CLIENT:

SOUTH CENTRAL RAILWAY
VIJAYAWADA DIVSION

PROJECT:

Upgradation of Nellore Railway Station on Design, Engineering, Procurement & Construction (EPC) Basis

EPC CONSULTANT:

SCL JCPL JV

STRUCTURAL DESIGN BASIS REPORT

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STRUCTURAL CONSULTANT
ARCH VIEW DESIGNS

DESIGN BASIS REPORT

PROSPOSED UPGRADATION OF NELLORE RAILWAY STATION ON DESIGN, ENGINEERING, PROCUREMENT & CONSTRUCTION (EPC) BASIS

Design Brief for Proposed Construction of RCC Design of Station Buildings and Accessory Buildings.

1) INTRODUCTION

GENERAL PROJECT INFORMATION

PROJECT TITLE: DEVELOPMENT/REDEVELOPMENT OF NELLORE RAILWAY STATION

LOCATION OF THE PROJECT: NELLORE, ANDHRA PRADESH

DESCRIPTION OF THE PROJECT:

Type of Buildings: RC framed structure.

Nellore is the city and district headquarters of Nellore district. It is famous for its agriculture and aquaculture. The city is a vibrant urban centre, which is pivotal to the economic activity of the surrounding areas such as Krishnapatnam port, industrial clusters of Nellore district, etc. The present population of the Nellore urban agglomeration is around seven lakhs and it is likely to register a population growth of 2-3% in the years to come. Indian railways have provided safe and affordable travel experience to all category of passengers throughout the year to connect to this city. Nellore railway station is Category – A station and an Adarsh station on Vijaywada – Guntur section under Vijaywada division. Approximately twenty-seven thousand passengers enjoy the railway facility at the Nellore railway station every day. This volume may go up to forty thousand on certain peak days. Approximately 84% of the passengers represent the short-led unreserved segment and only 16% belong to either medium or long-lead reserved segment.

RAILWAY STATION DEVELOPMENT The railway station redevelopment proposal consists of the following components: • Proposed passenger's centric space on both east and west sides. • Creation of connecting Airconcouse. • Extension of existing subway to both east and west directions to connect it to platform number four and arrival concourse areas on both sides. • Upgrading the Vehicular approach and Surface parking. • Cover over Platform over open to sky platforms. • If we talk about the setting of railway station and its connectivity, it is accessible from east and west sides. East side footfall is higher than the west side due its ease of accessibility to Nellore bus stand. In respect of reserved segment also it was seen that almost three fourth of the total passengers enter/exit from east side as compared to one fourth from the west side. There are a total of four platforms in the station complex and due to constant arrival and departure of the trains throughout the day, passengers acquired almost all the platform's area. The connecting subway is presently serving passengers of platform 1,2 and 3 only. In the present scenario the station complex comprises of one FOB also to cater the passenger flow.

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WEST SIDE DEVELOPMENT • Based on the above points, west side area has been given a uniform mass to accommodate existing buildings with a G+2 structure with additional food court and retail facilities, dedicated female and ac 3/2 tier waiting areas, cloak room, etc. In addition to these it also comprises of VIP lounge as well as Retiring rooms for the passenger facility. To provide an uninterrupted flow between passenger's and Office staff Railway offices are provided on the right side of the building on Ground, First & Second floor. Façade development has taken the Upgradation of Nellore Railway Station on Design, Engineering, Procurement & Construction (EPC) Basis Design Basis Report Page 4 NBCC (INDIA) LIMITED inspiration from the contemporary architecture. Similarly, a new block is added to the east side in continuation with the existing structure.

EAST SIDE DEVELOPMENT • East side has narrow land parcel, so the depth of the building is similar to the present building and traffic flow is kept in one direction. Its Ground Floor consists of Arrival Concourse with retail and waiting facility which connects to subway and platform through ramps on platform side and directly to the external area on the other side for maintaining a smooth flow of traffic without conflicting with the departing passengers. First Floor consists of Departure Concourse with existing ticket counter as well as upcoming waiting and food court with Vertical Circulating Elements for both Existing as well Proposed FOB. Existing FoB is narrow and insufficient to serve large number of influxes, so a proposal 6m wide FoB has been proposed on south side of the existing Airconcouse. EXTENSION OF EXISTING SUBWAY • Existing subway facility at the station complex is accessible from the west side building which connects to platform 1, 2 and 3. A proposal to extend the FoB to connect to arrival concourse at east and west side of station complex

2) STRUCTURAL DESIGN

The main considerations for the design of structure should be as follows: -

(a) Structure safety and stability.
(b) To meet the demands of aesthetics conceived by the architect.
(c) Availability of material, equipment and expertise.
(d) Constructability and ease of maintenance.
(e) Durability.

2.1) STRUCTURAL SYSTEM

The structure shall be designed as RC framed structure with normal slab & beams.

The Structure Foundations shall be designed for G+5 Floors on East & West Sides.

All the structures shall be designed in accordance with the relevant Indian code of practice for civil works i.e. IS 456:2000, IS 875:1987, IS 1893:2016, IS 4326:1993, IS 13920:2016.

2.2) DESIGN APPROACH

Structural Modeling: Three-dimensional models of building shall be generated using STAAD- Pro/Etabs. All the slab panels shall be idealized as plate / shell elements, columns and Beams will be idealized as Line Elements. All the shear walls will be idealized as plate / shell element. The structure shall be analyzed and designed for all possible combinations of gravity loads (dead and live loads), and lateral loads (earthquake load and wind loads).

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All the buildings of Type II shall be designed for earthquake loading (DL+LL+EQ). DL = Dead Load, LL = Live Load, EQ = Earthquake Load

Computer Models, Structural Analysis and Design

A preliminary three – dimensional finite element computer model has been formulated, incorporating all gravity, wind and seismic loads, to develop the concept framing for the building and ensure that the designed structural system provides satisfactory global building response. The model will be further developed during subsequent design stages to carry out detailed design. In general, the following software shall be utilized during the various stages of the design process.

STRUCTURAL DETAILS

- **STRUCTURE DIMENSIONS**

As per the provisions of IS 456:2000 if the length of the building is more than 45m then expansion joints shall be according to the provisions. In case expansion joint is not provided the structure is to be analyzed for Temperature loading.

DESIGN LOADINGS

Structure is proposed to be designed for critical load combinations of wind load and earthquake loads along with Dead load and Live loads. The basic wind speed of 50 m/sec to be considered as per IS: 875-2015 (part 3). It falls under earthquake zone-III as per IS: 1893-2016 (Part I).

- **DEADLOADS**

Design dead load shall include all self-weight and dead loads of elements. The following unit weights of materials are considered as per **IS: 875 (Part I)-1987**.

Reinforced cement concrete	: 25.0 kN/m^3
Reinforcement steel	: 78.5 kN/m^3
Brick masonry (Clay Bricks)	: 19.2 kN/m^3
Brick Masonry (AAC blocks (Light weight))	: 10.0 kN/m^3
Plain Cement Concrete	: 24.0 kN/m^3
Filling Material in Toilets	: 10.0 kN/m^3

- **LIVE LOADS IS: 875 (PartII)-1987.**

Based on the Type of occupancy of the Building, Imposed Live load shall be considered as per the code Provisions.

Corridors & Waiting & Office Areas	: 4.0 kN/m^2
Toilets	: 2.0 kN/m^2
Terrace	: 1.5kN/m^2

- **WIND LOADS IS: 875 (Part III)-2015.**

The wind load has been taken as per IS: 875 (Part-3) – 2015 and wind pressure calculation done as follows:-

$P_z = 0.6\ V_z^2$ kN/sqm

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$Vz = K_1 K_2 K_3 V_b$, Where, V_z = Design wind velocity

K_1 = Probability factor or Risk coefficient has been taken 1.0

K_2 = Terrain, height and structure size factor, category '2' and class 'B' have been considered.

K_3 = Topography factor = 1.0

V_b = Basic wind speed = 50m/s

Note: For small elements such as canopies wind load calculated as per class 'A'. The calculated wind load is applied on the peripheral joints as a joint load after multiplying the wind pressure with area of each joint and shape factor.

Special Note: Being a High Rise Building it shall be analyses for earthquake forces and wind load forces as per IS Code.

- **TEMPERATURE LOAD**

If the length of the buildings is more than 45m, the building shall be analyzed for thermal effects induced due to seasonal and diurnal temperature variations.

A temperature effect of ±10'C shall be considered for intermediate floors whereas a temperature variation of ± 25'C shall be considered for terrace floors.

For long term shrinkage effects, an equivalent temperature of + 10oC has been considered. As per IS code, the following load cases have been considered for thermal effects.

1.5 (DL + TL1 + TL2)

1.5 (DL + LL + TL1 + TL2)

1.5 (DL ± EQ + TL1 + TL2)

1.2 (DL + LL ± EQ + TL1 + TL2)

1.2 (DL + LL ± WL + TL1 + TL2)

TL1 = Temperature load due to temperature variation. TL2 = Temperature load due to shrinkage effects.

Seismic Loads as per IS 1893 (PartI)-2016

The structure is to be designed for the minimum static seismic base shear set out by IS 1893 (Part 1) : 2016 using the parameters shown in the table below. These forces are treated as ultimate forces.

Design Earthquake	10% chance of being exceeded within a 50-year return period
Seismic Zone	Zone III
Seismic Zone Factor, 'Z'	0.16
Soil Profile, Type-II	Medium
Occupancy of building	Commercial
Seismic Importance Factor 'I'	As per IS 1893-2016
Response Reduction Factor	As per IS 1893-2016
Response Reduction Factor	T = 0.09 H/√(d) H – Height of Building above Ground Floor LVL. d – Least lateral dimension of the building
Seismic Building Weight	To include all components of Self Weight, Superimposed Dead Load, any other permanent weight 50% of Live Load

Response spectrum method was used as per IS: 1893 (Part-1) 2016 with the following data:

Design horizontal seismic coefficient (Ah) = ZI (Sa)/ 2Rg

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STRUCTURE DESIGN CRITERIA

- **Grade of Concrete** : M30/M35
- **Grade of Steel** : Fe550D

Type of Foundation: Based on the Soil Report Isolated Footings with SBC of 170kN/m^2 at depth of 2m.

REQUIREMENTS FOR DURABILITY AND FIRE

Concrete cover requirements are governed by Indian Code. The values in the following table shall be appropriate for a fire rating of 2 hours.

Members in contact with the ground	Very Severe
Members in interior environments	Mild
Members in above-ground exterior environments	Moderate

CLEAR COVERS

- Clear Cover for Beams : 25mm
- Clear Cover for Columns : 40mm
- Clear Cover for Slabs and Staircase : 25mm
- Clear Cover for Footings : 75mm
- Clear Cover for elements in contact with ground : 50mm

The Structure will be designed as RC framed structure. The Structure system shall be **SMRF** (Special Moment Resistance Frame) with Reinforced Concrete Columns, Beams & Slabs.

As per the Soil report recommendations the foundation will be Isolated Footings and wherever necessary Raft and Combined footings provided when isolated footings overlap.

STRUCTURAL DESIGN

RCC Members

All structural elements of buildings will be designed using the Limit State Method and as per IS 456-2000. The member forces and support reactions as arrived through the analysis are utilized in the design of structural members as per IS456-2000.As per this method, the structure will be designed for all possible limit states of collapse and serviceability criterions. RC detailing is furnished considering the safety of the structure. The design detailing is furnished as per the provisions of SP34

LOAD CASES

The Ultimate Load cases for the design of Structure as per IS Code Provisions.

1) 1.5(Dead Load + Live Load)
2) 1.5(Dead Load + Seismic(+x))
3) 1.5(Dead Load + Seismic(+y))
4) 1.5(Dead Load + Seismic(-x))

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5) 1.5(Dead Load + Seismic(-y))
6) 1.2(Dead Load + Live Load+ Seismic(+x))
7) 1.2(Dead Load + Live Load+ Seismic(+y))
8) 1.2(Dead Load + Live Load+ Seismic(-x))
9) 1.2(Dead Load + Live Load+ Seismic(-y))
10) 1.5(Dead Load + Wind(+x))
11) 1.5(Dead Load + Wind(-x))
12) 1.5(Dead Load + Wind(+y))
13) 1.5(Dead Load + Wind(-y))
14) 1.2(Dead Load + Live Load +Wind(+x))
15) 1.2(Dead Load + Live Load +Wind(-x))
16) 1.2(Dead Load + Live Load +Wind(+y))
17) 1.2(Dead Load + Live Load +Wind(-y))
18) 0.9(Dead Load) + 1.5 (Seismic(+x))
19) 0.9(Dead Load) + 1.5 (Seismic(+y))
20) 0.9(Dead Load) + 1.5 (Seismic(-x))
21) 0.9(Dead Load) + 1.5 (Seismic(-y))
22) 0.9(Dead Load) + 1.5 (Wind (+x))
23) 0.9(Dead Load) + 1.5 (Wind(-x))
24) 0.9(Dead Load) + 1.5 (Wind(+y))
25) 0.9(Dead Load) + 1.5 (Wind (-y))
26) 26)1.5(Dead Load + Spec(x))
27) 27)1.5(Dead Load + Spec(y))
28) 28)1.2(Dead Load + Live Load +Seismic(x))
29) 29)1.2(Dead Load + Live Load +Seismic(y))
30) 30)0.9(Dead Load) + 1.5 (Spec (x))
31) 30)0.9(Dead Load) + 1.5 (Spec (y))

The Serviceability Load cases for the design of Structure as per IS Code Provisions.

1) 1.0(Dead Load + Live Load)
2) 1.0(Dead Load + Seismic(+x))
3) 1.0(Dead Load + Seismic(+y))
4) 1.0(Dead Load + Seismic(-x))
5) 1.0(Dead Load + Seismic(-y))
6) 1.0(Dead Load + Live Load+ Seismic(+x))
7) 1.0(Dead Load + Live Load+ Seismic(+y))
8) 1.0(Dead Load + Live Load+ Seismic(-x))
9) 1.0(Dead Load + Live Load+ Seismic(-y))
10) 1.0(Dead Load + Wind(+x))
11) 1.0(Dead Load + Wind(-x))
12) 1.0(Dead Load + Wind(+y))
13) 1.0(Dead Load + Wind(-y))
14) 1.0(Dead Load + Live Load +Wind(+x))
15) 1.0(Dead Load + Live Load +Wind(-x))

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16) 1.0(Dead Load + Live Load +Wind(+y))
17) 1.0(Dead Load + Live Load +Wind(-y))
18) 1.0(Dead Load + Spec(x))
19) 1.0(Dead Load + Spec(y))
20) 1.0(Dead Load + Live Load+ Spec(x))
21) 1.0(Dead Load + Live Load+ Spec(y))

ANALYSIS and DESIGN

- The Structure is modelled as 3-Dimensional structure using the **ETABS** software.
- Dynamic analysis is carried out as per **IS 1893:2016** (since Building is in Zone III) and design is based on **IS456:2000.**
- The Foundations designed and checked in **SAFE** software.

All Structures designed for respective no of floors / Capacity based on Table given below

LIST OF NATIONAL CODES USED IN THE STRUCTURAL DESIGN:

The following Indian Codes and Standards will be generally used for design of civil and structural works. In all cases, the latest revisions with amendments, if any, will be followed. For work not covered by Indian standards, other International Standards, as applicable will be followed.

S. No	Code	Description
1	IS:875 (Part-1) - 1987	Code of practice for Design Loads (Other than Earthquake) for Buildings and Structures – Unit Weights of Buildings Materials and Stored Materials.
2	IS:875 (Part-2) - 1987	Code of practice for Design Loads (Other than Earthquake) for buildings and Structures – Imposed loads.
3	IS:875 (Part-3) - 2015	Code of practice for Design Loads (Other than Earthquake) for Buildings and Structures – Wind loads.
4	IS:875 (Part-5) - 1987	Code of practice for Design Loads (Other than Earthquake) for Buildings and Structures – Special loads and Load Combinations.
5	IS: 456 - 2000	Code of Practice for Plain and Reinforced Concrete
6	IS:1786 - 2008	Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement.
7	SP: 34:1987	Handbook on concrete reinforcement and detailing.
8	SP 16: 1980	Design Aids for Reinforced Concrete to IS 456
9	IS:1893 (Part-1) - 2016	Criteria for Earthquake resistant design of structures.
10	IS: 13920:2016	Code of practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic forces.
11	IS:3370 (Part-1) - 2009	Code of practice for concrete structures for the storage of liquids – General Requirements
12	IS:3370 (Part-2) - 2009	Code of practice for concrete structures for the storage of liquids – Reinforced Concrete Structures
13	IS:3370 (Part-4) - 1967	Code of practice for concrete structures for the storage of liquids– Design Tables

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The project consists of following Structures

S. No	Structure Name	Designed for	Proposed Built up area/length	Units
1	EAST SIDE BUILDING	G + 5	1492	sqm
2	WEST SIDE BUILDING	G + 5	4854	Sqm
3	ARRIVAL CONCOURSE	G + 5	950	Sqm
4	AIR CONCOURSE		36m x 55.818m	
5	SUBWAY		185	
6	UGSR 6.0LAKH Lts		6.0	L lts
7	1.5 Lakh Lts OHSR		1.5	L Lts
8	Permanent Court Building	G + 3	1200	Sqm
9	STP		385	kLD

DESIGN BASIS FOR SUBWAY AND AIR CONCOURSE SHED

SITE DATA

S. No	Description		
1	End-User / Owner		SCR NELLORE RAILWAY
2	Contractor		SCL GCPLJV
3	Location		NELLORE
4	Project Title		UPGRADATION OF NELLORE RAILWAY STATION
5	Latitude		
6	Longitude		
7	Nearby City		NELLORE
8	Site Elevation		
9	Nearest Airport		
10	Nearest Seaport		
11	Barometric pressure	mmWc	
12	Ambient Temp (Min./Max.)	^{O}F	
13	Wet Bulb Temp.	^{O}C	-
14	Relative Humidity (Monthly) Min. / Max	%	
15	Rainfall (Year on Basis)	mm/year	
16	Wind Velocity	m/s	50
17	Wind Direction		NA
19	Seismic Zone		Zone: III of Indian Seismic zone

The Engineering scope involves the design & detailing for various structures of the Nellore Railway Station typically includes:

- 1-Air Concourse Shed
- 2- Subways

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(a) Structure safety and stability.

(b) To meet the demands of aesthetics conceived by the architect.

(c) Availability of material, equipment, and expertise.

(d) Constructability and ease of maintenance.

(e) Durability

STRUCTURAL SYSTEM

The structure shall be designed as RC framed structure with normal slab & beams.

The Structure Foundations shall be designed for G+5 Floors on East & West Sides.

All the structures shall be designed in accordance with the relevant Indian code of practice for civil works i.e. IS 456:2000, IS 875:1987, IS 1893:2016, IS 4326:1993, IS 13920:2016 and other structural steel buildings.

DESIGN APPROACH

Structural Modeling: Three-dimensional models of building shall be generated using STAAD-Pro/Etabs. All the slab panels shall be idealized as plate / shell elements, columns and Beams will be idealized as Line Elements. All the shear walls will be idealized as plate / shell element. The structure shall be analyzed and designed for all possible combinations of gravity loads (dead and live loads), and lateral loads (earthquake load and wind loads).

All the buildings of Type II shall be designed for earthquake loading (DL+LL+EQ).

DL = Dead Load, LL = Live Load, EQ = Earthquake Load

Computer Models, Structural Analysis and Design

A preliminary three – dimensional finite element computer model has been formulated, incorporating all gravity, wind and seismic loads, to develop the concept framing for the building and ensure that the designed structural system provides satisfactory global building response. The model will be further developed during subsequent design stages to carry out detailed design. In general, the following software shall be utilized during the various stages of the design process

Software's	Description
STAAD Pro – V8i	3 – Dimensional FEM Software for Building Analysis & Design
ETABS	3 – Dimensional FEM Software for Building Analysis & Design
AutoCAD	Software for Drafting and Detailing

FOUNDATION SYSTEM

- Considering good bearing capacity, raft foundation or open foundation may be proposed based on the Soil Bearing Capacity in Geotechnical Report below the building area.
- Following allowable bearing pressure given in the corresponding to various foundation widths at a depth of founding level below NGL in the soil report; same shall be adopted for the design.

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- The contractor shall be done extensive soil investigation before the final detailed design.
- **Design of Water Retaining Structures** – All water retaining structures, including raft slab, basement walls shall be designed to IS 456 & 3370, with a crack width of 0.2 mm for severe or very severe exposure. In addition, concrete for such structures shall be waterproof concrete.
- **Expansion Joints** – As far as possible expansion joints are to be avoided by taking temperature effects on the structure.
- **Foundation and Ground Retention System** –. It shall be noted that the Contractor shall carry out his own Soil Testing and analysis and shall follow the same.

MATERIAL DEAD LOADS

All the permanent loads on the structure shall be applied as dead loads. The dead load in a building shall comprise of self-weight of beams, columns, walls, partitions, floors, roofs and include the weight of all other permanent constructions in the building and shall conform to IS: 1911-Schedule of unit weights of buildings materials. Unit weight of various materials considered on the structural members considered follows: -

S.NO	Item	Density
1.	Concrete	2.50(t/m^3)
2.	Steel	7.85(t/m^3)
3.	Saturated Soil	2.0(t/m^3)
4.	Water	1.0(t/m^3)
5.	Glass	2.6(t/m^3)
6.	Aluminium	2.7(t/m^3)
7.	Aerated Light Weight Blocks	0.7(t/m^3)
8.	Dry Wall Partitions (102 mm thick)	0.05(t/m^2)
9.	100mm Fly ash blocks with 25mm Plaster	0.212(t/m^2)
10.	200mm Fly ash blocks with 25mm Plaster	0.372(t/m^2)
11.	115mm Brick Work with 25mm Plaster	0.275(t/m^2)
12.	230mm Brick Work with 25mm Plaster	0.50(t/m^2)

Following loads shall be considered in structure for analysis:-

I) Self wt. of structure.

II) Slab thickness and floor finish – as per actual.

III) Earth fills above basement roof – as per actual.

IV) Wall loads – as per actual.

V) Any other loads envisaged during the detailed engineering.

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LIVE LOADS

Live loads on the entire floor shall comprise all loads other than dead loads. The minimum live loads on different occupancies shall be considered as per IS: 875 (Part 2).

Live load shall be considered in design as per Table 1 of IS: 875 (Part 2)-1987 as per table below:

Building Structures:

Live loads shall be applied as given specific information mostly related to installation, operation, maintenance of process equipment in the building structure. Engineering judgement shall be exercised in taking into consideration the passing through moveable carrying equipment vehicle to the designated place and installing the equipment. Commonly used live loads otherwise shown below

S. NO	Occupancy or Use	Uniform (kN/m^2)	Concentrated (kN)
1.	**Assembly Buildings** a) With Fixed Seating b) Without Fixed seating	 4.0 5.0	
1	**Access floor systems:** Office use Computer use	 2.5 5.0	4.5
2	Exit facilities include waiting areas, lobby corridor, stairs and fire escapes, for buildings	4.0	4.5
3	Panel floors, battery rooms, MCC Floor	10.0 or as per Actual Panel Loads	4.5
4	Control, I/0, HVAC rooms floors	5.0	4.5
5	**Roofs:**		
5.1	Non-accessible flat roofs Accessible flat roofs	0.75 1.5	-
5.2	Sloping roofs	1.5	

Table 1 of IS:875(PART-2)-1987 shall be considered for the imposed loads if not defined above.

Non-Building Structures:

Loads generated during maintenance by workers, equipment, and material, along with temporary forces for repair, dismantling and painting of equipment etc. shall be considered as live loads.

S. NO	Occupancy or Use	Uniform (kN/m^2)	Concentrated (kN)	kN/m
1	Stair's landings and exit ways	4.0		
2	Access platforms, and walkways	2.5		
3	Catwalks/cross overs for maintenance access	2.5		
4	Maintenance Platform	2.5		
5	Ground-supported storage tank roof	1.2	-	
6	Operating floor	5.0		
7	Maintenance floor and equipment where parts or heavy tools may be stored	5.0		
8	Light duty pavements	20	100 (axle load)	
9	Heavy-duty pavement	50	200 (axle load)	
10	Standard Ladders load capacity	2.5		
11	Railing lateral load capacity			1.5
12	Deck ladders load capacity		1.5/step	

Note:

- Uniform and concentrated live loads listed above shall not be applied simultaneously.
- Where the live load is specified in equipment layout drawing GA, they shall be followed in the design

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EARTHQUAKE LOADS

The structure is to be designed for the minimum static seismic base shear set out by IS 1893 (Part 1):2016 using the parameters shown in the table below. These forces are treated as ultimate forces.

Design Earthquake	10% chance of being exceeded within a 50 year return period
Seismic Zone	Zone III
Seismic Zone Factor, 'Z'	0.16
Soil Profile, Type-II	Medium
Occupancy of building	Commercial
Seismic Importance Factor 'I'	As per IS 1893-2016
Response Reduction Factor	As per IS 1893-2016
Response Reduction Factor	$T = 0.09\ H/\sqrt{(d)}$ H – Height of Building above Ground Floor LVL. d – Least lateral dimension of the building

Seismic Building Weight	To include all components of Self Weight, Superimposed Dead Load, any other permanent weight 50% of Live Load

Response spectrum method was used as per IS: 1893 (Part-1) 2016 with the following data:
Design horizontal seismic coefficient (Ah) = ZI (Sa)/ 2Rg

RESPONSE UNDER SEISMIC CONDITIONS

Seismic analysis of structure shall be carried out by response spectrum method for the design of beam elements (Columns and Beams), whereas static design method shall be applied for the design of plate elements (Shear walls). However, minimum base shear and mass participation is achieved in both the approaches as per the provision of IS: 1893.

WIND LOAD

The wind load has been taken as per IS: 875 (Part-3) – 2015 and wind pressure calculation done as follows :-

$P_z = 0.6\ V_z^2$ KN/sqm

$V_z = K_1\ K_2\ K_3\ V_b$, Where V_z = Design wind velocity

K_1 = Probability factor or Risk coefficient has been taken 1.0

K_2 = Terrain, height and structure size factor, category '2' and class 'B' have been considered.

K_3 = Topography factor = 1.0

V_b = Basic wind speed = 50m/s

Note: For small elements such as canopies wind load calculated as per class 'A'. The calculated wind load is applied on the peripheral joints as a joint load after multiplying the wind pressure with area of each joint and shape factor.

Special Note: Being a High Rise Building it shall be analyses for earthquake forces and wind load forces as per IS Code.

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TEMPERATURE LOAD

If the length of the buildings is more than 45m, the building shall be analyzed for thermal effects induced due to seasonal and diurnal temperature variations.

A temperature effects of ±10'C shall be considered for intermediate floors whereas a temperature variation of ± 25'C shall be considered for terrace floors.

For long term shrinkage effects, an equivalent temperature of + 10oC has been considered. As per IS code, the following load cases have been considered for thermal effects.

1.5 (DL + TL1 + TL2)

1.5 (DL + LL + TL1 + TL2)

1.5 (DL ± EQ + TL1 + TL2)

1.2 (DL + LL ± EQ + TL1 + TL2)

1.2 (DL + LL ± WL + TL1 + TL2)

TL1 = Temperature load due to temperature variation.

TL2 = Temperature load due to shrinkage effects.

MATERIALS

Concrete: Concrete mix of M25 – M40 conforming with IS: 456 and CPWD specifications are used.

Concrete Grade

Controlled mix concrete shall be used.

S. NO	Group	Grade Designation	28 days Compressive Strength (Cylinder)	Application
1	Ordinary Concrete	C 10	10	Blinding/mud-mat concrete
		C 15	15	
		C 20	20	Mass/plain concrete
2	Standard Concrete	C 25	25	Minimum Grade for all structural concrete
		C 30	30	For heavy structures like a silo, mill foundation and preheater
		C 40	40	Grouting/Silo
		C 50	50	Grouting

Steel Reinforcement: Fe 500 Grade (TMT bars) conforming with IS: 1786.

Structural Steel: E350/275/250 Conforming to IS:2062

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DESIGN LIMIT STATES

The Limit state design method is used for the structural design of concrete members. For design of the individual members loads are combined in accordance with the loading combinations specified in IS 875 to achieve the respective limit state. These are listed as below: -

S. No.	Dead Load	Live Load	Earthquake/Wind Load
1	1.5	1.5	-----
2	1.2	1.2	1.2
3	1.2	1.2	0.6
4	1.5	-----	1.5
5	0.9	-----	1.5

LOAD COMBINATIONS

1. 1.5 * (DL + LL)
2. 1.5 * (DL +/- EQX)
3. 1.5 * (DL +/- EQZ)
4. 0.9DL +/- 1.5EQX
5. 0.9DL +/- 1.5EQZ
6. 1.2 * (DL + LL+/-EQX)
7. 1.2 * (DL + LL+/-EQZ)
8. 1.2 * (DL + LL)+/-0.6EQX
9. 1.2 * (DL + LL) +/- 0.6EQZ
10. 1.5 * (DL +/- WLX)
11. 1.5 * (DL +/- WLZ)
12. 0.9 * (DL +/- 1.5 WLX)
13. 0.9 * (DL +/- 1.5 WLZ)
14. 1.2 * (DL + LL +/- WLX)
15. 1.2 * (DL + LL +/- WLZ)

For non-orthogonal Columns the following additional load combination shall be used in the design. 16. 1.2 * (DL + LL +/- EQX +/- 0.30EQZ)

17. 1.2 * (DL+LL+/-EQZ+/-0.30EQX)
18. 1.5 * (DL+/-EQX+/-0.30EQZ)
19. 1.5 * (DL+/-EQZ+/-0.30EQX)
20. (0.9 * DL) +1.5(+/-EQX+/-0.30EQZ)
21. (0.9 * DL) +1.5(+/-EQZ+/-0.30EQX)

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Notations

DL = Dead Load

LL = Live Load

RLL = Reduced Live Load

EQX = Earthquake Load in X-direction

EQZ = Earthquake Load in Z-direction

WLX = Wind Load in X-direction

WLZ = Wind Load in Z-direction

Whereas X & Z are two principal axes.

ALLOWABLE DEFLECTIONS

1. The deflection under serviceability loads of structural members should not be such to impair the strength or efficiency of the structure leading to damage to the finish.
2. Recommended limits of deflection for certain structural members and systems for combination of Live loads/ Wind loads.
3. Structural Elements

Allowable deflections expressed in parts of the span

Floor beams and girders	
Main Beams and girders	1 /300
Secondary Beams	1 /250
Beams supporting equipment's	1/500
Beams Supporting Dynamic equipment's	1/1000

Recommended limits for vertical deflection from

IS 800:2007

Roof and Roofing Beams	
Main Beams	1 /250
Purlins	1 /180

Recommended limits for vertical deflection from IS-800:2007

Vertical framework elements	
Posts/wall columns, collar beams	1 / 200
Side Runners	1/ 250

Recommended limits for vertical deflection (IS 800:2007)

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Crane girders

As per IS 800:2007,

Runway beams	1 / 600 or 25 mm
Runway beam of a monorail hoist block	1 / 500

Note: Where the deflection due to the combination of dead load and live load is likely to be excessive, consideration should be given to pre-chamber the beams, trusses and girders. The value of desired camber shall be specified in the design drawing. Generally, for spans greater than 25 m, a camber approximately equal to the deflection due to dead loads plus half the live load may be used. The deflection of a member shall be calculated without considering the impact factor or dynamic effect of the loads on the deflection.

1. **Buildings**

   Horizontal Deflections for Buildings – H/300

   Recommended limits for horizontal deflection as per IS:456-200

2. **Deflection for Conveyor Bridges:**

   Main girders shall be checked for the following load combinations:

   - DL (total) + LL (material) +0.5 * LL (walking area) u = span /500

   The most adverse realistic combination and arrangement of live loads should be assumed.

   Dynamic and extraordinary loads should be considered. Primary beams supporting gears/motor at the drive station:

   This equipment is very sensitive to deflections due to the axle connection.

- Total local deflection = Span /500
- The permissible lateral deflection of trestles in transverse direction =H/500

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REQUIREMENTS FOR DURABILITY AND FIRE

Concrete cover requirements is governed by Indian Code. The values in the following table shall be appropriate for a fire rating of 2 hours. The following classification also applies in the design of structural elements:

Exposure	Classification
Members in contact with the ground	Very Severe
Members in interior environments	Mild
mbers in above-ground exterior environments	Moderate

In general, adopting the minimum concrete strengths and reinforcement covers shall ensure the durability and fire resistance of concrete elements. Values shown on the drawings shall not be less than the following:-

Element/Location	Minimum Cover (mm)	Minimum thickness (mm)	Minimum f_{ck}(used in the design)
Cast In Place Concrete			
1. Concrete cast against and permanently exposed to earth	75	200	30
2. Concrete exposed to weather and not in contact with ground (moderate)			
a) RC slabs	25	125	25
b) RC walls	25	200	35
c) RC beams	30	230	25
d) RC columns (Ties)	40	300	35

DESIGN CODESAND REFERENCE DOCUMENTS

CODES, STANDARDS AND COMMENTARIES

S. NO	CODE	NAME
1.	IS : 1893 – 2016	Criteria for Earthquake resistant deign of Structures
2.	IS : 13920	Ductile detailing of Reinforced Concrete Structures subjected to Seismic forces.
3.	IS : 4326 – 1993	Earthquake resistant Design and construction of Buildings
4.	IS : 875 – 2015 (Parts I -III & V)	Code and Practice for Design Loads (Other than earthquake) for Building and Structures like Dead, Imposed, Wind and other Loads
5.	IS : 456 – 2000	Plain and Reinforced Concrete (Code of practice)
6.	SP : 16	Design aids for Reinforced concrete Structure.
7.	SP : 34	Handbook on Concrete Reinforcement and Detailing
8.	S : 3370 Part I, Parts II and IV	Code of practice for Concrete structures for the storage of liquids.
9.	IS : 1786	Specification for High Strength Deformed Steel bars and wires for concrete reinforcement
10.	S : 1904	Code and Practice for design and Construction of Foundations in Soils
11.	IS : 2950	Code and Practice for Design and Construction of Raft Foundations
12.	IS : 800-2007(LSD)	Code of Practice for general Construction in Steel.
13.	IS 2911 (Part1 – Sec1 to 4) : 1979	Code of practice for Design and Construction of Pile Foundation
14.	NBC – 2016	National Building Code of India – 2016
15.	IRS	Manual for Standards and Specifications for Railway Stations 2009 issued by Ministry of Railways, Railway Board

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