GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

2023/Proj./GMRC/AMRP2/DBR/30/44 New Delhi, dated 22.08.2023

Managing Director,
Gujarat Metro Rail Corporation Limited
Block No.1, First Floor, Karmayogi Bhavan,
Behind Nirman Bhavan, Sector 10/A,
Gandhinagar, Gujarat - 382010

Sub: Approval of Design Basis Reports (DBR's) for Elevated Station and Viaduct of Ahmedabad Metro Rail Project, Phase-II of Gujarat Metro Rail Corporation Limited.

Ref: DBRs uploaded on RDSO's online portal by GMRCL on 17.07.2023

The Design Basis Reports (DBR)s for Elevated Station and Viaduct of Ahmedabad Metro Rail Project, Phase-II of Gujarat Metro Rail Corporation Limited (GMRCL) has been examined in consultation with RDSO and approval of Railway Board is hereby conveyed for the same.

Accordingly, approved copies of DBRs are enclosed.

Encl: As above

(**F. A. Ahmad**)
Director/Gati Shakti (Civil)-IV
Railway Board
Ph: 011-47845480
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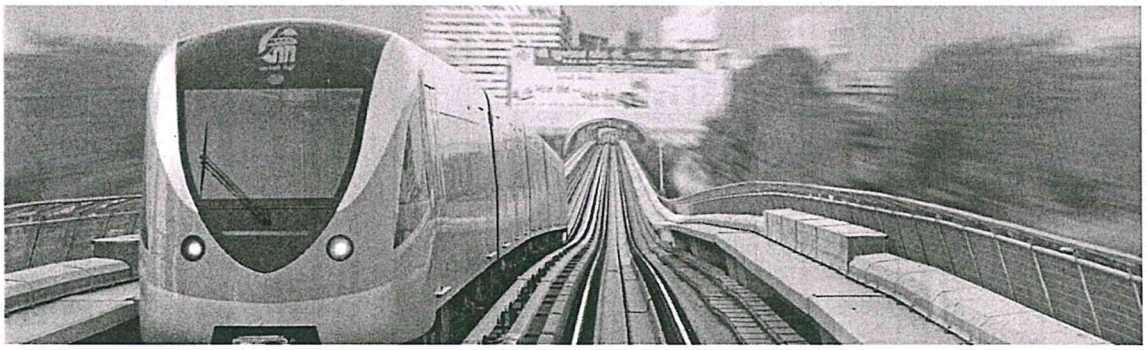
Copy to:

(i) **Executive Director/UTHS**, RDSO, Manak Nagar, Lucknow w.r.t letter No. UTHS/GMRC/AMRC2/P01/032021 dated 07.08.2023

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

DESIGN BASIS REPORT (DBR) FOR DESIGN OF ELEVATED STATIONS

JULY 2023



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GUJARAT METRO RAIL CORPORATION (GMRC) LIMITED.

(A SPV of Government of India and Government of Gujarat)

AHMEDABAD METRO RAIL PROJECT, PHASE – II

Contents

Project Directorate Approved 22/8/23 Railway Board

1.0 INTRODUCTION

1.1 Brief Description of the Project

Ahmedabad Metro Rail Project, Phase II comprises of two Corridors. The details of the two corridors are given below:

Corridor 1: Motera Stadium to Mahatma Mandir

Corridor 2: GNLU to GIFT City

Motera Stadium to Mahatma Mandir Corridor is 22.838 km long elevated corridor with Standard Gauge (SG). It comprises of 20 elevated stations. One depot-cum-workshop is proposed near Infocity station.

GNLU to GIFT City Corridor is 5.416 km long elevated corridor with Standard Gauge (SG), and it comprises of 2 elevated stations.

This design basis report pertains to elevated stations of Motera Stadium to Mahatma Mandir and GNLU to GIFT City corridors of Ahmedabad Metro Rail Project, Phase II.

The proposed list of stations is shown below:

S.No.	Station Name	Elevated/Underground	Remarks
Motera Stadium to Mahatma Mandir Corridor			
1	Koteshwar Road	Elevated	Interchange
2	Vishwakarma College	Elevated	
3	Tapovan Circle	Elevated	
4	Narmada Canal	Elevated	
5	Koba Circle	Elevated	
6	Juna Koba	Elevated	
7	Koba Gaam	Elevated	
8	GNLU	Elevated	Interchange
9	Raysan	Elevated	
10	Randesan	Elevated	
11	Dholakuva Circle	Elevated	
12	Infocity	Elevated	
13	Sectror-1	Elevated	
14	Sector-10A	Elevated	
15	Sachivalaya	Elevated	
16	Akshardham	Elevated	
17	Juna Sachivalaya	Elevated	
18	Sector-16	Elevated	
19	Sector-24	Elevated	
20	Mahatma Mandir	Elevated	

S.No.	Station Name	Elevated/Underground	Remarks
GNLU to GIFT City Corridor			
1	GNLU	Elevated	Interchange
2	PDPU	Elevated	
3	Gift City	Elevated	

Project Directorate Approved Railway Board

1.2 Scope

The objective of this Design Basis Report is to establish a procedure for the design of "Elevated Stations for Gujarat Metro Rail Corporation (GMRC) Limited Ahmedabad Metro Rail Project, Phase-II". This is meant to serve as guide to the designer but compliance with the rules there in does not relieve them in any way of their responsibility for the stability and soundness of the structure designed. The design of Elevated Stations require an extensive and thorough knowledge and entrusted only to specially qualified engineers with adequate practical experience in structure designs.

The DBR is only for structural design of Elevated Stations. Extended platform portion which is generally on single column or portal type structure shall be designed as part of viaduct.

The structural elements connected to the member on which metro live loads are supported may also be designed with taking loads applicable as specified in "Model Design Basis Report (DBR) for Viaduct of Metro System". LWR forces shall be specified by Metro, if RSI analysis is not a practicable. Load combination as per "Model Design Basis Report (DBR) for Viaduct of Metro System" shall also be considered. Other structural elements such as secondary beams, stub columns etc., may be designed as per IS: 456 2000.

Structures, where Metro Live loads are not applicable, the design of Plain and Reinforced Concrete Structures will generally be governed by IS:456-2000, Pre-stressed Concrete structures shall generally be governed by IS:1343, Steel structures design shall generally be governed by IS:800 & Seismic design shall be governed by IS: 1893.

1.3 Units

The main units used for design will be: [t], [m], [mm], [kN], [kN/m^2], [MPa], [^oC], [rad].

2.0 DESIGN SPECIFICATION FOR STATION BUILDING

2.1 Materials

2.1.1 Cement

For plain and reinforced concrete structures, cement shall be used as per clause 5.1 of IS: 456 and in case of pre-stressed concrete structures, as per clause 5.1 of IS: 1343.

2.1.2 Concrete

As per clause 6, 7, 8, 9 and 10 of IS:456 in case of Plain and Reinforced Concrete Structures and Clause 6, 7, 8, 9 and 10 of IS:1343 for Pre-stressed Concrete Structures.

Short-term modulus of elasticity (E_c) shall be taken as per cl. 6.2.3.1 of IS: 456 for Plain and Reinforced Concrete structures and IS: 1343 for Pre-stressed concrete structures.

The modular ratio for concrete grades shall be taken as per Annex B of IS: 456.

The Density of concrete shall be as per IS: 456.

2.1.3 Pre-stressing Steel for Tendons

As per clause 5.6.1 of IS: 1343.

2.1.3.1 Young's Modulus

As per pre-stressing steel used in accordance with Para 2.1.3 above.

2.1.3.2 Pre-stressing Units

As per clause 13 of IS: 1343.

2.1.3.3 Maximum Initial Pre-stress

As per clause 19.5.1 of IS: 1343.

2.1.3.4 Density

Weight of strands shall be as per relevant clauses of IS codes as per material being used as indicated in para 2.1.3 above.

2.1.3.5 Sheathing

As per clause 12.2 of IS: 1343.

2.1.4 Structural Steel

Structural steel used shall confirm to

a) Hollow steel sections as per IS: 4923 – 1997.

b) Steel for General structural purposes as per IS: 2062.

c) Steel tubes for structural purpose shall be as per IS: 1161.

Note:

(i) Grade of steel to be used shall be indicated, shall not be less than minimum grade as applicable, based on whether structure is taking moving loads or not and relevant code as indicated in note (ii) and (iii) below.

(ii) Design of steel structure will be governed by IRS Steel Bridge Code in case structure is taking moving loads of Metro, otherwise will be governed by IS: 800. In case of composite (steel-concrete) structures, it will be governed by IS: 11384 & IS: 3935.

(iii) Fabrication shall be done in accordance with IRS B1 (Fabrication Code), in case structure is taking moving loads of Metro, otherwise shall be done as per IS: 800.

2.1.5 Reinforcement

As per clause 5.6 of IS: 456 for Plain and Reinforced concrete structures and as per clause 5.6.2 of IS: 1343 for Pre-stressed concrete structures.

Note: For Seismic zone III, IV & V, HYSD steel bars having minimum elongation of 14.5 percent and conforming to requirements of IS:1786 shall be used.

2.1.5.1 Reinforcement Detailing

All reinforcement shall be detailed in accordance with clause 12 and 26 of IS: 456 for Plain and Reinforced concrete structures, as per clause 12.3 and 19.6.3 of IS: 1343 for Pre-stressed Concrete structures. Ductile detailing of seismic resisting RC elements, shall comply with ductile requirements of IS: 13920.

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2.2 Durability

Durability of Concrete shall be as per clause 8.0 of IS: 456 for Plain and Reinforced Concrete structures, as per clause 8.0 of IS: 1343 for Pre-stressed Concrete structures and Section 15 of IS: 800 for Steel Structures.

2.2.1 Concrete Grades

The minimum grade of concrete for all structural elements including piles, blinding layer and levelling course shall be as under:

Sr. No.	Structural Components	Minimum grade of concrete
A	Pre-tensioned girders	M50
B	Superstructure-deck slab, beams, piers and pier arms Portal beams Pedestal Shear key and seismic stoppers	M40
C	Crash barrier, pier protection	M40
D	Slabs, Beams, Walls, Columns	M35
E	Pile, Pile cap, Open foundation, Basement slab, Ancillary building foundation slab, Retaining wall	M35
F	Solid slab	M40
G	Blinding concrete or levelling course	M15

2.2.2 Cover to Reinforcement

As per clause 26.4 of IS: 456 for Plain and Reinforced Concrete Structures and clause 12.3.2 of IS: 1343 for pre-stressed concrete structures. Cover to pre-stressing steel shall be in accordance with clause 12.1.6 of IS: 1343.

2.2.3 Fire Resistance period

All the structural elements in the station building shall be designed for a minimum fire resistance period of 2 hours. The minimum element thickness for this fire resistance shall be as per clause 21 of IS: 456 for Concrete structures and as per Section 16 of IS: 800 for Steel structures.

2.2.4 Crack Width Check

All structural concrete elements shall be designed to prevent excessive cracking due to flexure, early age thermal effects and shrinkage. Flexural crack width shall be checked in accordance with clause 35.3.2 and 43 of IS: 456 for Plain and Reinforced Concrete Structures and clause 20.3.2 and 24.2 of IS: 1343 for Pre-stressed Concrete structures.

2.3 Clearances

i. **Clearance for Road Traffic:** As per relevant IRC specifications and Road Authority requirements.
ii. **Clearance for Railway Traffic:** Indian Railways Schedule of Dimensions (SOD) shall be applicable.
iii. **Clearances for Metro Traffic:** As per approved SOD of GMRC.
iv. **For utility services:** The clearances to utilities, drainage etc. shall be as mandated by the utility owner/department.

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2.4 Design Loads

Elementary loads to be considered for design are:

Dead Loads	DL
Super Imposed Loads	SIDL
Imposed (Crowd Live) Loads	LL
Earthquake Loads	EQ
Wind Loads	WL
Collision/Impact Loads/Derailment Loads	CL*
Construction & Erection Loads	EL
Temperature Loads	OT
Shrinkage	S
Creep	C
Earth & water pressure	EP
Surcharge Loads (Traffic, building etc.)	SR
Pre-stress Force	PR
Long Welded Rail Force	LWR
Differential Settlement	DS

*Load as applicable shall be taken.

2.4.1 Dead loads

Dead load shall be based on the actual cross section area and unit weights of materials and shall include the weight of the materials that are structural components of Elevated Station and permanent in nature.

2.4.2 Superimposed Dead Loads (SIDL)

Superimposed dead loads include all the weights of materials on the structure that are not structural elements but are permanent.

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

The minimum distributed and concentrated loads shall be in accordance to IS: 875, wherever SIDL values are not available in relevant codes, the following values shall be adopted:

Stations

For platform slab, the following assumptions will be taken:

- Suspension load - 2.0 kN/m^2 uniform loads.

  (Suspension load will be considered as load of false ceiling, plumbing & electrical equipments, Escalator Pits etc. This load is applicable wherever necessary.)

- PSD - As per contractor's specifications.

For the concourse area, the following assumption will be taken:

- Suspension load - 2.0 kN/m^2 uniform loads.

(Suspension load will be considered as load of false ceiling, plumbing & electrical equipments.)

- Lift and Escalator support shall be designed as per manufacturer's details.

Note: The wall loads will be taken based on actual location shown in architectural drawings. External wall load/glazing load will be taken as per details provided in architectural drawings.

SIDL for two tracks

Details of SIDL for two tracks:

Cables	0.7 kN/m
Cable troughs with cover	7.4 kN/m
Cable trays	0.1 kN/m
Concrete plinths for rails	28.0 kN/m
Rails + Pads	3.0 kN/m
Miscellaneous (OCS, signaling)	4.0 kN/m
Hand Rail	0.8 kN/m

2.4.3 Imposed (Crowd Live) Load

Imposed loads on station buildings are those arising from occupancy and the values include, normal use by persons, furniture and moveable objects, vehicles, rare events such as concentrations of people and furniture, or the moving or stacking of objects during times of re-organization and refurbishment, this shall be as per clause 19.3 of IS:456.

2.4.4 Earthquake Loads

Earthquake design shall follow the seismic requirements of IS: 1893 (Part 1). The provision as per Design Basis Report for Viaduct Metro System shall be followed where structures are taking moving loads of metro.

2.4.4.1 Drift Limitation

The storey drift in the building shall satisfy the drift limitation specified in clause 7.11.1 in IS: 1893.

2.4.4.2 Seismic Detailing

i. For reinforced concrete structures as per IS: 13920.
ii. For other structures as per IS: 4326.

2.4.5 Wind Loads

The wind load shall be calculated as per IS: 875 (Part 3).

2.4.6 Collision/Impact Loads/Derailment Loads

I. For road traffic as per IRC: 6.
II. For metro as per IRS Bridge Rule.
III. Clause 6.1.2 of IS: 875 (Part 5).

2.4.7 Construction and erection loads

The weight of all temporary and permanent materials together with all other forces and effects which can operate on any part of structure during erection shall be taken into account.

Allowances shall be made in the permanent design for any locked-in stresses caused in any member during erection.

2.4.8 Temperature

As per clause 19.5 of IS: 456. Temperature gradient shall be considered as per Clause 215 of IRC: 6, if applicable.

2.4.9 Shrinkage

The shrinkage strains shall be evaluated as per clause 6.2.4 of IS: 456 for Plain and Reinforced Concrete Structures and clause 6.2.4 of IS: 1343 for Pre-stressed Concrete structures.

For structure supporting Metro loading, the effects of shrinkage as per Cl. 5.2.3 of IRS-CBC shall be considered.

2.4.10 Creep

The creep strains shall be evaluated as per clause 6.2.5 of IS: 456 for Plain and Reinforced Concrete Structures and clause 6.2.5 of IS: 1343 for Pre-stressed Concrete structures.

For structure supporting Metro loading, the effects of creep as per Cl. 5.2.4 of IRS-CBC shall be considered.

2.4.11 Earth & Water Pressure

In the design of structures or parts of structures below ground level, such as retaining walls and underground pump room/water tank etc., the pressure exerted by soil or water or both shall be duly accounted for. When a portion or whole of the soil is below the free water surface, the lateral earth pressure shall be evaluated for weight of soil diminished by buoyancy and the full hydrostatic pressure (As per IS: 875 Part 5).

All foundation slabs/footings subjected to water pressure shall be designed to resist a uniformly distributed uplift equal to the full hydrostatic pressure. Checking of overturning of foundation under submerged condition shall be done considering buoyant weight of foundation.

If any of the structure supporting Metro loading is subjected to earth pressure, the loads and effects shall be calculated in accordance with Cl. 5.7 of IRS-Bridge Sub-structure & Foundation Code.

2.4.12 Surcharge Load

In the design of structures or parts of structures below ground level, such as retaining wall and underground pump room/water tank etc., the pressure exerted by surcharge from stationary or moving load, shall be duly accounted for.

2.4.13 Pre-stressing Force (PR)

The Pre-stressing Force should be as per IS: 1343.

2.4.14 Long welded Rail Force

A Rail Structure Interaction [RSI] analysis is required because the continuously welded running rails are continuous over the deck expansion joints. The interaction occurs because the rails are directly connected to the decks by fastening system.

1) Rail structure interaction studies shall be done as per provisions of UIC 774-3R with the following parameters specified in consultation with track design engineers:
   i. Track resistance in loaded and unloaded conditions.
   ii. Maximum additional stresses in rail in tension as well as compression on account of rail-structure interaction.
   iii. Maximum vertical deflection of the girder at ends.
2) Software and general methodology to be used for carrying out Rail-Structure Interaction analysis must be validated before adopting the same.
3) Representative stretches must be chosen for carrying out Rail-Structure Interaction.
4) Checks must be performed for break in rail continuity due to unusual conditions fractures or for maintenance purposes.
5) RDSO Guidelines for carrying out RSI studies shall be preferred.
6) LWR forces shall be considered in appropriate load combination as per IRS Concrete Bridge Code.

2.4.15 Settlement

Maximum and differential settlement shall not exceed, as provided in Table 1 of IS: 1904.

2.4.16 Other Forces and Effects

As per clause 19.6 of IS: 456.

2.5 Design Load Combinations

2.5.1 Ultimate Load Combinations

Each component of the structure shall be designed and checked for all possible combinations of applied loads and forces. They shall resist effect of the worst combination. Following shall be considered:

(i) Load combinations and factors as per Table 18 of IS: 456 for Plain and Reinforced Concrete Structures.
(ii) Load combination and factors as per Table 7 of IS: 1343 for Pre-stressed Concrete structures.
(iii) Load combination as per Section 3 and factors as per Section 5 of IS: 800 for Steel structures.
(iv) Load combination as per clause 6.3 of IS: 1893 (Part 1).
(v) Load combinations as per IRS CBC and RDSO guidelines for Seismic design of Railway Bridges where Metro live loads are applicable.

Note: (i) Load combination for construction load case shall be decided by Metro as per methodology of construction.

(ii) Reference of IRC: 6 or IS: 875 (Part 5) be taken for collision case if collision of road vehicles are involved as applicable.

2.5.2 Serviceability Load Combinations

The following load combinations and load factors shall be used for design for serviceability limit state:

I. Load combinations and factors as per Table 18 of IS: 456 for Plain and Reinforced Concrete Structures.

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II. Load combination and factors as per Table 7 of IS: 1343 for Pre-stressed Concrete structures.
III. Load combination as per Section 3 and factors as per Section 5 of IS: 800 for Steel structures.
IV. Load combinations as per IRS CBC where Metro live loads are applicable.

2.6. Deflection Criteria

The deflection limitations as per clause 23.2 of IS: 456 for Plain and Reinforced Concrete Structures, Clause 20.3.1 of IS: 1343 for Pre-stressed Concrete structures and Clause 5.6.1 of IS: 800 for Structural Steel members shall be followed.

2.6.1. Lateral Sway

The lateral sway at the top of the building due to Wind loads should not exceed H/500, where H is the height of the building.

2.7. 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). Fatigue check for

(i) RCC and PSC structures -As per clause 13.4 of IRS CBC.
(ii) Steel Structures –
a) In case of Metro live loads, as per clause 3.6 of IRS Steel Bridge Code shall govern. 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 done.
b) For other cases as per Section 13 of IS: 800.

*Damage equivalence factors (As per IRS Steel Bridge Code).

2.8. Foundations

2.8.1. Types of Foundation

Considering the nature of ground, type of proposed structures, expected loads on foundations, the following type of foundations are considered practical.

a) Spread or pad footing
b) Raft foundation
c) Pile foundation

No matter the type of foundation to be adopted, the following performance criteria shall be satisfied:

1) Foundation must not fail in shear.
2) Foundation must not settle by more than the settlements permitted as per Table-1 of IS: 1904.

2.8.2. Design of Pile

IS: 2911 shall be followed for design of pile, load capacity etc.

Pile Settlement

Methods of estimating the settlement of deep foundation depend upon the type of deep foundation and the manner of transfer of loads from the structure to the soil. Theoretical estimation of settlement shall be done in accordance with IS: 8009 (Part II) by integrating the vertical strain for the entire depth of soil and rock formation. The settlement of each pile and/or pile group should be determined and it should be demonstrated that such total and/or differential settlement can be tolerated by the structure.

2.8.3. Foundations

IS: 1904 shall be followed for design of foundations in soil. The safe bearing capacity for shallow foundations shall be calculated in accordance with IS: 6403.

Computation of Settlements of Foundations

The calculation for settlement of foundations shall be done as per:

- IS: 8009 (Part I) for shallow foundations.
- IS: 8009 (Part II) for deep foundations.

2.9 Design of Water Retaining Structure

It should be designed as per IS: 3370.

3.0 LIST OF DESIGN CODES AND STANDARDS

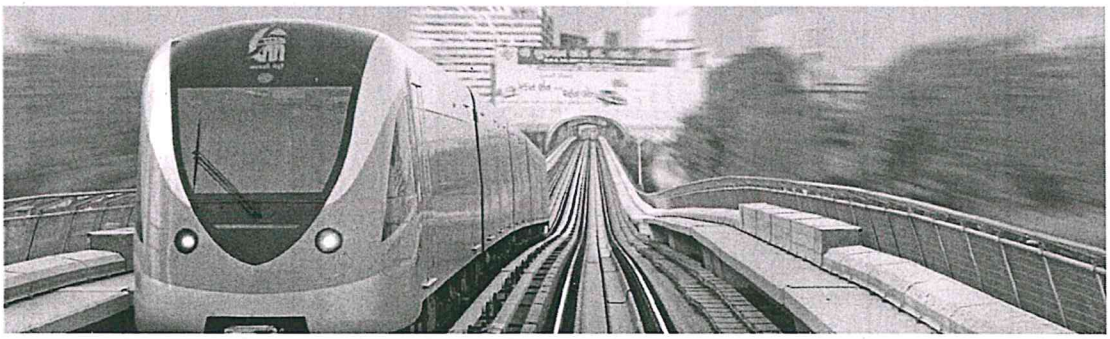
The designs of station buildings shall be carried out as per provisions of this Design Specifications. Reference shall be made to following codes for any additional information.

Order of preferences of codes shall be as follows: -

I. IS
II. IRS
III. IRC
IV. BS or Euro Code
V. AASHTO

DESIGN BASIS REPORT (DBR) FOR DESIGN OF VIADUCT

JULY 2023



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GUJARAT METRO RAIL CORPORATION (GMRC) LIMITED.

(A SPV of Government of India and Government of Gujarat)

AHMEDABAD METRO RAIL PROJECT, PHASE – II

Contents

Project Directorate Approved on 22/8/23 Railway Board

Digitally Signed
Signed by: ANAND SINGH BISHT
Reason: GMRCL Phase 2 Viaduct DBR
Location: Gandhinagar
Date: 17-Jul-2023 15:09:56

Project Directorate
Approved dt. 22/8/23
Railway Board

eSign

Digitally Signed
Signed by: ANAND SINGH BISHT
Reason: GMRCL Phase 2 Viaduct DBR
Location: Gandhinagar
Date: 17-Jul-2023 15:09:56

1. INTRODUCTION

1.1. Brief Description of Project

Ahmedabad Metro Rail Project, Phase II comprises of two Corridors. The details of the two corridors are given below:

Corridor 1: Motera Stadium to Mahatma Mandir

Corridor 2: GNLU to GIFT City

Motera Stadium to Mahatma Mandir Corridor is 22.838 km long elevated corridor with Standard Gauge (SG). It comprises of 20 elevated stations. One depot-cum-workshop is proposed near Infocity station.

GNLU to GIFT City Corridor is 5.416 km long elevated corridor with Standard Gauge (SG), and it comprises of 02 elevated stations.

This Design Basis Report pertains to Viaduct Portion of Ahmedabad Metro Rail Project, Phase-II from Motera Stadium to Mahatma Mandir and GNLU to GIFT City.

1.2. Geometrical Design Feature

Gradient, Maximum Degree of Curve, Spacing of track should be as per the approved SOD of GMRC.

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.

2. PROPOSED STRUCTURAL SYSTEM OF VIADUCT

2.1. Superstructure System

The Viaduct for Ahmedabad Metro Rail Project, Phase-II comprises of Precast Pretension U- girder. The standard gauge of 1435mm is to be followed. The center to center distance between the two tracks will be as per SOD of GMRC.

However at crossovers / turnouts / railway crossings/ highway crossings, precast pre-stressed I-girder (pre/post-tensioned) / steel girder with cast-in-situ concrete deck slab is to be provided.

Minimum clearance in case of PSC Superstructure and minimum dimensions shall be considered as per Clause 16.9.6 of IRS CBC.

Design of superstructure should be done in accordance with construction methodology/construction sequence to be adopted during execution by GMRC.

2.2. Emergency Walkway

Walkway on the viaduct shall be provided for evacuation of passengers in safe conditions. The walkway dimension shall conform to the approved SOD of Metro system.

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Reason: GMRCL Phase 2 Viaduct DBR
Location: Gandhinagar
Date: 17-Jul-2023 15:09:56

2.3. Bearing

Bearing will 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. CLEARANCE FOR STRUCTURES

3.1. Clearances for Road Traffic

As per relevant IRC specifications and Road Authority requirements.

3.2. Clearances for Railway Traffic

Indian Railways Schedule of Dimensions (SOD) shall be applicable.

3.3. Clearances for Metro Traffic

As per approved SOD of specific Metro system.

4. STRUCTURAL MATERIALS AND PROPERTIES

4.1. Cement

Clause 4.1 of IRS CBC.

4.2. Concrete

4.2.1. Density

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

4.2.2. Young's Modulus

Clause 5.2.2.1 of IRS CBC

4.2.3. Modular ratio

Clause 5.2.6 of IRS CBC

4.2.4. Minimum grade of concrete for structural elements

Clause 5.4.4 of IRS CBC.

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4.2.5. Thermal Expansion Coefficient

$\varepsilon = 1.17 \times 10^{-5}$ /°C (Clause 2.6.2 of IRS Bridge Rules).

4.2.6. Poisson's ratio

0.15 for all concretes.

4.3. Reinforcing steel

As per Clause 4.5 & 7.1.5 of IRS CBC.

4.4. Pre-stressing Hardware

4.4.1. Pre-stressing steel for tendons

4.4.1.1. As per Clause 4.6 of IRS-CBC.

4.4.1.2. Characteristic Strength: As per Clause 16.2.4.3 of IRS-CBC.

4.5. Pre-stressing Units

4.5.1. Jacking Force:

Jacking force (maximum initial pre-stressing force) shall be as per Clause: 16.8.1 of IRS CBC.

4.5.2. Pre-stress 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 shall conform to IS: 2062.

4.6.2. Fabrication shall be done as per provisions of IRS B1 (Fabrication Code).

4.6.3. Design of steel structures shall be done as per IRS Steel Bridge Code.

4.6.4. IS codes may be referred for steel-RCC composite construction.

4.6.5. Welding shall be done following IRS Steel Bridge Code, IRS Welded Bridge Code or relevant IS code for welding.

4.7. Structural Steel for Miscellaneous Use

4.7.1. Design shall be done as per IS: 800 and related provisions.

4.7.2. Hollow steel sections for structural use shall be as per IS: 4923.

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

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eSign

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Signed by: ANAND SINGH BISHT
Reason: GMRCL Phase 2 Viaduct DBR
Location: Gandhinagar
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4.7.4. Steel for General Structural Purposes shall be as per IS: 2062.

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

5. LOADS

5.1. Dead load (DL)

Dead load shall be based on the actual cross section area and unit weights of materials and shall include the weight of the material that are structural components of viaduct and permanent in nature.

5.2. Super Imposed Dead Load (SIDL)

Superimposed dead loads include 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/cable trough/signaling equipment/Third Rail for providing electric traction power to train etc. and will be considered in design as per site conditions.

Note: The SIDL can be of two types: Fixed or non-variable, and variable. In case Metro certifies that a portion of SIDL is of fixed or non-variable type and is not likely to vary significantly during the life of the structure and a special clause for ensuring the same 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 and Creep

Shrinkage and creep effects will be calculated as per IRS-CBC.

5.4. Live Load (LL)

The simply supported structures shall be designed for one of the loading envelopes (Light, Medium or Heavy) tabulated in the Annexure-I. The loading envelope chosen shall be as per the Rolling Stock planned to be used on the Metro system (i.e 16t).

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 design.

5.5. Coefficient of Dynamic Augment (CDA)

CDA shall be adopted as per IRS Bridge Rules.

5.6. Footpath Live Load

As per Clause 2.3.2 of IRS Bridge Rules.

5.7. Braking and Traction (BR/TR)

The value of braking and traction forces will be taken as per rolling stock used. For twin tracked decks carrying traffic in opposite directions, consideration should be given to braking forces from

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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 considered.

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 will be considered.

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 Clause 2.5 of IRS Bridge Rules.

5.9. Gradient Effect

Shall be considered as per site condition.

5.10. Wind Load (WL)

As per Clause 2.11 of IRS Bridge Rules.

5.11. Seismic Load (EQ)

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

5.12. Temperature Effect

Clause 2.6 of IRS Bridges Rules.

5.12.1. Overall Temperature (OT)

As per Clause 215.2 of IRC: 6.

5.12.2. Differential Temperature (DT)

As per IRC: 6.

5.12.3. Temperature Gradient

As per Clause 215 of IRC: 6.

5.13. Differential Settlement

Considered only in the design of continuous structures. Differential settlement between two adjacent viaduct piers will be:

- 12mm for Long Term Settlement.
- 6mm for Short Term Settlement (50% of Long Term).

5.14. Vehicle Collision Loads on Piers (VCL)

(a) Vehicle Collision load in piers: 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.

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5.15. Buffer Load

Provision of Buffers is contemplated at the end of temporary terminal stations during stage opening of the Corridors, at Pocket track ends and at terminal stations of the corridors (at the end of turn back/stabling lines). Such buffers will be of friction type. These buffers will 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 need to be designed for such buffer load. The exact buffer loads need to be interfaced and ascertained during the detailed design.

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 Clause 2.9 of IRS Bridge Rules.

5.18. Vibration Effect

Effect of vibration due to the movement of metro train on station bridge structure will be taken into consideration.

5.19. Forces on Parapets

As per Clause 2.10 of IRS Bridge Rules.

5.20. Derailment Load

Derailment loads shall be considered as per Appendix XXV of IRS Bridge Rules with relevant gauge. For ULS and Stability check, 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 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 SLS combination 5 of IRS-CBC a 1/1.75 co-efficient shall be applied to the derailment load.

5.21. Erection Forces

As per Clause 2.13 of IRS Bridge Rules.

6. LOAD COMBINATIONS

6.1. Methodology

Provisions of Bridge Rules/IRS Concrete Bridge Code shall be followed for load combinations.

6.2. Loading Condition

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

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6.3. Design as per Construction methodology and Construction Sequence

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

7. DESIGN PARAMETERS

7.1. Unit of Design

[t], [m], [mm], [kN], [kN/m^2], [MPa], [°C], [rad].

7.2. ULS Check

As per IRS Concrete Bridge Code.

7.3. SLS Check

As per IRS Concrete Bridge Code.

7.3.1. Crack Width

Crack width in reinforced concrete members will be checked for SLS Combination-1. Crack width will be as per Clause 15.9.8.2 of IRS CBC. Crack width shall not exceed 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 will be modified to the extent that actual axial load will be considered to act simultaneously.

7.3.2. Clause 10.4.1, 11.3.4 and 13.3 of IRS CBC shall be kept in view while calculating vertical deflection at mid span.

7.4. Fatigue Check

7.4.1. RCC and PSC structures

Clause 13.4 of IRS CBC shall govern.

7.4.2. Steel structures

Clause 3.6 of IRS Steel Bridge Code shall govern. If λ values are required to be used, the train closest to the actual train formation proposed to be run on metro system shall be used. Otherwise, detailed counting of cycles shall be done.

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

As per Clause 15.1.3 and 16.1.3 of IRS CBC.

7.7. Drainage

The drainage of deck shall be designed to cater the maximum envisaged rainfall intensity and suitable longitudinal and transverse slope should be provided. Moreover, the provisions of Clause 10.4.1.1 and 15.2.2 of IRS CBC shall be followed.

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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. Design of POT-PTFE Bearings shall be as per IRC: 83 Part-III.

8.1.3. Deign of Spherical and Cylindrical Bearing shall be as per IRC: 83 Part-IV.

8.1.4. Clause 15.9.11.3 & 15.9.11.4 of IRS CBC should be followed for considering replacement of bearings.

8.1.5. If bearings cannot accommodate the seismic forces, concrete shear keys/seismic restrainer shall be 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 of 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. Foundation shall be designed as per IRS Bridge Substructure and Foundation Code, IRS Concrete Bridge Code, Manual on the design and construction of well and pile foundation, IS-2911 and IRC-45.

8.3.2. Soil Structure analysis

When designing elements forces or estimating displacements, the soil stiffness shall be assessed based on the actual ground data.

9. PROJECT SPECIFIC ADDITIONAL INFORMATION/DETAILS

Nil

10. DESIGN CODES AND STANDARDS

The IRS codes shall be followed in-principle. Although main clauses have been mentioned in the DBR, the other relevant clauses as available 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.

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For other Design/detailing related issues:

i. IRC
ii. IS
iii. Euro Code
iv. Other national codes.

These codes with latest revisions including all addendums/notifications and correction slips only shall be used.

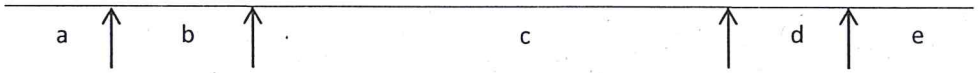
11. DESIGN SOFTWARE

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

ANNEXURE-I

Following Parameters have been taken for preparation of EUDL & LF Chart.

1. Train Formation — 2DMC+1TC+2DMC+1TC+2DMC
2. Axle Distances: — a=2.4m, b= 2.2m, c=12.8m, d=2.2m, e= 2.4m, overall length of DMC/MC for Combination-1 =22.0m



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 meters. 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 upto 10m, is that uniformly distributed load which produces the BM at the center 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 loads considered.

L (M)	EUDL (T)		LF (T)	
	SF	BM	TE	BF
0.5	32.00	32.00	03.20	02.92
1.0	32.00	32.00	03.20	02.92
1.5	32.00	32.00	03.20	02.92
2.0	32.00	32.00	03.20	02.92
2.5	33.73	32.00	06.40	05.74
3.0	38.15	32.00	06.40	05.74
3.5	41.31	32.00	06.40	05.74
4.0	44.00	32.00	06.40	05.74
4.5	46.22	34.39	06.40	05.74
5.0	48.00	36.65	06.40	05.74
5.5	52.28	38.55	06.40	05.74

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6.0	50.66	40.17	06.40	05.74
6.5	52.48	41.75	09.60	08.66
7.0	56.10	43.18	09.60	08.66
7.5	58.29	44.44	09.60	08.66
8.0	60.64	45.58	09.60	08.66
8.5	62.72	48.53	09.60	08.66
9.0	65.14	51.15	12.80	11.48
9.5	68.44	53.50	12.80	11.48
10.0	71.43	55.62	12.80	11.48
11.0	76.56	66.28	12.80	11.48
12.0	80.86	71.42	12.80	11.48
13.0	84.48	75.78	12.80	11.48
14.0	87.59	79.51	12.80	11.48
15.0	90.29	82.74	12.80	11.48
16.0	92.64	85.57	12.80	11.48
17.0	94.72	88.06	12.80	11.48
18.0	96.56	90.28	12.80	11.48
19.0	98.22	92.27	12.80	11.48
20.0	99.71	94.05	12.80	11.48
21.0	101.06	95.67	15.06	13.55
22.0	103.25	97.14	16.00	14.40
23.0	105.71	98.48	18.07	16.28
24.0	108.19	99.71	19.20	17.32
25.0	111.54	100.84	19.20	17.32
26.0	114.64	102.37	19.20	17.32
27.0	117.50	104.50	19.20	17.32
28.0	120.53	106.49	19.20	20.14
29.0	124.09	108.76	19.20	20.14
30.0	127.43	111.54	19.20	21.65

Notes:

1. The above values are corresponding to 16t axle configuration which has been calculated from the EUDL chart in Model DBR corresponding to 17t axle load.
2. For any other 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.
3. When loaded length lies between the values given in the table above, the EUDL for Bending Moment and Shear can be interpolated.
4. 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.
5. Impact Load to be considered separately.
6. Effects of Coefficient of Dynamic Augmentation needs to considered separately.

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