

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.

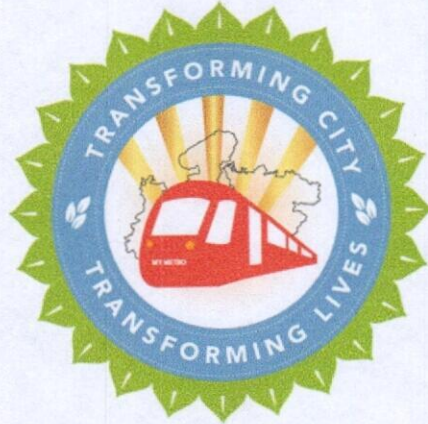
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29/09/2020
(D.K. Mishra)
Director/MTP
Railway Board
☎ 011-47845480

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

MADHYA PRADESH METRO RAIL CORPORATION LIMITED



Madhya Pradesh Metro Rail Co. Ltd.

BHOPAL AND INDORE METRO RAIL PROJECT

DESIGN BASIS REPORT (DBR)

for ELEVATED STATIONS

**Examined & Found in Order
Date**

May 2020

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

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Madhya Pradesh Metro Rail Corporation Limited (MPMRCL)

2nd Floor, Bhopal Smart City Development Corp. Ltd.,
Sector A, Berkheda, Bhopal – 462022,
Madhya Pradesh, India.

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1 INTRODUCTION

1.1 Brief description of the 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 Scope

The object of this Design Basis Document is to establish a common procedure for the design of "Elevated Stations for Metro Railways in India". 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 requires an extensive and thorough knowledge and entrusted to 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 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

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Reinforced Concrete structures will generally be governed by IS:456-2000, pre-stressed concrete structures 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/m²], [MPa], [°C], [rad].

2 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 clause 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 Prestressing Steel for Tendons

As per clause 5.6.1 of IS:1343.

2.1.3.1 Young's Modulus

As per prestressing steel used in accordance with Para 2.1.3 above.

2.1.3.2 Prestressing Units

As per clause 13 of IS:1343

2.1.3.3 Maximum Initial Prestress

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

- Hollow steel sections as per IS:4923-1997
- Steel for General Structural Purposes as per IS: 2062.
- 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 prestressed concrete structures. Ductile detailing of seismic resisting RC elements, shall comply with ductile requirements of IS:13920.

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 Prestressed 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 shall be indicated.

Minimum grade of concrete for blinding layers and levelling courses shall be indicated.

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 prestressed concrete structures. Cover to prestressing 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

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flexure, early age thermal 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 Prestressed 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) **Clearance for Metro Traffic:** The clearances to railway traffic shall comply with the Project Schedule of Dimensions (SOD).
- (iv) **For Utility Services:** The clearances to utilities, drainage etc shall be as mandated by the utility owner/department.

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 (DL)

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

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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 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 available for remaining Metro railway shall specify the Loads.

2.4.3 Imposed (Crowd Live) Load

Imposed loads-on station buildings are those arising from occupancy and the values includes, 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-organisation and refurbishment, 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 – I). The provision as per Design Basis Report for Viaduct of 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

- (iii) For Road traffic as per IRC 6.
- (iv) For Metro as per IRS Bridge Rule.

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

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The shrinkage strains shall be evaluated as per clause 6.2.4 of IS:456 for Plain and Reinforced Concrete Structures and clause 6.2.5 of IS:1343 for Prestressed concrete structures.

For structures supporting Metro loading the effects of creep as per clause 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 Structure and clause 6.2.5 of IS:1343 for Prestressed concrete structures.

For structures supporting Metro loading the effects of creep as per clause 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 wall 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 clause. 5.7 of IRS-Substructure code.

2.4.12 Surcharge Load

In the design of structures or part of structures below ground level, such as retaining walls 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 (LWR)

2.4.15 Long welded Rail Force shall be specified by Metro duly supported by either codal provision or calculation, if RSI analysis is not practicable. 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



Bhopal and Indore Metro Rail System
Design Basis Report (DBR) for Elevated Station

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 prestressed 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 IS:1893 (Part-I).
- (v) Load combination 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 be taken for collision case of collision of road vehicles are involved

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.
- (ii) Load combination and factors as per Table 7 of IS:1343 for prestressed 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.

2.5.3 Deflection Criteria

The deflection limitations as per clause 23.2 of IS:456 for Plain and Reinforced Concrete Structures and clause 20.3.1 of IS:1343 for Prestressed concrete structures shall be followed.

2.5.4 Lateral Sway

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

2.6 Fatigue Check

Fatigue phenomenon needs to be analysed 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.

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(ii) Steel Structures –

- 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 system shall be used. Otherwise, detailed counting of cycles shall be done.
- For other cases as per Section 13 of IS:800.

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

2.7 Foundations**2.7.1 Types of Foundations**

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

- Spread or pad footing
- Raft foundation
- Pile foundation

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

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

2.7.2 Design of Pile

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

Pile Settlement

Methods of estimating the settlement of deep foundations 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.

2.7.3 Foundations

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

Computation of Settlements of Foundations

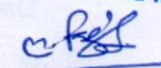
The calculations for settlement of foundations shall be done as per:

- IS:8009 Part-1 for shallow foundations
- IS:8009 Part-2 for deep foundations

2.8 Design of Water Retaining Structure

It should be designed as per IS:3370

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3 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. Euro Code or BS
- v. AASTHTO
- vi. Other National Codes are confirmed in the Project Viaduct DBR.

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Planning & Formulation Order
Date: 20/01/2020
No: 100/2020