GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

2015/Proj./Nagpur/DBR/2/8

New Delhi, dated 05.04.2017

Managing Director,
Maharashtra Metro Rail Corporation Limited,
(Maha-Metro) Metro House, 28/2,
C.K Naidu Marg, Anand Nagar, Civil Lines,
Nagpur, Maharashtra -440001


The Design Basis Report (DBR) Version-D (March, 2017) for Design and Construction of Elevated Stations for Nagpur Metro Rail project 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

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

Copy to: Executive Director/UTHS, RDSO, Manak Nagar, Lucknow w.r.t their letter No. UTHS/106/NMRCL/Civil dated 29.03.2017
NAGPUR METRO RAIL CORPORATION LIMITED
(A Joint-Venture of Govt. of India & Govt. of Maharashtra)

NAGPUR METRO RAIL PROJECT

DESIGN AND CONSTRUCTION OF ELEVATED STATIONS

DESIGN BASIS REPORT
VERSION – D (March 2017)

NAGPUR METRO RAIL CORPORATION LIMITED
METRO HOUSE, 28/2, ANAND NAGAR,
C.K.NAIDU ROAD, CIVIL LINES,
NAGPUR -440001
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1. INTRODUCTION

1.1. Brief Description of the Project

Two corridors have been identified for implementation in phase-I of Nagpur Metro Rail Project as per details given below:

**Corridor I: North-South Corridor: Automotive Square to Khapri**

**Corridor II: East-West Corridor: Prajapati Nagar to Lokmanya Nagar**

North-South Corridor is 19.658 km long corridor with Standard Gauge (SG), having 15.058 km elevated section and 4.6 km at-grade section. It comprises of 17 stations out of which 15 are elevated and 2 are at-grade. This corridor has 15 wayside stations and 2 terminal stations. One depot-cum-workshop is proposed near Khapri station.

East-West Corridor is 18.557 km long elevated corridor with Standard Gauge (SG) and it comprises of 19 elevated stations out of which 17 are wayside and 2 are terminal stations. One depot-cum-workshop is proposed near Lokmanya Nagar for this corridor.

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

The entire route will be elevated except 4.6 km which is at-grade. The proposed list of stations is shown below:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Station Name</th>
<th>Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-S Corridor: Automotive Square to MIHAN (19.658 km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Automotive Square</td>
<td>Elevated</td>
</tr>
<tr>
<td>2</td>
<td>Nari Road</td>
<td>Elevated</td>
</tr>
<tr>
<td>3</td>
<td>Indora Road</td>
<td>Elevated</td>
</tr>
<tr>
<td>4</td>
<td>Kadvi Chowk</td>
<td>Elevated</td>
</tr>
<tr>
<td>5</td>
<td>Gaddi Godam Square</td>
<td>Elevated</td>
</tr>
<tr>
<td>6</td>
<td>Kasturchand Park</td>
<td>Elevated</td>
</tr>
<tr>
<td>7</td>
<td>Zero Mile</td>
<td>Elevated</td>
</tr>
<tr>
<td>8</td>
<td>Sitaburdi (Interchange)</td>
<td>Elevated</td>
</tr>
<tr>
<td>9</td>
<td>Congress Nagar</td>
<td>Elevated</td>
</tr>
<tr>
<td>10</td>
<td>Rahate Colony</td>
<td>Elevated</td>
</tr>
<tr>
<td>11</td>
<td>Ajni Square</td>
<td>Elevated</td>
</tr>
<tr>
<td>12</td>
<td>Chhatrapati Square</td>
<td>Elevated</td>
</tr>
<tr>
<td>13</td>
<td>Jaiprakash Nagar</td>
<td>Elevated</td>
</tr>
<tr>
<td>14</td>
<td>Ujwal Nagar</td>
<td>Elevated</td>
</tr>
<tr>
<td>15</td>
<td>Airport</td>
<td>Elevated</td>
</tr>
<tr>
<td>16</td>
<td>New Airport</td>
<td>At-Grade</td>
</tr>
<tr>
<td>17</td>
<td>Khapri</td>
<td>At-Grade</td>
</tr>
<tr>
<td>S.No.</td>
<td>Station Name</td>
<td>Alignment</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>1</td>
<td>Prajapati Nagar</td>
<td>Elevated</td>
</tr>
<tr>
<td>2</td>
<td>Vaishno Devi Chowk</td>
<td>Elevated</td>
</tr>
<tr>
<td>3</td>
<td>Ambedkar Chowk</td>
<td>Elevated</td>
</tr>
<tr>
<td>4</td>
<td>Telephone Exchange</td>
<td>Elevated</td>
</tr>
<tr>
<td>5</td>
<td>Chittar Oil Chowk</td>
<td>Elevated</td>
</tr>
<tr>
<td>6</td>
<td>Agarsen Chowk</td>
<td>Elevated</td>
</tr>
<tr>
<td>7</td>
<td>Dosar Vaisya Chowk</td>
<td>Elevated</td>
</tr>
<tr>
<td>8</td>
<td>Nagpur Railway Station</td>
<td>Elevated</td>
</tr>
<tr>
<td>9</td>
<td>Sitabardi (Interchange)</td>
<td>Elevated</td>
</tr>
<tr>
<td>10</td>
<td>Jhansi Rani Square</td>
<td>Elevated</td>
</tr>
<tr>
<td>11</td>
<td>Institute of Engineers</td>
<td>Elevated</td>
</tr>
<tr>
<td>12</td>
<td>Shankar Nagar Square</td>
<td>Elevated</td>
</tr>
<tr>
<td>13</td>
<td>Lad Chowk</td>
<td>Elevated</td>
</tr>
<tr>
<td>14</td>
<td>Dharmpeth College</td>
<td>Elevated</td>
</tr>
<tr>
<td>15</td>
<td>Subhash Nagar</td>
<td>Elevated</td>
</tr>
<tr>
<td>16</td>
<td>Rachna Ring Road Jn.</td>
<td>Elevated</td>
</tr>
<tr>
<td>17</td>
<td>Vasdev Nagar</td>
<td>Elevated</td>
</tr>
<tr>
<td>18</td>
<td>Bansi Nagar</td>
<td>Elevated</td>
</tr>
<tr>
<td>19</td>
<td>Lokmanya Nagar</td>
<td>Elevated</td>
</tr>
</tbody>
</table>

1.2. Scope

The object of this Design Basis Document is to establish a common procedure for the design of "Elevated Stations for Nagpur Metro Rail Project". This is meant to serve as guide to the designer but compliance with the rules there in is so 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 structural 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 "Approved Design Basis Report (DBR) for Viaduct of Nagpur Metro Rail Project". LWR forces shall be specified by the Metro, if RSI analysis is not practicable. Load combination as per "Approved Design Basis Report (DBR) for Viaduct of Nagpur Metro Rail Project" 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 will generally be governed by IS:1343. Steel structures design shall generally be governed by IS: 800. Seismic design shall be governed by IS: 1893.

**NOTE:** For at-grade stations, in general the station building will not be subjected to Metro Live loads. Hence, it can be designed according to this Design Basis Report. In case, subway at any at-grade station supports metro live loads, the same shall be designed as per Approved Design Basis Report for Viaduct of Nagpur Metro Rail Project.
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 (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. 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 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 BI (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 Plan 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 8.0 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 layers and levelling courses shall be as under:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Structural component</th>
<th>Minimum Grade of concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Pre-tensioned girders</td>
<td>M50</td>
</tr>
<tr>
<td>B</td>
<td>Superstructure-deck slab, beams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pier and Pier arm</td>
<td>M40</td>
</tr>
<tr>
<td></td>
<td>Portal beams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pedestal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shear key and Seismic stoppers</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Crash barrier, Pier protection</td>
<td>M40</td>
</tr>
<tr>
<td>D</td>
<td>Slabs, Beams, Walls, Columns</td>
<td>M35</td>
</tr>
<tr>
<td>e</td>
<td>Pile, Pile cap, Open foundation, Basement slab, Ancillary building foundation slab, Retaining wall</td>
<td>M35</td>
</tr>
<tr>
<td>f</td>
<td>Solid slab</td>
<td>M40</td>
</tr>
<tr>
<td>g</td>
<td>Blinding concrete or levelling course</td>
<td>M15</td>
</tr>
</tbody>
</table>

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 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 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 Nagpur Metro Rail Project.
(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
Super Imposed Loads
Imposed (Crowd Live) Loads
Earthquake Loads
Wind Loads
Collusion/Impact Loads/Derailment Loads
Construction & Erection Loads
Temperature Loads
Shrinkage
Creep
Surcharge Loads (Traffic, building etc.)
Pre-stress Force
Long Welded Rail Force
Differential Settlement

*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 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 lift 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/m² 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/m² 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:

<table>
<thead>
<tr>
<th>Item</th>
<th>SIDL (kN/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cables</td>
<td>0.7</td>
</tr>
<tr>
<td>Cable troughs with cover</td>
<td>7.4</td>
</tr>
<tr>
<td>Cable trays</td>
<td>0.1</td>
</tr>
<tr>
<td>Concrete plinths for rails + Rail + Pad</td>
<td>31.0</td>
</tr>
<tr>
<td>Miscellaneous (OCS, signaling,)</td>
<td>4.0</td>
</tr>
<tr>
<td>Hand Rail</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Total: 44 kN/m for two tracks
22 kN/m for one track
Say 50 kN/m for two tracks
25 kN/m for one track

**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 of 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 "Approved Design Basis Report for Viaduct of Nagpur Metro Rail Project" shall be followed 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.
(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 from 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 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 buoyance
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 Substructure Code.
2.4.12. Surchage 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 on account of 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-CBC.

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 Combination

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 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-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 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 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 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 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.
(ii) Steel Structures –
   (a) In case of Metro live loads, as per clause 3.6 of IRS Steel Bridge Code shall govern. If \( \lambda^* \) 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 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-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:
- IS
- IRS
- IRC
- BS or Euro Code
- AASHTO