Urban Transport Directorate

“Program of new standard”

The following document has been proposed to be taken up for creation of New RDSO standard as per ISO document no. QO-D-8.1-1.

“Model DBR for design and construction of Elevated Station for Metro System”

The ongoing standard i.e. Model Design Basis Report (DBR) June, 2016, Version-2 for Design and Construction of Elevated station for Metros is attached herewith.

DA: as above

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

No. 2015/Proj./Model DBR/2/2 New Delhi, dated 21.06.2016

To,

Managing Directors,
(As per list attached)

Sub: Model Design Basis Report (June, 2016), Version-2 for Design & Construction of elevated stations for Metros.

The Model Design Basis Report (June, 2016), Version-2 for Design & Construction of Elevated Stations for Metro System has been examined in consultation with RDSO and approval of Railway Board is hereby conveyed.

Accordingly, approved copy of DBR is enclosed.

DA: As above

21.06.16

(Ruth Changsan)
Director/Works (Plg.)
Railway Board
☎ 011-23097061

Copy to : **(i) Secretary**, Ministry of Urban Development, Nirman Bhavan , New Delhi for Information

(ii) Executive Director/UTHS, RDSO, Manak Nagar, Lucknow w.r.t their letter No. UTHS/51 dated 08.06.2016 for information and uploading on RDSO's website please.

1. **The General Manager,** Metro Railway, Kolkata.
2. **Managing Director, Delhi Metro Rail Corporation Ltd.**, Fire Brigade Lane, Barakhambha Road, New Delhi-110001.
3. **Managing Director, Chennai Metro Rail Ltd.,** CMRL Depot, Admin Building, Poonamalee High Road, Koyambedu, Chennai-600086.
4. **Managing Director, Hyderabad Metro Rail Ltd.,** Metro Rail Bhawan, Saifabad, Hyderabad-500 004.
5. **Managing Director, Bangalore Metro Rail Corporation Ltd.,** 3rd Floor, BMTC Complex, K.H. Road, Shanthinagar, Bangalore-560 027.
6. **Managing Director, Rapid Metrorail Gurgaon Ltd.**, 2nd Floor, Ambience Corporate Towers, Ambience Island, NH-8, Gurgaon-122001.
7. **Managing Director, Jaipur Metro Rail Corporation Ltd.,** Khanij Bhavan, Behind Udyog Bhavan, C-Scheme, Jaipur- 302005.
8. **Managing Director, Kochi Metro Rail Ltd., 8th Floor, Revenue Tower, Park Avenue, Kochi. 682011.**
9. **Managing Director, Kolkata Metro Rail Corporation Ltd.**, Munsi Premchand Sarani, Kolkata-700021.
10. **Managing Director, Mumbai Metro One Private Ltd.,** Mumbai Metro One Depot, D N Nagar, J.P. Road, 4 Bungalows, Andheri (West), Mumbai 400053.
11. **Chairman & Managing Director, MEGA Company Limited**,5th Floor, Nirman Bhawan, Opp. Gate No.4, Sachivalaya,Sector-10A, Gandhinagar,Gujarat-382010.
12. **Managing Director, Lucknow Metro Rail Corporation Ltd.**, 1st Floor, Janpath Market, Hazratganj, Lucknow-226001.
13. **Managing Director, Pune Metro Rail Ltd.,** Pune, Maharashtra.
14. **Managing Director,** Nagpur Metro Rail Corporation Limited,Metro House, 28/2, C.K Naidu Marg,Anand Nagar, Civil Lines, Nagpur, Maharashtra -440001
15. **Managing Director, Mumbai Metro Rail corporation Limited,** Namttri Building, Plot No.13, E Block, Bandra-Kurla Complex, Bandra (East), Mumbai-400051.3
16. **CCRS/Northern Circle,** Safdarjung Railway Station (near CRIS), Chanakyapuri, New Delhi- 110 021

DESIGN AND CONSTRUCTION OF

ELEVATED STATIONS

MODEL

DESIGN BASIS REPORT

June, 2016

TABLE OF CONTENTS

1. INTRODUCTION

1.1. Brief Description of the Project

The Project brief to be given by Metro, for which the DBR is submitted.

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 require 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 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. 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 (Ec) 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. Prestressing Steel for Tendons
As per clause 5.6.1 of IS:1343.

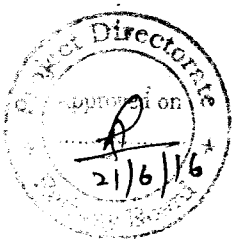
2.1.3.1. Young's Modulus
As per prestressing steel used in accordance with Para 2.1.3 above.

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
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 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 leveling 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 thicknesses 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 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) **Clearances for Metro Traffic:** As per approved SOD of specific Metro system.

(iv) **For utility services-** The clearances to utilities, drainage etc shall be as mandated by the utility owner/ department.

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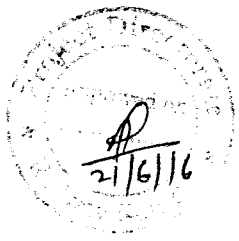
2.4. Design Loads

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 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, 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 –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 cl. 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.

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 prestressed concrete structures.
For structure supporting Metro loading the effects of creep 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 prestressed 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).

Project Directorate Approved 21/6/16 Railway Board

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-Substructure Code.

2.4.12. Surcharge Load

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 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

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

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 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 of IS:1893 (Part-I) .
(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 be taken for collision case if 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.

2.6. 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.

2.6.1. 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 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

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

2.9 Design of Water Retaining Structure

It should be designed as per IS 3370.

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. BS or Euro Code
v. AASHTO
vi. Other references listed in section 4.5.