International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

Comparative Study of Waffle Slab and Conventional Slabs with Bracing System Using Time History Analysis

Shivani Singh[1], Vinayak Mishra[2]

[1](M.Tech. Structural Eng.), Civil Engineering Department, Institute of Engineering and Technology, Lucknow
[2]Assistant Professor, Civil Engineering Department, Institute of Engineering and Technology, Lucknow

---***---

Abstract - *An Earthquake ground motions are greatly influenced by the analysis and design of structure. Analysis of the structure with various slab arrangements, such as standard slabs, grid/waffle slabs, and braced structures, is the goal of this work. Traditional slab designs are typically not chosen for large span structures, but waffle slab and ribbed slab are the most appropriate and cost-effective options. However, these slabs have recently seen significant growth as these are lighter, durable and shows minimal signs of visible damage due to presence of waffle pod in the slabs. The bracing system allows load to be transmitted from the frame to the braces, increasing the structure's capacity to withstand lateral loads. Using ETABS software, time history analysis is performed in order to study the seismic stresses' effects on structures with different slab layouts. Storey drift, base shear, and storey displacement are among the parameters that have an impact on a structure's performance and are vital in determining how building will respond under seismic loads and other load combinations. IS 456-2000 code is taken into consideration for designing purpose. Live loads are taken in accordance to IS 875-part 1 and earthquake analysis is performed according to IS 1893-2016 Part 1*

Key Words: Waffle Slab, Conventional Slab, Bracing System, Time history analysis, Multi-storey building

1. INTRODUCTION

This An earthquake is strong shaking of the earth resulting from the energy released by tectonic plate movement. Often, earthquakes result in severe damage to life and property[1]. An expanding quantity of research has been conducted in this area due to the growing interest in designing earthquake-resistant constructions or buildings [2]. It is critical to ensure that the structure is capable of withstanding horizontal ground vibrations. RCC slab structure is an important part of the building that is designed to bear both vertical and horizontal loads during earthquakes. While, conventional slab is one that is supported by standard beams and columns. In a typical slab, the load is distributed from the slab to the beam, the beam to the column, and the column to the foundation. [3]. On the other hand, waffles are made to cover large span with least possible & have been widely used nowadays in both residential and commercial structures such as auditoriums, airports, theatre halls, and show rooms, roofing etc. where there is minimal or no need for columns. The severity of the quakes and the qualities of the structure determine a structure's strength and stability during an earthquake. Bracing is an economical and efficient way to strengthen the frame structures against lateral loads. The steel braces are usually placed in vertically aligned spaces.[4] Steel bracing are cost-effective, easy to install, takes up less area and provide the extra strength and stiffness. Braced frames are highly effective for structures subjected to severe lateral loads, such as earthquake loads. Time history analysis is an adaptive method for evaluating seismic behaviour of multi-storey building for the range of seismic intensities in order to understand how parameters such as storey shear , displacement, storey stiffness etc. affects seismic performance[5].The primary goal of the study is to evaluate the structural behaviour using waffle slab and conventional slab with X- type bracing in seismic zone IV in type II(medium) soil .

2. Literature Review:

Kaushal Vijay Rathod, Sumit Gupta[2020]: This research paper discusses the outcomes of a time history study performed on a ten-story building. There is a necessity to study seismic analysis in order to develop earthquake resistance structures in order to assure safety against seismic forces of multi-story buildings. This seminar report uses ETABS to do a nonlinear time history analysis on a ten-story RCC building frame while taking into account the timing of the 1940 El Centro Earthquake[6].

The work by **Dhanaraj M. Patil , Keshav K. Sangle [2015]:** The seismic response characteristics of various structures with distinct bracing methods are evaluated in order to evaluate seismic behaviour of each system.

Manoj Kumar M, Victor Samson Raj A,et al [2020]: A structure's ductility and energy dissipation capability play a key role in its ability to withstand seismic force. Bracing was utilized to increase a steel-framed structure's ability to dissipate energy. Here, a steel-framed G+14 story building was chosen for examination. The addition of the X, V, and zipper bracing increased the ability of these structures to dissipate energy. For the analytical analysis, STAAD PRO and SAP2000 are used. Pushover analysis is used to relate the performance of the various braced framed structures. For all steel frames, the positioning of the bracings on the edge structure has raised the base shear conveying limit, raised the performance point, and decreased the displacement of the roof.

As per previous study by **Mirza Mahaboob Baig, , Abdul Rashid , Y Pavan Sai Durga Reddy et.al 2020:** The purpose of their study is to determine behaviour of waffle slab constructions when the obstructing columns have been removed from the building's hall and room. This study concludes that ribbed/waffle slab structures are more susceptible to lateral loads than conventional slab structures because of an increase in self-weight. The research was carried out in seismic zone III and it was found that, in high seismic zones, ribbed slab structures perform less than conventional slab buildings because they have fewer columns, but that performance can be improved by structural retrofitting[4] .

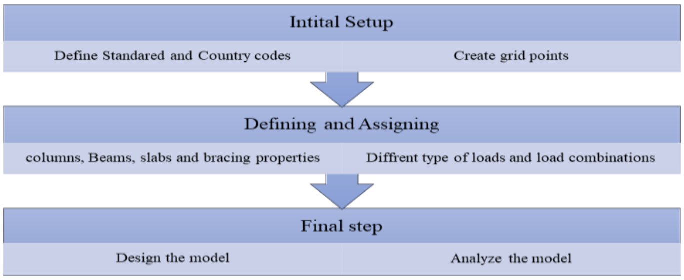
Sawwalakhe, A. K., & Pachpor, P. D. (2021): The study's goal is to determine which of the regular slab, flat slab with drop, and grid floor is the most economical. For a G+5 commercial multi-story structure with a flat slab, a conventional slab, and a gird slab, variables such as storey displacement, shear force, bending moment, and storeys drift were examined in this work. The total number of structures studied for this purpose is 18. All structures in India's seismic zone III have had their performance and behaviour examined using dead load, live load, and seismic load.[7].

2.1. Research Significance:

1. To compare the performance-based analysis of conventional slab and waffle slab in commercial building of seismic zone IV.
2. To perform time history analysis on conventional slab and waffle slab.
3. To study and compare the seismic parameters such as storey drift, storey shear, displacement, and storey stiffness, joint displacement etc.

3. Methodology:

This paper includes modelling G+4 building by creating a plan of dimension 45m*45m with storey height of 5m each. Defining & assigning properties of materials, RC frame section properties and load condition, using ETABSv16 software. Then we define time history function taking Chamoli earthquake data as reference for the analysis& the study is performed on seismic zone IV.



3.1 Modelling Parameters:

Table 1: Building parameter

Area of the building	45*45 m^2
Height of the building	25m
Columns	C1 450*450mm^2 C2 450*350 mm^2 C3 450*600 mm^2
Beams	B1 350*400 mm^2 B2 350*500 mm^2
Slab Type	Waffle slab
Slab thickness	90mm
Spacing of ribs	1500mm
Width of ribs	200mm
Overall depth	800mm
Bracings	X-type (ISA 200*200*15)

Table 2: - Material properties:

Name	Type	Design strength	E (M-pa)	Unit-weight (kN/m^3)
Concrete	M-30	Fc=30 M-pa	27386.13	25
HYSD	500	Fy=500 M-pa	200000	76.9729

3.2 Loading Conditions:

Seismic Loads	(IS 1893:2016)
Live load	5 KN/m^2 (IS 875-Part 2)
Dead load	6.8 KN/m^2 (IS 875-Part 1)
Seismic zone	IV
Seismic Zone Factor Z	0.24
Response Reduction Factor(R)	5
Importance factor (I)	1.5
Soil Type	II-(medium)
Scale factor (I.g/R)	1.962

Fig1. Loading Properties

3.2 Structural Modelling:

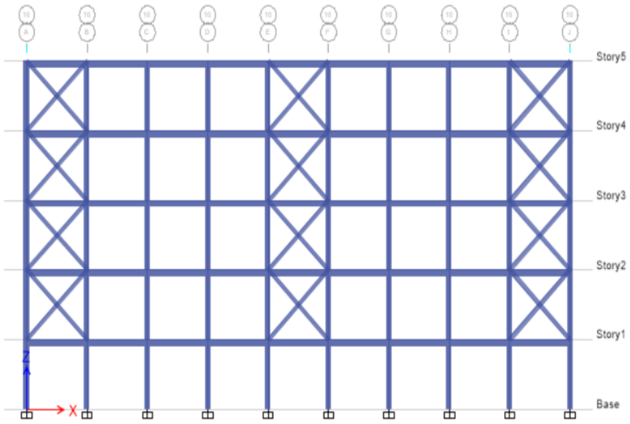


Fig 2: Elevation View Of Both Models

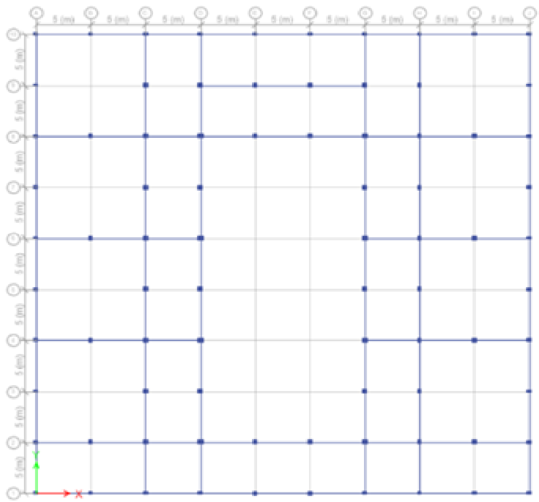


Fig 3: Plan View of The Slab

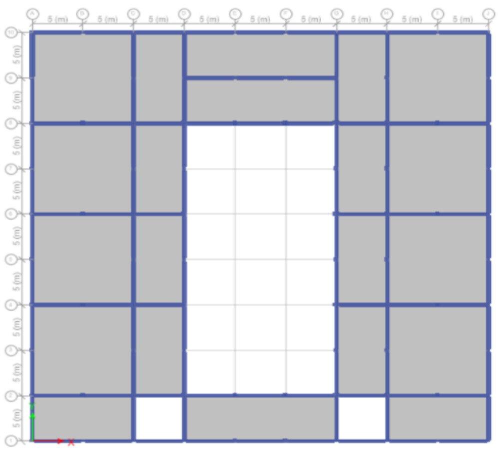


Fig 4: Conventional Slab

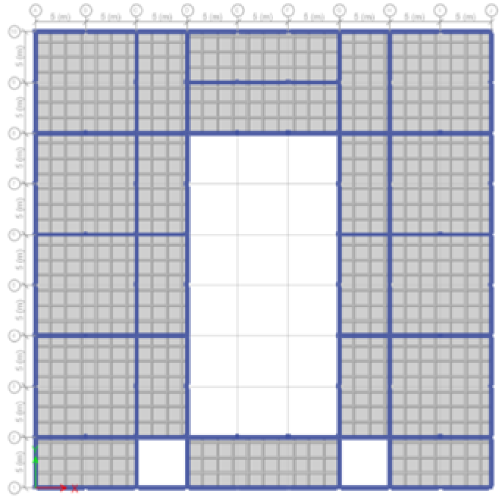


Fig 5: Waffle Slab

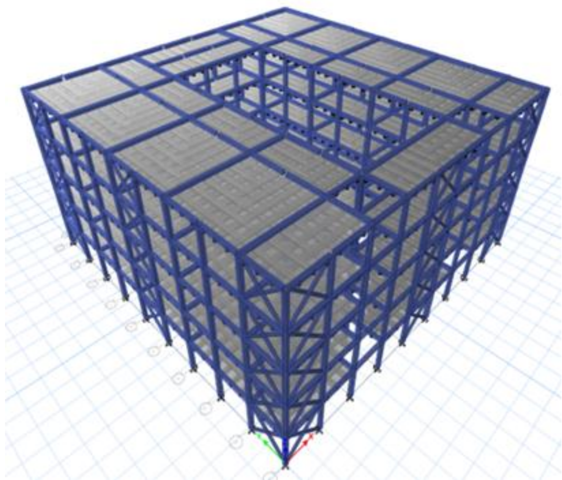


Fig 6: Waffle Slab with X-bracing

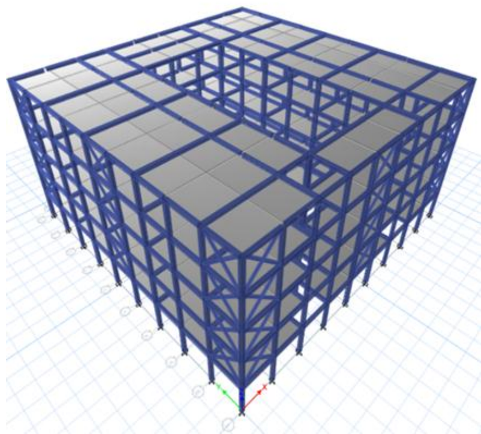


Fig 7: Conventional Slab with X-bracing

4. Results and Discussion:

As a result of comparison between the braced and non-braced G+4 structure , following inferences has been made:

4.1 Joint Displacement:

The maximum joint displacement at 23.24sec. is found to be 492.455mm in conventional slab. Similarly, the max value of joint displacement for waffle slab is found to be 263.666mm at 5.02sec. The value for waffle slab is observed to be 47% less than that of conventional slab.

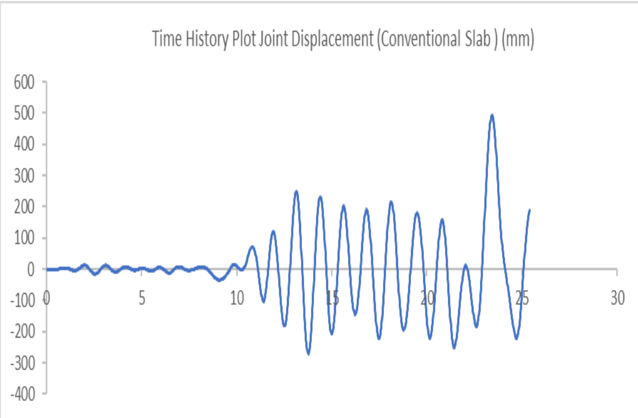


Chart 1: Displacement due to Conventional Slab

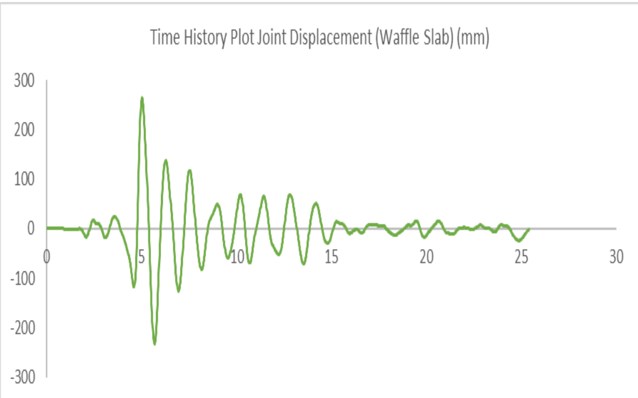


Chart 2: Displacement due to Waffle Slab

4.2 Storey Drift:

As per IS 1893 (part 1): **2002 CI. 7.11. 3**, the storey drift limit is 0.004 times the storey height[8]. and according to the graphs obtained maximum drift is 0.001655 on waffle slab and .0010588 on conventional slab which is within the permissible limits.

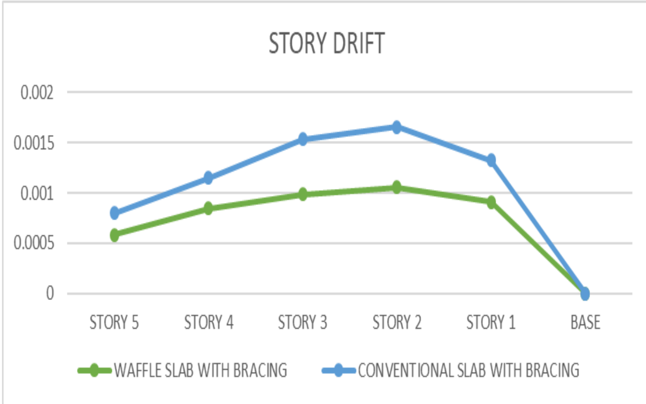


Chart 3: Storey Drift

4.3: Storey Stiffness:

Storey stiffness is a more for conventional slab structure in comparison to waffle slab structure. The value gradually increases moving from bottom to top storey reaches peak and fall suddenly. The maximum values obtained for conventional slab and waffle slab are 668862.633 kN/m & 657529.69 kN/m.

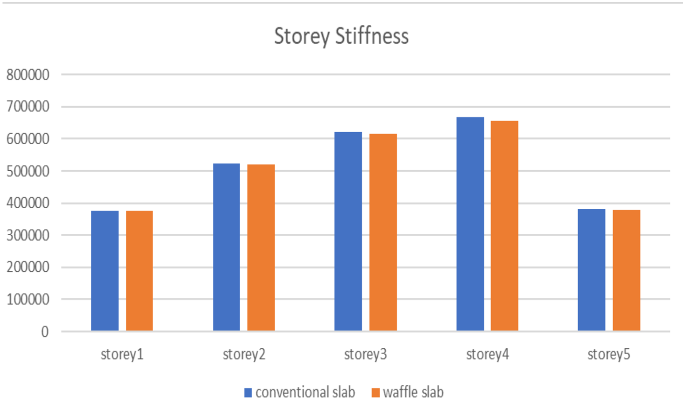


Chart 4: Storey Stiffness

4.4 Storey Displacement: Storey displacement is maximum at the top storey (27.361mm) for conventional slab and minimum at the structure's base. While for waffle slab the maximum displacement is (24.26mm). Max value of storey displacement for waffle slab is approx. 16% less than the maximum value of displacement in the other.

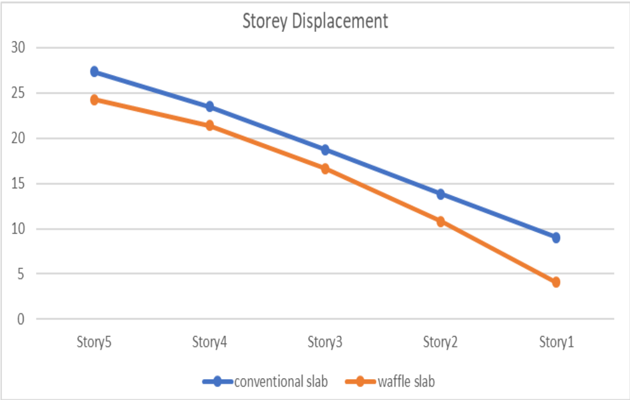


Chart 5: Displacement of buildings

5. Conclusions:

Comparative study of waffle slab and conventional slab both having bracing system using time history analysis shows that waffle slab has approx 12% less displacement than conventional slab i.e, waffle slab performs better when it comes to lateral joint displacement of joint label 1, Storey 5. While the maximum values of storey drift conclude that waffle slab shows lower drift i.e. approx. 57% lower than conventional slab storey drift values. Any storey's storey drift induced by the required minimum designed lateral force, with a partial load factor of 1.0, may not be larger than 0.004 times the storey height, per IS 1893 Part 1: 2002 Cl. 7.11.3. The plots show a maximum drift of 0.02, which is within acceptable bounds. Moreover, conventional slab shows slightly lesser Storey stiffness as compared to waffle slab [9]. However, storey displacement values conclude that conventional slab displaces 11% more than waffle slab. Hence, this can be concluded from the results that conventional slab lags behind in some aspects such as storey displacement and drift in comparison to waffle slab i.e, waffle slab performs better with bracings which reduces deflections and increases stability of the structure.

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

6. References:

[1] C. H. Lokesh Nishanth, Y. Sai Swaroop, D. C. K. Jagarapu, and P. K. Jogi, "Analysis and design of commercial building with different slab arrangements using ETABS," in *Materials Today: Proceedings*, Jan. 2020, vol. 33, pp. 700–704. doi: 10.1016/j.matpr.2020.05.823.

[2] V. P. Thakkar, A. K. Chandiwala, and U. D. Bhagat, "Comparative Study of Seismic Behavior of Flat Slab and Conventional RC Framed Structure." [Online]. Available: www.ijert.org

[3] "COMPARATIVE STUDY OF THE SEISMIC PERFORMANCE OF RCC BUILDING WITH RIBBED SLAB AND GRID SLAB 140."

[4] M. M. Baig, A. Rashid, Y. P. S. D. Reddy, and T. G. N. . V. Krishna, "A comparative study on seismic analysis of G+6 building with ribbed slab & conventional slab using SAP2000 software," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1112, no. 1, p. 012026, Apr. 2021, doi: 10.1088/1757-899x/1112/1/012026.

[5] D. M. Patil and K. K. Sangle, "Seismic Behaviour of Different Bracing Systems in High Rise 2-D Steel Buildings," *Structures*, vol. 3, pp. 282–305, Aug. 2015, doi: 10.1016/j.istruc.2015.06.004.

[6] K. V. Rathod and S. Gupta, "A nonlinear time history analysis of ten storey rcc building," *Int. Res. J. Eng. Technol.*, vol. 7, no. June, pp. 56–2395, 2020.

[7] A. K. Sawwalakhe and P. D. Pachpor, "Comparative Study Of Conventional Slab, Flat Slab And Grid Slab Using ETABS," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1197, no. 1, p. 012020, Nov. 2021, doi: 10.1088/1757-899x/1197/1/012020.

[8] I. Standard, "la jpukvksa osQ HkwdEijks / h fMtkbu osQ ekunaM Criteria for Earthquake Resistant Design of Structures," vol. 1893, no. December, 2016.

[9] IS 456, "Plain Concrete and Reinforced," *Bur. Indian Stand. Dehli*, pp. 1–114, 2000.

[10] Rathod, K. V., & Gupta, S. (2020). A nonlinear time history analysis of ten storey RCC building. *International Research Journal of Engineering and Technology*, *8*.