PROJECT NAME: - UPGRADATION OF CHANDIGARH RAILWAY STATION

CLIENT: - RAILWAY LAND DEVELOPMENT AUTHORITY

EPC CONTRACTOR:- M/s. AHLUWALIA CONTRACTS (INDIA) PVT. LTD.

ARCHITECT: - M/s. ANA-DESIGN STUDIO PVT. LTD.

STRUCTURAL CONSULTANT:-

CONSTRUCTURE DESIGNS PVT. LTD.

DESIGN BASIS REPORT

UPGRADATION OF CHANDIGARH RAILWAY STATION

SN.	Revision no. & Reason	Date	Document No.	Author	Checker
01	R0	16-12-2022	CDPL/RP/CRS/DBR/R0	SHANU BHATT	HARIOM GERA
02	R1 [updating floor heights & soil capacity.	12-01-2023	CDPL/RP/CRS/DBR/R1	SHANU BHATT	HARIOM GERA
03	R2 [changed Live load]	05-02-2023	CDPL/RP/CRS/DBR/R2	SHANU BHATT	HARIOM GERA
04	R3 [for cmnts. received]	17-02-2023	CDPL/RP/CRS/DBR/R3	SHANU BHATT	HARIOM GERA
05	R4 [Updating for procedure order no. 10]	14-03-2023	CDPL/RP/CRS/DBR/R4/RTS	SHANU BHATT	HARIOM GERA
06	R5 [Updating for cmnts received for Response reduction factor]	17-04-2023	CDPL/RP/CRS/DBR/R5/RTS	SHANU BHATT	HARIOM GERA
07	ADDENDUM-I	01-06-2023	CDPL/RP/CRS/DBR/R5/RTS/ ADDENDUM-I	SHANU BHATT	HARIOM GERA
08	R6 [Revised for cmnts. received on 11/09/23	12-09-2023	CDPL/RP/CRS/DBR/R6/RTS	SHANU BHATT	HARIOM GERA
09	R7 [Revised for cmnts. received on 21-10-2023	27-10-2023	CDPL/RP/CRS/DBR/R7/RTS	SHANU BHATT	HARIOM GERA
10	R8 (Final)	14-12-2016	CDPL/RP/CRS/DBR/R8FINAL/RTS	SHANU BHATT	HARIOM GERA

14-12-23 R8 FINAL

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CONTENTS

List of Figures

List of tables

1. Project Brief

Brief Description & Salient features:

Project consists of 2 station building blocks (Chandigarh side & Panchkula side) comprising of Ground floor, Mezzanine floor, Concourse floor, 3rd floor & terrace. The two blocks are connected by a concourse; besides there are 2 no. Foot Over Bridges (FOB1 – Arrival 01; FOB 2 – Arrival 02), through roofs, cover over platform (Platform Shed).

Entry Exit Blocks (station buildings):

Ground floor is planned for ticketing support office, security check, departure lobby (double height), a few retail shops, executive lounge, office of station master, office of chief inspector, office space & male and female toilets. Mezzanine(1st) floor is planned for office area and toilets. Concourse (2nd) floor is planned for retail spaces, food court (double height), enquiry counters & toilets. 3rd floor is planned for paid waiting lounge and toilets. A separate DBR is submitted and approved for the station buildings.

Concourse, FOB, Through Roof and Cover over Platform

The concourse will have waiting halls, cafeteria, ticket counters, retail shops and other purposes. The above-mentioned details have been inferred from the architectural drawings issued by EPC Contractor. FOB are for pedestrian movement. Cover Over Platform and Through Roof are intended to provide cover to passengers.

The Structural system will be based on Modular Concept. Modular design represents the repetition of Modules which in turn, guarantees the speed of construction. It becomes a tool for bringing together and setting out all individual elements. The following Modular elements will be used in this project.

- Grid system used
- Modularity of Columns/Beams/Slabs.
- Modularity of Through roof.
- Modularity of Foundations.

Scope:

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.

Applicable Structures for this DBR:

STRUCTURE NAME	STRUCTURE TYPE
Air Concourse	Permanent
FOBs	Permanent
Through Roof	Permanent
Cover over platform	Permanent

Design Life:

The design life of the structure is assumed as 100 years for Air concourse, Through Roof, cover over Platform and FOB (for important buildings in Table-1, IS 875(part3):2015). This requirement is applicable for concrete works as well as for the composite design/steel construction and not applicable to replaceable finishing materials, water proofing membranes and thermal insulations (if

any). Hence periodic maintenance/refurbishment is required for all replaceable material for longer life.

Basic Dimensional Clearances:

Basic dimensional clearances as required by Railways to be followed as per Indian Railways schedule of dimensions (IRSOD). (Attached in Annexure-A)

Building Location:

Site for the proposed project of Chandigarh Junction railway station is located at Chandigarh.

Structural System:

Concourse & FOBs:

The floor plan layout of the building is such that it is largely symmetrical (in plan) with respect to both axes. Steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction has the biggest advantage of combined action of steel and concrete in structural design as well as construction. This system results in speedy construction with a possibility of working on parallel front.

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 for economy and fast construction execution. The lateral resistance system shall be ductile shear walls/Braces with SMRF, with R in line with provisions of Table 3 of IRS Seismic Code.

The lateral loads will be resisted by shear walls, Braces and the columns, thus the connecting beams being moment connected with the columns. The proposed system will comply with the provisions of IS1893 suitably considering aspects force transfer mechanism suggested as well as like lateral vertical/lateral displacement provisions of the elements/frame.

Encased-steel columns ("I" Section) laid out in a rectangular/Square grid according to architectural and structural needs. 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*. In RCC walls & composite columns, steel members can be erected up to 4 floor including the steel column itself and concrete encasing of the steel columns shall be done thereafter.

Through Roof & Cover over Platform:

Hollow section steel columns for platform cover and encased columns have proposed for through roof. Colour coated sheet with thermal insulation for through roof and corrugated colour coated sheet for platform have been proposed. Z/Box Purlin shall be used for both roofs. The lateral resistance system shall be SMRF, with R=2 in line with provisions of Table 3 of IRS-Seismic code.

Grid System Used:

Typical grid size in the structure is kept strategically to go with the concept of modularization. 12m/24m/36m grid size are proposed for vertical (perpendicular to platform), and horizontal grids are placed as per site (distance between platform).

Besides this grid dimension is also optimal for seating arrangement & furniture layout as desired in the structure environment. With this grid choice, the beams (depth wise, maximum 300/500/550/650/950/1250 mm drop below deck sheet) & column (plan sizes-wise) are also obtained with suitable clearance for services & best space savings in carpet area.

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Basic Structural Framing:

Fig. 1 Structural Framing: Concourse & FOB

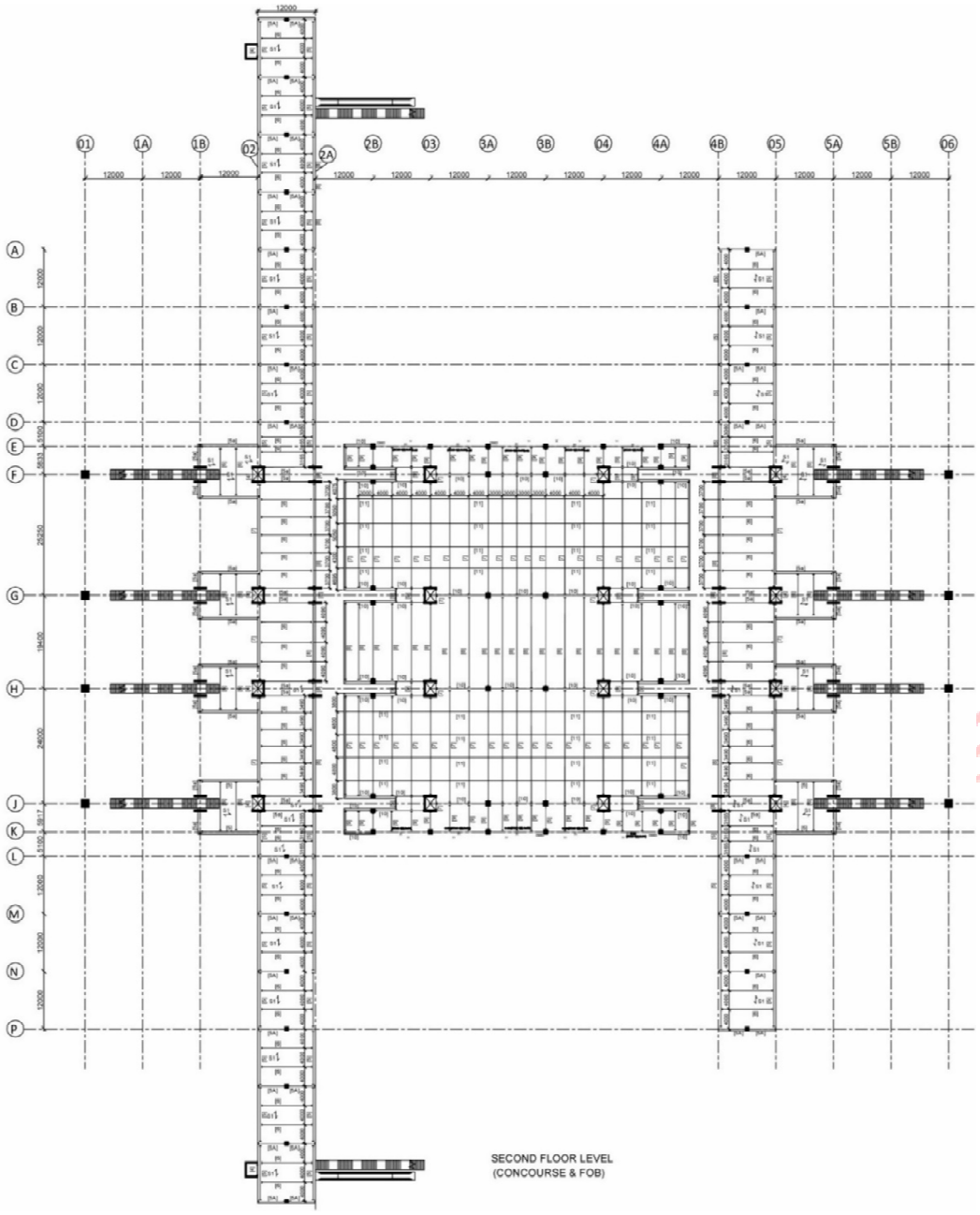

Fig. 2 Structural Framing: Through Roof

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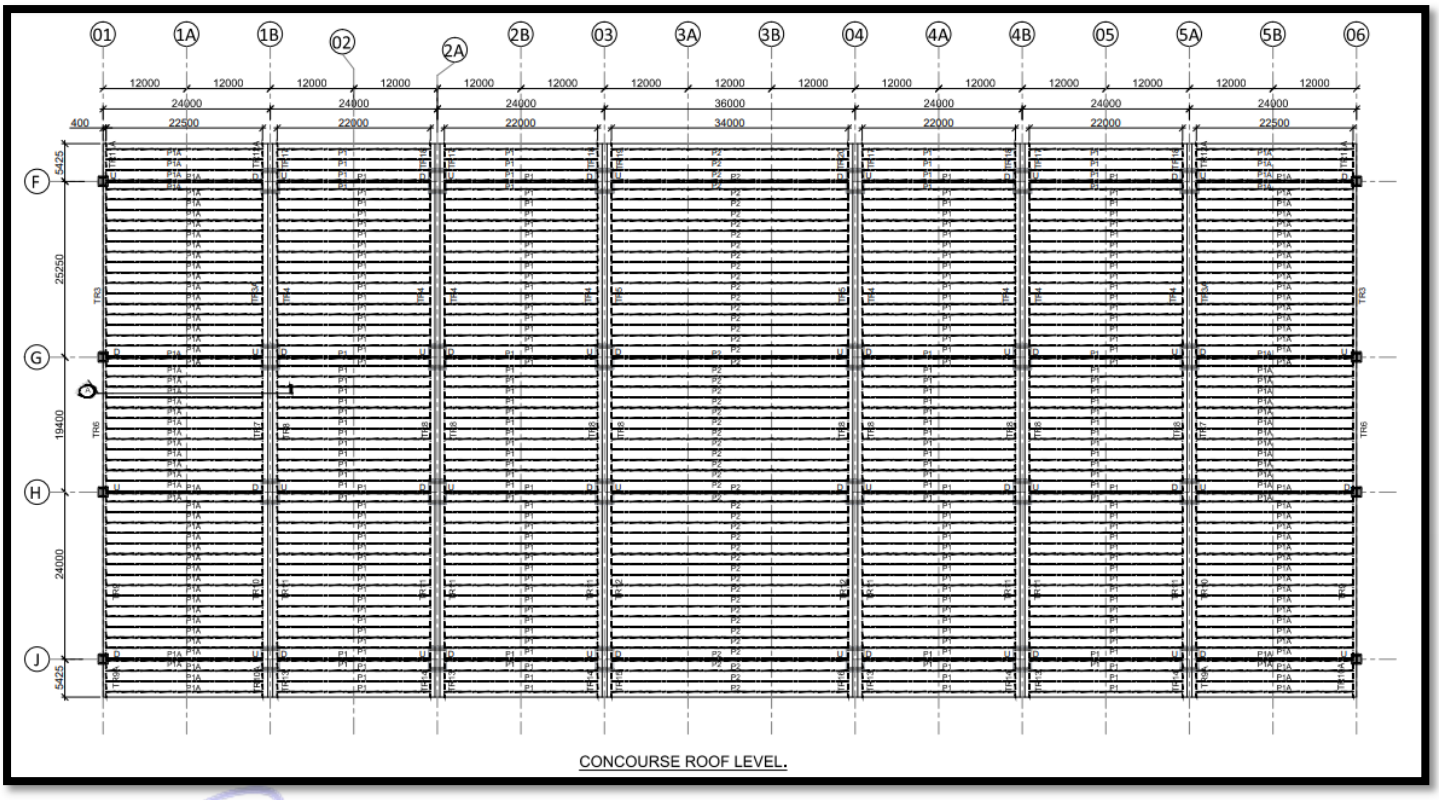

2. Codes & Standards

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:

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.
- IR Bridge Rules: Rules specifying the loads for Design of Superstructure & Substructure of bridges & for assessment of the strength of existing bridges.
- IRS Seismic Code: Earthquake resistant design of Railway Bridges.
- IRC 6: Standard specifications & Code of practice for road bridges.
- IRC 112: Code of practice for concrete road bridges.
- IRC:SP: 114: Guidelines for Seismic Design of road bridges.

Foundations: -

- IRS: Code of practice for the design of sub-structures & Foundations of bridges.
- 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

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parts).
- IS:2911-1-1 Code of practice for design and construction of pile foundation.

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:10262-2009 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.
- IRS: Concrete Bridge Code.

Structural Steel & Composite Construction: -
- IRS: Specification for fabrication & Erection of steel girder bridges & locomotive turn tables.
- 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:3757- Specification of high strength structural bolts.
- IS:1364- Hexagon Bolts, Screws and nuts of product grade A & B.
- IS:7215 -1995 Tolerances for fabrication of steel structures.
- AISC:360-2016 Specification for Structural Building (Only Chapter-I refer for composite beam and column design).
- EC-4 Design of composite steel and concrete structures Part.
- IS:11384-2022 Code of practice for composite construction in structural steel and concrete

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)
- 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 IS 1893- 1976 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)

- IS:4326: 1993 Code of practice for earthquake resistant design and construction of buildings
- RDSO report no. BS-115(Rev 2): Guidelines for composite construction including shear connectors

Material: -

- RDSO report no. BS-111(Rev 6): Guidelines for use of high strength friction grip (HSFG) bolts on bridges on Indian Railways.
- 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.
- IS:2185 part 3 Concrete masonry Unit – Autoclaved cellular (Aerated) Concrete Blocks

Welding standards: -

- IS:16003 Specification and qualification for welding procedures for metallic materials.
- IS:814 Covered electrodes for manual metal arc welding of carbon and carbon manganese steel-specification.
- IS:816 Code of practice for use of metal arc welding for general construction in mild steel.
- IS:4353 Submerged arc welding of mild steel and low alloy steels recommendations.
- AWS D1.1. American Welding Society Structural Welding Steel.
- ASME Sec II – Part C Specifications for welding Rods, Electrodes and Filler Metals.

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.

Code Hierarchy: -

Order of preferences of codes shall be as follows:

1. IRS
2. IRC
3. IS
4. EURO/BS/AISC
5. Other references listed in section 2.

3. Materials of construction

Reinforced Concrete:

The cement used for RCC work in the sub structure & super structure will be OPC (Grade 43 and 53).

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. 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:

Table 1 Grade of RCC elements

Description	**Grade** ***[≥Min. grade as per cl. 6.1.2, table 5, IS 456:200]***	**Max. Size of Aggregate (mm) [Cl. 5.3.3 IS456:2000]**	**Type of Cement used in Design Mix.** ***[Cl. 5.1 IS456:2000]***
Raft foundation/ Combined Footing/Isolated foundation	M40/M35	20	OPC
Shear Walls & Columns	M80/M60/M40/M35	20	OPC
Retaining Wall	M35	20	OPC
Slab	M35/M40	20	OPC

- 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 MPa, a minimum elongation of 16% with a provision of UTS/YS ratio ≥1.10 and other specifications conforming to cl. 8.1, table 3 of IS: 1786 shall be adopted for 8mm to 32mm dia. bars.

Structural Steel:

- 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. Rectangular and square hollow section Yst 355/Yst 310 corresponding to IS 4923-2017.
- Deck sheet shall be TR-60/TR-80 of 1-1.2mm thick. With yield stress of E350 MPa with minimum 275 gsm galvanization of Corus/Jindal/TATA or any other make approved by zonal railways.

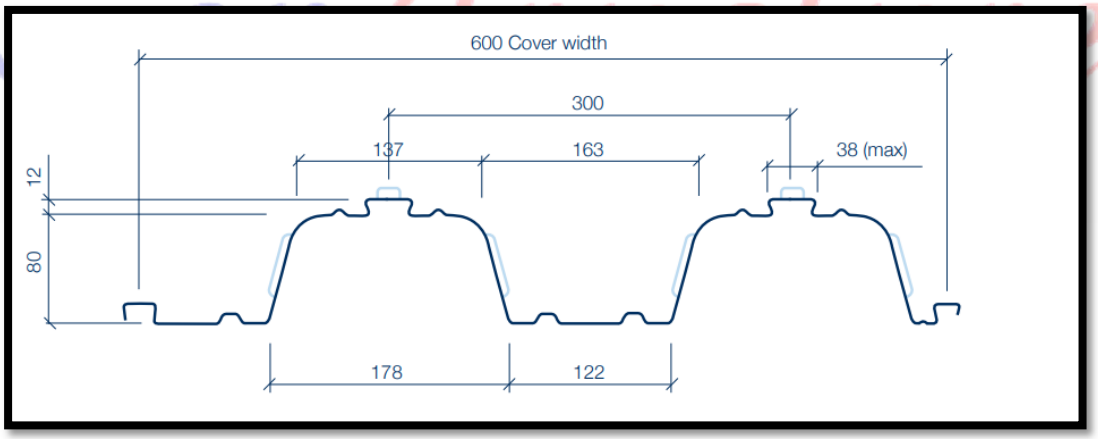

Fig. 3(a) Typical deck profile sheet (TR80)

- 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. as per RDSO report BS-115.
- Bolts of grade 8.8/10.9 as per IS: 4000 to be use. Anchor rods/bolts shall be E250 MPa conforming to IS standard.
- Welding technology & allowable stresses to be as per IS 16003 & IS 816. IS Codes and RDSO guidelines are based on AWS D.1.1. AWS D1.1 covers the requirement laid down in IS Codes and provide clarity with regards to compliance of the standards therefore same shall be followed for preparing Quality Assurance and Inspection and testing plan as approved by competent authority.

Flooring and Waterproofing

The flooring and waterproofing shall be provided as per specification, architectural DBR and approved by competent authority.

4. Loadings

Dead Loads:

Following unit weights of building materials have been considered in accordance with Cl. 2.1, table 1 IS: 875 (Part I) -1987:

Table 2 Unit weights of building materials

Description	Density of material
Reinforced cement concrete (up to 5% steel)	25 kN/m^3
Screed concrete floor	20 kN/m^3
Brick masonry including plaster (12mm plaster)	22 kN/m^3
Cement mortar / plaster	20 kN/m^3
Floor finish (stone/tile)	24 kN/m^3
Brick bat coba for terracing/waterproofing roof	20 kN/m^3
Glass	25.0 kN/m^3
AAC Block Masonry (As per IS 2185 part 3)	7.5 kN/m^3
Thermocol (density -25 kg/cum)	0.25 kN/m^3
TR-80(1.2 thk.) (Refer profile properties below)	0.148 kN/ m^2

Profile Properties

Nominal Thickness mm	Design Thickness (bare steel) mm	Weight of Profile kg/m²	Weight of Profile kN/m²
0.9	0.86	11.37	0.112
1.0	0.96	12.59	0.123
1.2	1.16	15.10	0.148

Fig. 3(b) Typical deck profile sheet (TR80) Properties reference: JSWSMD-STA-1004 V5 TR80]

Additional Dead Loads:

Following Loads have been considered in accordance with unit weights given in Cl. 2.1, table 1 of IS:875-(Part I) -1987:

Table 3 Flooring Dead Loads

LEVELS	LOAD TYPE	Loading(kN/m2)
Air Concourse		
Floor (125mm floor finish)	Floor Finish	3.0
Platform		
Floor (40mm floor finish)	Floor Finish	1.0
FOBs		

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LEVELS	LOAD TYPE	Loading(kN/m2)
Floor (62.5mm floor finish)	Floor Finish	1.5

Imposed Loads:

(a) Live loads:

Live loads considered in design are in accordance with table-1, IS:875(Part II)-1987 for Type-Assembly Buildings. (Live loads used are ≥ those mentioned in code)

Table 4 Live load

LEVELS	LOAD TYPE	LL(kN/m2)
Air Concourse		
	Typical floor	5
	Staircase	5
	Roof	0.75
Platform		
	Roof	0.75
FOBs		
	Floor	5

(b) Partition Loads:

Partition load of 3.0 kN/m^2 taken on all floors of Concourse. (Except staircase)

(c) Wall Load- AAC block masonry:

Considering plaster of 12mm on one face and 12mm on other face.

- 200mm.thk. Wall = (0.2mx1mx7.5kN/m^3)+((0.012m+0.012m)X1mx20kN/m^3)=1.98 kN/m-ht.
- 100mm.thk. Wall = (0.1mx1mx7.5kN/m^3)+((0.012m+0.012m)x1mx20kN/m^3)=1.25 kN/m-ht.

** Density of AAC 7.5 kN/m^3 and plaster as 20 kN/m^3 as given in table 2 Self weight.

Services Loads:

Services load of 1.0 kN/m^2 taken on all floors for concourse.

Collateral Loads:

Wherever applicable, following collateral loads are taken:

1. Solar Panel (or as per actual if higher)- 0.35kN/m^2

Wind Loads:

Wind loads have been worked out based on basic wind speed of 50 m/s, terrain of category-4 structure as per cl 4.2.2 NBC 2016 vol-1, part6, section1 (as per IS:875 (part-3) 2015, amended in 2020). Basic input data for the wind analysis assumed as follows:

Table 5 Wind parameters

	Wind Parameter
Basic Wind speed, Vb	50 m/s (as per cl 4.4.2)
Terrain category	3
Risk coefficient factor k1	1.08
Terrain, height & structure size factor k2	1.01 at 20m (Varies with height as per code)
Topography factor k3	1.0
Importance factor for cyclonic region k4	1.0

	Wind Parameter
Wind directionality factor Kd	0.9-As per clause 7.2.1
Area averaging factor Ka	Varies from 0.8 to 1 as per clause 7.2.2
Combination factor Kc	0.9-As per clause 7.3.3.13

Basic Wind speed upto 10m height is 47m/s as per cl 6.2 Annex-A, IS 875-part 3: 2015.

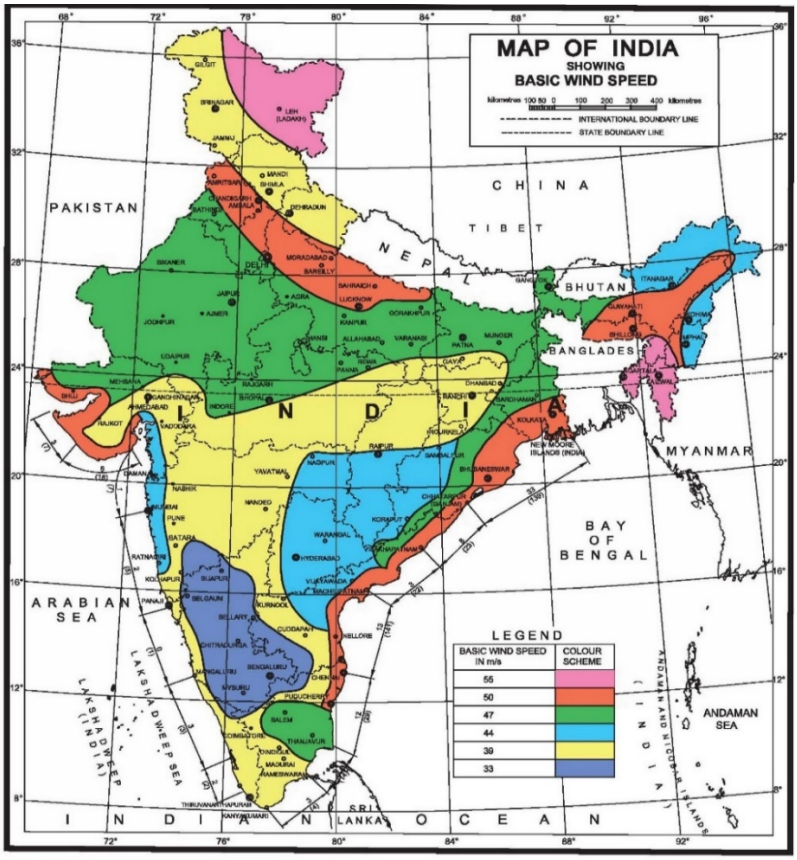
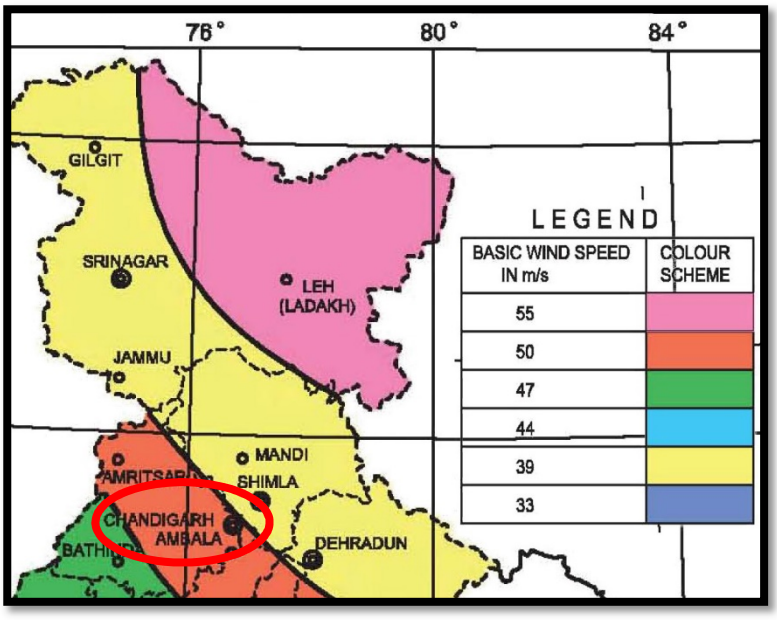


Fig. 4(b) Wind speed as per NBC 2016



4(c) 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-IV.

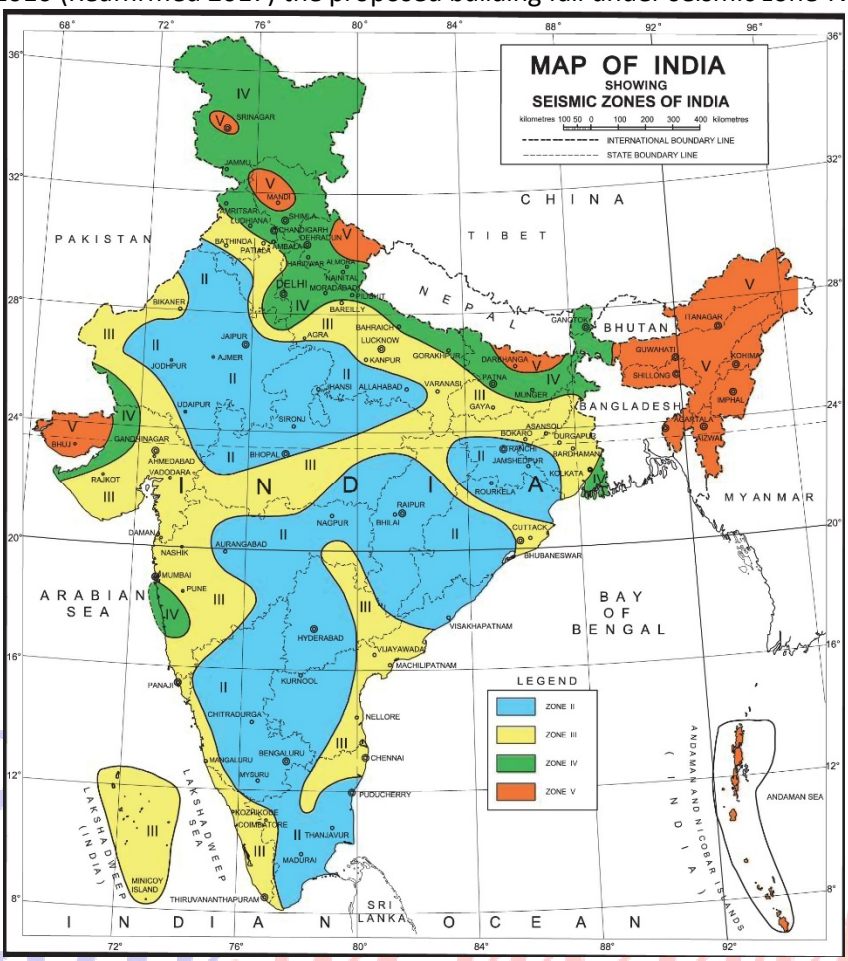

Fig. 5(a)

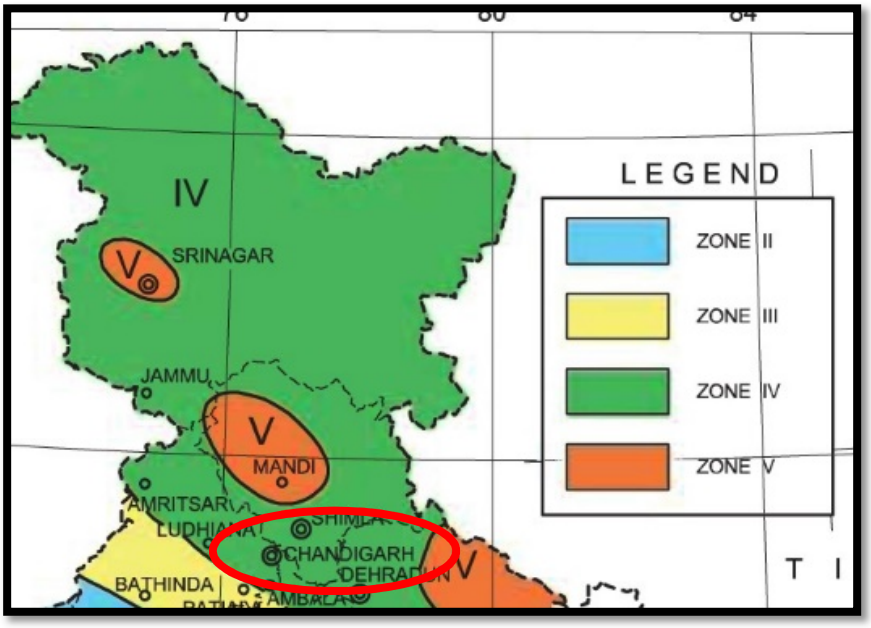

Fig. 5(b)

Fig. 5(a) & 5(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 1893:2016:

Table 6 Time period

Structure	Type	Height of structure h (m)	Time period calculation formula	Time period (s)
Air concourse	RC-Steel Composite MRF	20	$0.080h^{0.75}$	0.76
Through roof	Steel MRF	20	$0.085h^{0.75}$	0.80
	RC-Steel Composite MRF	20	$0.080h^{0.75}$	0.76
Cover on platform	Steel MRF	5	$0.085h^{0.75}$	0.28

Natural periods of the foot over bridges will be calculated based on the assumption that the structure behaves as an inverted pendulum in the transverse direction and a portal, fixed at the base of piers and pinned at the bearings, in the longitudinal direction.

Importance factor calculation

The importance factor for various structures under consideration in this report is derived based on table 8 (Clause 7.2.3) IS 1893:2016.

Table 7 Importance factor

Structure	Importance factor	Lateral load resisting system
Air concourse	1.5	Important service & community buildings or structures
Through roof	1.5	Important service & community buildings or structures
Cover on platform	1.5	Important service & community buildings or structures
Foot over bridges	1.5	Important service & community buildings or structures

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 3 of IRS Seismic code for Concourse & FOBs and with table 23 IS 800:2007 for through roof & cover over platforms:

Table 8 Response reduction factor

STRUCTURE	RESPONSE REDUCTION FACTOR	REMARKS
AIR CONCOURSE	2 for super structure 4 for shear walls, 2.5 for encased steel columns 2 for foundations	Response reduction factor taken as per table-3 of IRS Seismic Code. Lateral Load resisting system – Special Moment Resisting Frame
FOBs		
THROUGH ROOF	2	
COVER ON PLATFORMS	2	

According to note 1 of Table-9 of IS1893:2016, RC and steel structures in Seismic Zones III, IV and V shall be designed to be ductile and hence, OMRF (ordinary moment resisting frames) are not allowed in those seismic zones. Hence, care must be exercised in selecting the lateral load resisting system of the structure.

Design & Detailing for earthquake loads in steel structures is as per Sec-12, IS 800:2007.

Special Moment Resisting Frames (SMRF)

- Special moment frames shall be made of E450 steel of IS2062.
- In compliance with section 12.11.2.1 of IS 800:2007, all beam-to-column connections shall be rigid and designed to withstand a moment of at least 1.2 times the full plastic moment (M_p) of the connected beam.
- The connection shall withstand shear resulting from 1.2 DL + 0.5 LL plus the shear resulting from the application of 1.2 M_p in the same direction at each end of the beam. The shear strength need not exceed a value corresponding to load combinations: a) 1.2 DL + 0.5 LL ± 2.5 EL and b) 0.9 DL ± 2.5 EL (Clause 12.11.2.2 and 12.2.3 of IS 800:2007). (EL = Earthquake Load)
- As per clause 12.11.3, beam and column sections shall be either plastic or compact. • The sections selected for beams and columns shall satisfy the following relation:

$$\sum \frac{M_{pc}}{M_{pb}} \geq 1.2$$

Where ΣM_{pc} = sum of the moment capacity in the column above and below the beam centerline and ΣM_{pb} = sum of the moment capacity in the beams at the intersection of the beam and column centerlines.

- Fixed column bases and their anchor bolts should be designed to withstand a moment of 1.2 times the full plastic moment capacity of the column section
- Both fixed and hinged column bases shall be designed to withstand the higher of full shear under any load case or 1.2 times the shear capacity of the column section.

Soil Type

Types of soils are classified as Type I, Type II and Type III according to Clause 6.4.2.1 IS1893:2016. Type I, II and III soils refer to rock or hard soils, medium or stiff soils and soft soils respectively.

It is necessary to determine the type of soil on which the structure will be placed in order to determine the correct spectrum to be used for estimating Sa/g.

Based on the type of foundation and soil, the net bearing pressure in soils can be increased as per Table 1 and Table 2 of IS 1893:2016.

A Ground Type II is taken for this project. Annex C of IS 1893-Part 1: 2016 provides an indication of the range of geologies of India. Allowing for superficial weathered rocks and superficial deposits such as sedimentary rocks, which is shown to be extensive in northern India, Ground Type II has been assumed. This applies to medium stiff ground profiles. The ground is not susceptible to liquefaction or cyclic softening under the design earthquakes report considering properties of soil observed (High SPT Value / Silty Sand/ Silty Clay) during soil investigation.

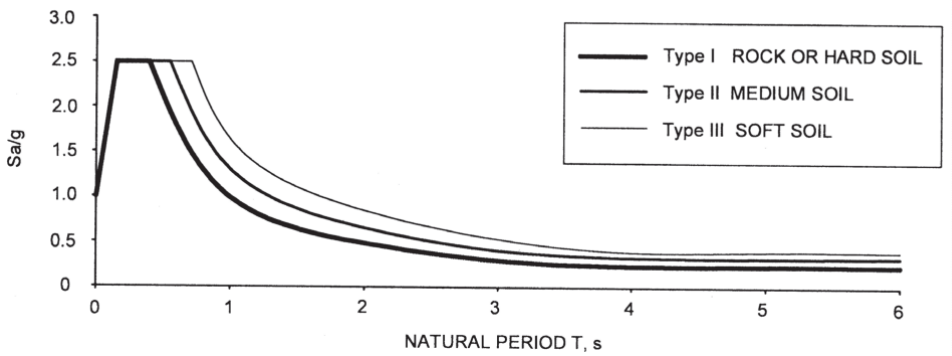

Fig. 6(a) Design acceleration coefficient (Sa/g) as per IS1893-part1: 2016

ANNEX C

(*Foreword*)

MAP OF INDIA SHOWING PRINCIPAL LITHOLOGICAL GROUPS

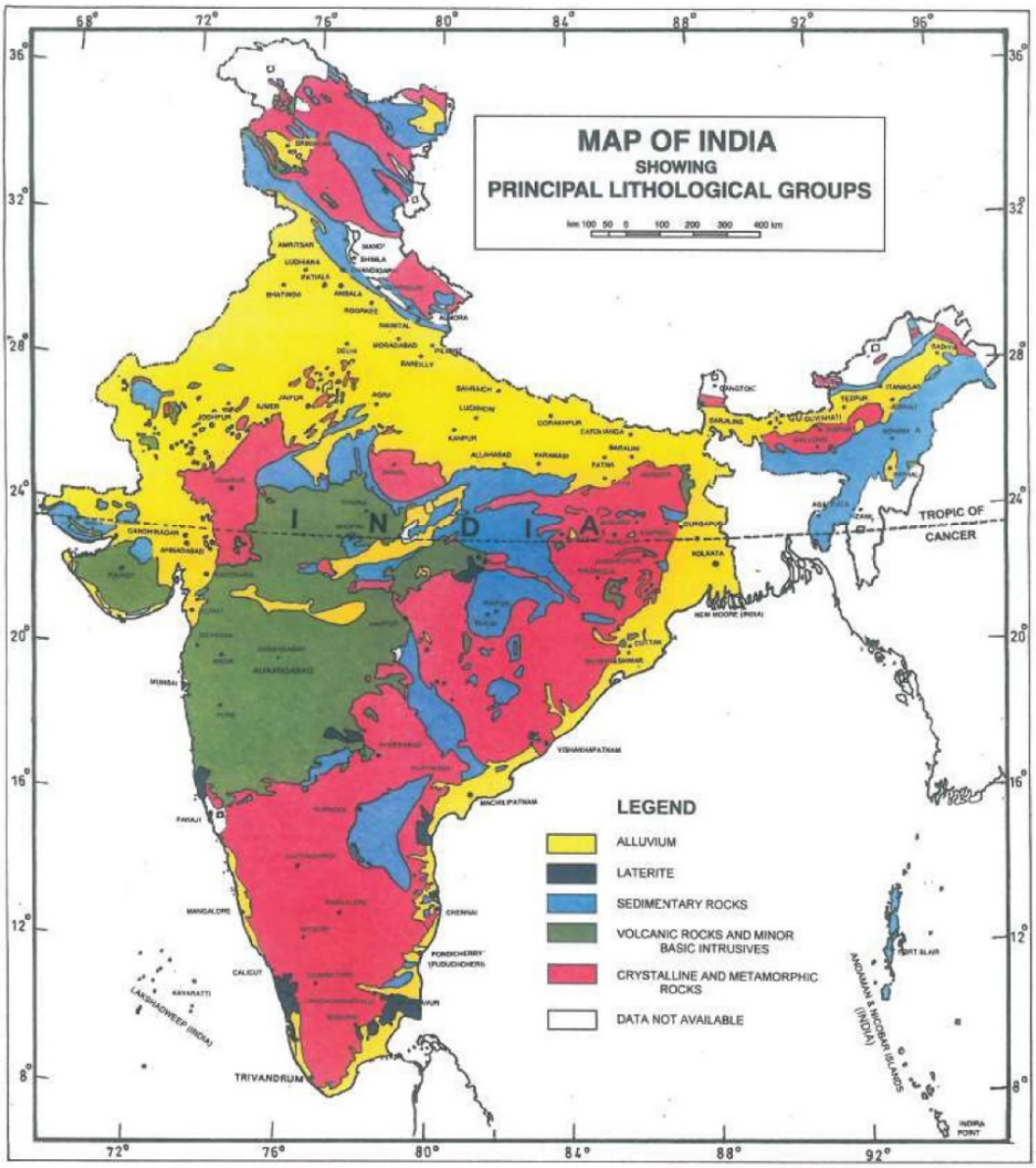

Fig. 7 Lithological groups as per ANNEX-C, IS 1893(part1):2016

Seismic Weight

Clause 7.3 of IS 1893 specifies to consider full dead load plus 50% of imposed load (5kN/m^2 asper IRS Bridge Rules) 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 air concourse, 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

As per clause 7.7.1 of IS1893-2016, except regular buildings lower than 15m in Seismic Zone II, the linear dynamic analysis shall be performed to obtain the design lateral force. Hence, the response spectrum method of dynamic analysis shall be employed for all such type of structures, including foot

over bridges.

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 depicted in Table 6 of this report.

Damping Ratio

According to clause 7.2.4 of IS1893:2016 and 5.4.2.5 of SP7 for concourse and FOB 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, when the structure is

(i) Located in seismic zone IV or V or
(ii) Having vertical or plan irregularities or
(iii) Rested on soft soil or
(iv) A bridge or
(v) Having long spans or
(vi) Having large horizontal overhangs of structural members or subsystems

The effects due to vertical earthquake shaking shall be considered. Therefore, due to the length of span vertical effects shall be considered for both the Zone II and Zone IV case.

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

$$A_v = \frac{(\frac{2}{3})(\frac{Z}{2})(2.5)}{(\frac{R}{I})}$$ clause 6.4.6 of IS 1893: 2016 and Clause 9.4.1 of IS 1893 Part-3: 2014

With reference to Table 5 (v) of IS 1893, buildings undergo complex earthquake behaviors and hence damage, when they do not have lateral force resisting systems oriented along two plan directions that are orthogonal to each other. Hence, in compliance with clause 6.3.2.2 and 6.3.4.1 of IS: 1893:2016, such building systems shall be designed for earthquake load combinations listed below.

Seismic vibration in the longitudinal, transverse and vertical directions shall be combined following the rule:

r1 ± 0.3r2 ± 0.3r3 (IS1893:2016 cl. 6.3.4.1, IRC: SP: 114-2018, cl.4.2.2 & Cl. 7.2.1 of IRS Seismic bridge code for FOB and concourse)

where r1 is the leading seismic direction and r2, r3 are the remaining seismic directions.

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.

Max. Temp = 45 º C
Min Temp = 5 º C
Average Humidity: Varying from 25% to 75%

Derailment Loads:

Derailment loads are applied for tracked bridges. Air concourse and FOB do not fall under this category.

Fatigue Loads:

Fatigue loads are applied for moving train/vehicle live load which generate fatigue. Whereas

Concourse and FOBs have a category of pedestrian live load (as specified by IRS Concrete Bridge code) hence not considered.

Accidental Loads:

As per cl. 2.16.4.3.1 of IRS Bridge Rules, our structure is considered as not vulnerable for accidental loads.

5. Method of Design

Design Methodology:

The design of Composite Columns and beam is being done using IS 11384-2022 or IRC-22 or AISC:360-2016 while considering RDSO reports BS 115/BS 130 and RCC element as per IS 456-2000 and SP-16. Limit state method is being followed as per IS 800-2007 for design of steel structures and connection designs.

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.

- 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 IS 11384-2022 or IRC-22 or BS-130 or AISC:360-2016
- Limit state method is being followed as per IS 800-2007 for design of steel structures.

LOAD COMBINATIONS:

Serviceability load combinations and Ultimate load combinations used for analysis and design as per table 12 of IRS Concrete bridge code and IRS Seismic code.
All dead, imposed, wind loads are calculated and applied as per IS 875 (part 1,2&3).

Serviceability load combinations and Ultimate load combinations used for analysis and design are follows:

In lieu of combination 2 of Clause 11.0 of IRS Concrete Bridge Code, following load combinations shall be used as per IRS Seismic code:

(A) Ultimate limit state design

1) 1.25DL + 1.5 DL(S) +1.5EQ + 1.4 PS+ 1.7 EP
2) 1.25DL + 1.5DL(S) + 0.5(LL + LL (F)) + 1.2EQ + 1.7 EP + 1.4PS + 1. 4HY + 1.4BO
3) 0.9DL + 0.8DL(S) + 1.5EQ + 1.4 PS + 1.7 EP

(B) Serviceability Limit State

1) 1.0 DL+1.2 DL(S) +1.0 EQ + 1.0 EP + 1.0PS + 1.0HY+ 1.0BO
2) 1.0 DL + 1.2 DL(S) + 0.5(LL+LL(F)) + 1.0EQ + 1.0 EP + 1.0PS + 1.0HY + 1.0 BY

The symbols used in above equation are explained as below:

DL = dead load,
DL(S) = superimposed dead load,
LL = Full live load (without any reduction)
The live load (LL) includes impact effect, longitudinal forces (tractive and braking), and centrifugal force.
LL (F) = live load on footpath,
EQ = earthquake load,

EP = earth pressure,
ER = erection load such as cranes, machines etc.
PS = prestressing load,
HY = hydrodynamic load,
BO = buoyancy load,
SH = shrinkage load,
CR = creep load,
TE = temperature load.

Table 9: Load Combinations

TABLE 12

LOADS TO BE TAKEN IN EACH COMBINATION WITH APPROPRIATE Y_{fL}
(Clauses 11.2 and 11.3)

LOAD		LIMIT STATE	Y_{fL} TO BE CONSIDERED IN COMBINATION				
			1	2	3	4	5
Dead weight of concrete		ULS SLS	1.25 1.00	1.25 1.00	1.25 1.00	1.25 1.00	1.25 1.00
Superimposed dead load		ULS SLS	2.00 1.20	2.00 1.20	2.00 1.20	2.00 1.20	2.00 1.00
Wind	During erection	ULS SLS	- -	1.25 1.00	- -	- -	- -
	with dead and superimposed dead loads only and for members primarily resisting wind loads.	ULS SLS	- -	1.60 1.00	- -	- -	- -
	With dead plus superimposed dead plus other appropriate combination 2 loads.	ULS SLS	- -	1.25 1.00	- -	- -	- -
	Relieving effect of wind	ULS SLS	- -	1.00 1.00	- -	- -	- -
Earth quake	During erection	ULS SLS	- -	1.25 1.00	- -	- -	- -
	With dead and superimposed dead loads only	ULS SLS	- -	1.60 1.00	- -	- -	- -
	With dead plus superimposed dead plus other appropriate combination 2 loads.	ULS SLS	- -	1.25 1.00	- -	- -	- -
Temperature	Restraint against movement except frictional	ULS SLS	- -	- -	1.50 1.00	- -	- -
	Frictional restraint	ULS SLS	- -	- -	- -	1.50 1.00	- -
	Differential temperature effect	ULS SLS	- -	- -	1.15 0.80	- -	- -
Differential settlement		ULS SLS	As specified by engineer				
Earth Pressure	Fill retained and or live load surcharge	ULS SLS	1.70 1.00	1.70 1.00	1.70 1.00	1.70 1.00	- -
	relieving effect	ULS	1.00	1.00	1.00	1.00	-
Erection temporary loads (when being considered)		ULS	-	1.30	1.30	-	-
Live load on foot path		ULS SLS	1.50 1.00	1.25 1.00	1.25 1.00	- -	- -
Live load		ULS SLS	1.75 1.10	1.40 1.00	1.40 1.00	- -	- -

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 will be used as specified in the relevant codes.
- Serviceability loads combinations with suitable live load reduction factor as per IS: 875 (Part-2) will be used for foundation design.
- For construction stage loading, 1 DL + LL of 100kg/m^2 to be considered.

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 Software and design of isolated footing, retaining wall base to be prepared in excel sheet and provided in pdf format. The foundation has been designed by considering max allowable net bearing pressure (q_a net) of 12.5T/sq. m at 2 m depth for Panchkula side building & max allowable net bearing pressure(q_a net) of 23.6T/sq. m at 3 m depth for Chandigarh side building as per latest soil investigation report (Report no.: P9202233901 from Chandigarh Test House). As per soil investigation report maximum allowed settlement is 75mm for raft and 50 mm for Isolated footing and Code (IS 1904) Table 1 is also taken in consideration for differential settlement.

Based on calculated safe bearing capacity in accordance with IS codes, Isolated/combined footing may be used for Air concourse, Through roof, COPs and FOBs.

- For underground/Water tanks type of structure suitable raft system will be adopted.
- For the lift core areas based on lift pit depth requirements the foundation may go deeper.
- For Machine foundations (if any such as for DG sets/Pumps etc.) Block foundation design shall be done as per codal recommendations.

Pile foundation is considered at locations where working space is limited. To address difference in settlement characteristics of deep and shallow footings, necessary pour strip or other arrangements shall be provided.

****Soil report attached in Annexure B**

Design of composite element:

Composite Beam & 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 design methodology is well adapted in ETABS software modelling and the resulting sections are safe and practical. Composite column design shall be done as per IS 11384 2022 or IRC:22 or AISC:360-2016 considering RDSO reports BS 115/ BS 130. Calculations shall be submitted in pdf format as report generated by the software.

The construction methodology is execution friendly as well as time saving since structural steel columns up to 4 floors or 15 meters can be erected & tied with floor structural beams. Decking work can be taken up on these floors. The sufficiency of structural steel column alone is checked for the loading of upto four levels (upto 15 meters). Subsequently, floor wise, the reinforcement is put in position & columns RCC executed to get 'composite action'. 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 or 15 meters at a time).

Secondary and Primary beam design shall be as per IS: 11384 2022 or IRC:22 or AISC:360-2016 considering RDSO reports BS 115/BS 130. Connection shall be designed for required capacity as per relevant codes.

tability:

Stability of structure against overturning and sliding as per Clause 20.0 of IS: 456-2000 and cl. 17 of IS 1904 and IRS Substructure and Foundation code is followed in the design and listed as below:

- Factor of safety against overturning:
  Restoring moment to be at least 2 times the maximum overturning moment due to the characteristic dead load and 1.5 times the maximum overturning moment due to the characteristic imposed loads.
- Factor of safety against sliding: 1.5
  In both the above cases, 0.9 times of characteristic dead load only to be considered in the design.

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Serviceability Requirement:

This is given with following limitations:

- For Vertical deflections (Total load deflections) =Span/250 for Serviceability.
- Span/350 for material susceptible to breaking OR 20mm, whichever is less.
- Lateral sway of Structure=Height/ 500.
- Drift shall not exceed 0.4% of story height.
- For Cracking- For all RCC elements shall be cracked section and limiting crack width to 0.2 mm.

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:

- **Walking vibrations:**

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 $\frac{a0}{g} = 0.005$.

Running vibration to be limited up to 2.4 Hz and ascending/descending vibrations on stairs to be between 1.2-4.5 Hz (as per ISO 2631-2).

IS 800-2007 recommends referring specialist literature for walking vibrations. Walking vibration check is inbuilt in *ETABS* software being used for analysis and design. The results from ETABS shall be adopted for design consideration for walking vibrations.

- **Vibrations due to train movement:**

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, Vibration report from specialized vibration consultant appointed EPC contractor attached in Annexure-C.

Property Modifier Used in *ETABS*:

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.

Table 10 Property modifiers used

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

Where,

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

6. Analysis methodology and software used

The structures shall be analyzed as composite steel structure using *ETABS* software for considering the

relevant Indian Standard Codes. Applicable Dead, Live, Wind and Seismic Loads along with appropriate load combinations have been considered. Software like *ETABS*, STAAD, and SAFE shall be used for analysis and design. All secondary composite steel beam connections to main beams are simple connection and primary beam and cantilever to columns are considered as moment connection.

The floor comprise of RCC slabs over deck sheet, which is supported over structural beams (plate girders) in a composite manner. A 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 for verification of results.

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.

Design Philosophy for Thermal & Shrinkage effects:

- 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 2 months of adjacent side castings completion.
- Long term shrinkage effects are suitably considered by taking 5 degree variation in the *ETABS* model analysis.

Weld technology & allowable stresses:

Welding technology & allowable stresses to be as per IS 16003 and IS 816. Indian codes and RDSO guidelines are based AWS D1.1. AWS D1.1 covers the requirement laid down in IS Codes and provide clarity with regards to compliance of the standards therefore same is followed for preparing Quality Assurance and Inspection and testing plan as approved by competent authority.

7. Concrete Cover

Nominal concrete clear cover to all reinforcement Including Links (as per clause26.4 of IS: 456-2000) considering environment exposure condition is moderate & fire resistance of 2 hrs.

Table 11 Concrete Cover

Structural Element	Face	Nominal Cover
Foundation	All sides	50 mm
Column	All sides	40 mm
Shear Wall	All sides	30 mm
Beams	For Continuous For Simply Supported	30 mm 40 mm

Structural Element	Face	Nominal Cover
Slabs	Continuous floor Simply supported floor	25 mm 35 mm
Retaining wall	Earth side Inside Water Side (Water Tank) STP wall Liquid face	30 mm 30 mm 30 mm 40 mm
Deck Slab	Top side Bottom side	30 mm 50 mm

8. 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.

9. Façade Cleaning System

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

10. Structural Maintenance

Periodical inspection of the structure should be done to identify repair work and take necessary action accordingly. Maintenance should be done in accordance with IRS Bridge manual. Some of the common maintenance works have been listed below:
For Structural Steel:

1. Paintwork:

- Periodical through paint: The entire steel work should be painted at regular intervals which vary from six years in arid zones to one year in highly corrosive areas. The Chief Engineer shall prescribe the periodicity of painting.
- Patch Paint: When small area of paint shows pronounced deterioration, which requires immediate remedy, it is not desirable to wait for the girder or the member as a whole becoming due for periodic painting. The affected areas must be patch painted.
- Paint schedule & methodology to be followed as per IRS Bridge Manual.

2. Bolts:

- Loose bolts should be identified and fixed.
- If a bolt is found to be cracked, cause of crack should be identified and bolt should be replaced immediately.
- For HSFG bolts, painting schedules and methodologies to be followed as specified in IRS bridge manual for the girder as a whole.

3. For RCC:

1. The areas around bearings shall be kept free of ballast, debris dust, oil / grease etc.
2. Drainage system shall be thoroughly cleaned and repaired as necessary before the onset of monsoon.
3. Protective surface coat, where provided, shall be maintained.
4. Superstructure and bearings shall be maintained as per the design requirements and any deficiencies/defects noticed during inspection shall be attended to.

11. 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(2) 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 proofing coating shall be Cement Spray based or as per architectural requirements.
- Low density Cement based compound conforming to UL263 or BS 476 Pt 20/21 or Warrington-LPCB may be used 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 4-hour fire rating.

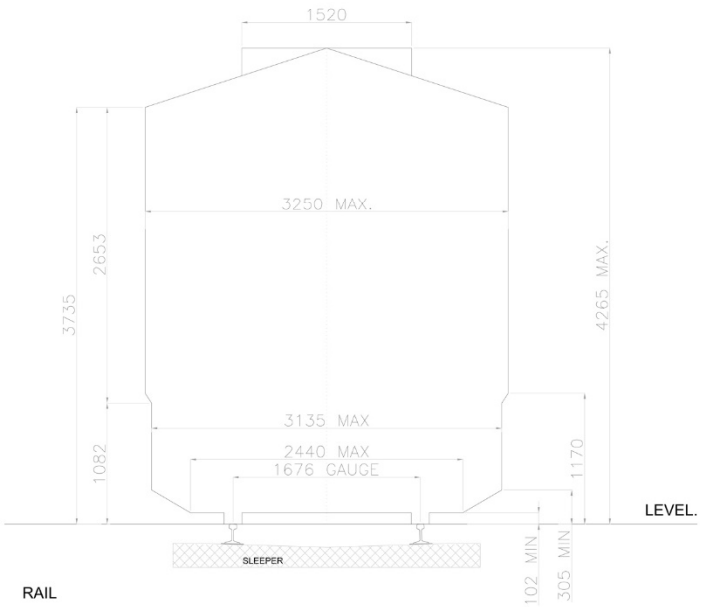
ANNEXURE-A

(SOD)

MAXIMUM MOVING DIMENSIONS (SOD)

DIAGRAM NO:- 1D (EDO/T-2202)1676MM GAUGE OF SOD, REVISED , 2004

MAXIMUM MOVING DIMENSIONS.



NOTE:- ALL DIMENSIONS ARE IN MILLIMETRES.
EXCEPT WHERE OTHERWISE SHOWN.

DIMENSIONS OF IR / BG STOCK

DIMENSIONS	ICF / RCF			LHB	EMU	
	STD COACH	D.DECK	LONG COACH		MOTOR COACH	TRAILER COACH
GAUGE	1676	1676	1676	1676	1676	1676
LENGTH OVER BUFFERS	22297	22297	24125	24000	----	----
LENGTH OVER BODY	21337	21337	23165	23540	20726	20726
COACH WIDTH	3250	3050	3250/3100	3240	3660	3660
HEIGHT OF COACH BODY	3111	3360/4055	3111	2941	2895	2895
WHEEL-BASE	2896	2896	3200	2560	2896	2896
DISTANCE BETWEEN BOGIE CENTERS	14783	14783	15543	14900	14630	14630
DISTANCE BETWEEN SIDE BUFFERS	1956	1956	1955	----	----	----
HEIGHT OF BUFFER/ CBC FROM RL.	1105	1105	1105	----	1035	1035

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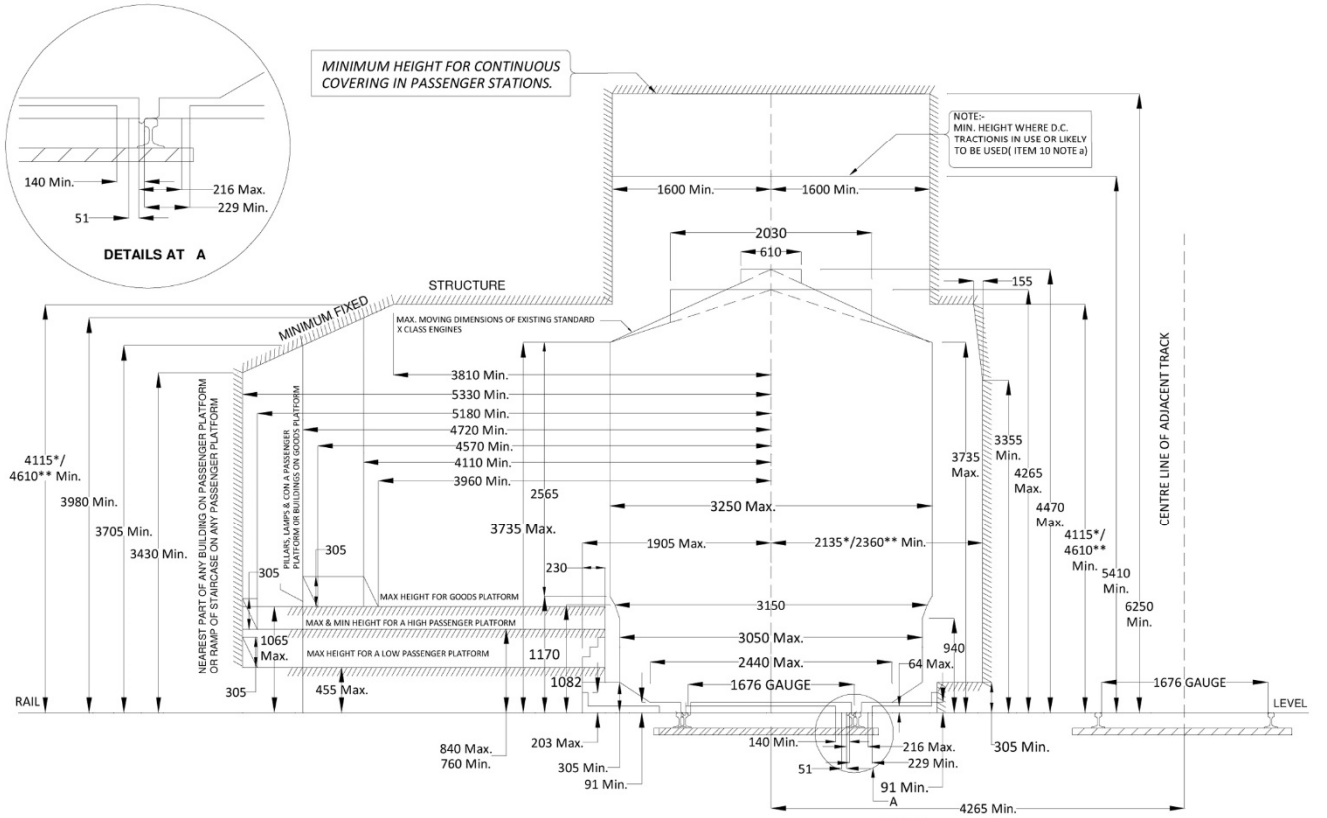
DIAGRAM NO. 2
1676 mm GAUGE

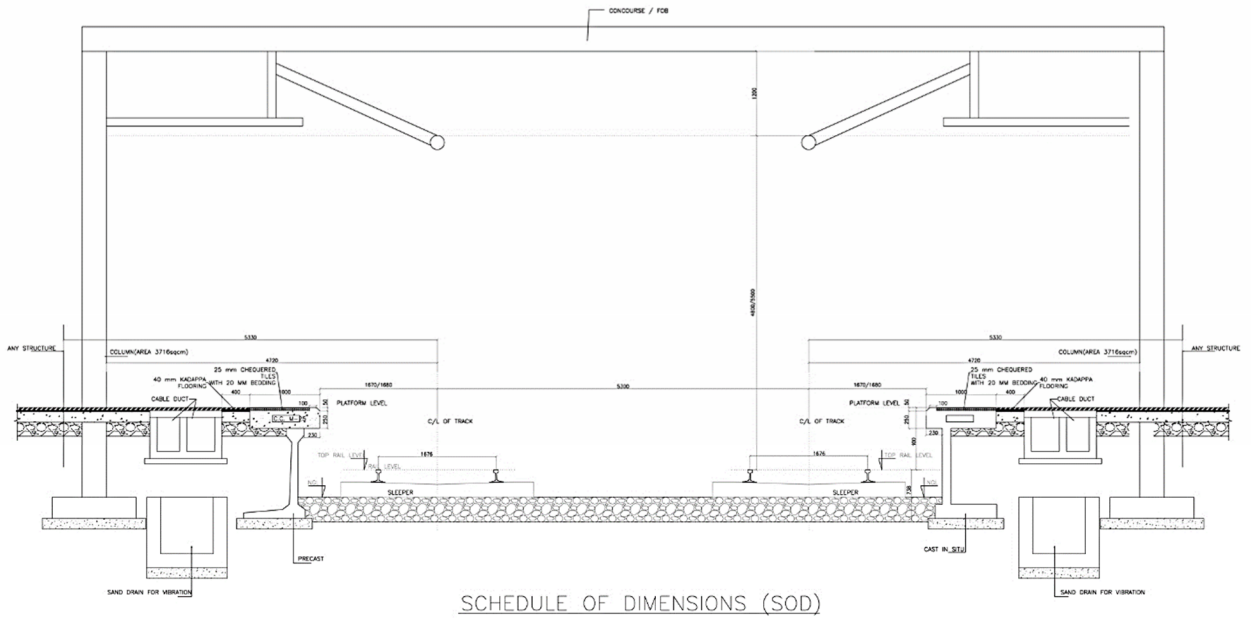
STANDARD DIMENSIONS IN STATIONS
TO SUIT 25 kV.A.C. TRACTION SCHEDULE I-CHAPTER II

NOTE:- THE DISTANCES SPECIFIED, APPLY ONLY IN CASE OF STRAIGHT TRACK. ON CURVES, THE HORIZONTAL DISTANCE SHOULD BE INCREASED BY AN AMOUNT 'D' TO ALLOW FOR THE LEAN DUE TO SUPER-ELEVATION CALCULATED BY THE FOLLOWING FORMULA, WHERE 'H' IS THE HEIGHT OF THE CONTACT WIRE, 'S' THE SUPERELEVATION AND 'G' THE GAUG OF THE TRACK, ALL DIMENSIONS BEING IN METRES $D = \frac{H \times S}{G}$



NOTE:- ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE OTHERWISE SHOWN.

NOTE:-
* - *For existing works*
** - *For new works or alteration to existing works*



SCHEDULE OF DIMENSIONS (SOD)

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Date: 2023.12.14 16:11:53 +05'30'

ANNEXURE-B

(Soil Report)

ANNEXURE-C

(Vibration DBR/ Vibration Report)

ANNEXURE-D

(Climatic data of Chandigarh)

ANNEXURE-E

(Technical Data Sheet for Deck Sheet)