-based essentially on CP-110
IS: 1364	Hexagon Head Bolts, Screws & nuts of product grades A & B Part 1 (Part 1 Hexagon. Head Bolts (size range M 1:6 to M64)
IS: 13920	Ductile detailing of reinforced concrete structures subjected to seismic forces code of practice
IS: 1489	Specification for Portland pozzolana cement (Fly ash based)
IS: 1786	High strength deformed steel bars and wires for concrete reinforcement
IS: 1893	Criteria for Earthquake Resistant Design of structures
IS: 1904	Design and construction of foundations in soils: general requirements.
IS: 1905	Code of practice for structural use of unrein forced masonry.
IS: 2062	Specifications for weldable Structural steel
IS: 2502	Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement
IS: 2911	Code of practice for Design and construction of Pile Foundation Part]

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(Part 1/Sec 1) Concrete Piers Section 2 Board Cast-in-situ-piles (with amendments) IS 2911 Code of Practice for Design & construction of Pile Foundations Part 4 Load test on piles

IS: 2950 Design and construction of raft foundations

IS: 3935 Code of Practice for Composite Construction

IS: 4326 Code of practice for Earthquake resistant design and construction of Buildings

IS: 4923 Hollow steel sections for structural use —specification

IS: 8009 Calculation of settlements of shallow foundations

IS: 8112 Specifications for 43 grade ordinary Portland cement

IS: 9103 Specifications of Concrete admixtures

IS: 11384 Code of practice' for` Composite Construction in Structural Steel and Concrete

IS: 12070 Code of practice for Design and construction of shallow foundation on Rocks

IS: 12269 Specification for 53 grade ordinary Portland cement

IS: 14268 Uncoated Stress Relieved Low Relaxation Seven-ply Strands for prestressed concrete

IS: 14593 Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks

BS CODES (WITH LATEST VERSIONS)

BS: 4447 Specifications for the performance of pre-stressing anchorage for post-tensioned concrete.

BS: 4486 Specifications for high tensile bars used for pre-stressing.

BS: 5400 Code of Practice for Design of Concrete Bridges Part 4-1990.

BS: 5400 Code of Practice for design of Steel Bridges Part 3-2000

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BS: 8006 Code of Practice for strengthened reinforced soils and other fills-1995. BS: 8007 Design of Concrete structures for retaining liquids.

OTHERS (WITH LATEST VERSIONS)

- UIC: 774 3R Rail structure interaction
- MORTH and Highways specifications.

11. DESIGN SOFTWARE:

For Kolkata East West Metro Project, the commercial software STAAD has been used.

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