

STRUCTURAL DESIGN BASIS REPORT

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1. FOREWORD

The intent of this document is to identify and record all the pertinent input requirements, analysis & design criteria for structural design of the buildings & other ancillary infrastructures. It is aimed at formulating the basis of the structural analysis, design & detailing the structural scheme of the building which will be compatible with the architectural themes, satisfying the functional needs, at the same time confirming to the Indian Standards and other applicable building norms to ensure that the structure remains safe, durable and fully operational to support heavy fire training loads and extreme thermal exposures.

This report covers the minimum design requirement to establish the unified design basis that will form the overall design philosophy to be adopted in the structural design of the proposed building.

The design shall aim to achieve

- Structural and functional integrity of overall structure of the proposed buildings.
- Desirable Structural performance under characteristic service design loadings.
- Resistance to load due to natural phenomena i.e. wind and earthquakes.
- Structural durability and maintainability of the building.

The various components of the projects shall be as mentioned in the Architectural detailed reports/drawings. The indicative summary of the different components of the projects are as given below:-

S.No.	Name of work	No. of Storyes
1	FIRE STATION CUM TRAINING & CLASSROOM	G+1
2	INDUSTRIAL TRAINING TOWER	G+2
3	RESCUE TOWER.	G+5
4	CHANGE ROOM & VISITOR GALLERY.	Ground Floor only
5	B.A TRAINING GALLERY.	Ground Floor only
6	SIMULATION BUILDING.	G+3

It is the sole responsibility of the contractor to get the entire structural design and drawings vetted by any IIT/NIT with their Signature, Seal and forwarding letter. It is to be noted that vetted drawings duly Signed but without Seal and forwarding letter shall be treated as invalid. The vetted design and drawings shall be submitted by the contractor to the concerned Executive Engineer for further approval from the Cheif Engineer of the Bihar Police Building Construction Corporation. All structural models and analysis with soft copies of all drawings in **Pendrive** shall be submitted to Executive Engineer. Whenever required, the structural consultant of EPC contractor shall have to visit the head office of Bihar Police Building Construction Corporation for necessary discussion.

2. DESIGN PHILOSOPHY

The proposed “**Construction of Fire station cum Training & Classroom, Industrial Training Tower, Rescue Tower, Change room & Visitor Gallery, B.A. Training Gallery and Simulation Building for Fire Training Institute at Bihta and other infrastructure including Parade Ground and Fire Hydrant facilities in the state of Bihar.**” consists of SMRF RCC column- beam framed structure. In accordance with IS 1893 Part I : 2016, the seismic weight of the structure shall be calculated to determine the lateral inertia forces generated during an earthquake. The Total seismic weight of the building shall be computed as the sum of the seismic weight of all individual floors.

3-D Analysis of all the building structures will be carried out using STAAD.PRO/ETABS/SAP and analysis results shall be used for designing the various element. All designs shall strictly conform to the various IS - Standards.

Internal surface of Wall, Column, Beam and Slab of Live fire testing and training facility, high temperature material testing and simulation, material storage room shall be finished with refractory brick with adhesive. Adhesive applied need to be fire proofed for 2 hrs and proper quality check of refractory brick and adhesive to tbe done by the EPC contractor and to tbe

approved by the Engineer in Charge. Extra load to be considered for the fire testing equipment and RCC structure to be designed to withstand the load of fire for 4 hrs.

Proper soil investigation including liquefaction analysis should be done very precisely. If soil is found liquefiable, proper mitigation of liquefaction should be done and test should be carried out post-mitigation of the treatment. It is the responsibility of the EPC contractor to get the post mitigation test results vetted by any IIT/NIT and shall submit it to concerned the Executive Engineer for getting approval from Chief Engineer of the corporation.

Fire training centre required massive underground or overhead watertank for drills. If there are overhead or staging watertank, 100% water weight shall be added to the seismic weight of that specific level. Any Heavy permanently fixed Steel fire apparatus/ Simulators or smoke trainers shall be counted at 100% of their dead weight.

3. MATERIALS

The self-weight of the various elements is computed based on the unit weight of materials as given below: -

Materials	Unit weight (kN/m³)
Steel	78.50
Plain Cement Concrete	24.00
Reinforced Cement Concrete	25.00
Cement Concrete Solid Block work	20.00
Cement Concrete Aerated Block work	10.00
Soil	20.00
Water	10.00
Aluminium	28.00
Glass	25.00
Density of finishes	20.00
Cement Concrete screed	24.00

3.1 Concrete

Concrete item	Grade(minimum)	Max. size of Aggregate (mm)
Foundation	M30	20
Column	M30	20
Beams	M25	20
Slab	M25	20
Staircase	M25	20
Other RCC Member	M25	20

Grade of concrete shall be as per approved design, suitable chemical admixture shall be used. Foam concrete wherever required shall be provided.

All the mix proportioning shall be as per guidelines given in IS 10262:2019 and the same shall be carried out by any IIT/ NIT.

3.2 Reinforcement

Steel reinforcement shall be of Grade Fe 500 conforming to IS: 1786-1985.

Reinforcement bars shall be high strength deformed steel bars produced by thermomechanical treatment process of grade Fe500, conforming requirement of IS 1786 (2008) and IS 9077-1979 of recent edition. Reinforcement binding should be done with galvanized iron binding wire thickness and material specification should as per necessary IS Code. Routine testing of reinforcement as per IS 1786 (latest revision) and binding wire should be done as per necessary clause laid in IS Code 2 and Standard specification.

3.3 Structural Steel

All structural steel used shall be confirmed to IS 2062. As per table 2 of IS 2026 (latest revision) steel grade E350 is used in design calculation of all members sizes with following properties.

Unit mass	7850 kg/m ³
E	200000 N/mm ²

Ultimate tensile strength	570N/mm ²
Yeild stress	450N/mm ² for thickness less than 20 mm
Percentage Elongation	20% (minimum)
Charpy V-notch energy	E>20J at RT

4. LOADING PARAMETERS

4.1 Imposed dead loads

Apart from the superimposed live load, other dead due to stationary building elements are also mentioned hereunder, which arise due to walls, floor finishes, services, false ceilings, filling in sunken areas etc.

The imposed loads that are envisaged to act permanently (wherever applicable) are as following:

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Items	Intensity in kN/m ² of plan area
Weatherproof course & thermal insulation	4.0 or Depends on the thickness; slope and kind of material to be used for Weather proofing.
Floor Screed**25thk	0.5
Floor finish***	1.5
Sunken portion in toilet with brick Jelly concrete (200 thick)/Foamed Concrete	4.0

Above imposed load may be raised as per Architectural and Structural requirements.

In toilet area the actual partition loads shall be calculated and maximum value considered.

- ** Floor screed of 25 mm thick shall be considered for the entire floor except roof.
- *** Floor finishes Load due to tile and bedding mortar.

4.2 Imposed Live loads

The superimposed load or otherwise live load assessed based on the occupancy classifications as per IS: 875 (Part 2 latest revision) – shall be followed.

The concentrated loads are considered to be applied in position, which produce maximum stresses and where deflection is the main criteria.

4.3 Wind / Seismic loads

The impact of these loads has to be considered on structural design. The wind pressure shall be calculated on the provisions laid in IS: 875 (Part 3) – 2015.

Design wind speed

$$V_Z = V_b \cdot k_1 \cdot k_2 \cdot k_3$$

$$V_b \longrightarrow \text{Basic wind speed for Patna} = 47 \text{ m/s}$$

$$k_1 \quad \text{Risk coefficient for all general buildings} = 1.0$$

(For a design life of 50 years)

$$k_2 \quad \text{Terrain category 2} = 1.0$$

$$k_3 \longrightarrow \text{Topography factor} = 1.0$$

\longrightarrow

$$V_Z = V_b \cdot k_1 \cdot k_2 \cdot k_3$$

Based on the above, Design Wind Speed

Design wind pressure

$$P_z = 0.6 \times V_z^2$$

Further to Design Wind Pressure (PZ) appropriate pressure coefficient will be used as applicable.

Wind loads on cladding/glazing:

For designing the cladding / glazing supports, the wind load will govern the design, for which Local wind intensity as per IS 875 (Part 3) will be considered.

The loading due to earthquake is assessed based on the provisions of IS: 1893-2016 (P1) and IS 16700:2017.

The seismic load calculations will be carried out in accordance with IS: 1893:2016.

RCC Detailing shall be carried out as per IS 13920: 2016.

The design horizontal seismic co-efficient (Ah) shall be determined by the following method.

$$A_h = Z/2 \times I/R \times S_a/g$$

Where,

Z	Zone Factor for (Zone V)	0.36
I	Importance Factor	1.5
R	Response Reduction Factor (SMRF)	5.0

Medium soil will be considered as per soil report and Damping 5%.

Analysis should be done as per IS 1893 2016 and detailing should be done as per IS 13920 2016.

5.0 LOAD COMBINATIONS

The various load shall be combined in according with the stipulations in IS: 875 (Part 5) – 1987. Whichever combination produces the most unfavourable effect in the building, foundation or structural member concerned shall be adopted.

Following load combinations of the member forces will be considered for arriving at the design forces.

The following abbreviations are used in specifying different load combinations:

DLF = Dead Load of floors

DLW = Dead Load of walls

DL = Dead Load (sum of DLF and DLW)

LL = 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

Where, X and Z are two principal axes.

1. DLF
2. DLW
3. DLF + DLW
4. LL
5. EQX
6. EQZ
7. WLX
8. WLZ
9. DL + LL
10. 1.5 (DL + LL)

11. $1.5(DL+EQX)$
12. $1.5(DL-EQX)$
13. $1.5(DL+EQZ)$
14. $1.5(DL-EQZ)$
15. $0.9DL+1.5EQX$
16. $0.9DL-1.5EQX$
17. $0.9DL+1.5EQZ$
18. $0.9DL-1.5EQZ$
19. $1.2(DL+LL+EQX)$
20. $1.2(DL+LL-EQX)$
21. $1.2(DL+LL+EQZ)$
22. $1.2(DL+LL-EQZ)$
23. $1.5(DL+WLX)$
24. $1.5(DL-WLX)$
25. $1.5 (DL +WLZ)$
26. $1.5 (DL -WLZ)$
27. $0.9DL+1.5WLX$
28. $0.9DL-1.5WLX$
29. $0.9DL+1.5WLZ$
30. $0.9DL-1.5WLZ$
31. $1.2(DL+LL+ WLX)$
32. $1.2(DL+LL- WLX)$
33. $1.2(DL+LL+ WLZ)$
34. $1.2(DL+LL- WLZ)$

For non-orthogonal Columns, the following additional load combinations shall be used in the design.

$$35. 1.2(DL+LL+EQX+ 0.3EQZ)$$

$$36.1.2(DL+LL - EQX- 0.3EQZ)$$

$$37.1.2(DL+LL+EQZ+ 0.3EQX)$$

$$38.1.2(DL+LL - EQZ-0.3EQX)$$

$$39. 1.5(DL+EQX+0.3EQZ)$$

$$40.1.5(DL+EQX-0.3EQZ)$$

$$41.1.5(DL - EQX+0.3EQZ)$$

$$42.1.5(DL - EQX-0.3EQZ)$$

$$43.1.5(DL+EQZ+0.3EQX)$$

$$44.1.5(DL+EQZ-0.3EQX)$$

$$45.1.5(DL - EQZ+0.3EQX)$$

$$46.1.5(DL - EQZ-0.3EQX)$$

$$47.0.9DL+1.5(+EQX+0.3EQZ)$$

$$48.0.9DL+1.5(+EQX-0.3EQZ)$$

$$49.0.9DL+1.5(-EQX+0.3EQZ)$$

$$50.0.9DL+1.5(-EQX-0.3EQZ)$$

$$51.0.9DL+1.5(+EQZ+0.3EQX)$$

$$52.0.9DL+1.5(+EQZ-0.3EQX)$$

$$53.0.9DL+1.5(-EQZ+0.3EQX)$$

$$54. 0.9DL+1.5(-EQZ-0.3EQX)$$

6.0 NOMINAL COVER FOR REINFORCEMENT

From Durability requirement, exposure condition is assumed as ‘**Moderate**’ for Structural elements below ground floor level.

The nominal cover to reinforcement to meet Durability requirement shall be as followed: -

Moderate	-	30 mm
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The nominal cover to main reinforcement shall be as followed: -

Column

40 mm or dia of longitudinal Reinforcement
whichever is greater.

Raft foundation - 75mm

For Two-hour fire resistance requirement, the nominal cover to reinforcement shall be as followed: -

Slab - 35 mm for simply supported

25 mm for continuous

Beams - 40 mm for simply supported

30 mm for continuous

For any other element not specified above, clear cover shall be as per the clause 26.4 of IS:456-2016.

7.0 PROPOSED APPROACH OF STRUCTURAL ANALYSIS

The building is a R.C.C. Beam, Slab and column structure. After preliminary sizing of various structural members, a computer model of the structural frame of the building shall be generated for carrying out computer analysis for the effect of vertical and lateral load that are likely to be imposed on the structure.

The building structure will be analysed using STAAD.PRO/ETABS for the following computer model of the building for appropriate load and its combinations, as per relevant clauses in IS code. The most unfavourable effect is chosen for design.

Floor analysis of typical floor – for vertical load with building space frame or plain frames in transverse / longitudinal directions or substitution frame in transverse / longitudinal directions.

Space frame analysis of the structure – for wind / earthquake load

Geometrical dimensions, member properties and member-node connectivity, including eccentricities will be modelled in the analysis problem.

Wind / earthquake load derivations will be carried out using coefficients / factors in accordance with the relevant codes.

The permissible values of the load factors and stresses will be utilized within the purview of the Indian Standards.

The computer analysis will produce individual member forces, reactions at foundation level and deflection pattern of the entire structure as well as individual member sizes and arrive at the

most appropriate design of the structural members. Some re-runs of the analysis programmer might be required for arriving at the optimum structural space frame characteristics that satisfy the strength and stability criteria in all respects.

8.0 STRUCTURAL DESIGN METHODOLOGY.

All R.C. C structures will be designed according to the limit state method as specified in IS: 456 - 2000. Steel structures will be designed as per IS: 800 2007, and detailing should be done as per IS 13920 -2016.

Materials of construction will be predominantly concrete with consideration for strength and durability, Grade of concrete is suggested as M: 30/M: 25, in view of the level of stresses to be borne both in compression as well as flexural members.

High yield strength Deformed bars conforming to IS: 1786 with $F_y = 500$ Mpa will be used as reinforcement.

Cover to reinforcement shall be in accordance with IS 456 corresponding to moderate exposure conditions and to satisfy fire rating of 2 hrs.

9.0 FOUNDATION SYSTEM

9.1 Foundations for Building

Isolated /Raft/Pile/Piled-Raft foundation shall be adopted as per the geo-technical report duly approved by the competent authority. In case of Pile Foundation, suitable number of piles shall be tested for Initial Test/Routine Test/Pile Integrity Test as per IS Code, Other important parameters to be followed as per I.S. code and direction of C.E. of the corporation.

10.0 STABILITY OF STRUCTURES

For the purpose of stability of the structure as a whole against overturning, the restoring moment shall not be less than 1.2 times.

The maximum overturning moments due to dead load plus 1.4 times the maximum overturning moments due to imposed loads. In case where dead load provides the restoring moments, only 0.9 times dead load shall be ignored.

The factor of safety against sliding shall not be less than 1.4

Factor of safety against buoyancy shall be not less than 1.2 ignoring the superimposed loading.

11.0 OTHER DATA

Specific requirements of floor and wall cut outs for services, kitchen and toilet areas, external architectural features, and entrance canopies will be provided as required by Architects and Service Engineers.

Lift loads and lifts machine room equipment and cut out layouts will be obtained from the lift manufacturers. An impact factor of 100% will be considered in the lift supporting structures.

11.1 Expansion joints

Structures longer than 45m will be separated with expansion joints. Structures with different structural behaviour shall also be provided with expansion joints. Also, seismic gap should be maintained as per codal requirements. The construction of the joints should be made through specialised agency having well experience of SITC of seismic joints.

11.2 Contractor's Digital Project Management and Quality Systems:-

The Contractor shall, at its own cost, implement, maintain and utilize industry-standard digital project management and monitoring software (such as Primavera P6, MS Project, digiQC or equivalent system approved by the Corporation) throughout the construction of the project. The Contractor's responsibilities shall include:-

- (i) **Work Programme and Progress Monitoring:-** The Contractor shall prepare, maintain and submit a detailed Resource and Cost-Loaded Work Programme using Primavera P6 or MS Project. The Contractor shall continuously update the schedule and submit periodic progress reports (Weekly/Monthly) indicating Actual vs Planned and take preventive measures for the mitigation of delays.
- (ii) **Real-Time Quality Monitoring & Digital Documentation:-** The Contractor shall implement a digital Quality Management and Reporting System (e.g. digiQC or equivalent) to track and record all building Quality Parameters in real time. All activities shall be directly accessible to the Corporation's Engineers as authorized by C.E./EE.
- (iii) The Bihar Police Building Construction Corporation (BPBCC) shall be the sole and exclusive Data custodian of all digital records.
- (iv) The Contractor shall bear all expenses related to software licensing, hardware, and specialized personnel required to operate these system effectively.

12 GENERAL NOTES:-

- (i) Whenever required or as per direction by the E/I , NDT (Non-Destructive Test) of concrete shall be carried out by the EPC Contractor and no extra payment shall be admissible for this.
- (ii) Exposed structural steel members shall be painted with fire-resistant material/paint with a 2-hour fire rating as per direction of E/I.
- (iii) Foamed concrete shall be used as per the direction of the E/I.
- (iv) If there arises any condition for Re-baring, it shall be the sole responsibility of the EPC Contractor to get the work carried out with

a methodology duly approved by the C.E. (Chief Engineer) of BPBCC Re-baring shall be carried out by Hilti, Fischer, or equivalent company with prior approval of C.E., Patna. No extra Payment shall be admissible for these activities.

- (v) Wherever required, Sheet Piling shall be done by the EPC Contractor to ensure the necessary safety at site as per design. No extra cost is payable for this.

13 DESIGN STANDARDS

In the analysis, design and detailing of the building, the following relevant Indian Standard Codes shall be used.

Sl. 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 material.
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 - 2016	Code of Practice for Plain and Reinforced Concrete.
6.	IS 1893:2016	Criteria for earthquake resistance design of structures
7.	IS 13920: 2016	Ductile Detailing of Reinforced Concrete Structures
8.	IS: 1786 - 1985	Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement.
9.	IS: 432(Part 2) - 1982	Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement Hard Drawn Steel Wire.
10.	IS: 1904 – 1986	Indian Standard Code of Practice for Design & Construction Foundations in Soil: General Requirements.
11.	IS: 2062 – 1999	Steel for General Structural Purposes. Specification.
12.	IS: 1161 - 1998	Specification for Steel tubes for Structural Purposes.
13.	IS: 800 - 2007	Code of Practice for General Construction & design for Steel.
14.	IS: 4326 - 2013	Code of Practice for Masonry work.
15.	SP-34	Handbook on Concrete Reinforcement & detailing.
16.	SP-16	Reinf. design of RC members.

17.	IS 9103	Chemical admixture.
18.	IS 383	Code of testing of Coarse and fine aggregates.
19	IS 10262	Mix Proportioning of concrete.
20	IS 10262	Mix Proportioning of concrete.
21.	IS 1200	Earthworks, Concrete works, Brickworks.
22.	IS 4923	Hollow Steel Sections.
23.	IS 3370	Concrete Structures for Storage of Liquid.
24.	NBCS - 25	National Building Constructions Standards.
25.	SP 3370	Hand book for Structural Engineers.
26.	SP 22	Exploratory Hand book on codes of Earthquake Engineers.
27.	IS 2386	Methods of tests for aggregate for concrete.
28.	IS 2430	Methods of sampling.
29.	IS 4082	Specifications for storage of materials.
30.	IS 2250	Compressive strength test for cement mortar cubes.
31.	IS 269-2015	Specifications for 33, 43 and 53 grade OPC.
32.	IS 455	Specifications for PSC (Portland slag cement).
33.	IS 1489	Specifications for PPC (Portland pozzolana cement).

34.	IS 6452	Specifications for HAC for structural use (high alumina cement).
35.	IS 6452	Specifications for HAC for structural use (high alumina cement).
36.	IS 4031	Chemical analysis and tests on cement.
37.	IS 1199	Methods of sampling and analysis of concrete.
38.	IS 516	Methods of test for strength of concrete.
39.	IS 13311	Ultrasonic testing of concrete structure.
40.	IS 4925	Specifications for concrete batching plant.
41.	IS 3032	Test on water samples.
42.	IS 12200	Specifications for PVC (Polyvinyl Chloride) watebars.
43	IS 1077	Specifications for bricks for masonry work.
44.	IS 5454	Methods of sampling of bricks for tests.
45.	IS 3495	Methods of testing of bricks.

The above list is suggestive and not exhaustive. Apart from these basic codes, any other related codes shall also be referred wherever required or as per direction of E.I and it shall be binding to follow the provisions of those codes.

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