DESIGN OF PREFAB RC BUILDING USING EPS FOR DISASTER RESISTANCE

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Engineering of prefab structures

ANALYSIS, DESIGNING AND STRUCTURAL DETAILING OF REINFORCED CONCRETE BUILDING USING EPS

- **Construction materials conforming to IS: 12269 IS: 3812IS: 2386**
- **Evaluation of design loads as per IS: 875 (Parts 1-3), IS: 15498 and as per IS: 1893 (Part 1)**
- **Analysis of the building for Dead Loads, Imposed Loads, Wind Loads and Seismic Loads**
- **Design of the building and foundation as per IS: 456-2000 (2005)**
- **Guildelines/Recommendations to be followed during the Construction**

Typical Building Plan

Assumed Location: Vishakapattinam

(Courtesy: M/s CTSPL)

LOAD EVALUATION

Dead Loads

The unit weight of concrete:

for beams, columns and walls (excluding EPS portion).

The dead load due to slab and floor finish have been distributed over the adjoining beams. Based on the tributary widths, the udl values have been obtained for edge beams and on all other beams, and on beams next to staircases.

Imposed Loads

live load as per IS:875 (Part 2)

The live load has to be distributed over the surrounding beams. Based on the tributary widths, the udl values have been obtained for edge beams, all other beams and on beams next to staircases

Wind Loads

Basic wind speed (V_b) of 65 m/s (234 kmph) corresponding to cyclonic conditions as per IS: 15498 by assuming post-cyclone importance. As per IS: 875 (Part 3) :

k_1 = 1.0 (mean return period of 50 years)

k_2 = 1.0 up to 10 m height & 1.034 for 10 m - 13.4 m (terrain 2; class A)

k_3 = 1.0 (flat topography)

$V_d = k_1\ k_2\ k_3\ V_b$ = 65m/s upto 10 m & 67.21m/s for 10 – 13.4 m height

$p_d = 0.6\ V_d^2$

For wind direction perpendicular to longer face of the building, the force coefficient has been obtained as 1.2 as per IS: 875 (Part 3) (Fig. 4).

The wind loads have been calculated using the following expression:

$F = C_f \times p_d \times A_e$ (in kN)

where A_e = tributary area on the building at each of the loading node for the analysis.

Seismic Loads

Seismic loads as per IS: 1893 (Part 1). The design horizontal seismic coefficient A_h has been obtained as given below:

$$A_h = (Z/2)\ (I/R)\ (S_a/g)$$

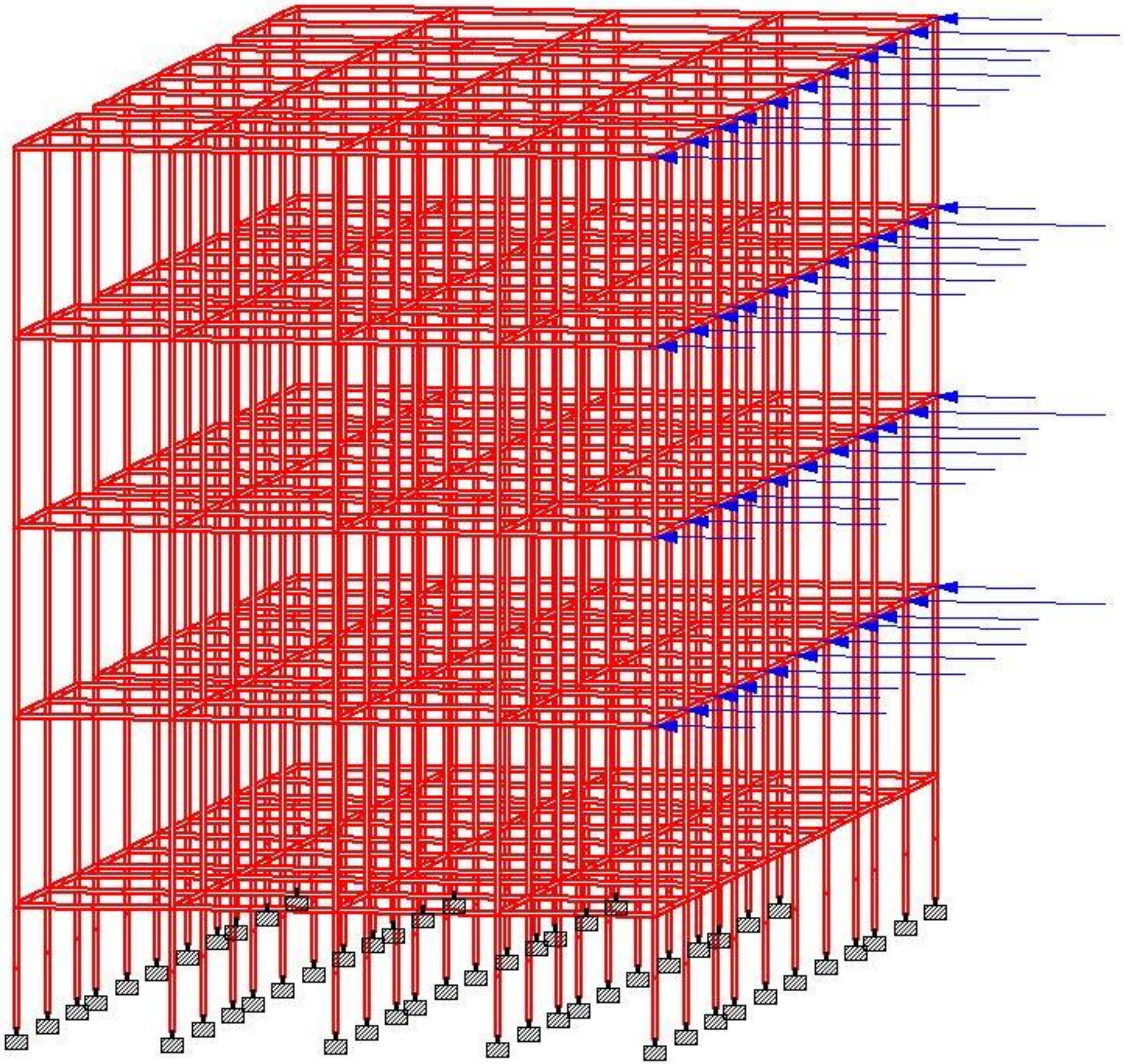
where Z = 0.1 (for zone II as per Table 2 and Annex E of IS:1893 (Part 1) for Visakhapatnam)

I = 1 (Table 6 of IS:1893 (Part 1)) R = 3 (Table 7 of IS:1893 (Part 1))

$S_a/g = 2.5$ (for time period, $T = 0.075 \times 13.4^{0.75} = 0.525$s; ref. IS:1893(P1)

$$A_h = 0.042$$

From the total design lateral force, wind load combination can be considered further for structural analysis of the building.



View of the applied wind loads on the modeled building

STRUCTURAL DESIGN AND DETAILING

The following grades of concrete and steel are considered for the design of the building and foundation:

Concrete: M30 Steel: Fe 415

The building and foundation has been designed using limit state design approach.

STRUCTURAL ANALYSIS

Following load combinations to design the beams, columns and slabs:

i) 1.5 DL + 1.5 IL

ii) 1.5 DL + 1.5 WL

iii) 0.9 DL + 1.5 WL

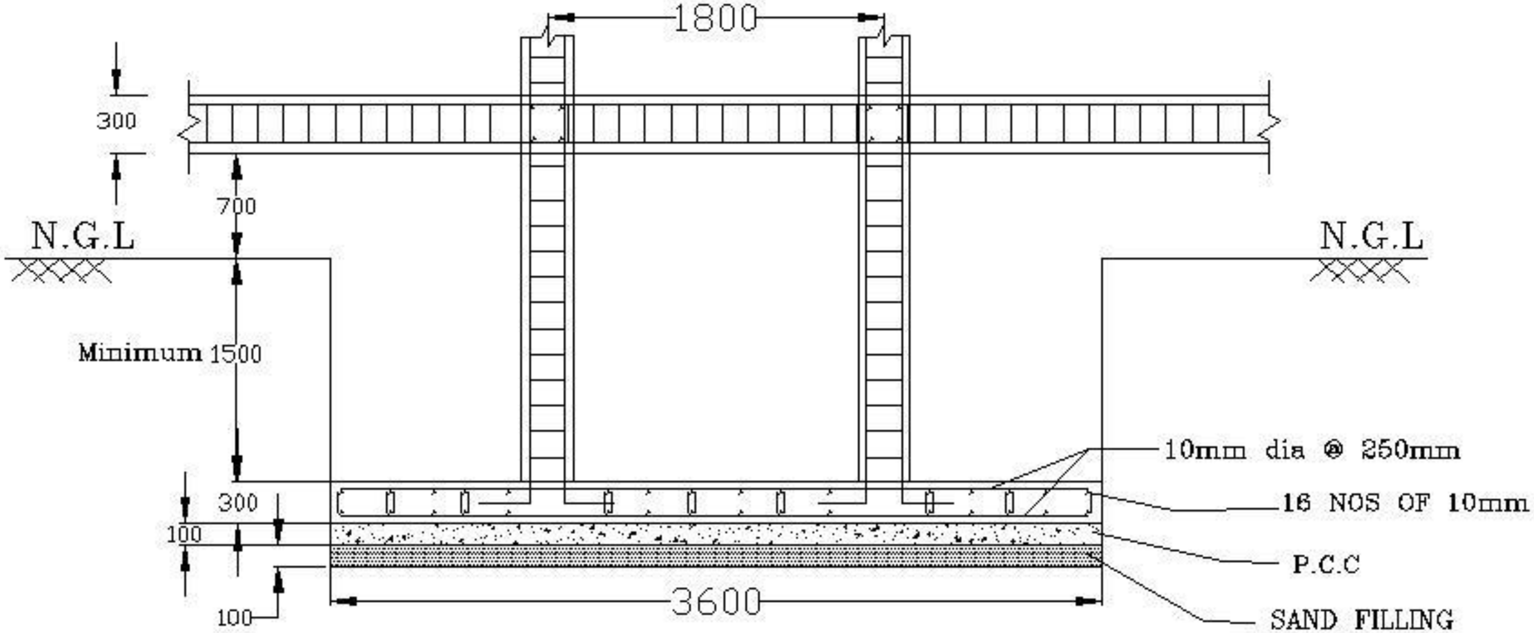
iv) 1.2 DL + 1.2 IL + 1.2 WL

where DL = Dead Load; IL = Imposed Load; WL = Wind Load

EPS panel of 150 mm thicknesses has been considered (with 80 mm thickness EPS and concrete of 35 mm thickness on either side of EPS)

Foundation

For this building, strip footing along the shorter length of the building has been adopted. Based on the reaction forces at the foundation level, the footing sizes have been arrived for different Safe Bearing Capacity (SBC) values of the soil. It is to be noted that the foundation should be rested on the soil with respective safe bearing capacity with depth not less than 1500 mm.



Middle strip footing near staircase

GUIDELINES/RECOMMENDATIONS FOR CONSTRUCTION

- Expanded polystyrene (EPS) is found to be an attractive component in the design of light weight panels
- EPS is an excellent material for home construction because of its low thermal conductivity, moderate compressive strength, and excellent shock absorption.
- EPS is lightweight and panels can be erected easily, without expensive equipment. Openings can be simply cut out of the EPS and fitted with windows and doors.
- EPS has many distinct functional applications, the best known and most widely used to date is as a lightweight fill material.
- EPS is the most common core material, used in 85% of all panels.
- EPS has moisture-resistant structure composed of millions of tiny air-filled pockets. It generally does not release ozone-depleting chlorofluorocarbons (CFCs).
- The material is molded into large blocks and cut to the proper shapes for use in structural panels and the core is responsible for providing thermal insulation, counteracting shear and transverse forces and resisting moisture penetration.
- The EPS core also reduces the panel's weight compared to some other prefabricated structural panel systems, making EPS panels easier to construct.
- The engineering properties of primary interest for core materials are density, shear modulus, and shear stiffness, stiffness perpendicular to the faces, thermal insulation, and acoustic insulation.

Steel Wire Mesh and Shear Connectors

EPS panels are embedded with 10-gauge galvanized steel trusses. 14-gauge steel mesh is welded or clipped to the protruding points of the trusses. Once the wall and roof panels are connected with wire clips, they are finished with 35 mm thick concrete on either side

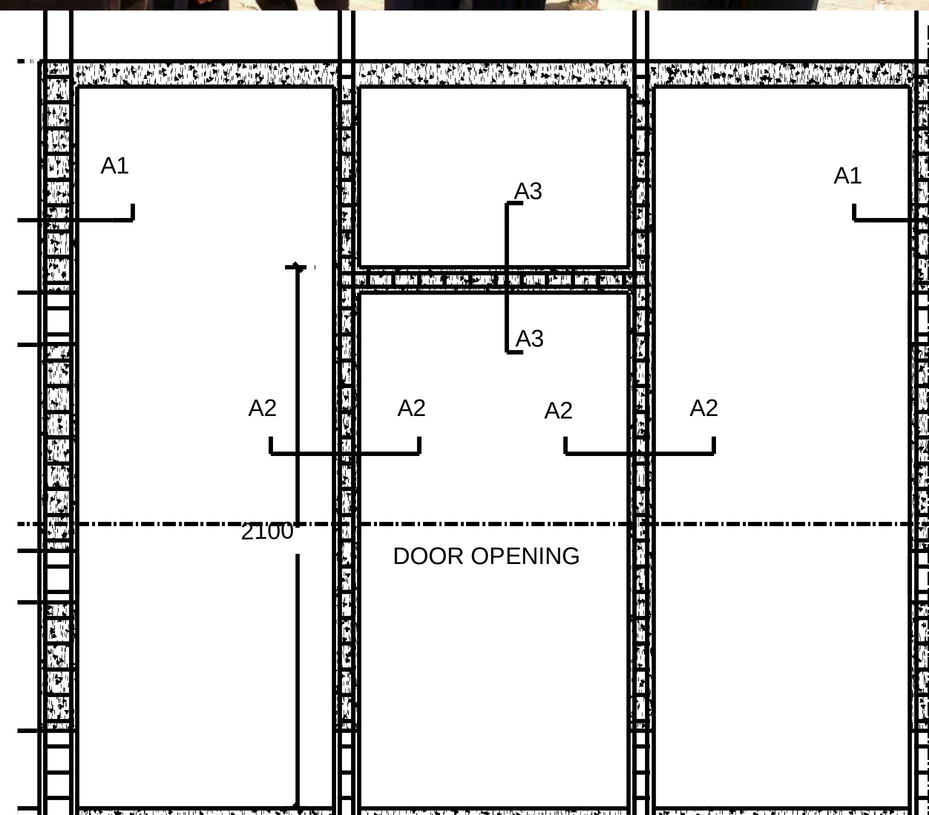
Self Compacting Concrete (SCC)

Insufficient compaction drastically lowers the strength and durability performance of concrete, no matter how well it is designed. Further improper or insufficient compaction not only results in non-homogeneous, concrete but drastically lowers its performances. SCC is able to flow freely under its own weight both horizontally and vertically and completely fill the formwork of any size and shape without leaving voids. During placement and while flowing, the concrete retains its homogeneity without separation of aggregates from paste or water. Coarse aggregates do not sink downwards through the fresh concrete mass. SCC is characterized by unique concreting method that does not require vibration for compaction during placing. It can be used in applications where conventional concrete is difficult to use, such as complicated irregular shaped configurations thin and heavily reinforced structural elements.

Ordinary Portland cement conforming to IS: 12269

Fly ash conforming to grade 1 of IS: 3812

Fine aggregate and coarse aggregates as per IS: 2386



Typical EPS panel diagram showing the ribs with door openings

Construction sequence with special detailing for EPS wall panels for disaster resistance

1. The main rebars from the columns above plinth level and from the column below plinth level need to be extended in both ways to ensure adequate anchoring as per relevant BIS codal provisions.

2. Provision of additional rebars in the EPS wall panel region.

3. Provision of rib columns between two EPS wall panels

4. EPS wall panels with provision of door and windows with lintels.

5. The wire mesh in both the Wythe of EPS panel is welded to the main reinforcement in the ribs. The concreting is done staggered in the RC ribs, to facilitate the jointing of the EPS panels.

6. Anchoring the rib reinforcement upto foundation level

Typical construction site

Summary

- Quality control and construction shall be followed as per relevant BIS Codal provisions
- Cube tests need to be carried out as per BIS Codal requirements
- Tension tests on steel reinforcement need to be carried out as per relevant BIS codal requirements
- It is recommended to use rebars satisfying BIS requirements.
- It is also recommended that the exposure of EPS to fire need to be prevented.
- All the electric/plumbing fixtures/accessories preferred to be embedded in the rib column/beam regions.
- Proper weathering course needs to be provided for the roof.
- Proper detailing along with special detailing wherever recommended is applicable.

Prefab Technologies of CSIR-SERC

- **Prefabricated Toilet core unit**
  (Water-supply, Electricity and Drainage)
- **Prefab segmented strip foundation**
  (10 SBC)
- **Prefab funicular shells**
  (for one way / continuous slab)
- **Gravel sand bricks**
- **Prefab foamcrete wall panels**

THANK YOU