DESIGN BASIS REPORT

MAJOR UPGRADATION OF YESVANTPUR JUNCTION RAILWAY STATION

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01	R0	04-02-2023	CDPL/RP/YPR/DBR/R0
02	R1	27-02-2023	CDPL/RP/YPR/DBR/R1
03	R2	18-04-2023	CDPL/RP/YPR/DBR/RTS/R2

DBR includes Air concourse, East side elevated road and Platform.

PROJECT NAME: -
MAJOR UPGRADATION OF YESVANTPUR JUNCTION RAILWAY STATION

CLIENT: -
SOUTH WESTERN RAILWAYS, BANGALORE

EPC CONTRACTOR:
GIRDHARI LAL CONSTRUCTIONS PVT. LTD.

LEAD DETAIL DESIGNER:
DESIGN ACCORD

Structural Consultant:
CONSTRUCTURE DESIGN PVT. LTD.

CONSTRUCTURE DESIGNS PVT. LTD.

26/05/23

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1. GENERAL

i. Scope & Purpose:

The Indian Railways has envisaged the redevelopment of 400 Railway Station across India as world's largest multi-modal integration and transit-oriented development project with the objective of creating iconic railway stations. Different bodies are implementing the project, with RLDA being one of the implementing bodies. RLDA's objectives in this regard are two- fold

- Provide world- class facilities and service levels to railway passengers at the Railway Station.
- Achieve the above at a minimum cost to the exchequer by monetizing the commercial development potential on the land parcels adjoining the railway station.

Our scope of work for this projects is as follows:

i) To prepare Design Basis report

ii) To suggest economical structural system.

iii) To prepare the 3D analysis model.

iv) To perform the structural design in accordance with the provision of the relevant codes.

v) To coordinate the structural design with the architectural/services requirements.

vi) To prepare structural drawings for the design performed.

ii. Brief About work:

Project consists of the following:

- Station building at West side. It is a B+G+2 structure.
- Arrival & departure Ramps at east side.
- Air concourse with roof, across the platform connecting West & East Side. It is at 10.2m Lvl and 216m wide.
- Multi-Level car parking at East side. Which is a G+5 structure with provision of 4 future storeys.
- RPF office and Bangalore rural railway police station at East side.
- Linen store & office at East side.
- Platform roof coverings platform 1, 2&3, 4&5, 6.

The above-mentioned details have been inferred from the architectural drawings issued by EPC Contractor.

Scope of DBR:

Scope of this DBR includes Air concourse, East side elevated road and Platform.

Building Location, Zone & floor heights:

Site for the proposed project of Yesvantpur Junction railway station is located at Bengaluru. It lies under zone-II seismic zone.

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Floor Heights:

Air Concourse: **9.00 m (+10.2 m level)**

2. DESIGN SCHEME / BASIS OF DESIGN

i. Types of structures:

RCC: In this steel is embedded in such a manner that the two materials act together in resisting forces. The reinforcing steel- rods, bars, or mesh- absorbs the tensile, shear, and sometimes the compressive stresses in a concrete structure. RCC Frame structure consists beam and slab arrangement which in turn rests on vertical RCC members such as columns.

Steel: It is a metal structure which is made of structural steel components which connect with each other to carry loads and provide full rigidity. Because of the high strength grade of steel, this structure is reliable and requires less raw materials. One of the major issues with Steel is lesser stiffness and high fire proofing cost.

Composite: These are the ones which combine of more than one material such as concrete, steel etc. in any combination. Steel RCC Composite combines the better properties of the both i.e. concrete in compression and steel in tension, they have almost the same thermal expansion and also results in speedy construction.

ii. Materials to be used:

Reinforced Concrete:

The Unit weight of RCC is 25KN/m3. Cement used for RCC work in the sub structure & super structure will be PPC or OPC (Grade 43 and 53) with FLYASH conforming to IS: 8112-1989 and 12269-1987. The Fly ash % will be meeting the design mix requirements and in line with stipulations of IS456 & IS1489 part-1. All RCC works will be mechanically vibrated to produce dense, sound and durable concrete as per specifications. The water quality used in all stages of construction shall strictly confirm to IS: 456-2000.
**Fly ash to be used in concrete only with OPC & not PPC.

The grade of concrete in the location at beam/slab-column junction shall be kept matching with the column grade below.

The following grades of Reinforced concrete shall be adopted:

Description	Grade	Max. Size of Aggregate (mm)	Type of Cement used in Design Mix.
Raft foundation/ Combined Footing/Isolated foundation	M25/M30	As per codal standards	OPC/PPC
Shear Walls & Columns	M30	As per codal standards	OPC/PPC

Retaining Wall	M25/M30	As per codal standards	OPC/PPC
Beam/Slab	M25/M30	As per codal standards	OPC/PPC

Table 1 Grade of RCC elements

- All reinforcing steel to be used in the structural elements shall be:

High yield strength deformed TMT bars with a minimum yield stress of 500/550 MPa, a minimum elongation of 14.5% and other as well as IS:13920 provision of UTS/YS ratio >1.15 specifications conforming to IS: 1786 shall be adopted for 8mm to 32mm dia. bars.

Structural Steel:

- The Unit weight of Structural steel is 78.5KN/m3
- Structural steel encased column shall be built up in high tensile steel with a yield stress of E450 MPa conforming to IS: 2062.
- Structural steel beam shall be Rolled/built up section high tensile steel with yield stress of E450 MPa and UB rolled section shall be E450/E350 MPa conforming to IS: 2062.
- Deck sheet shall be TR-60 of 1mm thick. with yield stress of E350 MPa with minimum 275 gsm galvanization of Corus/Jindal make.
- Shear studs shall have yield stress of E350 MPa. Dia. of 19/22/25mm shall be used based on the modular requirements of beam spans / spacing/ forces etc.
- Bolts of grade 8.8 as per IS: 4000 to be used which after torque application will develop friction grip. Anchor rods/bolts shall be E250 MPa conforming to IS standard
- Welding electrodes shall be E8018 conforming to AWS D1.1.

The flooring and waterproofing is used as per specifications.

iii. Structural System:

Concourse:

A composite steel frame structural system has been proposed for all floors with enough stiffness by providing shear walls to keep lateral displacements within limits. Steel–concrete composite columns have been chosen to reduce the column sizes. Further, composite floor system has been introduced using trapezoidal profile composite steel deck sheeting. The lateral resistance system shall be shear walls/Braces with OMRF, with R=3 in line with provisions of Table 9 of IS-1893:2016, Part-1).

The lateral loads will be resisted by shear walls, Braces and the columns. The floor system consists of primary and secondary steel beams supporting an overlaid deck slab. Column to column beams are moment resisting beam and all secondary beams are moment released beams and shall be modelled accordingly in the ETABS.

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Through Roof & Platform Cover:

CFT columns for platform cover and encased columns have proposed for through roof. Z/Box Purlin shall be introduced for both roofs. The lateral resistance system shall be OMRF, with R=3 in line with provisions of Table 9 of IS-1893:2016, Part-1).

East Side Elevated Road:

The structural system chosen for the East side elevated roads consists of RCC Frame with beams & columns. Detailing shall be done as per codal provisions. The lateral resistance system shall be OMRF to control lateral forces/displacement.

iv. Design Philosophy/Detailing of structure:

The design of Composite Columns & beam is being done using AISC: 360-2010 and RCC element as per IS456-2000 and SP-16. Limit state method is being followed as per IS 800-2007 for design of steel structures and connection designs. Detailing shall be done in such a way that it meets min. & max. reinf. Requirements & min. & max. spacing requirements as per suitable codal provisions.

The 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.

(f) All structural members should conform to provisions laid in IS 13920, SP 34,SP 6.

- The design of RCC columns, beam & slabs will be done using IS456-2000, IS 1893-2016 & SP-16.
- The design of Composite Columns & beam is being done using AISC:360-2010
- Limit state method is being followed as per IS 800-2007 for design of steel structures.

Design of composite elements:

Composite Column

The steel columns (comprising of the two structural forms namely structural steel & structural concrete) shall start from approx. 2.5m below the 1st floor level thus ensuring that the composite beam framing for plinth level is facilitated. The AISC:360-2010 Specification provides simple and practical methodology for composite column by permitting design of composite columns by LRFD (Load and Resistance Factor Design). The design methodology is well adapted in ETAB software modelling and the resulting sections are safe and practical. Composite column design will be done as per AISC:360-2010 and calculations shall be submitted in pdf format of excel sheet.

The construction methodology is execution friendly as well as time saving since structural steel columns up to 4 floors can be erected & tied with floor structural beams. Decking work can be taken up on these floors. The sufficiency of structural column alone is checked for the loading of these four levels subsequently, floor wise, the reinforcement is put in position & columns RCC executed to get 'composite action'. Of course, the composite column design caters to the full loading which shall be

incident only after all floors construction.
This construction sequence facilitates parallel working (in up to 4 levels at a time)

Secondary beam
Directly designed using ETABS. Pre-camber may be used where necessary, so that the deflection is suitably addressed. The web openings will be strategically provided for provision closure to point of inflection, where moments will be minimal & shear will also not be at its peak

Primary beam (Moment Redistribution in beams design)
The redistribution up to 100% is accepted by way of 'plastic design'. Accordingly, the primary analysis of beams is done conventionally & then moments redistributed using plastic design only up to 50% so that the hogging (support moments) are controlled within the designed limits & the sagging moments are increased for which the section provision is efficiently made. A separate model will be prepared in ETABS (only for the primary beams) where the redistributed moments of design only- thus ensuring that the assumption of rigid joints is maintained. An innovative deck placement with an eye towards best beam depths will be adopted where the beams will not necessarily span in the direction opposite to the corrugations of the sheet. The extent of moments obtained (after redistribution using plastic theory) will be checked for 'no-overstressing' condition,

Connections design
The connections should have the required capacity considered after redistribution of moments. There is no possibility of brittle failure since the ductile connections will permit rotation at the joint resulting in no possibility of sudden failure.

Stability:

Stability of structure against overturning and sliding as per Clause 20.0 of IS: 456-2000 is followed in the design and listed as below:

- Factor of safety against overturning:
  Restoring moment to be at least 1.2 times the maximum overturning moment due to the characteristic dead load and 1.4 times the maximum overturning moment due to the characteristic imposed loads.
- Factor of safety against sliding: 1.4
  In both the above cases, 0.9 times of characteristic dead load only to be considered in the design.

Serviceability Requirement:

This is given with following limitations:

- For Vertical deflections (Total load deflections) =Span/250 for Serviceability. ***(IS 456:2000 cl 23.2)***
- Span/360 for material susceptible to cracking. ***(IS 800:2007 Table 6)***
- Lateral displacement of Structure for Wind Loads=Height/ 500. ***(IS 456:2000 cl 20.5)***
- Drift shall be 0.4% of story height. ***(IS 1893 part-1:2016 cl 7.11.1.1)***
- For Cracking- For all RCC elements shall be cracked section and limiting crack width to 0.2 mm. ***(IS 456:2000 cl 35.3.2)***

(Drift- The maximum horizontal relative displacement due to earthquake forces between two successive floors shall not exceed 0.004 times the difference in level between these floors.)

Floor vibrations due to walking:
Floors can be subjected to impulse loading due to a variety of sources in buildings resulting in

vibrations being felt by building occupants. Typically, in buildings, the most significant cause of floor vibrations is walking excitation, and levels must be kept within certain limits to ensure that adverse comments from building occupants are kept to a minimum, walking acceleration shall be less than $\frac{a0}{g} = 0.005$ and calculation shall be adopted direct from Etab.

Floor vibrations due to train movements:

Vibrations due to movement of trains to be checked and kept in accordance with the relevant sections of design national/international codes and relevant literature will be referred for adequate vibration-controlled floor design.

For the same, EPC contractor will appoint a consultant which specializes in Vibration Control systems.

The vibration control documentation can be provided at a later stage.

Property Modifier Used in ETAB:

Cracked RC section properties shall be modified separately for serviceability limit state (SLS) and ultimate limit state(ULS) design as per clause 6.4.3.1 of IS1893-2016.

S.No.	Structural Element	For SLS Condition		For ULS Condition	
		Area	Moment of Inertia	Area	Moment of Inertia
1	Slabs	1.0 Ag	0.35 Ig	1.0 Ag	0.25 Ig
2	Beams	1.0 Ag	0.70 Ig	1.0 Ag	0.35 Ig
3	Columns	1.0 Ag	0.90 Ig	1.0 Ag	0.70 Ig
4	Shear Walls	1.0 Ag	0.90 Ig	1.0 Ag	0.70 Ig

Table 2 Property Modifier used

Where

- Ag Represent gross area of member
- Ig Represent gross moment of Inertia of member

v. Loads & Load Combinations:

Dead Loads:

Dead weight will include, self-weight.

Following unit weights have been considered in accordance with IS: 875 (Part I) -1987 and IS: 1911:

Description	Density of material
Reinforced cement concrete	25 KN/m^3
Structural steel	78.5 KN/m^3
Plain cement concrete	24 KN/m^3
Brick masonry including plaster	22 KN/m^3
Cement mortar / plaster	20 KN/m^3
Floor finish (stone/tile)	24 KN/m^3
Brick bat Cuba for terracing/waterproofing roof	20 KN/m^3
Glass	25.0 KN/m^3
Façade Load	2.5 KN/m/R/m height
Moist, sweet earth for filling of planters	20 KN/m^3
Foam Concrete	10 KN/m^3
AAC Block Masonry	7.5 KN/m^3

Thermo Col 25 kg/cum	0.25 KN/m^3
TR-60	0.111 KN/ m^2

Table 3 Unit weights of building materials

Super Imposed Dead Loads and Live Loads:

Superimposed Dead loads & live loads have been considered in design in accordance with IS:875 (Part II)-1987.

Wall Load- Fly ash blocks: Considering plaster of 12mm on one face and 12mm on other face.

- 200mm.thk. Wall = (0.2mx1mx1mx7.5KN/m^3)+((0.012m+0.012m)x20KN/m^3)=1.98 KN/m ht
- 100mm.thk. Wall = (0.1mx1mx1mx7.5KN/m^3)+((0.012m+0.012m)x20KN/m^3)=1.25 KN/m ht

RCC Liquid retaining structures (UGT, Fire Fighting tank, STP & OHT):

As per IS 3370 part i-iv (All parts).

Wind Loads:

Wind loads have been worked out based on basic wind speed of 33 m/s (as per cl 4.4.2 section 1, part6 of NBC 2016). Basic input data for the wind analysis assumed as follows:

Wind Parameter	
Basic Wind speed, Vb	33 m/s (as per cl 4.4.2)
Terrain category	3
Risk coefficient factor k1	1.0
Terrain, height & structure size factor k2	0.91-1.02: Varies with height as per code.
Topography factor k3	1.0
Importance factor for cyclonic region k4	1.0
Wind directionality factor Kd	0.9-As per clause 7.2.1
Area averaging factor Ka	0.8-As per clause 7.2.2
Combination factor Kc	0.9-As per clause 7.3.3.13

Table 4 Wind parameters

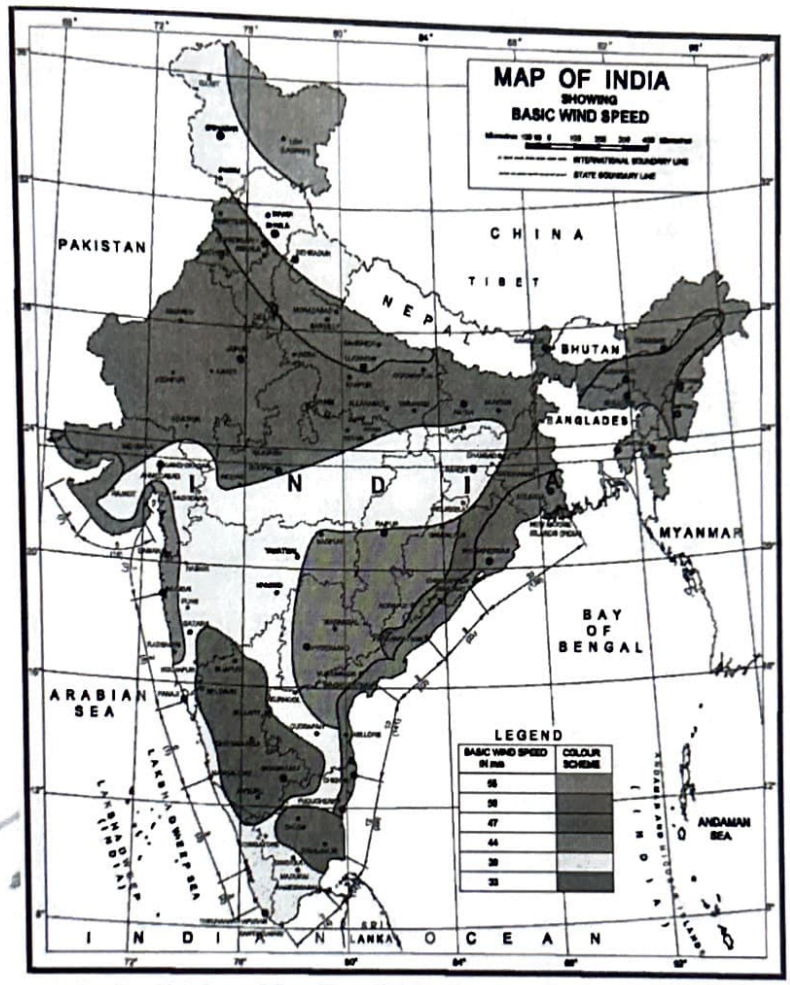

Fig 1 (a)

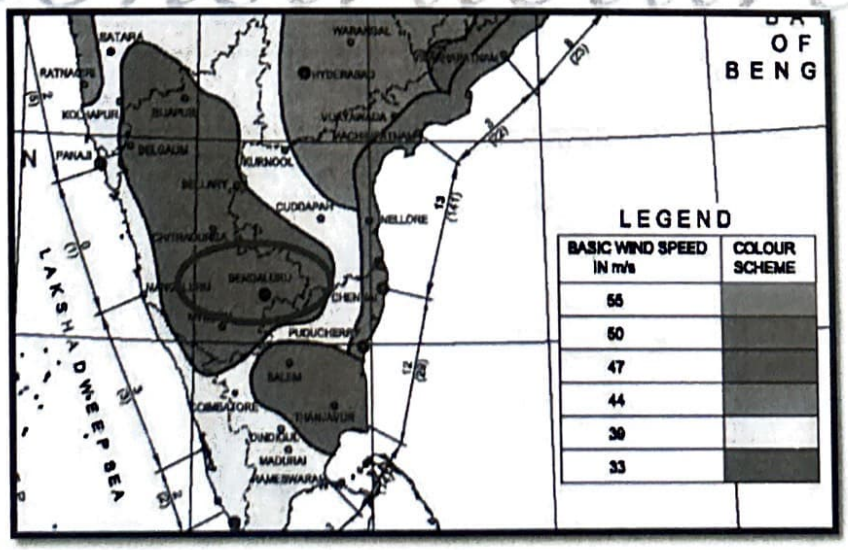

Fig 1 (b)

Fig. 1(a) & 1(b) Wind speed as per NBC 2016

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Seismic Loads:

As per IS1893-2016 (Reaffirmed 2017) the proposed building fall under seismic zone-II.

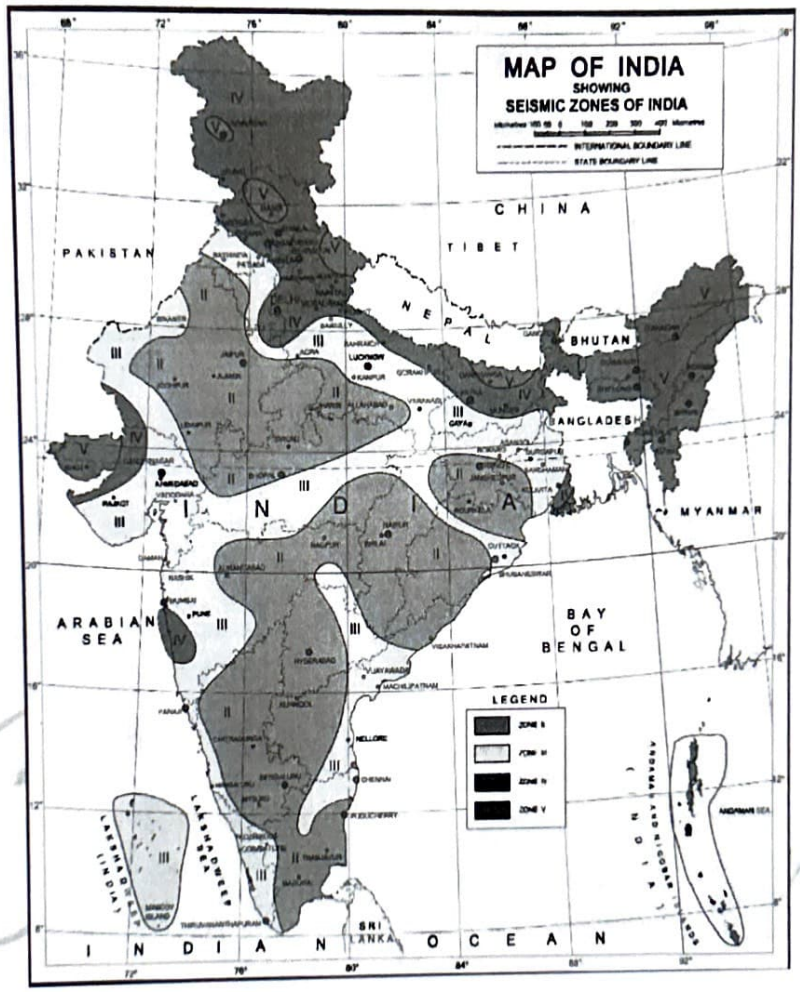

Fig. 2(a)

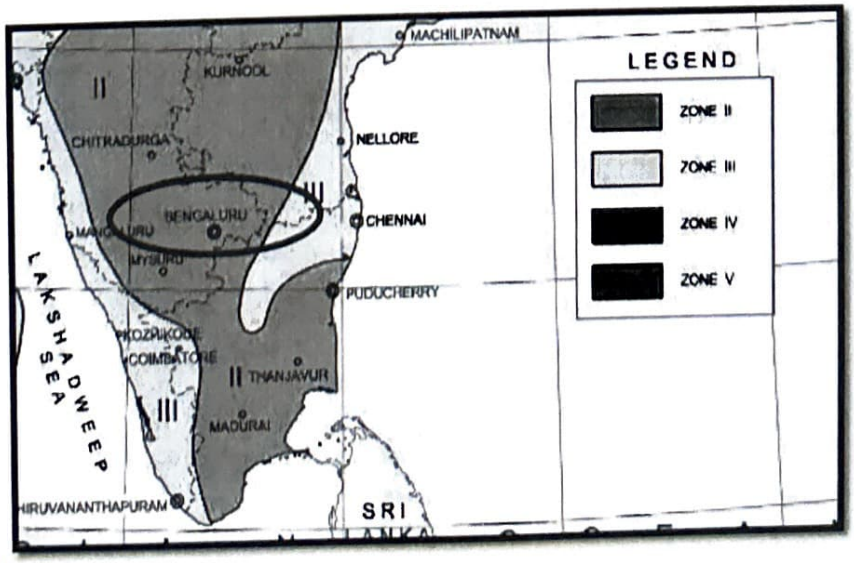

Fig. 2(b)

Fig. 2(a) & 2(b) Seismic zone as per IS1893-part1: 2016

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Time period calculation

The approximate fundamental translational natural period Ta of oscillation of structure will be Calculated in accordance with clause 7.6.2: of IS 1893-part1: 2016.

Importance factor calculation

The importance factor for various structures under consideration in this report is derived based on table 8 (Clause 7.2.3).

Structure	Importance factor	Lateral load resisting system
Air concourse	1.5	Important service & community buildings or structures
Through roof	1	All other structures
Elevated Road	1	All other structures
Cover on platform	1	All other structures

Table 5 Importance factor

Response Reduction factor calculation

Depending upon lateral load resisting system of the structure, response reduction factor is given as per table below in compliance with Table 23 IS800:2007/ IS 1893-part-1:2016:

Structure	Response reduction factor	Lateral load resisting system
Air concourse	3	Ordinary Moment Resisting Frame (OMRF)
Through roof	3	Ordinary Moment Resisting Frame (OMRF)
Elevated Road	3	Ordinary Moment Resisting Frame (OMRF)
Cover on platform	3	Ordinary Moment Resisting Frame (OMRF)

Table 6 Response reduction factor

Ordinary Moment Resisting Frames (OMRF)

- Rigid moment connections should be designed to withstand a moment of lesser of 1.2 times of the full plastic moment of the connected beam or the maximum moment that can be delivered by the beam to the joint.
- The rigid connections should be designed to withstand a shear resulting from the load combination 1.2 DL + 0.5 LL + shear corresponding to the design moment defined above.

Soil Type

Types of soils are classified as Type I, Type II and Type III according to IS1893:2016 (Clause 6.4.2.1).

Type I, II and III soils refer to rock or hard soils, medium or stiff soils and soft soils respectively.

As per soil report, Soil type is II, Medium soil.

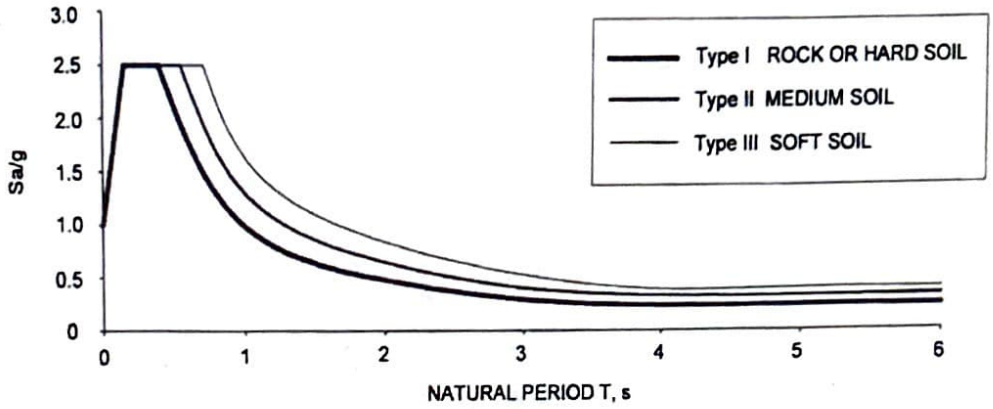

Fig. 3 Design acceleration coefficient (Sa/g) as per IS1893-part1: 2016

Seismic Weight

Clause 7.3 of IS 1893 specifies to consider full dead plus percentage of imposed load for estimating design seismic force. In compliance with clause 7.3.2, imposed load on roof except equipment and permanently fixed facilities need not be considered. Hence, for through roofs and cover on platforms no imposed load is assumed to contribute to the seismic weight of the structure.

However, for structure where imposed load is above 3 kN/m^2 , 50% of total imposed load shall be considered in calculation of seismic weight (table-10, clause 7.3.1).

Seismic Analysis Methods

Response spectrum method of dynamic analysis is employed for all type of structures.

In compliance with clause 7.7.3 of IS 1893:2016, the design base shear estimated using dynamic analysis methods shall not be less than the design base shear calculated using a fundamental period as per clause 7.6.2: of IS 1893-part1: 2016

Damping Ratio

According to clause 7.2.4 of IS1893:2016, irrespective of the material of construction, the value of damping shall be considered as 5% of critical damping for estimating horizontal seismic coefficient Ah.

Vertical Earthquake Effect

In compliance with clause 6.3.3.1 of IS1893:2016 wherever required.

The design seismic acceleration spectral value Av shall be calculated as:

$$A_v = \frac{\left(\frac{2}{3}\right)\left(\frac{Z}{2}\right)(2.5)}{\left(\frac{R}{I}\right)} \qquad \text{(cl. 6.4.6, IS1893:2016)}$$

Temperature & Shrinkage Loads:

The temperature load has been applied in case length of structure is more than 45m for seasonal

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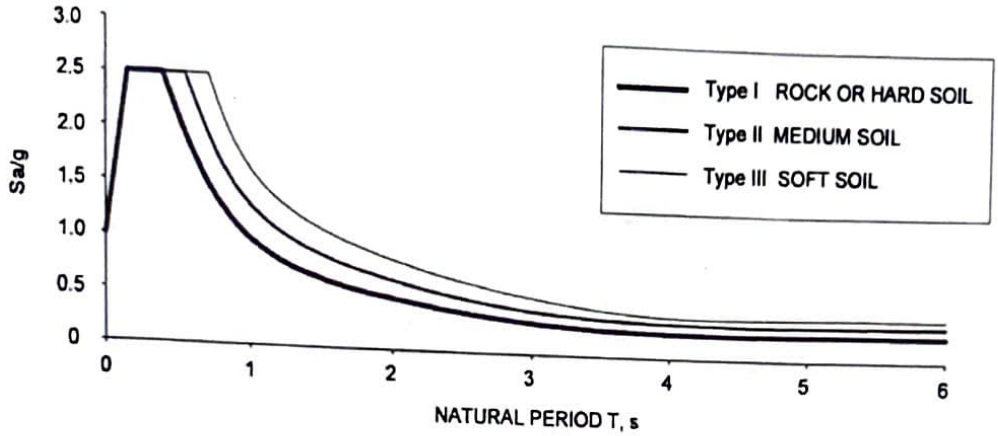

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Temperature & Shrinkage Loads:

The temperature load has been applied in case length of structure is more than 45m for seasonal

and diurnal variation and for shrinkage effects; it is converted into equivalent temperature for applying in ETABs model. In view of maximum and minimum peak temperature data available, temperature load of 20º C will be considered in design of open terrace and shrinkage load of -5º C shall be applied on every floor. Temperature load is not required for intermediate floor due to constant temperature load.

LOAD COMBINATIONS:

Load combinations Used for Strength, Serviceability are tabulated below:

For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be considered as applicable.

Dead Load	DL + SDL
Live loads	LL
Non-Reducible Live Load	NRLL
Seismic Loads in X-Dir	Eqx
Seismic Loads in Y-Dir	Eqy
Wind Load in X-Dir	WLx
Wind Load in Y-Dir	WLy
TEMP Raise	TR*
TEMP Fall	TF*
Scaled Seismic Loads in X-Dir	Rx
Scaled Seismic Loads in Y-Dir	Ry

Table 7 Load Types and notation

Serviceability load combinations and Ultimate load combinations used for analysis and design as per IS 456 and IS 1893 is as follows:

Serviceability Limit State Load Combinations:

Table 10 Serviceability Limit State Load Combinations

Load Combination	Dead Load (DL)	Live Load (LL)	Seismic Load (EQ)	Wind Load (WL)	Temp load(TR/TF)
DL+LL/Temp	1.0	1.0	-	-	0.6
DL+ EQ	1.0	-	1.0	-	-
DL+WL	1.0	-	-	1.0	-
DL+LL+EQ/WL	1.0	0.8	0.8	0.8	

Ultimate Limit State Load Combinations:

Table 11 Ultimate Limit State Load Combinations

Load Combination	Dead Load (DL)	Live Load (LL)	Seismic Load (EQ)	Wind Load (WL)	Temp load(TR/TF)
DL+LL/Temp	1.5	1.5	-	-	0.9
DL+ EQ	1.5 or 0.9	-	1.5	-	-
DL+WL	1.5 or 0.9	-	-	1.5	-
DL+LL+EQ/WL	1.2	0.6	1.2	1.2	-

Notes:

- Earthquake and wind loads are reversible
- Wind load and earthquake loads are considered for both x & y directions. Whenever imposed load is combined with earthquake load, the appropriate part of imposed load as specified in IS: 1893-2016 / Clause 7.3.3 of seismic code will be used both for evaluating earthquake effect and for combined load effects used in such combination.
- Serviceability loads combinations with suitable live load reduction factor as per IS: 875 (Part-2) will be used for foundation design.

vi. Foundation Design:

Foundation shall be designed accordance to IS 456: 2000(2016). Analysis and design of raft/combined/isolated foundation shall be done by safe and design of isolated footing, retaining wall base to be prepared in excel sheet and provided in pdf format. The foundation will be designed by considering max allowable gross bearing pressure as per latest soil investigation report. As per soil investigation report maximum allowed differential settlement for type of footing and Code (IS 1904) Table 1 will also be taken in consideration for differential settlement.

Water Table will be considered as per soil investigation report.

vii. Software used for Analysis:

The concourse & Through roof shall be analyzed as composite steel structure, East side elevated roads as RCC framed structure and Platform covering as steel structures using ETABS software considering the relevant Indian Standard Codes. Software like ETABS, STAAD, and SAFE shall be used for analysis and design.
Rigid Diaphragm action shall be assumed in the ETABS analysis so that the transfer of load to frames and shear walls is facilitated depending on their flexibility and their location in the structure. All nodes within the diaphragm extents shall be tied together in the model to the center of rigidity of the system with infinite in-plane stiffness. This facility is available in ETABS modelling.
For design of individual elements suitable excel spreadsheets are to be used.

3. Codal Provisions

Throughout this specification, references have been made to appropriate Indian Standards & AISC code (as and when required) with approved level of workmanship and/or materials comprehensive list of relevant standards is compiled below:

i. Loads: -

- IS:875 -1987/2015 Code of Practice for design loads (other than earthquake) for Buildings and structure (All parts)

- IS: 1893-2016(R2021) Criteria for earthquake resistant design of structure.

ii. **Foundations: -**

- IS:1080-1985(2016) Code of Practice for design and construction of shallow foundations on soils (other than raft, ring and shell)
- IS:1904-1986(2020) Code of Practice for design and construction of foundations in soils general requirement
- IS:2950-1981(2013) Code of Practice for design and construction of raft foundations
- IS:2974-1998(2013/2015) Code of Practice for design and construction of machine foundations (All parts)
- IS:8009-1976/1980(2013/2015) Code of Practice for calculation of settlement of foundations (All parts)

iii. **RCC: -**

- IS:456 -2000(2021) Code of Practice for plain and reinforced concrete.
- IS:458 -1988 Specification for precast concrete pipes.
- IS:3370-2021(Part i-iv) Code of Practice for concrete structures for the storage of liquids:(All parts).
- IS:4326-2013 (R2018) Code of Practice for earthquake resistant design and construction of buildings.
- IS:5525-1969(2013) Recommendation for detailing of reinforced concrete works.
- IS: 1786-2008 Specification for high strength deformed steel bars and wires for concrete reinforcement.
- IS:10262-2019 Recommended guidelines for concrete mix design.
- IS: 1893 (Part-1)-2016(R2021) Criteria for earthquake resistant design of structures (General provisions and building).
- IS: 13920-2016 (R2021) ductile design & detailing of RC structures subjected to seismic forces.

iv. **Structural Steel & Composite Construction: -**

- IS: 800 -2007(2012) Code of Practice for general construction in steel.
- IS:806 -1968(2013) Code of Practice for use of steel tubes in general building construction.
- IS:808 -1989 Dimensions for hot rolled steel beam, column channel and angle section.
- IS:816 -1998 Code of Practice for use of metal arc welding for general construction in mild steel
- IS:1161-1998 Steel tubes for structural purposes.
- IS:4000-1998 High Strength bolts in steel structures – Code of Practice.
- IS:7215 -1995 Tolerances for fabrication of steel structures.
- AISC:360-10 Specification for Structural Building (Only Chapter-I refer for composite beam and column design).
- EC-4 Design of composite steel and concrete structures Part.

v. **Miscellaneous: -**

- IS: 432(part 2)-1995 Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement
- IS: 6313(part II) 2001 Standards for anti-termite treatment
- IS:1905-1998 Code of Practice for structural use of unreinforced masonry
- IS: 3067-1995 Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings.
- SP:6 -1998 Handbook for structural engineers (all parts)

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- SP:7 -2016 National Building Code of India
- SP:16-1999 Design Aids for reinforced concrete to IS:456-1978
- SP:22-1982 Explanatory handbook on codes for earthquake engineering and IS:4326-1976
- SP:24-1983 Explanatory handbook on Indian Standard code of Practice for plain and reinforced concrete
- SP:34-1987 Handbook of concrete reinforcement and detailing (SCIP)

vi. Material: -

- IS: 269 -2015 Specification for Ordinary, rapid hardening and low heat Portland cement.
- IS: 455 -1995 Specification for Portland blast furnace slag cement.
- IS: 1489-1991 Specification for Portland pozzolana cement
- IS: 4031-1991 Method of physical tests for Portland cement.
- IS: 383 - 2016 Specification for coarse and fine aggregates from natural sources for concrete.
- IS: 516 – 1999 Method of test for strength of concrete.
- IS: 1199-1999 Method of sampling and analysis of concrete.
- IS: 1566-2000 Specification for plain hard drawn steel wire fabric for concrete reinforcement.
- IS: 4990-1998 Specification for plywood for concrete shuttering works.
- IS: 2645-1999 Specification for integral cement water proofing compounds.

vii. Welding standards: -

- AWS D1.1 - American Welding Society (AWS): Structural Welding (Steel).
- ASME Sec II –Part C Specifications for welding Rods, Electrodes and Filler Metals.

Apart from these basic codes any other related codes shall also be followed wherever required.

Many of above listed standards may not be directly used in detailed design, however, the comprehensive list is captured so that an approval for their use is obtained at DBR stage itself. Wherever appropriate Indian standard does not exist for any item, appropriate British standards/American standards will be used.

4. Miscellaneous

Additional Considerations to design method

Expansion Joint:

Expansion joints are recommended when structure exceeds 45m length. The width of the joints is being calculated as per IS-1893-2016, clause7.11.3.

However even if the length of building this project is more than 45m, the expansion joints can be avoided by carrying out thermal analysis to ascertain their effect and accordingly the design shall be carried out. Construction joints will be planned with the coordination of construction agencies.

Plan and vertical irregularities in accordance with cl. 4.4.3 of IS 4326, fig. 3 & fig. 4c of IS 1893:2016.

Design Philosophy for Thermal & Shrinkage effects:

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- To avoid shrinkage stresses in Non-Tower slabs, compensatory strip to be provided as per structural drawings.
- The compensatory strips shall be suitably located in the region of length beyond minimum 45m and maximum within 55m.
- Compensatory Strips shall be casted after minimum 30 days to maximum two months of adjacent side castings completion.
- Long term shrinkage effects are suitably considered by taking 5degree variation in the ETABS model analysis.

Concrete Cover

Nominal concrete Clear Cover to All Reinforcement Including Links (As per Clause26.4 of IS: 456-2000) considering Environment condition is Moderate.

Structural Element	Face	Nominal Cover
Foundation	All sides	50 mm
Column	All sides	40 mm
Shear Wall	All sides	30 mm
Beams	For Continuous	30 mm
	For Simply Supported	40 mm
Slabs	Continuous floor	25 mm
	Simply supported floor	35 mm
Retaining wall	Earth side	30 mm
	Inside	30 mm
	Water Side (Water Tank)	30 mm
	STP wall Liquid face	40 mm
Deck Slab	Top side	30 mm
	Bottom side	50 mm

Table 10 Concrete cover

Excavating Methodology

Excavation shall be done as per structural drawing for excavation.

Fire Rating

In line with requirements, the fire rating provisions have been adopted.

- All composite beams shall be coated with fire resistance spray applied coating for Two hours fire rating. Using Cement based material.
- Steel beams shall not be painted (i.e., No primer application) to ensure bonding for spray applied coatings.
- Fire proof coating shall be Cement Spray based.
- Low density Cement based compound conforming to UL263 or BS 476 Pt 20/21 or

Warrington-LPCB for 2-hour fire rating to Structural Steel Beams.

- RCC slab of min. 90 mm thickness placed over the deck sheet provides a 2 hour fire rating as per the guidelines provided by 'deck sheet' manufacturer in line with BS 5950-1 provision. Accordingly, the metal deck does not require any fireproof coating.
- All columns/shear walls/staircases/lift walls are designed for 2 hour fire rating.

Equipment (DG Set & Others)

- DG set- this is kept clear from the main framing by way of suitable separation gap so that the possibility of vibration transmission does not arise.
- Other equipment- which is either static or those with insignificant vibrations such as cooling towers will be kept directly on the floors by way of vibration isolation pads.

Façade Cleaning System

Structure support system for Façade cleaning at terrace shall be provided as per vender requirement

Abbreviations:

Abbreviations	Meaning
Ag	Gross Area
AWS	American Weld Standards
CFT	Concrete Filled Tubes
DG	Diesel Generator
Ig	Gross moment of inertia
LRFD	Load and Resistance Factor Design
OHT	Overhead Tank
OMRF	Ordinary Moment Resisting Frame
OPC	Ordinary Portland Cement
PPC	Portland Pozzolana Cement
RCC	Reinforced Cement Concrete
SLS	Serviceability Limit State
STP	Sewage Treatment Plant
Thk.	Thickness
UGT	Underground Tank
ULS	Ultimate Limit State
UTS	Ultimate tensile strength
YS	Yield Strength

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