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SEISMIC ANALYSIS OF HIGH RISE BUILDING FLOOR SLABS USING STAAD PRO

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Abstract - As a result, high rise structures with basic frame and plate frame systems are the focus of the current work's analytical parametric investigations. In this work, stiff diaphragms are suggested as a possible solution to the issues, and effective analytical modeling techniques are carried out using the super-elements. An effective approach is suggested in the current study to analyses multi-story buildings while taking the impacts of floor slabs into consideration. The current study's aim is to assess the behavior of a structure when the reinforced concrete slab is taken into consideration during structural analysis. Using STAAD Pro software, two separate analyses are performed: Equivalent Static Analysis (ESA) and Response Spectrum Analysis (RSA). The load combinations are taken into account in accordance with IS 1893(Part-1): 2002. For Zone III taken into consideration in this inquiry, the outcomes in terms of design base shear, displacements, responses, and time period in simple frame structures and plate frame structures are compared. It was discovered that taking into account the impact of slabs in the structural analysis of case study buildings will result in reduced displacement values and higher response and base shear values. The outcomes also demonstrate a minor improvement in the lateral stability of bare frames due to the slabs.

Keywords: Equivalent Static Method, Response Spectrum Method, STAAD. Pro V8i

1. INTRODUCTION

The creation of high-rise structures is required due to population growth and land shortages. It will take longer and there will be more opportunity for human error if we use the conventional method of manual construction design. Software is therefore needed to get a result that is more accurate. STAAD Pro is a widely used civil engineering structural programmed that can address issues like wind analysis and seismic analysis using different load combinations to validate different codes like IS456:2000, IS1893:2002, IS875:1987, IS1893:2016, and so forth.

STAAD stands for "Structural Aided Analysis and Design" in its entire form. One of the greatest programmes for structural analysis and even designing structures utilizing analyzed reports is STAAD Pro. We choose STAAD Pro because of these advantages:

Various loads that a building may encounter include the following:

(1) Dead load
(2) Live load
(3) Wind load
(4) Seismic loads or earthquake loads

2. METHODOLOGY

(1)Structural Configuration

Seismic analysis is used in the current work to investigate the impacts of floor slabs on RCC building models. Here, symmetric building model analysis is done. Various models are taken into account in the study, including

1. Simple frame model
2. Plate frame model

In order to simulate RC multistory buildings with and without slabs in the study, the finite element technique methodology is used. According to IS 1893 (Part-1): 2002Equivalent Static Analysis (ESA) and Response Spectrum Analysis (RSA) are used to seismically evaluate building models. Additionally, the structures are regarded as being in zone III.

(2)Parameters Considered

(1) Analysis method Equivalent static analysis (ESA) and Response spectrum analysis (RSA) in STAAD.Pro.

(2) Stiffness of floor slab-

For the building models that will be taken into consideration for the investigation, the lateral design forces are calculated in this study using the equivalent static technique and the response spectrum method in accordance with the provisions of IS 1893 (Part -1): 2002. To determine the significance of doing a seismic analysis, the buildings are analyzed based on the findings of the building for various zones for various load combinations.

By using lateral load analysis, the current work is extended to investigate these consequences on our building models. The current work also examines how floor slabs affect building models that are taken into consideration in Zone III.

3. MODELING AND ANALYSIS

For this study, two structures with an identical floor plan of 25 m x 15 m and having an equal number of storey's (9(G+8)) were taken into consideration. As illustrated in Figures 1 and 2, the floor plans were split into 5 x 3 bays such that the centre to centre distance between two grids was, respectively, 5 meters on both sides. As illustrated in Figure 3, the building's plinth height is 2 meters above the foundation base, with an anticipated floor height of 3.2 meters for all storey's

Model 1: Building having Simple frame.

Model 2: Building having Plate frame

The modeling of the structure has been done using the structural software STAAD.Pro as per the data given below:-

1. **Description Of Building**

- Type of structure: Multi-storey RC frame structure
- Number of stories: 9 (G+8)
- Ground storey height: 3.2 m
- Intermediate storey height: 3.2 m
- Depth of foundation: 2 m
- Type of soil: Hard soil

2. Materials

- Grade of concrete: M20
- Density of concrete: 25kN/m2
- Modulus of elasticity of concrete: 5000√fck (As per IS 456:2000,)
- **3. Member dimensions**
- Beam Size: 230mm x 450 mm
- Column Size: 230mm x 450 mm
- Slab Thickness: 125 mm
- Wall Thickness: 230 mm

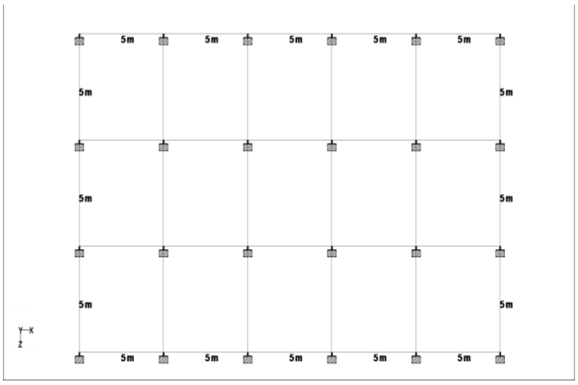

Figure 1 Typical Floor Plan for all 9(G+8) Floors

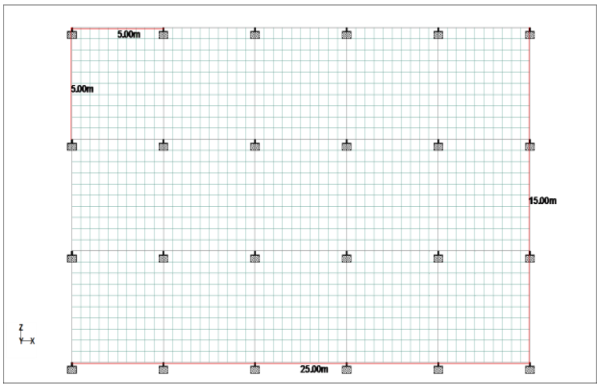

Figure 2 Typical Floor Plan for all 9(G+8) Floors with plate frame

In the modeling of the construction, the loads of the slab, the perimeter wall, and the parapet wall were taken into account. Even though the sizes and qualities of all the components and materials were known, there was not enough time to correctly account for all of their behaviors. As a result, the following assumptions were established for the structural modeling to keep things simple:

1. Linear elastic materials with uniform, isotropic properties were considered to make up the construction.
2. It was thought that the impacts of non-structural and secondary structural elements, such as brick infill walls and staircases, would be insignificant.
3. The foundation for the analysis was thought to be rigorous.

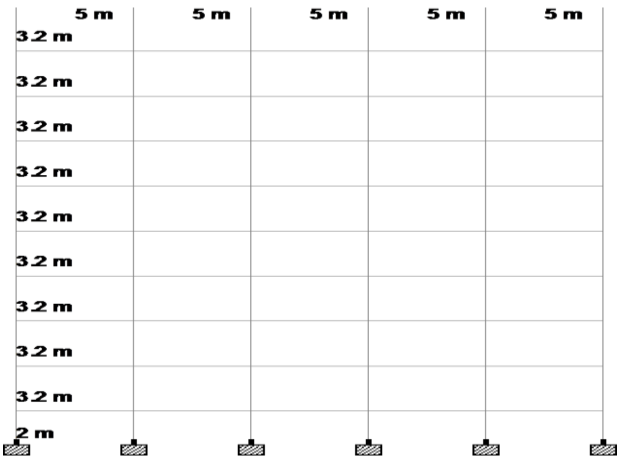

Figure -3 Elevation of the Building

(1) Equivalent Static Method

Most structures still undergo seismic analysis with the still-current presumption that the lateral (horizontal) force is identical to the real (dynamic) loading. The durations and forms of natural modes of vibration are not necessary for this procedure, with the exception of the basic period.

Determination of Design Base Shear (V_B) of the building.

$$V_B = A_h \text{ x } W \text{ ………………… (1)}$$

$$Ah = \frac{Z}{2} \text{ x } \frac{I}{R} \text{ x } \frac{Sa}{g} \text{ …………… (2)}$$

V_B = Base Shear , A_h= Horizontal Seismic Coefficient ,W = Total Weight of Structure , Z = Zone Factor , I = Importance Factor

R = Response Reduction Factor , S_a/g = Average Response Acceleration Co-efficient

The total design lateral pressures at every level above the storey under consideration are referred to as storey shear. According to the following formula, the design base shear V_B calculated must be spread throughout the height of the building:

$$Q_i = V_B \text{ x } \frac{W_i h_i^2}{\Sigma W_i h_i^2} \text{ ……………… (3)}$$

Qi = Design lateral force at floor , Wi = Seismic weight of floor, , hi= Height of floor i measured from base,

In accordance with IS 1893 (Part 1) 2002, the following load combinations are taken into account for analysis and design:

Load combination	Load factors
Gravity analysis	1.5 (DL+LL)
Equivalent Static Analysis	1.2 (DL+ LL -EQX)
	1.2 (DL+ LL–EQZ)
	1.5(DL– EQX)
	1.5(DL–EQZ)
	0.9 DL– 1.5 EQX
	0.9 DL– 1.5 EQZ
Response Spectrum Analysis	1.2 (DL+ LL– RSX)
	1.2 (DL+ LL –RSZ)
	1.5(DL– RSX)
	1.5(DL –RSZ)
	0.9 DL –1.5 RSX
	0.9 DL –1.5 RSZ

(2) Response Spectrum Method

The lateral loads produced by the program me match the IS 1893 (Part 1): 2002 seismic zone III and 5% damped response spectrum. The seismic mass is determined in this case utilising the complete dead load plus 25% of the live load, much like in the equivalent static analysis (ESA). For all construction modes, the 5% damped response spectrum is taken into account. Analysis is done after establishing the response spectrum situation.

According to clause 7.8.2 of IS 1893 (Part 1): 2002, scaling must be done if the displacements and base shears obtained by the response spectrum method are less than the equivalent static base shear. To do this, multiply the response spectrum base shear by the ratio of the equivalent static base shear (V_B) to the response spectrum base shear (V_B).

Load Calculations

1. **Dead Load**

The self wt. of the structural members is taken care in the software

- Periphery Wall load : (3.2-0.45) x0.23 x 22 = 14 kN/m
- Parapet Wall load : 1.2 x 0.23 x 22 = 6.1 kN/m
- Slab load: 0.125 x 1.0 x 1.0 x 25 = 3.125kN/m2
- Floor Finish load: 1 kN/m2

2. **Live Load**

- Live load on floor: 3.0kN/m2 (Table 1 of IS 875(Part-2): 1987)
- Live load on roof: 1.5kN/m2

3. **Seismic Load**

- Seismic zone: Zone-III (for Belgaum City As per IS 1893(Part 1) 2002, pp-35)
- Type of Structure: Ordinary shear wall with OMRF (Table 7 of IS1893(Part -1): 2002, pp-23)
- Height of Building: 30.8 m
- Damping ratio: 5% for RC frame structure
- Seismic zone factor (Z): 0.16 (Table 2 of IS 1893(Part-1):2002, pp16)
- Importance factor (I): 1.0 (Table 6 of IS 1893(Part-1): 2002, pp-18)
- Response reduction factor (R): 3.0 (Table 7 of IS 1893(Part-1): 2002, pp-23)
- Foundation Soil type = Type-1(Hard Soil) (As per IS 1893(Part-1): 2002, pp-16)
- Design horizontal seismic coefficient (As per IS 1893(Part-1): 2002, pp-14) For all Models Ah = 0.0267 sec (As per Eq. No. 2)
- Design Seismic Base Shear: VB =Ah x W (As per Eq. No. 1)

STAAD View

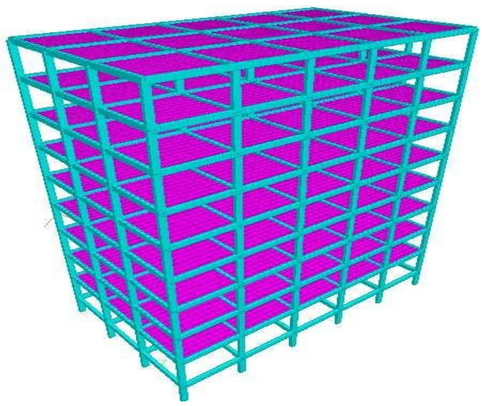

Figure 4 Model of Simple Frame Structure

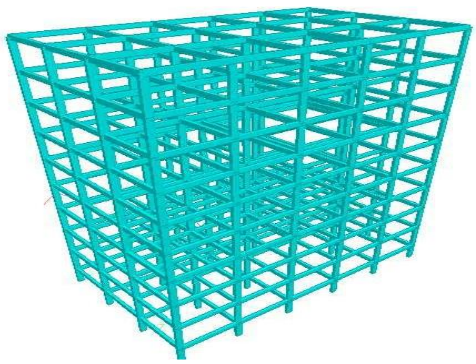

Figure.5: Model of Simple Frame Structure with Plates

4. RESULTS AND DISCUSSIONS

In this chapter, the findings from two distinct types of analyses Equivalent Static Analysis and Response Spectrum Analysis conducted on various building models for Zone III are discussed. STAAD Pro software is used to do the analysis. Following the completion of the static and dynamic study of the models under consideration, their behavior will be

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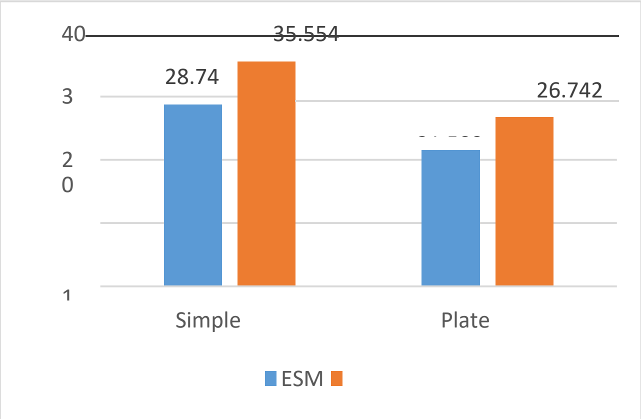
examined and contrasted in terms of the following table parameters

1. Maximum displacement
2. Maximum reactions
3. Base shear
4. Time Period

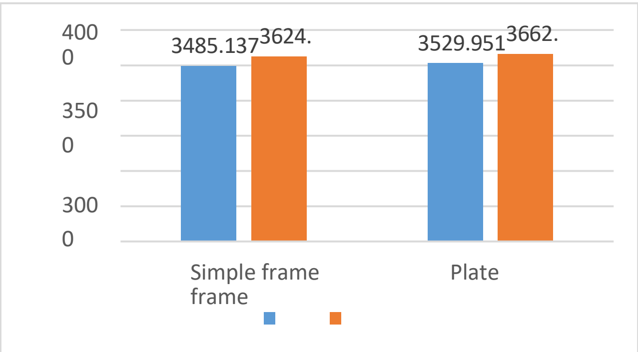
1- Maximum Displacement

The results for maximum displacement of building models considered with and without slabs are obtained from ESM & RSM and are given below



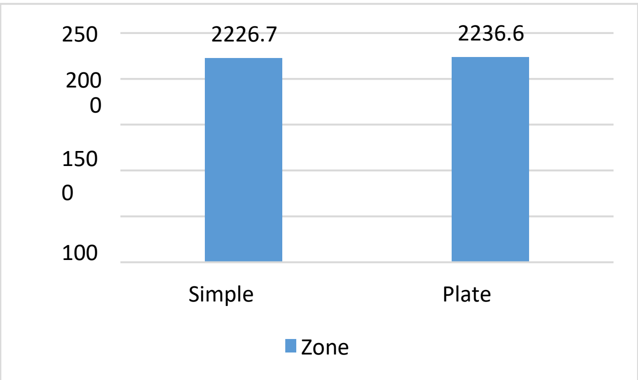
1- Maximum Reaction

Provides the results for maximum responses for building models that were studied with and without slabs



2- Base shear

The table below shows the findings for base shear of building models in the X direction when slabs are evaluated with and without them.



3- Time Period

- Time period for all the models in X direction and Z direction will be the same respectively.
- Time period for X direction = 0.5544 seconds for all the models.
- Time period for Z direction = 0.7159 seconds for all the models.

5. CONCLUSIONS

1. When compared to models without slabs, support responses are higher in the case of models.
2. The base shear of the structure with slabs is marginally higher than the base shear of the structure without slabs. Therefore, the crucial outcomes will come from the model without slabs.
3. Different common floor slab thicknesses in multistory frames, such as 150mm, 175mm, and 200mm, may be studied. In addition, additional typical dimensions for beams and columns may be used.
4. Reexamine the frame construction using various concrete grades.
5. The investigation can be expanded to compare stiff and flexible flooring.
6. The impact of floor slabs as well as the inclusion of bracings and shear walls in multistory frames may be studied.
7. The investigation might be carried out further by making slab apertures.

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