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STUDYING THE RESPONSE OF FLAT SLABS & GRID SLABS SYSTEMS IN CONVENTIONAL RCC BUILDINGS

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ABSTRACT

Modern slab systems have showed potentials for improvement in the conventional techniques of slab casting. Recent advances in the field of RCC Design are linked to the use of Flat Slabs and Grid Floors. Flat Slabs are highly versatile elements widely used in construction, providing minimum depth, fast construction and allowing flexible column grids. In flat slabs, the beams used in conventional slabs are done away and the slab is made to rest directly over the columns. In case of higher loads, a drop panel or a column head is provided to reduce the intensity of loads. Flat slabs are particularly appropriate for areas where tops of partitions need to be sealed to the slab soffit for acoustic or fire reasons. Grid floor systems consist of beams spaced at regular intervals in perpendicular directions, monolithic with slab. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement. This paper focuses on studying the behavior of conventional slab, flat slab and grid slab separately. A comparative study was done to identify the best slab system.

KEYWORDS: STAAD. Pro, Flat Slabs, Grid Slabs, RCC Structures, Design

There has been an increasing demand for construction of tall buildings due to an ever increasing urbanization and flexuous population. Earthquake is the bane of such tall structures. As the earthquake forces are haphazard in nature & unpredictable, we need to acuminate engineering tools for analyzing structures under the action of these forces. Thus a careful modeling of such earthquake loads needs to be done, so as to evaluate the behavior of the structure with a clear perspective of the damage that is expected. To analyze the structure for various earthquake intensities and then perform checks for various criteria at each level has become an essential practice for the last couple of decades. (Romy M and PrabhaC , 2011).

Earthquake causes different shaking intensities at different locations and the damage induced in buildings at these locations is also different. Thus, it is necessary to construct a structure which is earthquake resistant at a particular level of intensity of shaking, and assimilate the effect of earthquake. Even though same magnitudes of earthquakes are occurring due to its varying intensity, it results into dissimilar damaging effects in different regions. Hence, it is necessary to study variations in seismic behavior of multistoried RC framed building for different seismic intensities in terms of various responses such as lateral displacements, story drift and base shear. Hence the seismic behavior of buildings having similar layout needs to be understood under different intensities of earthquake. For determination of seismic responses, it is necessary to carry out seismic analysis of the structure using different available methods. (Duggal S K, 2010).

Objectives of this Study

- To perform dynamic analysis of multistoried RCC buildings with Flat slab & Grid slab (10 Storey) having Square geometry, using Response Spectrum Analysis, considering earthquake Zone II as per the Indian Standard code of practice IS 1893-2002 part-I: Criteria for Earthquake resistant structure.
- To model different structures with aforementioned configuration and compare them using design aids like STAAD.Pro.
- To compare seismic behavior of multistoried RCC building with Flat slab & Grid slab for different earthquake intensities in terms of various responses such as, base shear, Story displacements, Story Drift, Axial Force, Time Period.
- To find the relationship between earthquake intensities and responses.

MODELLING AND ANALYSIS

10 storied buildings are modeled using conventional slabs, flat slabs & grid slabs respectively. These buildings were given square geometry. These are then analyzed using response spectrum method for earthquake zone II of India. The details of the modeled building are listed below. Modal damping of 5% is considered with SMRF and Importance Factor (I) =1. The

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following assumptions were made before the start of the modeling procedure so as to maintain similar conditions for all the three models:

- Only the main block of the building is considered. The staircases are not considered in the design procedure.
- The building is to be used for exhibitions and so no interior walls are provided.
- Only external walls 230 mm thick with 12 mm plaster on each side will be provided. However in the present study, only the frame is considered and hence, walls are not provided.
- At ground floor, slabs are not provided and the plinth is resting 2m above the ground.
- The beam beams are resting centrally on the columns so as to avoid the conditions of eccentricity.
- For all structural elements, M25 & Fe415 are used.
- The footings are not designed. Supports are assigned in the form of fixed supports.
- Seismic loads are considered in the horizontal direction only and the vertical direction are assumed to be insignificant.
- Sizes of the members are as follows: (All dimensions are in mm)

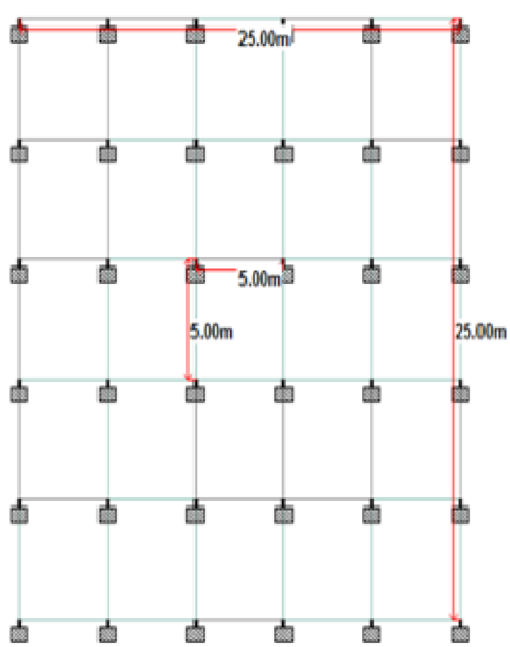


Figure 1: Plan of Proposed Model

Table 1: Member Properties & Specifications for the various Models

SN	Specifications	Size
1	Plan dimensions	25m x 25m (X*Z)
2	Length in X- direction	25 m
3	Length in Z- direction	25 m
4	Floor to floor height	4.0 m
5	Plinth Level	2 m
6	Total height of Building	42, 82 & 122 m
7	Spacing of Ribs	1 m
8	Size of Ribs	0.3 m x 0.3 m
9	Slab Thickness for flat slab	200 mm
10	Soil Type	Hard
11	Grade of concrete	M 25
12	Grade of Steel	Fe 415
13	Beam Size	0.5 m x 0.3 m
14	Column Size	0.6 m x 0.6 m
15	Location	Seismic Zone II
16	Live Load on Slabs	3 kN/m^2

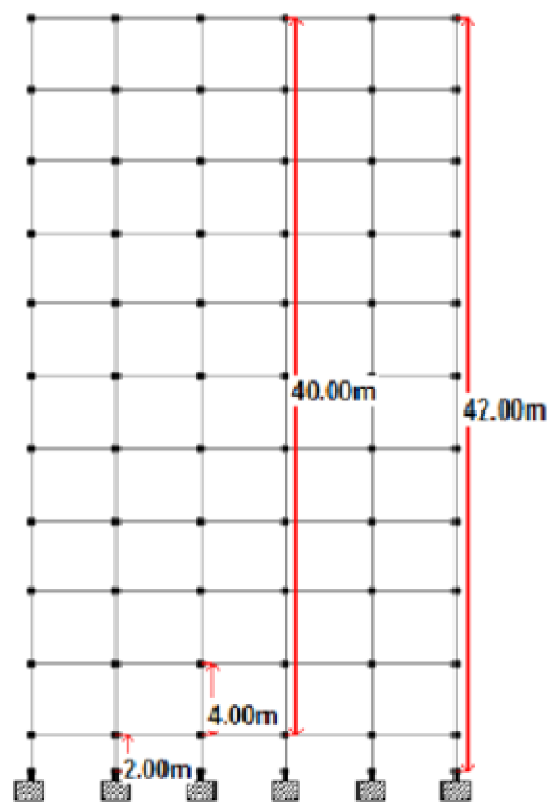
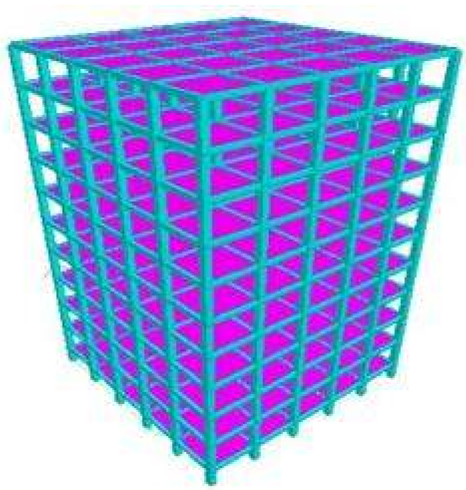


Figure 2: Elevation of Proposed Model



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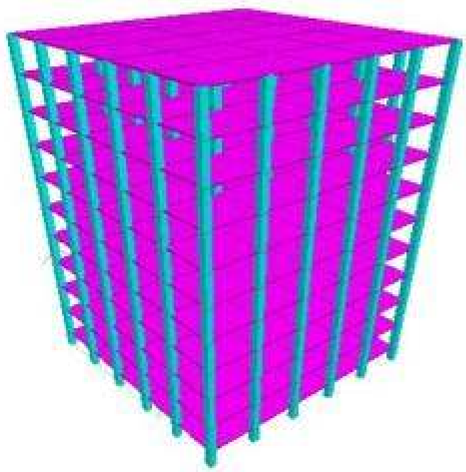

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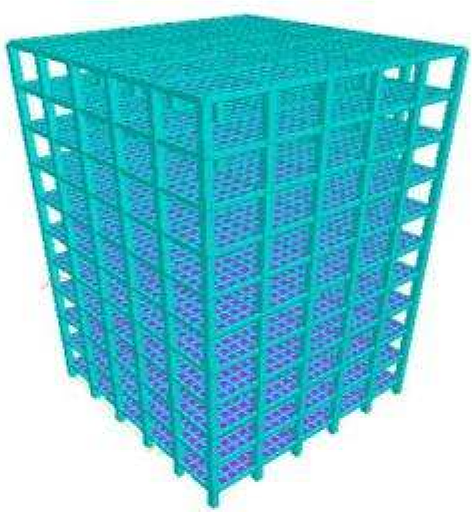

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Figure 3: Generated models of Structures (10 storey) with: (a) Conventional Slab, (b) Flat Slab, (c) Grid Slab

The behavior of all the three framing systems is taken as a basic study on the modeled structure. The lateral drift/deflection ratio is checked against the clause 7.11.1 of IS-1893:2002 i.e. under transient seismic loads.

The following parameters were considered to present a comparison between the different frames:

- ✓ Materials used
- ✓ Maximum Nodal Deflection
- ✓ Maximum Beam Shear & Moments
- ✓ Maximum Plate Stresses

The following load combinations are considered during the analysis of the model:

- ✓ 1.5 DL + 1.5 LL
- ✓ 1.2 DL + 1.2 LL
- ✓ 1.2 DL + 1.2 LL + 1.2 EQX
- ✓ 1.2 DL + 1.2 LL - 1.2 EQX
- ✓ 1.2 DL + 1.2 EQX
- ✓ 1.2 DL - 1.2 EQX

For asserting the simplest yet reliable method for analysis, the combined action of DL, LL & EQ forces are considered i.e. 1.2 DL + 1.2 LL + 1.2 EQX. The structure with different framing system has been modeled using STAAD.PRO software with the above mentioned load conditions and combinations. Slabs are added in the form of 4-noded plates and the entire slab is divided into 4 segments (supported on beams on all four sides).

I. RESULTS AND DISCUSSION

The behavior of all the framing systems is taken as a basic study on the modeled structure. The lateral drift/deflection ratio is checked against the clause 7.11.1 of IS-1893:2002 i.e. under transient seismic loads. The following parameters were considered to present a comparison between the different frames:

Materials Used

Approximate costing of materials can be found out by taking base charges as INR 5000/- per cum. of concrete and INR 50/- per kg. of steel.

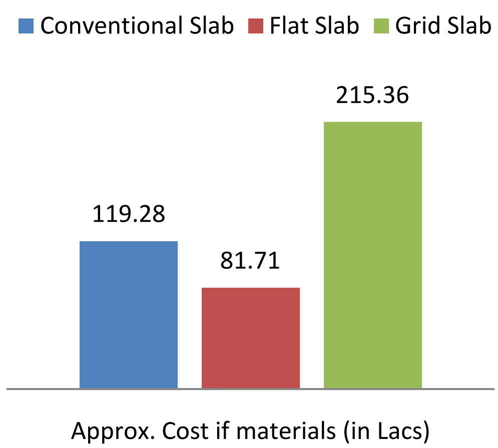


Figure 4: Cost Comparison of Materials

Maximum Nodal Deflection

Table 2: Comparison of Nodal deflections

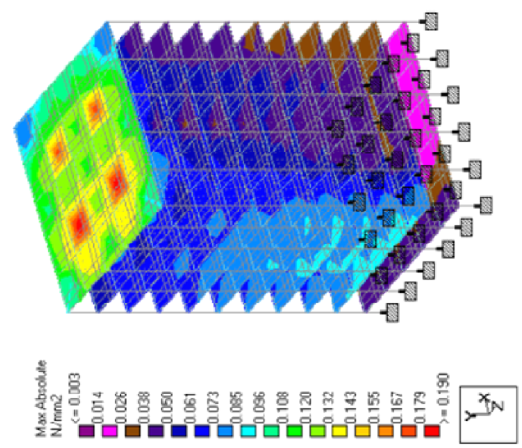
Deflection	Conventional Slab	Flat Slab	Grid Slab
Max. X (mm)	15.593	18.115	21.000
Min. X (mm)	– 0.011	0.000	0.000
Max. Y (mm)	– 0.352	0.000	0.000
Min. Y (mm)	– 0.469	– 8.226	– 13.061
Max. Z (mm)	0.021	0.018	0.031
Min. Z (mm)	– 0.021	– 0.018	– 0.031

Maximum Beam Shear & Moments

Table 3: Comparison of Beam Stresses & Moments

Parameter	Conventional Slab	Flat Slab	Grid Slab
Max. Fx (KN)	3394.4333	2948.166	4502.561
Min. Fx (KN)	– 156.012	69.501	– 3.508
Max. Fy (KN)	42.381	34.211	59.863
Min. Fy (KN)	– 27.686	– 17.002	– 58.584
Max. Fz (KN)	27.679	18.571	51.637
Min. Fz (KN)	– 27.679	– 18.571	– 51.637
Max. Mx (KNm)	0.367	0.096	15.191
Min. Mx (KNm)	0.367	– 0.096	– 15.191
Max. My (KNm)	63.319	42.977	117.728
Min. My (KNm)	– 63.319	– 42.977	– 117.728
Max. Mz (KNm)	83.244	66.891	117.673
Min. Mz (KNm)	– 86.280	– 70.214	– 126.204

Maximum Plate Stress:



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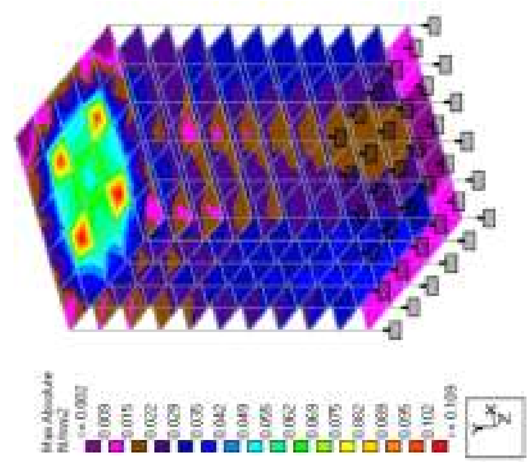

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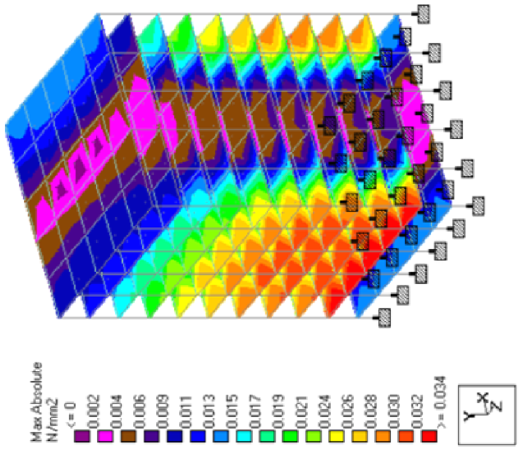

(c)

Figure 5: Plate Stresses due to acting load (1.2 DL + 1.2 LL + 1.2 EQX): Conventional Slab, (b) Flat Slab, & (c) Grid Slab

CONCLUSION

It is clear to all that the seismic hazard has to be carefully evaluated before the construction of important and high-rise structures. Based on the above analytical study carried out on 3 structures, the following deductions are made:

- The frame with flat slabs clearly provides more safety to the designers and it proves to be extremely cost effective.
- In all the systems, the storey drift is within the permissible limits as per IS:1893 (Part 1). However grid floors showed better results when compared to other models.
- There is an increase of 45.97 % in the cost of Conventional slabs and an increase of 163.57 % in the cost of Grid Slabs when compared to Flat Slabs. This also results in a deduction of 66.12 % in the amount of storey drift in Flat Slabs.
- There is a huge increase in the quantity of concrete and steel in case of Grid Slabs when compared to Flat Slabs or Conventional Slabs. This is because of the higher number of beams in the model.
- The lateral loading is most effectively resisted in Flat Slabs. Thus the service life will be largest for this framing configuration.
- Due to the falling of the zone, the earthquake hazard will also increase. In such cases, Flat slabs with shear walls are applicable.
- The Response Reduction Factor plays an important role on the variation of cost.
- To further increase the effectiveness of the structure, earthquake resisting techniques such as shear walls & base isolation can be used.

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