GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

E-File No. 2020/Proj/MPMRCL/DBR/30/4 New Delhi, dated 29.09.2020

Managing Director,
Madhya Pradesh Metro Rail Corporation Limited, (MPMRCL),
2nd Floor, Bhopal Smart City Development Corporation Limited,
Sector-A, Berkheda, Bhopal-462022, Madhya Pradesh

Sub: Approval of Design Basis Reports (DBR)'s for Viaducts, Elevated Stations and Bored Tunnel Sections (May, 2020) for Bhopal and Indore Metro Rail Projects of Madhya Pradesh Metro Rail Corporation Limited (MPMRCL).

Ref: MPMRCL's letter No. 3640/MPMRCL/2020 dated 02.06.2020

The Design Basis Reports (DBR)'s for Viaducts, Elevated Stations and Bored Tunnel Sections (May, 2020) for Bhopal and Indore Metro Rail Projects of Madhya Pradesh Metro Rail Corporation Limited (MPMRCL) has been examined in consultation with RDSO and approval of Railway Board is hereby conveyed.

Accordingly, approved copies of DBRs are enclosed.

Encls: As above

29/09/2020
(D.K Mishra)
Director/MTP
Railway Board
☎ 011-47845480

Copy to: (i) **Executive Director/UTHS**, RDSO, Manak Nagar, Lucknow w.r.t RDSO's letter No. UTHS/120/MPMRCL/Civil dated 12.06.2020

(ii) **OSD/UT & Ex-Officio Joint Secretary**, Ministry of Housing & Urban Affairs (MoHUA), Nirman Bhavan, New Delhi-110001

716537/2020/O/o DD(Project)

MADHYA PRADESH METRO RAIL CORPORATION LIMITED

Madhya Pradesh Metro Rail Co. Ltd.

BHOPAL AND INDORE METRO RAIL PROJECT

DESIGN BASIS REPORT (DBR)

for VIADUCT

May 2020

Digitally signed by
MANISH GANGAREKAR
Date: 2020.06.02
12:17:06 +05'30'

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

Madhya Pradesh Metro Rail Corporation Limited (MPMRCL)
2nd Floor, Bhopal Smart City Development Corp. Ltd.,
Sector A, Berkheda, Bhopal – 462022,
Madhya Pradesh, India.

BLANK PAGE

Table of Contents

Examined & Found in Order
Date

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

1 INTRODUCTION

1.1 Brief Description of Project

A. Bhopal Metro Rail Project

- Bhopal Metro Rail Project is a rail-based Metro system on standard gauge tracks (1435 mm).
- Bhopal Metro Rail Project has two lines, Purple line and Red line and 1 Depot area serving both the lines.
- Purple Line has a total of 16 stations, of which 14 are elevated and 2 are underground.
- Red Line has a total of 14 stations, and all are elevated including a passenger interchange with Purple Line.
- Traction Power will be based on 750V DC system using third rail as contact line.

B. Indore Metro Rail Project

- Indore Metro Rail Project is a rail-based Metro system on standard gauge tracks (1435 mm).
- Indore Metro Rail Project consists of Yellow Line (Ring Line) and 1 Depot area.
- Yellow Line has a total of 26 elevated stations and 4 Underground Stations.
- Traction Power will be based on 750V DC system using third rail as contact line.

1.2 Geometric Design Feature

The gradient, maximum degree of curve, spacing of tracks etc. shall comply with the Project Schedule of Dimensions (SOD).

1.3 Scope of DBR

This Design Basis Report provides design criteria for the Metro viaduct tracked sections.

All civil design works shall be performed taking into consideration this Design Basis Report.

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

2 PROPOSED STRUCTURAL SYSTEM OF VIADUCT

2.1 Superstructure system

The superstructure shall be either a precast post tensioned segmental box girder, a precast pre-tensioned U-girder or a precast pre/post tensioned I-Girder with cast-in-situ deck.

Economical spans should be designed and spans should be designed as per the site conditions.

At major stakeholder crossings of existing structures, special bridges shall be with simply supported, continuous spans of either Steel, Steel-Concrete composite or balanced Cantilever construction or any other suitable options.

2.2 Emergency Walkway

Front of train evacuation is proposed so a side emergency walkway will not be provided.

2.3 Bearing

Bearings shall be either Elastomeric, POT PTFE or Spherical.

2.4 Substructure system

The substructure design shall consist of Pile, Pile Cap, Shear Key, Crash barrier, Piers and Pier Caps.

2.5 Foundation system

In general pile foundations shall be adopted, but open foundations may be considered provided the soil parameters permit.

2.6 Parapets

Parapets are to be either monolithic with the precast deck, or precast reinforced concrete stitched to the precast deck. Minimum clear height of Parapets shall be 1.2m.

3 CLEARANCES FOR STRUCTURES

3.1 Clearance for Road Traffic

Minimum Clearance to road traffic shall be 5.5m as per Indian Road Congress (IRC) specifications and Road Authority requirements.

3.2 Clearance for Railway Traffic

Clearance for railway traffic shall comply with Indian Railways SOD.
Where the viaduct crosses existing railway tracks the design shall be approved by the relevant Railway Authority.

3.3 Clearances for Metro Traffic

The clearances for Metro traffic shall be as per the approved Project SOD.

4 STRUCTURAL MATERIALS AND PROPERTIES

4.1 Cement

Cement shall comply with IRS CBC Clause 4.1.

4.2 Concrete

4.2.1 Density

Density of concrete shall be as per Table-1 of IS: 875 (Part -1).

1. The density of concrete for Pre-Stressed Concrete (PSC) and RCC Concrete based on reinforcement percentage shall be 24/25 kN/m^3.
2. The density of Plain Cement Concrete (PCC) shall be 23 kN/m^3.

4.2.2 Young's Modulus

The Young's Modulus of Elasticity shall comply with IRS CBC Clause: 5.2.2.1.

4.2.3 Modular Ratio

The Modular Ratio shall comply with IRS CBC Clause: 5.2.6.

4.2.4 Minimum Grade of Concrete for Structural elements

The minimum grade of concrete shall comply with IRS CBC Clause: 5.4.4.

4.2.5 Thermal Expansion Coefficient

The Coefficient of Thermal Expansion $\epsilon = 1.17 \times 10^{-5}$ / °C shall comply with IRS Bridge Rules Clause: 2.6.2.

4.2.6 Poisson's Ratio

Poisson's ratio for all concretes shall be 0.15.

4.3 Reinforcing Steel

All reinforcement steel shall comply with IRS CBC Clauses 4.5 and 7.1.5.

4.4 Prestressing Hardware

4.4.1 Prestressing steel for Tendons

4.4.1.1 All prestressing steel tendons shall comply with IRS CBC Clause 4.6.

4.4.1.2 The characteristic strength of all prestressing steel tendons shall comply with IRS CBC Clause 16.2.4.3.

4.5 Prestressing Units

4.5.1 Jacking force

The jacking force (maximum initial prestressing force) shall comply IRS CBC Clause 16.8.1.

4.5.2 Prestress Losses

Prestress losses shall comply with IRS CBC Clauses 16.8.2 and 16.8.3.

4.5.3 Sheathing

Sheathing shall comply with IRS CBC Clause 7.2.6.4.2.

4.5.4 Anchorages

Anchorages shall comply with IRS CBC Clauses 7.2.6.4.3 and 16.8.3.4.

4.6 Structural steel for Steel and Composite Bridges

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/DBR6

4.6.1 Steel shall comply with IS: 2062.

4.6.2 Fabrication shall comply with IRS B1 (Fabrication code).

4.6.3 The design of all steel structures shall comply with IRS Steel Bridge Code.

4.6.4 For steel-concrete composite construction IS codes shall be used.

4.6.5 All welding shall comply with the IRS Steel Bridge Code, IRS welded Bridge Code or relevant IS codes for welding.

4.7 Structural Steel for Miscellaneous Use

4.7.1 The design shall comply with IS: 800.

4.7.2 Hollow steel sections for structural use shall comply with IS: 4923.

4.7.3 Steel tubes for structural use shall comply with IS: 1161.

4.7.4 Steel for general structural use shall comply with IS: 2062.

4.7.5 Relevant codes may be adopted for Stainless Steel as per requirement.

5 LOADS

5.1 Dead Loads (DL)

The dead load shall be based on the actual cross-sectional area and unit weights of the materials, and it shall include the weight of the materials that are structural components of the viaduct and permanent in nature.

5.2 Superimposed Dead Loads (SIDL)

Superimposed dead loads shall include all the weights of materials on the structure that are not structural elements but are permanent. This shall include the weight of the track form plinths, rails, fasteners, cables, parapets, hand-rails, third rail, cable-troughs, signalling equipment etc. and will be considered in the design as per the site conditions.

Note:

The SIDL can be of two types: Fixed or non-variable, and variable. In case the Metro certifies that a portion of the SIDL is of fixed or non-variable type and it is not likely to vary significantly during the life of the structure and a special clause is incorporated in the Metro's maintenance manual, the load factors applicable for dead load may be considered for this component of SIDL.

5.3 Shrinkage & Creep (SC)

Shrinkage and Creep effects shall comply with IRS CBC.

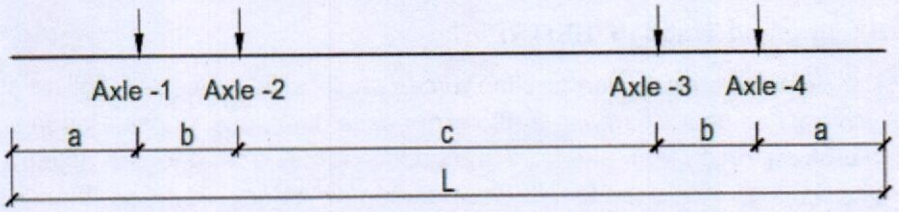
5.4 Live load (LL)

5.4.1 Vertical Train Live Load

Each component of the structure shall be designed and checked for all possible combinations of the following loads and forces.

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO



All axle loads = 16 tonnes

Maximum number of successive cars = 6

Configuration (Alternate 1) :

a = 2.30 m (overhang)

b = 2.40 m (wheel base in a Bogie)

c = 12.60 m (distance between Axle 2 and Axle 3)

L = 2a+2b+c =22.00 m

Configuration (Alternate 2) :

a = 2.60 m (overhang)

b = 2.20 m (wheel base in a Bogie)

c = 12.40 m (distance between Axle 2 and Axle 3)

L = 2a+2b+c =22.00 m

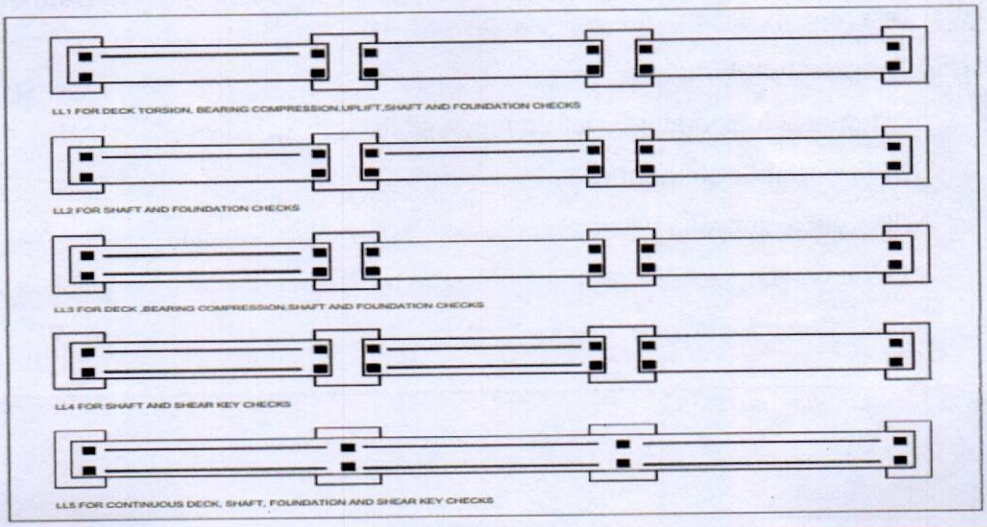
Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

Moving load analysis shall be carried out in order to estimate the maximum longitudinal force, maximum shear and maximum Bending Moment. Simply supported structures shall be designed for loading envelopes as tabulated in Annexure 1 of this DBR.

Loads other than standard trains like track machines, cranes, any new rolling stock etc., which may come on this structure should be within the loading envelope initially decided by the metro as above.

For special structures like continuous structures, cable stayed bridges etc. the actual train loads may be used for the design.



5.5 Coefficient of Dynamic Augment (CDA)

The Coefficient of Dynamic Augment shall comply with IRS Bridge Rules.

5.6 Footpath Live Load (LFP)

Footpath live loads shall comply with IRS Bridge Rules Clause 2.3.2.

5.7 Braking and Traction (BR/TR)

The value of braking and traction forces shall be taken as per Rolling stock used. For twin tracked decks carrying traffic in opposite directions, consideration should be given to braking forces from one train and traction forces from another, acting simultaneously which will be maximum longitudinal loading on a deck. For more than 2 tracks, Clause 2.8.4 of IRS Bridge Rules shall be complied with.

As per Clause 2.8.5 of IRS Bridge Rules, when considering seismic forces, in transverse / longitudinal seismic condition, only 50% of gross tractive effort /braking force shall be complied with.

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

5.8 Centrifugal Force (CF)

On curved track, the centrifugal forces shall be determined in accordance with IRS Bridge Rules Clause 2.5.

5.9 Gradient Effect

The gradient effect shall be considered as per the alignment design.

5.10 Wind Load (WL)

Wind loads shall comply with IRS Bridge Rules Clause 2.11.

5.11 Seismic Load (EQ)

"Seismic Code for Earthquake Resistant Design of Railway Bridges" shall be followed. The code also covers load combination and ductile detailing aspects.

5.12 Temperature Effect

Temperature effect shall comply with IRS Bridge Rules Clause 2.6.

5.12.1 Overall Temperature (OT)

Overall temperature shall comply with IRC: 6 Clause 215.2.

5.12.2 Differential Temperature (DT)

Differential temperature shall comply with IRC: 6.

5.12.3 Temperature Gradient

Differential temperature shall comply with IRC: 6 Clause 215.

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

5.12.4 Differential Settlement (DS)

Differential settlement is to be considered only in the design of continuous structures.

Maximum differential settlement between two adjacent viaduct piers shall be:

- 12mm for long term settlement

- 6mm for short term settlement (50% of long term).

5.13 Vehicle Collision Loads on Piers (VCL)

a) Vehicle collision loads shall comply with IRC: 6 Clause 222.

b) Rules specifying the loads for design of superstructure and substructure of bridges and for assessment of the strength of existing bridges should be done as per IRS Bridge Rules.

5.14 Buffer Load (BL)

Buffers shall be provided at the end of temporary terminal stations during stage opening of the Corridors, at Pocket track ends and at corridor terminal stations (at the end of turn back/stabling lines). Such buffers will be of friction type.

These buffers shall be designed to have stopping performance based on mass of fully loaded train and its deceleration to avoid damage to the train or buffer.

Viaduct elements shall be designed for such buffer loads. The exact buffer loads need to be interfaced and ascertained during the detailed design.

5.15 Long Welded Rails (LWR) Forces

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

5.16 Racking Forces (RF)

The horizontal transverse loading due to racking shall comply with IRS Bridge Rules Clause 2.9.

5.17 Vibration Effect

The effect of vibration due to the movement of metro trains on station bridge structures shall be taken into consideration.

5.18 Forces on Parapets (PP)

Forces on parapets shall comply with IRS Bridge Rules Clause 2.10.

5.19 Derailment Load (DER)

Derailment loads shall comply with IRS Bridge Rules Appendix XXV, with Standard Gauge.

For the Ultimate Limit State (ULS) and Stability checks the loading shall be proportioned as per the maximum axle load.

Sacramento derailment criteria may be used for U-Girders. This criterion corresponds to the application of 40% of one coach weight (including dense crush load) applied horizontally as a 3m long uniform impact load on the U girder top flange. This derailment load corresponds to a ULS load. For the Serviceability Limit State (SLS) Combination 5 of IRS CBC a 1/1.75 co-efficient shall be applied to the derailment load.

5.20 Erection Forces

Erection forces shall comply with IRS Bridge Rules Clause 2.13.

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

5.21 Elementary Loads Definition

Elementary loads taken into account are:

Elementary Loads		Acronym	
Dead Load			DL
Super Imposed Dead Loads			SIDL
Shrinkage			S
Creep			C
Prestressing Force			PS
Live Load	LL	Coefficient of Dynamic Impact	CDA
		Footpath Live load (when live load on footpath is considered, then no Coefficient of Dynamic Augment (CDA) on Train live load to account for stationary train under emergency condition).	LFP
		Longitudinal force (tractive, braking)	BR/TR
		Centrifugal Force	CF
Wind pressure effect	WL	Longitudinal direction	WL_x
		Transverse direction	WL_z
Seismic Force/ Earthquake Load	EQ	Longitudinal direction	EQ_x
		Transverse direction	EQ_z
		Vertical direction	EQ_y
Overall temperature effect			OT
Differential temperature			DT
Differential settlement			DS
Vehicle Collision Load			VCL
Buffer Load			BL
Long welded rail forces			LWR
Racking forces			RF
Forces on parapets			PP
Derailment Load			DER

6 LOAD COMBINATIONS

6.1 Methodology

Load combinations shall comply with the Provisions of Bridge Rule and IRS CBC.

6.2 Loading Condition

The superstructure, bearings, sub-structure and foundations shall be checked for the one-track loaded condition as well as the both tracks loaded condition, for single span and both spans loaded conditions.

6.3 Design as per Construction methodology and Construction sequence

The design of the viaduct shall be in accordance with the construction methodology and construction sequence to be adopted during execution.

7 DESIGN PARAMETERS

7.1 Units for Design

The main units used for design shall be: [t], [m], [mm], [kN], [kN/m2], [MPa], [°C], [rad]

7.2 Ultimate Limit State (ULS) Check

Ultimate limit state shall comply with IRS Concrete Bridge Code.

7.3 Serviceability Limit State (SLS) Check

Serviceability limit state shall comply with IRS Concrete Bridge Code.

7.3.1 Crack Width

The crack width in reinforced concrete members shall be checked for SLS Combination 1.

The crack width shall comply with IRS CBC Clause 15.9.8.2.

Crack width shall not exceed the admissible value based on the exposure conditions given in IRS CBC Clause 10.2.1.

For crack control in columns IRS CBC Clause 15.6.7 will be modified to the extent that the actual axial load will be considered to act simultaneously

7.3.2

IRS CBC Clause 10.4.1, 11.3.4 and 13.3 shall be used to calculate vertical deflection at mid-span.

7.4 Fatigue Check

7.4.1 RCC and PSC Structures

Fatigue design shall comply with IRS CBC Clause 13.4.

7.4.2 Steel Structures

Steel structures shall comply with IRS Steel Bridge Code Clause 3.6.

If λ values are required to be used, the train closest to the actual train formation proposed to be run on the metro system shall be used. Otherwise, detailed counting of cycles shall be carried out.

7.5 Durability

7.5.1

Durability shall comply with IRS CBC Clause 5.4.

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

7.5.2 Cover to reinforcement shall comply with IRS CBC Clause 15.9.2.

7.6 Design Life

IRS CBC Clause 15.1.3 and 16.1.3 shall be complied.

7.7 Drainage

The drainage of the deck shall be designed to cater for the maximum envisaged rainfall intensity and suitable longitudinal and transverse slope shall be provided.

Drainage shall comply with IRS CBC Clause 10.4.1.1 and 15.2.2.

8 DESIGN METHODOLOGY

8.1 Bearing System

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

8.1.2 Design of POT-PTFE bearings shall comply with IRC: 83 Part III.

8.1.3 Design of Spherical and Cylindrical bearings shall comply with IRC: 83 Part IV.

8.1.4 Replacement of Bearings

For replacement and maintenance of the bearings the design shall comply with Clauses 15.9.11.3 and 15.9.11.4 of IRS: CBC.

8.1.5 If bearings cannot accommodate the seismic forces, concrete shear keys or seismic restrainer shall be provided.

8.1.6 Uplift

If required, a holding-down device connecting the deck and the pier head shall be designed in order to prevent the deck from overturning. The holding-down device may be integrated in the pot-bearing system or through a separate system of bars embedded in the pier cap and viaduct with appropriate details, permitting translation/rotation.

The design criteria for holding down devices (upward force limit requiring holding down device, design formulas) shall be taken from the latest international practice (ASSHTO, MOTC codes).

8.2 Pier cap and Pier

8.2.1 The design of a pier cap as a corbel shall comply with IRS CBC Clause 17.2.3.

8.2.2 In the case of the shear span to effective depth ratio being greater than 0.6 the pier cap shall be designed as a flexural member.

8.2.3 The effective length of any cantilever pier for the purpose of slenderness ratio the calculation shall comply with IRS CBC.

8.3 Foundation

8.3.1 Foundation Design

The foundations design shall comply with IRS Bridge Substructure and Foundations Code, IRS CBC, Manual on the design and construction of well and pile foundations. The foundation design shall also comply with IS: 2911 and IRC: 45.

8.3.2 Soil structure analysis

When designing element forces or estimating displacements the soil stiffness shall

be assessed based on the actual ground data.

9 PROJECT SPECIFIC ADDITIONAL INFORMATION AND DETAILS

Nil

10 DESIGN CODES AND STANDARDS

The IRS codes shall be followed in principle. Although the main clauses have been mentioned in the DBR, other relevant clauses wherever applicable in the IRS codes shall also be followed. If provisions are not available in IRS, the order of preference shall be as follows, unless specifically mentioned otherwise in the relevant clause of DBR.

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 codes

iv. Other National codes

A list of various design codes and standards to be used at various stages of works is appended in Annexure 2. These codes with latest revisions including all addendums/ notifications and correction slips only shall be used.

11 DESIGN SOFTWARE

Any commercial or proprietary software can be used for analysis and design provided the same is validated with manual computations or other standard software in multiple scenarios.

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

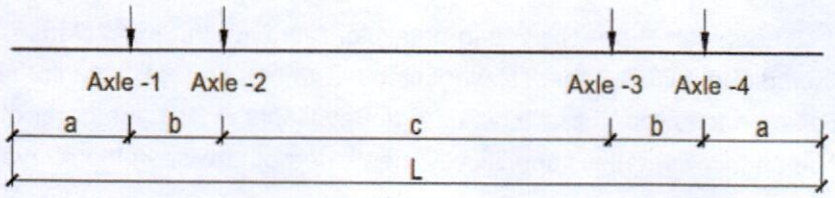
ANNEXURE 1 - EUDL

EQUIVALENT UNIFORMLY DISTRUBUTED LOAD & LONGITUDINAL FORCE CHART FOR METRO LOADING

1. Train Formation: 1DMC+1TC+2DMC+1TC+1DMC

2. Axle Distances: a=2.60 m, b=2.20 m, c=12.40 m

   Overall length of DMC/MC for combination = 22.00 m (MPMRCL)



3. Standard Maximum Height of Centre of Gravity from Rail Level: 1830mm for 1676mm Gauge and 1700mm for 1435mm Gauge

4. Maximum Axle Load: 16.0t

5. Tractive Effort (TE): 20% of Vertical Axle Load for DMC/MC

6. Braking Force (BF): 18% of Vertical Axle Load for DMC/MC/TC.

7. Loaded Length: For Bending Moment, L is equal to the effective span in metres. For Shear, L is the loaded length in meters to give the maximum Shear in the member under consideration.

8. EUDL (BM): The Equivalent Uniformly Distributed Load (EUDL) for Bending Moment (BM), for spans up to 10m, is that uniformly distributed load which produces the BM at the centre of the span equal to the absolute maximum BM developed under the standard loads. For spans above 10m, the EUDL for BM, is that uniformly distributed load which produces the BM at one-sixth of the span equal to the BM developed at that section under the standard train loads considered.

9. EUDL (SF): EUDL for Shear Force (SF) is that uniformly distributed load which produces SF at the end of the span equal to the maximum SF developed under the standard train load considered.

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

Examined & Found in Order
Date
Auth. Sign. : ADE/Civil/UTHS/RDSO

L (m)	EUDL (t)		LF (t)	
	SF	BM	TE	BF
1.0	32.00	32.00	3.20	2.88
1.5	32.00	32.00	3.20	2.88
2.0	32.00	32.00	3.20	2.88
2.5	35.84	32.00	3.20	5.76
3.0	40.85	32.00	6.40	5.76
3.5	43.89	32.00	6.40	5.76
4.0	46.40	33.64	6.40	5.76
4.5	48.36	36.54	6.40	5.76
5.0	49.92	38.94	6.40	5.76
5.5	51.20	40.96	6.40	5.76
6.0	52.27	42.68	6.40	5.76
6.5	53.17	44.17	6.40	5.76
7.0	54.00	45.47	6.40	5.76
7.5	56.32	46.60	9.60	8.64
8.0	58.80	47.61	9.60	8.64
8.5	60.99	48.51	9.60	8.64
9.0	62.93	49.31	9.60	8.64
9.5	65.35	50.04	12.80	11.52
10.0	68.48	59.76	12.80	11.52
11.0	73.89	63.53	12.80	11.52
12.0	78.40	70.88	12.80	11.52
13.0	82.22	73.06	12.80	11.52
14.0	85.49	76.93	12.80	11.52
15.0	88.32	80.40	12.80	11.52
16.0	90.80	83.22	12.80	11.52
17.0	92.99	85.94	12.80	11.52
18.0	94.93	88.32	12.80	11.52
19.0	96.67	90.47	12.80	11.52
20.0	98.24	92.21	12.80	11.52
21.0	99.66	94.00	12.80	11.52
22.0	101.24	95.42	16.00	14.40
23.0	103.79	96.95	16.00	14.40
24.0	106.13	98.24	19.20	17.28
25.0	109.57	99.42	19.20	17.28
26.0	112.74	100.60	19.20	17.28
27.0	115.67	103.00	19.20	17.28
28.0	118.40	104.71	19.20	17.28
29.0	121.05	106.72	22.40	20.16
30.0	124.48	109.50	22.40	20.16
31.0	127.69	112.20	22.40	20.16
32.0	131.60	114.75	25.60	23.04
33.0	135.37	117.10	25.60	23.04
34.0	138.92	121.16	25.60	23.04
35.0	142.26	124.35	25.60	23.04
36.0	145.42	128.00	25.60	23.04
37.0	148.41	131.60	25.60	23.04
38.0	151.24	134.66	25.60	23.04
39.0	153.93	137.85	25.60	23.04
40.0	156.48	140.70	25.60	23.04
41.0	158.91	143.63	25.60	23.04
42.0	161.22	146.28	25.60	23.04
43.0	163.42	148.83	25.60	23.04

L (m)	EUDL (t)		LF (t)	
	SF	BM	TE	BF
44.0	165.80	151.22	28.80	25.92
45.0	168.53	153.60	28.80	25.92
46.0	171.27	155.52	32.00	28.80
47.0	174.43	157.95	32.00	28.80
48.0	177.47	159.95	32.00	28.80
49.0	180.38	161.96	32.00	28.80
50.0	183.17	164.04	32.00	28.80
51.0	186.04	166.48	32.00	31.68
52.0	189.23	168.72	32.00	31.68
53.0	192.36	171.49	32.00	34.56
54.0	195.91	174.22	32.00	34.56
55.0	199.33	176.92	32.00	34.56
56.0	202.63	179.36	32.00	34.56
57.0	205.81	181.91	32.00	34.56
58.0	208.88	184.32	32.00	34.56
59.0	211.85	187.03	32.00	34.56
60.0	214.72	189.76	32.00	34.56
61.0	217.50	192.43	32.00	34.56
62.0	220.18	195.57	32.00	34.56
63.0	222.78	198.60	32.00	34.56
64.0	225.30	201.38	32.00	34.56
65.0	227.74	204.28	32.00	34.56
66.0	230.40	207.01	32.00	37.44
67.0	233.17	209.65	32.00	37.44
68.0	236.05	212.22	32.00	40.32
69.0	239.12	214.71	32.00	40.32
70.0	242.10	217.15	32.00	40.32
71.0	245.01	219.94	32.00	40.32
72.0	247.83	222.67	32.00	40.32
73.0	250.78	225.50	35.20	43.20
74.0	253.88	228.43	35.20	43.20
75.0	257.03	231.42	38.40	46.08
76.0	260.38	234.26	38.40	46.08
77.0	263.65	237.05	38.40	46.08
78.0	266.83	239.75	38.40	46.08
79.0	269.93	242.53	38.40	46.08
80.0	272.96	245.60	38.40	46.08
81.0	275.91	248.46	38.40	46.08
82.0	278.79	251.61	38.40	46.08
83.0	281.60	254.31	38.40	46.08
84.0	284.34	257.83	38.40	46.08
85.0	287.02	260.10	38.40	46.08
86.0	289.64	263.76	38.40	46.08
87.0	292.19	266.60	38.40	46.08
88.0	294.98	269.42	41.60	46.08
89.0	297.78	272.11	41.60	48.96
90.0	300.73	274.77	44.80	48.96
91.0	303.75	277.38	44.80	51.84
92.0	306.72	279.93	44.80	51.84
93.0	309.61	282.43	44.80	51.84
94.0	312.44	284.88	44.80	51.84
95.0	315.45	287.25	48.00	51.84

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

L (m)	EUDL (t)		LF (t)	
	SF	BM	TE	BF
96.0	318.50	289.60	48.00	51.84
97.0	321.65	292.19	51.20	54.72
98.0	324.89	294.75	51.20	54.72
99.0	328.00	297.35	51.20	57.60
100.0	331.22	300.23	51.20	57.60
101.0	334.26	302.92	51.20	57.60
102.0	337.25	305.60	51.20	57.60
103.0	340.19	308.54	51.20	57.60
104.0	343.08	311.42	51.20	57.60
105.0	345.94	314.35	51.20	57.60
106.0	348.48	317.38	51.20	57.60
107.0	351.30	320.43	54.40	57.60
108.0	354.07	323.40	54.40	57.60
109.0	356.70	326.21	54.40	60.48
110.0	359.50	329.15	57.60	60.48
111.0	362.38	331.95	57.60	60.48
112.0	365.37	334.69	57.60	63.36
113.0	368.37	337.40	57.60	63.36
114.0	371.31	340.06	57.60	63.36
115.0	374.21	342.77	57.60	63.36
116.0	377.05	345.23	57.60	63.36
117.0	379.82	347.75	57.60	63.36
118.0	382.59	350.23	57.60	63.36
119.0	385.29	352.76	57.60	63.36
120.0	387.95	355.15	57.60	63.36
121.0	390.56	357.77	57.60	63.36
122.0	393.13	360.00	57.60	63.36
123.0	395.66	363.07	57.60	63.36
124.0	398.14	365.81	57.60	63.36
125.0	400.86	368.28	57.60	63.36
126.0	403.00	371.19	57.60	63.36
127.0	405.37	373.81	57.60	63.36
128.0	407.70	376.40	57.60	63.36
129.0	410.00	378.92	57.60	63.36
130.0	412.26	381.43	57.60	63.36

Note:

1. For any combination/vehicle to be permitted to run on the metro system, its EUDL for vertical load as well as longitudinal force (LF) shall be worked out and compared with design EUDL & LF given in table above.
2. When loaded length lies between the values given in the table above, the EUDL for Bending Moment and shear can be interpolated.
3. Where loaded length lies between the values given in the table, the tractive effort or braking force shall be assumed as that for the longer loaded length.
4. Impact Load to be considered separately.

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

ANNEXURE 2 – List of Codes

IRS CODES (WITH LATEST VERSIONS)

IRS Substructure & Foundation Code

IRS Bridge Rules

IRS Concrete Bridge Code

IRS Steel Bridge Code

IRS Fabrication Code (B1)

IRS Welded Bridge Code

IITK-RDSO Guidelines on Seismic Design of Railway Bridges

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: 22	Standard Specification & Code of Practice for Road Bridges, Section VI – Composite Construction of Road Bridges
IRC: 24	Standard Specification & Code of Practice for Road Bridges, Section V – Steel Road Bridges
IRC: 112	Code of Practice for Concrete Bridges
IRC: 78	Standard Specification & Code of Practice for Road Bridges-Section Foundations and Sub-structure
IRC: 83(I)	Standard Specification & Code of Practice for Road Bridges, Part I Metallic Bearings
IRC: 83(II)	Standard Specification & Code of Practice for Road Bridges, Part II Elastomeric Bearings
IRC: 83(III)	Standard Specification & Code of Practice for Road Bridges, Part III Pot, Pot-cum-PTEF, Pin and Metallic Guide Bearings
IRC-SP-71	Guidelines for Design and Construction of Pre-cast Pre-tensioned Girders for bridges

IS CODES (WITH LATEST VERSIONS)

IS: 269	Specifications for Ordinary and Low Heat Portland cement
IS: 383	Specifications for coarse and fine aggregate from natural sources for Concrete
IS: 432	Specifications for Mild steel & medium tensile steel–bars (Part 1)
IS: 456	Plain and Reinforced Concrete – Code of Practice
IS: 800	Code of Practice for General construction in Steel
IS: 875	Code of Practice for Design Loads Parts 1,2,3,4 & 5 (Other than Earthquake) for Building and structures

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/UTHS/RDSO

IS: 1080	Design and Construction of shallow foundations in soils (Other than Raft, Ring & 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 M1:6 to M64)
IS: 13920	Ductile Detailing of Reinforced concrete structures subjected to Seismic structures code of practice
IS: 1489	Specifications for Portland Pozzolan 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 Foundation in soils General Requirements
IS: 2062	Specifications for Weldable structure steel
IS: 2502	Codes of Practice Bending and Fixing of Bars for Concrete Reinforcement
IS: 2911(Part-1/Sec2)	Code of Practice for Design and Construction of Pile Foundations Part-1 Concrete Piles Section 2 Bored Cast-in-situ Piles (with amendments)
IS: 2911	Code of Practice for Design & Construction of Pile Foundation 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 settlement of shallow foundations
IS: 9103	Concrete Admixtures - Specifications
IS: 11384	Code of Practice for Composite Construction in Structural Steel and Concrete
IS: 12070	Code of Practice for Design and Construction of Shallow Foundations on Rocks
IS: 14268	Uncoated stress Relieved Low relaxation Seven-ply Strands for pre-Stressed 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 Prestressing Anchorages for Post-Tensioned construction
BS: 4486	Specifications for High Tensile steel bars used for Prestressing
BS: 5400	Code of Practice for Design of Concrete Bridges Part 4 -1990
BS: 5400	Code of Practice for Fatigue Part 10-1990

Examined & Found in Order
Date

Auth. Sign. : ADE/Civil/PTHS/RDSO

BS: 8006 Code of Practice for Strengthened Reinforced soils and other fills-1995

BS: 8007 Design of Concrete Structures for Retaining Aqueous Liquids

OTHERS (WITH LATEST VERSIONS)

UIC: 776-1R	Loads to consider in Railway Bridge Design
UIC: 776-3R	Deformation of Bridges
UIC-774-3R	Rail Structure Interaction
UIC-772-2R	Code for the use of Rubber Bearings for Rail Bridges
CEB-FIP	Model Code 1990 for concrete structures FIP Recommendations for the Acceptance of Post tensioning Systems
MoRT&H	Specifications for Road and Bridge Works
Eurocode 0	Basis of Structural Design

Eurocode 1 Actions on Structures – Part 2 Traffic Loads on Bridges

Eurocode 2 Design of Concrete Structures Part 1 and Part 2

RDSO Guidelines for Carrying out RSI

NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems

Examined & Found in Order
Date

Auth. Sign. : ADE/C[illegible]/RDSO