International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

SEISMIC ANALYSIS OF RCC BUILDING WITH CONVENTIONAL SLAB, FLAT SLAB AND GRID SLAB USING E-TABS

SANJAY JANIWARAD[1], K P THEJASWI[2], K B PRAKASH[3]

[1]P. G. Student, Department of Civil Engineering, Govt Engineering College, Devagiri, Haveri, Karnataka, India
[2]Assistant Professor, Department of Civil Engineering, KLS Gogte Institute of Technology,Belagavi,Karnataka,India
[2]Principal, Govt Engineering College, Devagiri, Haveri, Karnataka, India

---

Abstract - *Earthquakes can create serious damage to structures. The structures already built without precautions are vulnerable to future earthquakes. The damage to structures causes deaths, injuries, economic loss, and loss of functions. Earthquake risk is associated with seismic hazard, vulnerability of buildings and the exposure. Seismic hazard quantifies the probable ground motion that can occur at site. Vulnerability of a building is important in causing risks to life. Increase in urban population led to development of tall building structures. Structural reinforced concrete floor system is one of the significant system and is effective to transfer gravity and lateral loads to foundation. The present study aims to compare the behavior of conventional slabs, flat slabs and grid slabs each when constructed with masonry wall, shear wall or bracing under the action of lateral loads. Seismic parameters like storey drift, storey shear, storey displacement and storey stiffness are compared in each case to study the behavior of these slabs by using ETABS.*

Key Words: conventional slab, flat slab, grid slab, lateral load, storey shear, storey drift, ETABS.

1. INTRODUCTION

India is a developing country with the world's second largest population. The reduction in living areas, the need to use remaining land as efficiently as possible, and the desires of large corporations to construct large prestigious buildings for their own use have resulted in a significant rise in the number of tall buildings in our major cities, as well as in other countries, over the last 30 years. The building is a 3D structure, it is generally planned, analysed and designed as an assemblage of 2D (planar) subsystems laying primarily in the horizontal and vertical planes (e.g., floors, roof, walls, plane frames, etc.). This partition into a horizontal (floor) system and a vertical (framing) system is mostly suitable in studying the load resisting mechanisms of a structure. The RCC floor (horizontal) system resists the vertical or gravity loads (DL and LL) acting on it and then transmit these to the vertical framing system.

RCC slabs along with long spans extend over numerous bays and solitary rested on columns without beams are called as Flat slabs. Flat slab systems are actually easy to construct and is competent to need the minimum structure height for a specified number of storeys. A significant bending moment and vertical forces occur in a zone of supports in such a system.

Grid floors are made up of intersecting beams that are spaced at regular intervals in both directions and are designed uniformly. For a good architectural appearance, this floor structure is typically rectangular or square in form. Beam spacing is normally kept constant. For architectural purposes, beams are often made to cross at diagonals. This floor system is designed to last long. Grids are structures being used to fill vast column-free spaces and are exposed to regular force exerted across their plane.

Continuous vertical masonry or concrete walls may be used as both aesthetic and functional elements to withstand vertical and lateral loading. The tolerance to dynamic forces is entirely due to this shear wall in buildings. Since, these walls are more solid horizontally than rigid frames, they are often more cost-effective up to 35 floors. Shear walls are ideal for use in lodging and housing developments where the story-by-story design enables the wall to function as a vertical consistent sound and flame barrier amongst spaces and dwellings.

Bracings are commonly used in buildings to withstand horizontal loads by shifting lateral loads to the ground, thus preventing the building from swaying. Depending on the design requirements, bracing can be made of concrete or steel.

2. OBJECTIVE OF THE STUDY

The ultimate focus of all structural elements utilized in the construction of buildings is to efficiently pass vertical forces. Dead load, live load and snow load are the three most common loads caused by gravity. Structures are often exposed to horizontal pressures due to wind, explosions, earthquakes, along with gravity loads. These horizontal loads come into effect when building height is high or speed of wind is more or building is situated in earthquake prone area. Large pressures, sway movements, and turbulence can all be caused by horizontal forces. Hence, it's critical that building being strong enough to withstand gravity loads while still being robust enough to resist horizontal loads.
Main objective of this work is to compare the behavior of conventional slabs, flat slabs and grid slabs each when constructed with masonry wall, shear wall or bracing under the action of lateral loads. Modelling and analysis is done using ETABS. Different variables such as displacement, storey drift, storey shear are compared in each case to study

the behavior of conventional slabs, flat slabs and grid slabs under the action of lateral loads.

3. MODELLING IN ETABS

In this present study, 11storey RC building is taken into account. ETABS and MS EXCEL are the software used. This building is analysed and designed according IS code stipulations. Dynamic investigation is done to get the displacement and drift. The ETABS gives apparatuses to spreading out floor surroundings, column and dividers in concrete or in steel.

Following steps are to be followed for elementary modelling, analysis and design procedure:

- Start a new model
- Select the units and codes to be used
- Defining materials
- Defining sections
- Defining diaphragm
- Defining load pattern
- Defining mass source
- Drawing
- Assigning support
- Assigning load
- Assigning diaphragm
- Assigning mesh
- Defining load combination
- Read the model
- Analysing the model
- Checking the model
- Extract the result
- Save the model

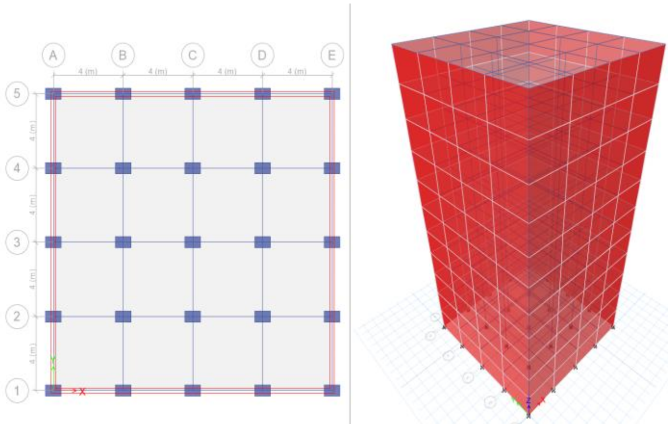

Fig -1: Plan and Elevation of the building

3.1 Structural inputs of the building

Building properties:

- Form of building – RC moment resisting frame
- Grid spacing – uniform 4m in each X and Y direction
- Total dimension – 16m x 16m
- Floor height – 3.0m
- No. of stories – 11 story

Material Properties:

- Density of concrete – 25 kN/m^3
- Young's modulus of concrete – 2.5x10^4 N/mm^2
- Grade of steel – Fe500
- Young's modulus of steel – 2x10^5 N/mm^2
- Density of brick masonry – 20 kN/m^3

Frame section properties:

- Beam size – 450mm x 600mm
- Column size – 600mm x 900mm

Wall/Slab section properties:

- Thickness of slab – 150 mm
- Wall thickness – 250 mm

3.2 Design loads

Dead load, super dead load, live load and earthquake loads are taken. Each load is taken and is assigned as per IS codes 875 and 1893.

• Dead load

i. The self-load of the structure is determined automatically.

ii. Periphery wall load: 9.75 kN/m^2

iii. Floor finish: 1.0 kN/m^2

• Live load

i. Live load on floor: 3 kN/m^2

ii. Live load on rooftop: 1 kN/m^2

• Seismic load

Zone (Z) Factor: 0.16 (III)

Soil type: Medium

Response reduction factor: 5

Importance factor: 1.0

Damping: 5%

3.3 Abbreviations used

Following are the abbreviations for models used in ETABS software;

M1- Conventional slab with masonry
M2- Conventional slab with shear wall
M3- Conventional slab with bracing
M4- Flat slab with masonry
M5- Flat slab with shear wall
M6- Flat slab with bracing
M7- Grid slab with masonry
M8- Grid slab with shear wall
M9- Grid slab with bracing

4. RESULTS AND DISCUSSIONS

Table-1 give the results of displacements, story drift, story stiffness and story shear. Graphical representation of the same is depicted in the figures.

Table -1: Overall comparative results of all models.

Description of Model	Displacement in 11th story (mm)	Story drift in 11th story	Story stiffness in 11th story (kN/m)	Story shear in 11th story (kN)
M1	24.5	0.000379	946892	3185.89
M2	9.2	0.000228	4317963	2925.53
M3	6.7	0.000003	394763382	1042.48
M4	26.7	0.000423	630422	2542.32
M5	7.9	0.000191	3812996	2166.82
M6	6.4	0.000002	389930926	720.05
M7	25.5	0.000399	1060427.9	3592.87
M8	10	0.000249	4431650	3280.31
M9	6.2	0.000003	414934187	1226.41

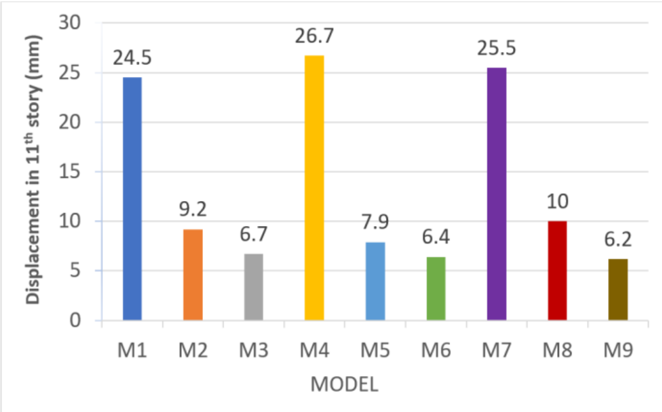

Fig -1: Variations of displacement in all models (mm)

Maximum displacement is considered for comparison of structural models. From the results of analysis of different models we can observe that story displacement is maximum at top story of structures. Total displacement of any story with respect to ground is termed as story displacement. Maximum permissible story displacement is 0.004h (where 'h' is story height). Compared to all models, displacement is minimum in grid slab with bracing (M9) as shown in fig.-1.

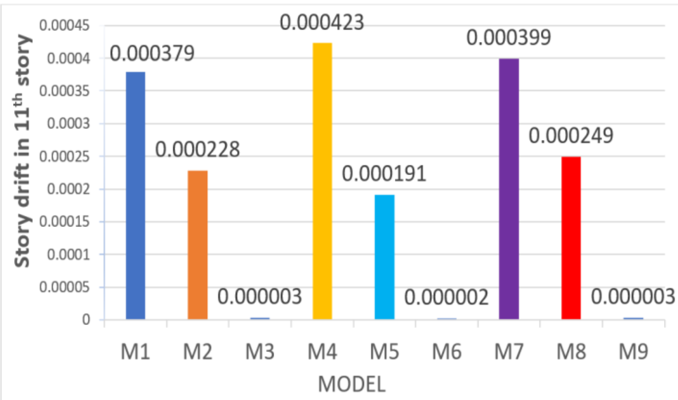

Fig -2: Variations of story drift in all models

Story drift is defined as ratio of difference between displacements of two consecutive floors to the height of that floor. From fig.-2, it can be noted that story drift values of different types of buildings are within the permissible limit as per IS 1893:2002 codal provision i.e., 0.4% of floor height. For this case we have 3000mm as floor height. Therefore, limited drift value is 12mm. Compared to all models storey drift is minimum in flat slab with bracing (M6).

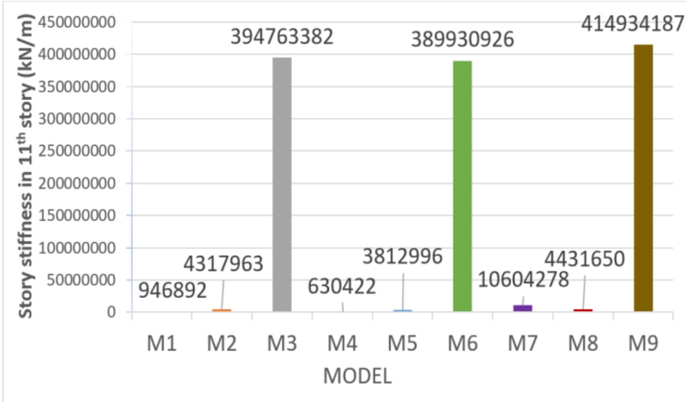

Fig -3: Variations of story stiffness in all models (kN/m)

Story stiffness is estimated as the lateral force producing unit translational lateral deformation in that story, with the bottom of story restrained from moving laterally, i.e., only translational motion of bottom of the story is restrained while it is free to rotate. Compared to all models story stiffness is minimum in flat slab with masonry (M4). While maximum story stiffness is in grid slab with bracing (M9) as shown in fig-3.

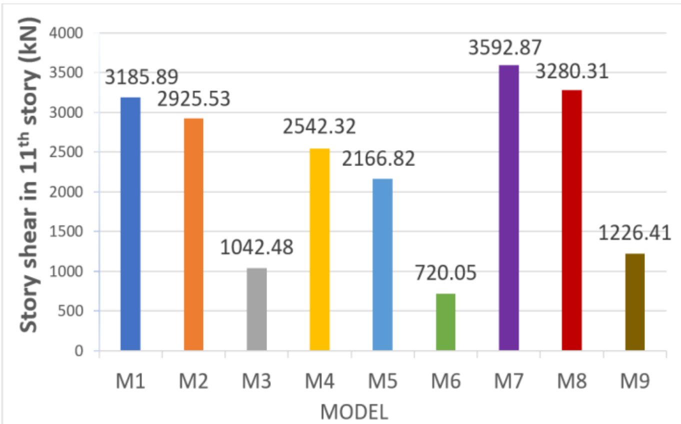

Fig -4: Variations of story shear in all models (kN)

Story shear is a lateral force acting on a story due to forces such as seismic and wind force. Compared to all the models story shear is minimum in flat slab with bracing (M6). While maximum story shear is in grid slab with masonry (M7) as shown in fig -4.

5. CONCLUSIONS

In this work an effort has been made to understand the performance of various slab systems like conventional slab, flat slab and grid slab systems. The analysis of the same is made to check the results such as story displacement, story drift, story stiffness, story shear. Based on this study following conclusions are presented here;

1. Conventional slab with bracing (M3) is showing less displacement as compared to conventional slab with masonry (M1) and conventional slab with shear wall (M2).
2. Flat slab with bracing (M6) is showing less displacement as compared to flat slab with masonry (M4) and flat slab with shear wall (M5).
3. Grid slab with bracing (M9) is showing less displacement as compared to grid slab with masonry (M7) and grid slab with shear wall (M8).
4. Conventional slab with bracing (M3) is showing less story drift as compared to conventional slab with masonry (M1) and conventional slab with shear wall (M2).
5. Flat slab with bracing (M6) is showing less story drift as compared to flat slab with masonry (M4) and flat slab with shear wall (M5).
6. Grid slab with bracing (M9) is showing less story drift as compared to grid slab with masonry (M7) and grid slab with shear wall (M8).
7. Conventional slab with bracing (M3) is showing higher story stiffness as compared to conventional slab with masonry (M1) and conventional slab with shear wall (M2).
8. Flat slab with bracing (M6) is showing higher story stiffness as compared to flat slab with masonry (M4) and flat slab with shear wall (M5).
9. Grid slab with bracing (M9) is showing higher story stiffness as compared to grid slab with masonry (M7) and grid slab with shear wall (M8).
10. Conventional slab with bracing (M3) is showing less story shear as compared to conventional slab with masonry (M1) and conventional slab with shear wall (M2).
11. Flat slab with bracing (M6) is showing less story shear as compared to flat slab with masonry (M4) and flat slab with shear wall (M5).
12. Grid slab with bracing (M9) is showing less story shear as compared to grid slab with masonry (M7) and grid slab with shear wall (M8).
13. Grid slab with bracing gives overall better performance as compared all other models.

REFERENCES

[1] Amit A. Sathawane, R.S. Deotale (2012), "Analysis and design of flat slab and grid slab and their cost comparison", International Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol. 01, Issue 3, pp. 837-848.

[2] Ramya D, Sai Kumar A.V.S (October, 2015), "Comparative study on design and analysis of multi-story building (G+10) by Staad.pro and ETABS software", International Journal of Engineering Sciences and Research Technology, ISSN: 2277-9655, Vol. 04, No. 10.

[3] Makode R. K, Akhtar S and Batham G (2014), "Dynamic analysis of multi-story RCC building frame with flat slab and grid slab", Al Int. Journal of Engineering, Research and Applications, Vol. 04, No. 02, Version 1, pp. 416-420.

[4] Bothara S D and Varghese V (2012), "Dynamic analysis of special moment resisting frame building with flat slab and grid slab", International Journal of Engineering Research and Applications, Vol. 02, No. 4, pp. 275-280.

[5] Sable K S, Ghodechor V A and Khandekar S B (2012), "Comparative study of seismic behaviour of multi-story flat slab and conventional reinforced concrete framed structures", International Journal of Computer Technology and Electronics Engineering, Vol. 02, No. 03.

[6] Ramakrishna Hegde, Chethana and Nanditha Vinod Kumar (2018), "Comparative study on seismic analysis of conventional slab, flat slab and grid slab system for a RC framed structures", International Research Journal of Engineering and Technology, e-ISSN: 2395-0056, Vol. 05 Issue: 09.

[7] Salman I. Khan and Ashok R. Mundhada (2015), "Comparative study of seismic performance of multi-storied RCC buildings with flat slab & grid slab", International Journal of Current Engineering and Technology, e-ISSN 2277-4106, Vol. 05, No. 03.

[8] Sudhir Singh Bhaduria, Nitin Chhugani (2017), "Comparative analysis and design of flat and grid slab system with conventional slab system", International Research Journal of Engineering and Technology, e-ISSN: 2395-0056, Volume: 04, Issue: 08.

[9] Vishesh P. Thakkar, Anuj K. Chandiwala and Unnati D. Bhagat (2017), "Comparative study of seismic behavior of flat slab and conventional RC framed structure", International Journal of Engineering Research & Technology, ISSN: 2278-0181, Vol. 06, Issue: 04.

[10] Gouramma G. and Jagadish Kori G. (2015), "Seismic performance of different RC slab systems for tall building", International Journal of Engineering Research, Vol. 03, Issue: 04.

[11] Vivek K and Rama Rao G V (2020), "Seismic analysis and comparison between flat slab and grid slab with different masonry in fills", International Journal of Advanced Science and Technology, Vol. 29, No. 4, pp. 11278-11289.

[12] Navyashree K, Sahana T.S (2014), "Use of flat slabs in multi-story commercial building situated in high seismic zone", International Journal of Research in Engineering and Technology, eISSN: 2319-1163, Vol. 03, No. 08.

[13] Utane S. N. and Dahake H. B. (2016), "Effect of shape irregularity on flat slab and waffle slab industrial building under lateral loading", International Journal of Engineering Science and Innovative Technology, Vol. 05, Issue: 02.

[14] Mohammed Fatir, Kolhar M. H and Anjum Algur (2016),"Relative study of seismic analysis between flat slab and grid slab of RCC structures with different masonry infills in two different zones", International Journal of Research in Engineering and Technology, eISSN: 2319-1163.

[15] Ashwini A. Gadling and Pajgade P. S. (2016),"Review on analysis and design of rcc shear walls with and without openings", International Journal of Engineering Research and Applications, Vol. 06, Issue: 12, ISSN : 2248-9622.
[16] Rameshkumar H. Mali and Shreepad Desai (2018),"Performance of flat slabs & flat plates in high seismic zone with varying stiffness", International Research Journal of Engineering and Technology, Vol. 05, Issue: 08.
[17] Reshma R. and Arunima V. R. (2017), "Seismic analysis of multi storied irregular building using flat slab and grid slab in zone III & V", International Research Journal of Engineering and Technology, Vol. 04, Issue: 06.
[18] More R. S, Sawant V. S. and Suryawanshi Y. R. (2013), "Analytical Study of Different Types of Flat Slab Subjected to Dynamic Loading", International Journal of Science and Research, Vol. 04, Issue: 07.
[19] DhanaSree S. and Arunakanthi E. (2020), "Seismic analysis of flat slab by using ETABS", International Journal of Innovative Technology and Exploring Engineering, Vol. 09, Issue: 03, ISSN: 2278-3075.
[20] IS 1893: Part1: 2016; Criteria for earthquake resistant design of structures: General provisions and buildings.

BIOGRAPHIES

Mr. SANJAY JANIWARAD
M.Tech in Structural Engineering,
Government Engineering College,
Haveri, Karnataka, India.

Mr. K P THEJASWI
Assistant Professor,
Department of Civil Engineering,
KLS Gogte Institute of Technology,
Belagavi, Karnataka, India.

Prof. K B PRAKASH
Principal,
Government Engineering College,
Haveri, Karnataka, India.