GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

2018/Proj./MEGA/DBR/30/26 New Delhi, dated 28.12.2018

Managing Director,
Metro Link Express for Gandhinagar and Ahmadabad
(MEGA) Company Limited, 5th Floor,
Nirman Bhawan, Opp. Sachivalaya Gate No.4,
Sector-10-A, Gandhi Nagar,
Gujarat -382010

Sub: Design Basis Report for Design & Construction of Metro Link Express for Gandhinagar and Ahmedabad (MEGA) project, for Elevated Stations as per Model DBR.

Ref: MEGA letter No. MEGA/DBR/RDSO/2018/18/002 dated 03.11.2018

The Design Basis Report for Design & Construction of Metro Link Express for Gandhinagar and Ahmedabad (MEGA) project, for Elevated Stations has been examined in consultation with RDSO and approval of Railway Board is hereby conveyed.

Accordingly, approved copy of DBR is enclosed.

Encl: As above

28.12.2018

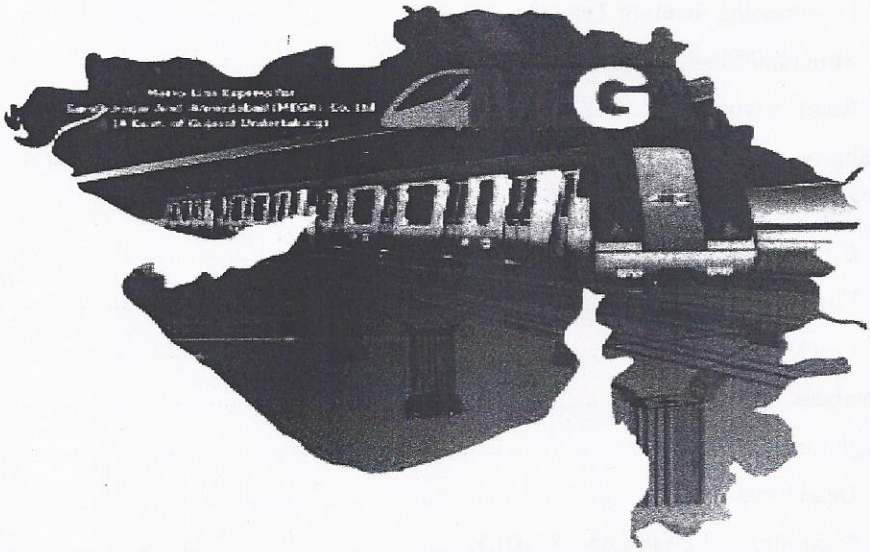
(Ruth Changsan)
Director/MTP
Railway Board
☎ 011 -47845480

Copy to: (i) **Executive Director/UTHS**, RDSO, Manak Nagar, Lucknow w.r.t RDSO's letter No. UTHS/81/MEGA/Civil dated 03.12.2018

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

DESIGN BASIS REPORT (DBR) FOR DESIGN AND CONSTRUCTION OF ELEVATED STATIONS (R-1)

NOVEMBER 2018



METRO-LINK EXPRESS FOR GANDHINAGAR AND AHMEDABAD
(MEGA) COMPANY LIMITED.

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

MEGA Co. Ltd. PROJECT PHASE - 1

Examined & Found in order
Date 03/12/18

Auth. Sign. : Director/Civil UTHS/RDSO

Project Directorate Approved on 28/12/18

Metro Link Express For Gandhinagar And Ahmedabad (MEGA) Co. Ltd. A Govt. of Gujarat Undertaking

Contents

Examined & Found in order
Date

Director Directorate
Approved on
28/12/18
Railway Board

Metro Link Express for Gandhinagar Ahmedabad
A Govt. of Gujarat Undertaking

Metro Link Express For Gandhinagar and Ahmedabad Co. Ltd. A Govt. of Gujarat undertaking

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Examined & Found in order
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1.0 INTRODUCTION

1.1 Brief Description of the Project

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

Corridor 1: East-West Corridor: Vastral Gam to Thaltej Gam

Corridor 2: North-South Corridor: Motera Stadium to APMC

East-West Corridor is 20.737 km long with Standard Gauge (SG), having 14.402 km elevated section and 6.335 km underground section. It comprises of 17 stations out of which 13 are elevated stations and 4 are underground stations. One depot-cum-workshop is proposed near Apparel Park station.

North-South Corridor is 18.522 km long elevated corridor with Standard Gauge (SG), and it comprises of 15 elevated stations. One depot-cum-workshop is proposed near APMC station at Gyaspur.

This design basis report pertains to elevated stations of East-West and North-South corridors of Ahmedabad Metro Rail Project.

The entire route will be elevated except 6.335 km which is underground section. The proposed list of stations is shown below:

S.No.	Station Name	Elevated/Underground	Remarks
E-W Corridor: Vastral Gam to Thaltej Gam			
1	Vastral Gam	Elevated	
2	Nirant Cross Road	Elevated	
3	Vastral	Elevated	
4	Rabari Colony	Elevated	
5	Amraiwadi	Elevated	
6	Apparel Park	Elevated	
7	Kankaria East	Underground	
8	Kalupur Railway Station	Underground	
9	Ghee Kanta	Underground	
10	Shahpur	Underground	
	Old High Court	Elevated	Interchange
11	Stadium	Elevated	
12	Commerce Six Road	Elevated	
13	Gujarat University	Elevated	
14	Gurukul Road	Elevated	
15	Doordarshan Kendra	Elevated	
16	Thaltej	Elevated	
17	Thaltej Gam	Elevated	

Examined & Found in order
Date

Auth. Sign. : Director/Civil UTHS/RDSO

Project Directorate Approved on 28/12/18 Railway Board

Metro Link Express For Gandhinagar & Ahmedabad Co. Ltd. A Govt. of Gujarat Undertaking

S.No.	Station Name	Elevated/Underground	Remarks
N-S Corridor: Motera Stadium to APMC			
1	Motera Stadium	Elevated	
2	Sabarmati	Elevated	
3	AEC	Elevated	
4	Sabarmati Railway Station	Elevated	
5	Ranip	Elevated	
6	Vadaj	Elevated	
7	Vijay Nagar	Elevated	
8	Usmanpura	Elevated	
9	Old High Court	Elevated	Interchange
10	Gandhigram	Elevated	
11	Paldi	Elevated	
12	Shreyas	Elevated	
13	Rajiv Nagar	Elevated	
14	Jivraj	Elevated	
15	APMC	Elevated	

1.2 Scope

The objective of this Design Basis Report is to establish a procedure for the design of "Elevated Stations for Metro-Link Express for Gandhinagar and Ahmedabad Project (Phase-1)". 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 "Structural Design Basis Report (DBR) for Viaduct (Version-5) for Metro-Link Express for Gandhinagar and Ahmedabad Project (Phase-1) which is approved by RDSO dated 28/08/2015". Load combination as per "Structural Design Basis Report (DBR) for Viaduct (Version-5) for Metro-Link Express for Gandhinagar and Ahmedabad Project (Phase-1) which is approved by RDSO dated 28/08/2015" shall also be considered. Other structural elements such as secondary beams, stub columns etc., may be designed as per IS:456.

Structures, where Metro Live loads are not applicable, the design of Plain and Reinforced Concrete Structures will generally be governed by IS:456, 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.

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Date
Auth. Sign. : Director/Civil UTHS/RDSO

Project Directorate Approved on 28/12/18 Railway Board

Metro Link Express For Gandhinagar & Ahmedabad (MEGA) Co. Ltd. A Govt. of Gujarat Undertaking

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

Project Directorate Approved on 28/12/18 Railway Board

Examined & Found in order
Date

Auth. Sign. : Director/Civil UTHS/RDSO

Metro Link Express For Gandhinagar Ahmedabad Co. Ltd. A Govt. of Gujarat Undertaking

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 govern 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.

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 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 courses 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

Examined & Found in order
Date
Auth. Sign. : Director/Civil UTHS/RDSO

Metro Link Express For Gandhinagar & Ahmedabad A Govt. of Gujarat Undertaking

Project Directorate Approved on 28/12/18 Railway Board

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 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 Metro-Link Express for Gandhinagar and Ahmedabad.

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 Load	WL

Project Directorate Approved on 28/12/18 Railway Board

Examined & Found in order
Date
Auth. Sign. : Director/Civil UTHS/RDSO

Metro Link Express For Gandhinagar & Ahmedabad A Govt. of Gujarat Undertaking

Collision/Impact Loads/Derailment Load	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.

Project Directorate Approved on 28/12/18 Railway Board

Examined & Found In order
Date
Auth. Sign. : Director/Civil UTHS/RDSO

Metro Link Express For Gandhinagar And Ahmedabad (MEGA) Ltd. A Govt. of Gujarat Undertaking

(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 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-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 Structural Design Basis Report (DBR) for Viaduct (Version-5) for Metro-Link Express for Gandhinagar and Ahmedabad Project (Phase-1) which is approved by RDSO dated 28/08/2015 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).

Project Directorate Approved on 28/12/18 Railway Board

Examined & Found in order
Date
Auth. Sign. : Director/Civil UTHS/RDSO

Metro Link Express For Gandhinagar & Ahmedabad A Govt. of Gujarat Undertaking

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 Concrete Bridge Code 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 Concrete Bridge Code 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.

Examined & Found in order
Date
Auth. Sign. : Director/Civil UTHS/RDSO

Project Directorate Approved on 28/12/18 Railway Board

Metro Link Express For Gandhinagar And Ahmedabad Undertaking A Govt. of Gujarat

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 774-3 R 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:

Project Directorate Approved on 28/12/18 Railway Board

Examined & Found in order
Date
Auth. Sign. : Director/Civil UTHS/RDSO

Metro Link Express For Gandhinagar & Ahmedabad Dev. Co. Ltd. A Govt. of Gujarat Undertaking

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 Concrete Bridge Code 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.
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 Concrete Bridge Code 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 Pre-stressed 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 Concrete Bridge Code.
II. Steel Structures –

Examined & Found In order
Date
Auth. Sign. : Director/Civil UTHS/RDSO

Project Directorate
Approved on
28/12/18
Railway Board

Metro Link Express For Gandhinagar And Ahmedabad (MEGA) Co. Ltd.
A Govt. of Gujarat Undertaking

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.

Project Directorate Approved on 28/12/18 Railway Board

Examined & Found in order
Date
Auth. Sign. : Director/Civil UTHS/RDSO

Metro Link Express For Gandhinagar & A Govt. of Gujarat Undertaking

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

Metro Link Express For Gandhinagar And Ahmedabad (MEGA) Co. Ltd. A Govt. of Gujarat Undertaking

Project Directorate Approved on 28/12/18 Railway Board

Examined & Found in order
Date
Auth. Sign : Director/Civil UTHS/RDSO