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Comparative Study of the Seismic Performance of Multi-storey Buildings with Different Structural Systems

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Abstract: As per the previous records of earthquakes, there is an increase in the demand of earthquake resistance structures. So it is necessary to design and analyse the structure by considering seismic effect. To resist the seismic forces different structural systems are commonly used in multi-storey buildings. The aim to this work is to determine to most effective RC frame of 32-storied and 64-storied structure with lateral load resisting system such as Frame, Frame Tube, Braced Tube, Diagrid, Tube-in-tube, and Shear Wall-frame, Outrigger Structures. The behaviour of RC frame with different structural systems has been studied and conclusions are made by comparing Base shear, maximum storey drift, top storey displacement, top drift, time period as per IS1893-2016 (Part-1). The building is modelled and analysed using software ETABS 21.

Keywords: Frame, Frame Tube, Braced Tube, Diagrid, Tube-in-tube, Shear Wall-frame, Outrigger Structures, Dynamic Method (Response Spectrum Method and Time History Method), Story drift, Displacement, Etabs

I. INTRODUCTION

With the continuous increase in global population, there has been a significant rise in land usage. This phenomenon is referred to as urban expansion. Urban expansion poses several environmental challenges, such as increased air pollution and higher energy consumption. To accommodate the growing population while minimizing these adverse effects, the construction of high-rise or tall buildings becomes essential. To ensure the stability and safety of tall structures, especially under lateral forces, different structural systems are implemented. These include rigid frame structures, braced frame structures, shear wall systems, diagrid structures, outrigger systems, and tubular structures. One of the major concerns in the design of high-rise buildings is their performance during earthquakes. Earthquakes generate substantial horizontal forces that can severely damage structural components, potentially leading to collapse. To prevent such failures, it is crucial to incorporate lateral force-resisting systems into the design. These systems not only enhance the building's resistance to seismic and wind forces but also provide the necessary stiffness and strength to withstand both vertical and lateral loads. In this study investigate and compares the Base shear, maximum storey drift, top storey displacement, top drift, time period of RC frame of 32-storied and 64-storied structure with lateral load resisting system such as Frame, Frame Tube, Braced Tube, Diagrid, Tube-in-tube, and Shear Wall-frame, Outrigger Structures. The building is modelled and analysed using software ETABS 21. Non-linear Dynamic Analysis (Time History Analysis) is carried out for different structural systems and Base shear, maximum storey drift, top storey displacement, top drift, time period is calculated and compared.

II. STRUCTURAL MODELING

A. Geometrical Properties of Building

Table-1 Geometrical Properties of Building		
S.No.	Particular	Dimensions
1	Building Plan Area	900 square meter
2	Typical Storey Height	3 metre
3	Column Cross Section Size	1000x1000mm
4	Beam Cross Section Size	300x600mm
5	Diagrid Cross Section Size	600x600mm
6	Bracing Cross Section Size	600x600mm
7	Shear Wall Thickness	300mm
8	Slab Thickness	200mm
9	Beam-Column Joint	Rigid
10	Beam-Diagrid Joint	Pinned
9	Foundation	Fixed at ground level

B. Material Properties of Buildings

Table-2 Geometrical Properties of Building		
S.No.	Material	Grade
1	Concrete (beam, bracing, column, diagrid)	M30
2	Concrete (shear wall)	M30
3	Concrete (slab)	M30
4	Reinforcement (rebar)	HYSD-500

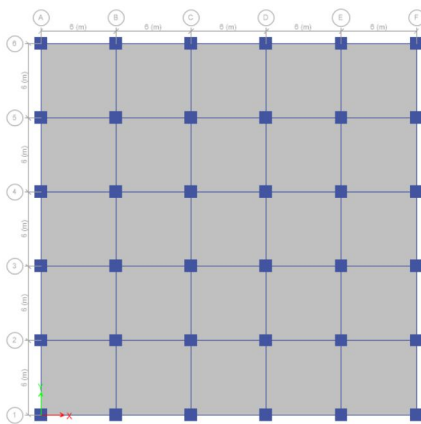


Fig-1 Typical Braced Frame plan/
Conventional Frame plan

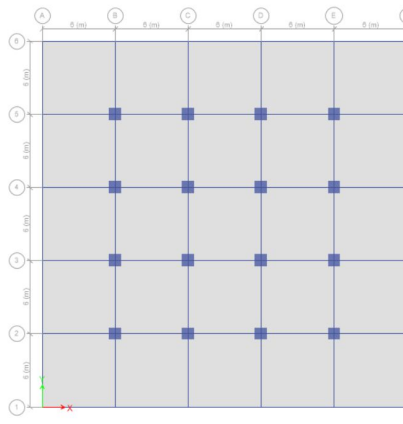


Fig-2 Typical Diagrid Frame plan

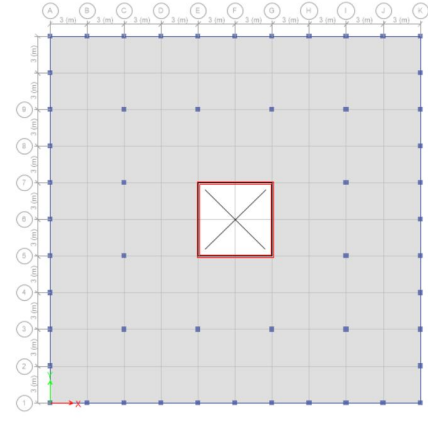


Fig-3 Typical Frame Tube plan

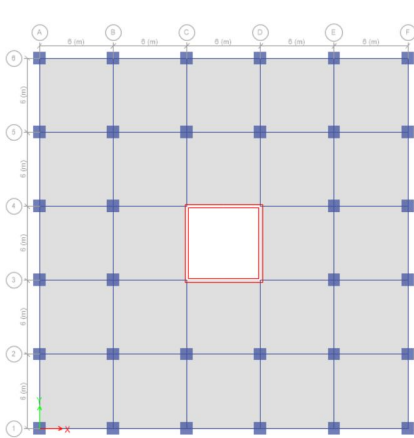


Fig-4 Typical Outrigger plan/
Typical Shear wall Frame plan

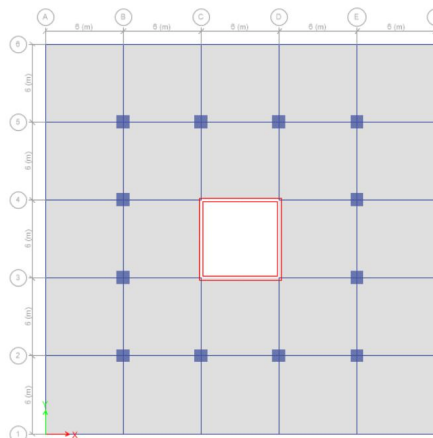


Fig-5 Typical Tube in Tube Frame plan

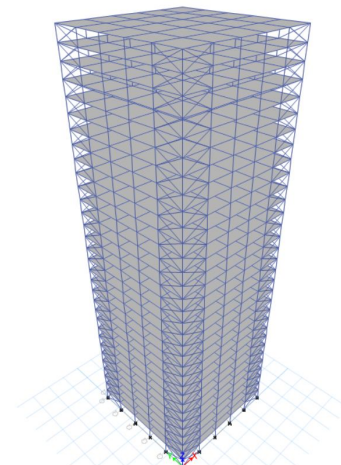


Fig-6 32-Storey Braced Frame 3D
view

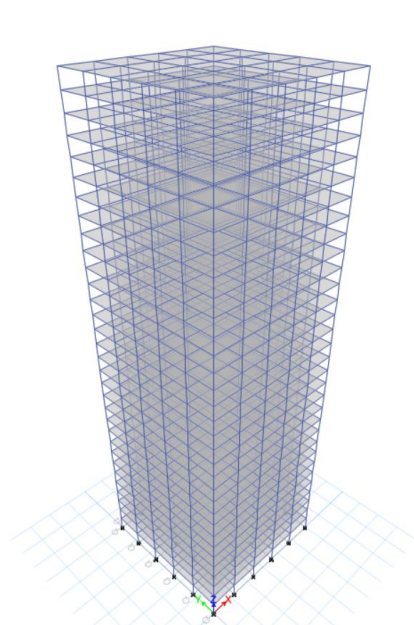


Fig-7 32-Stoery Conventional Frame 3D

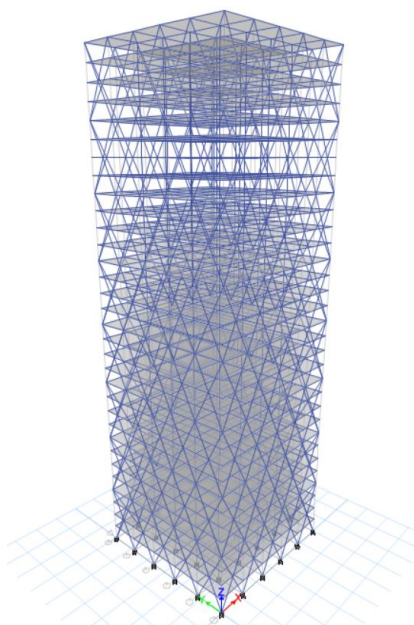


Fig-8 32-Stoery Diagrid Frame 3D view

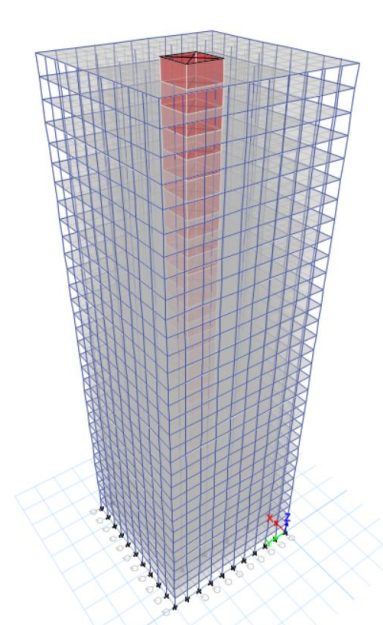


Fig-9 32-Stoery Frame Tube 3D view

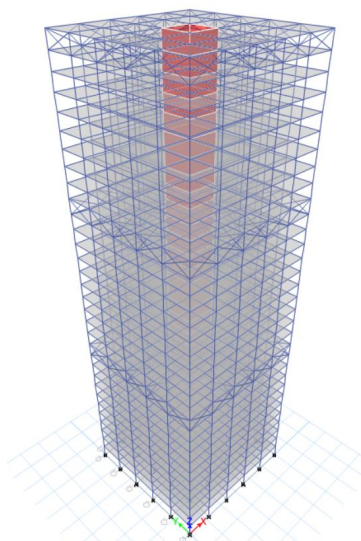


Fig-10 32-Stoery Outrigger 3D view

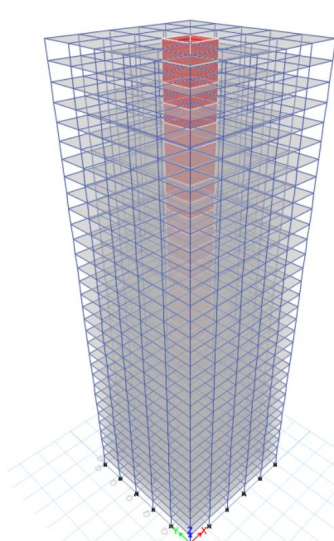


Fig-11 32-Stoery Shear wall Frame 3D view

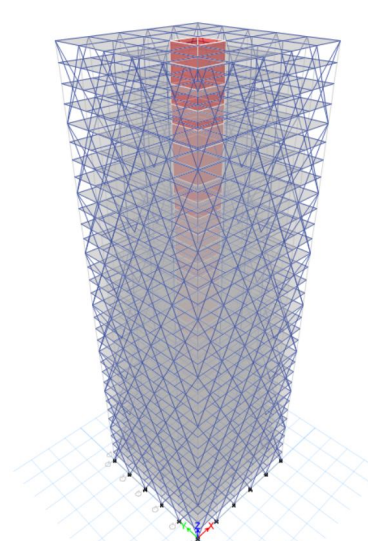


Fig-12 32-Stoery Tube in Tube Frame 3D

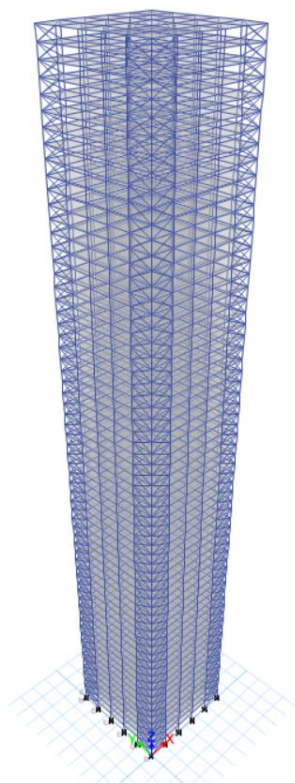


Fig-13 64-Stoery Braced
Fame 3D view

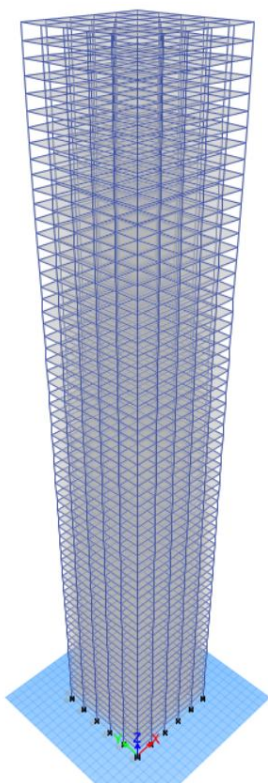


Fig-14 64-Stoery Conventional
Fame 3D view

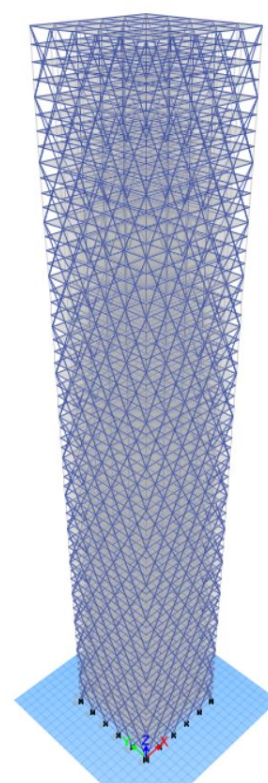


Fig-15 64-Stoery Diagrid
Fame 3D view

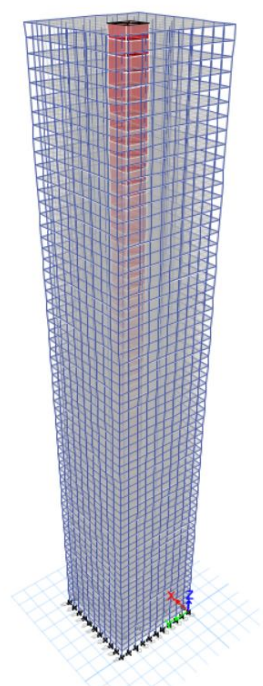


Fig-16 64-Stoery Frame Tube
3D view

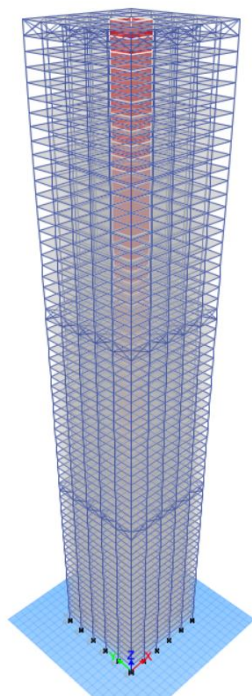


Fig-17 64-Stoery Outrigger
3D view

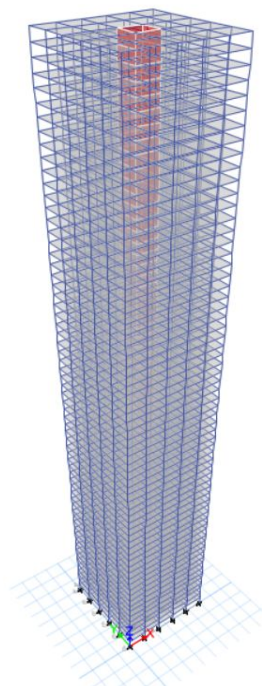


Fig-18 64-Stoery Shear wall Frame
3D view

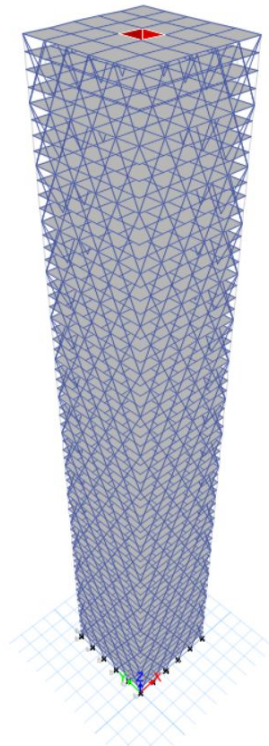


Fig-19 64-Stoery Tube in Tube Frame 3D

III.TIME HISTORY ANALYSIS ETABS

- 1) Time History Analysis: It is an analysis of dynamic response of the structure at each instant of time, when its base is subjected to a specific ground motion time history.
- 2) Loads: All loads action on the building except wind load were considered. These are-
 - Dead load (member self-weight)
 - Live load (as per IS 875 part-2-1987)
 - Lateral load due to earthquake (as per IS 1893 part-1-2016)
- 3) Member loading:
 - a. Self-weight (software calculated)
 - b. Live load: 3KN/m^2
 - c. Earthquake load in X and Y direction. Table 3 shows the seismic data.

Table-3 Seismic data		
1	Earthquake zone	2
2	Importance factor	1
3	Type of soil	Soft
4	Response reduction factor	5
5	Time period	Program calculated
6	Damping ratio	5%
7	Time history data	Bhuj india

IV.ANALYSIS RESULTS

The analysis of all the models has been done and results are shown below the parameter which were studied are on the behavior of the building during seismic excitation are Base shear, maximum storey drift, top storey displacement, top drift, time period.

A. Base Shear

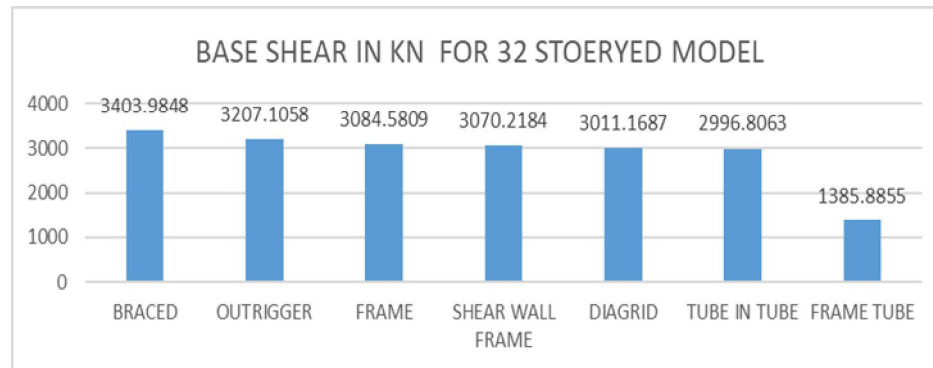


Fig-20 32-Storey Base Shear.

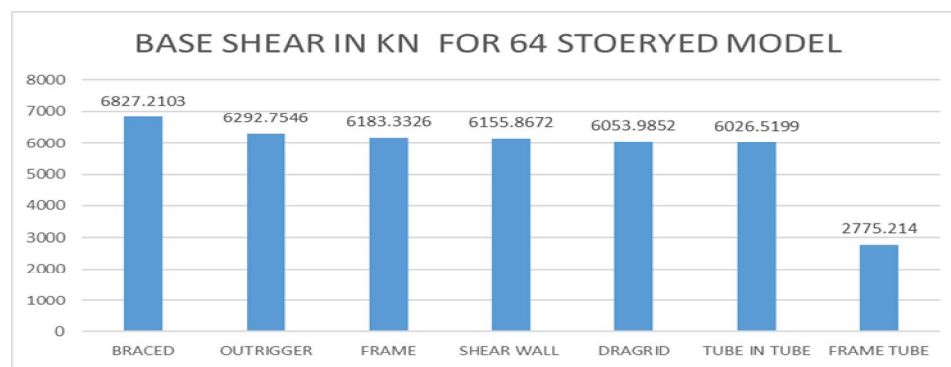


Fig-21 64-Storey Base Shear.

B. Maximum Storey Drift

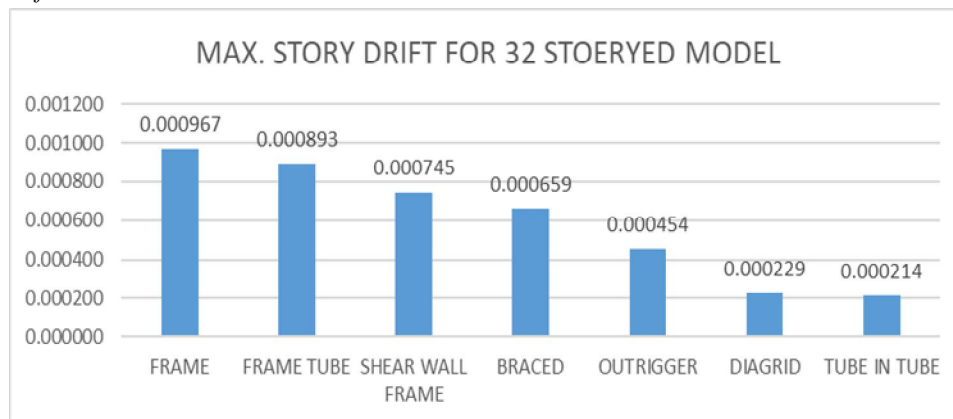


Fig-22 32-Storey maximum story drift.

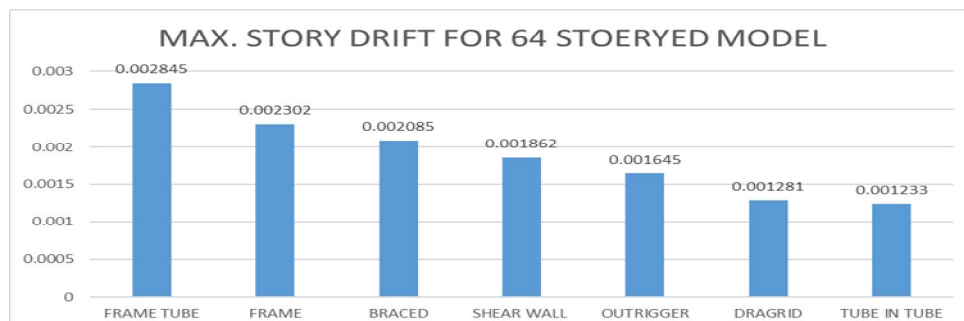


Fig-23 64-Storey maximum story drift.

C. Top Story Displacement

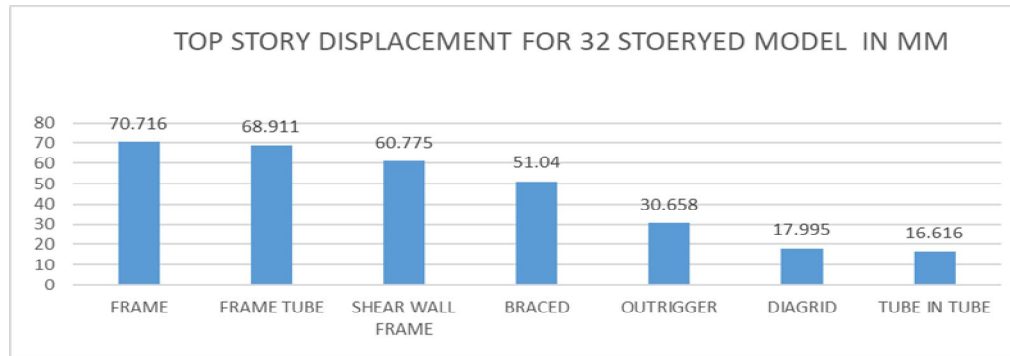


Fig-24 32-Stoery top story drift.

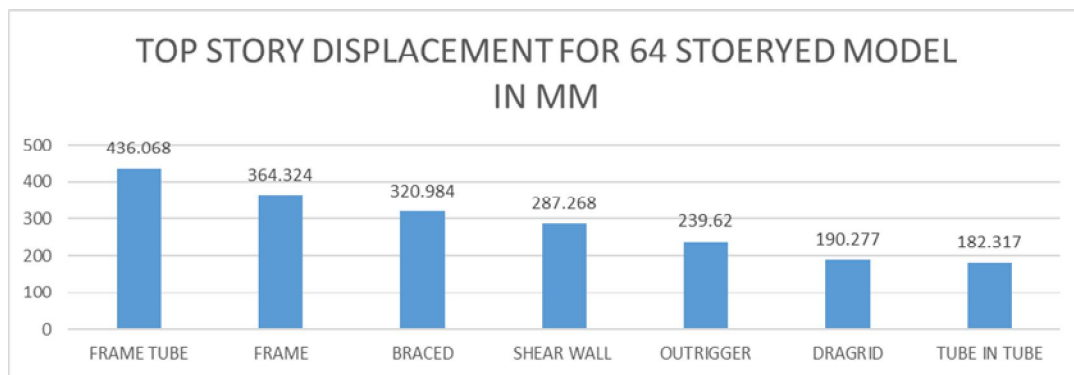


Fig-25 64-Stoery top story drift.

D. Top Drift

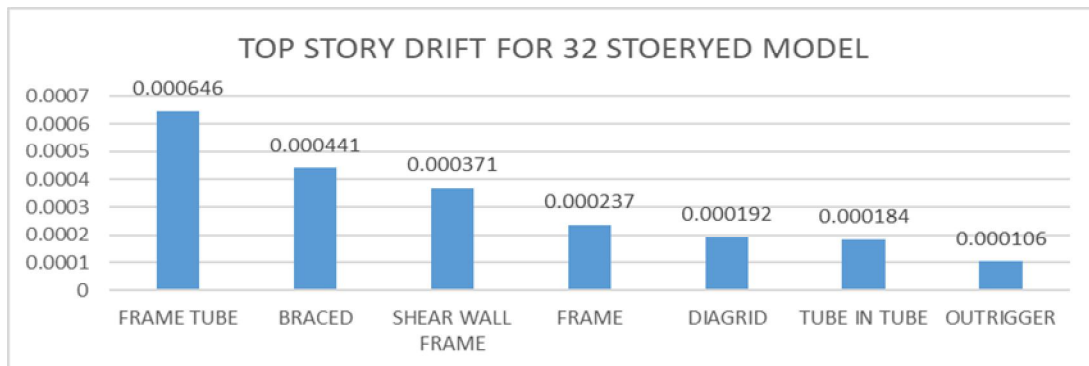


Fig-26 32-Stoery top story drift.

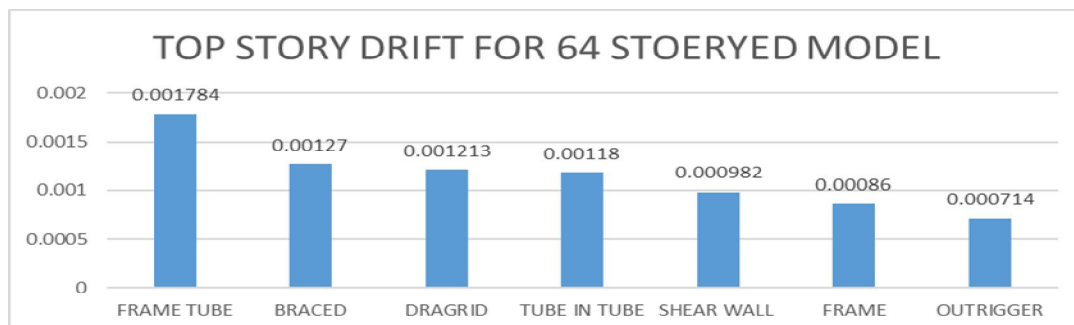


Fig-27 64-Stoery top story drift.

E. Time Period

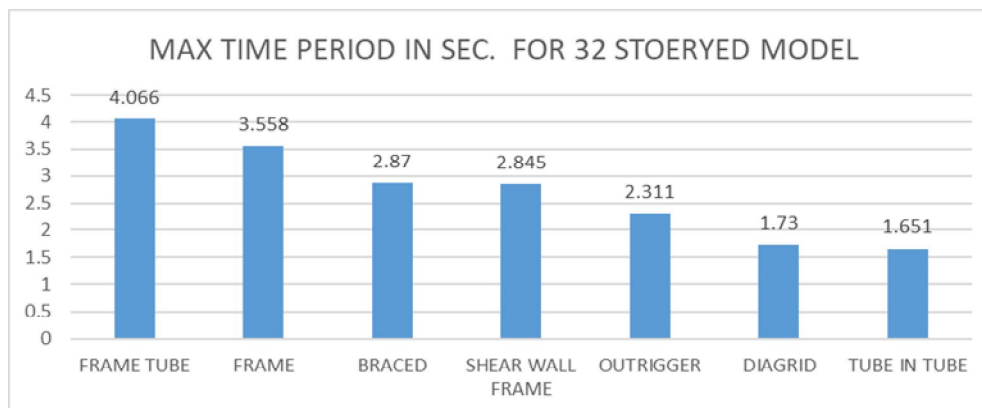


Fig-28 32-Stoery time period

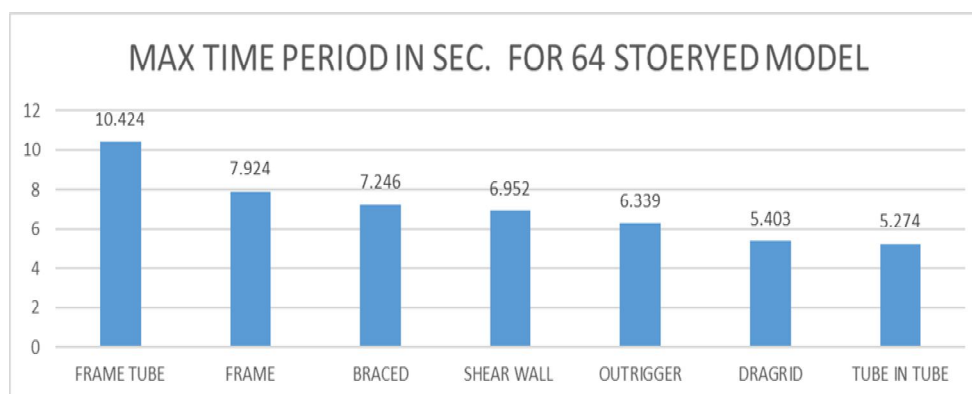


Fig-29 64-Stoery time period

V. CONCLUSIONS

- 1) Outrigger and Braced Systems exhibit very high flexibility in some cases, which might not be ideal unless well-controlled through damping or other seismic measures. They are effective in limiting drift but may need careful detailing to avoid excessive displacements or resonances.
- 2) Diagrid and Tube-in-Tube Systems show shorter time periods, suggesting high stiffness and better control over lateral displacements-suitable for tall buildings in high seismic zones.
- 3) Shear Wall Frame and Frame Tube Systems provide a balanced seismic response, making them reliable for medium- to high-rise buildings with moderate-to-high seismic demand.
- 4) The presence of multiple entries with widely varying time periods for the same system indicates that design variations (geometry, material properties, damping ratios) significantly influence seismic behavior.

While in comparison with 64 storey models-

- a) Braced, Frame, and Outrigger systems show the highest increase in time periods, suggesting these are most impacted by height and may need additional seismic damping or energy dissipation systems in taller configurations.
- b) Tube in Tube and Frame Tube systems maintain relatively lower time periods, indicating higher stiffness and potential for better seismic performance in controlling drift and reducing base shear.
- c) Systems like Shear Wall and Diagrid (or Diagrid) are known for stiffness and lateral strength, and their performance in tall structures reinforces their value in seismic design.

REFERENCES

- [1] Ali, S. M., Raju, V. D., & Raza, M. N. (2024). Comparative study on Full outrigger system and Half outrigger system in tall building with varying configuration. ZKG International, IX(I), 4049–4063.

- [2] Anil.K.Chopra (2007), "Text book on Dynamics of Structures -Theory and Application to Earthquake Engineering".
- [3] B. S. Taranath, "Reinforced Concrete Design of Tall Buildings".
- [4] Babhulkar, S., Dabhekar, K. R., Sanghai, S. S., & Khedikar, I. P. (2021). Comparative study of seismic behavior of diagrid structure with conventional structure. In IOP Conference Series: Materials Science and Engineering (Vol. 1197, No. 1, p. 012049). IOP Publishing. <https://doi.org/10.1088/1757-899X/1197/1/012049>
- [5] Bhale, S. A., & Shimpale, P. M. (2022). Analytical Study on Seismic Performance of Diagrid Structural System. Journal of Emerging Technologies and Innovative Research (JETIR), 9(10), 2210202. Available at: [JETIR](<https://www.jetir.org>).
- [6] Bhat, A. F., & Kumar, V. (2022). Comparative study on deflection of a multistoried building with shear wall and core wall. International Journal for Research in Applied Science & Engineering Technology, 10(V), 3743–3758. <https://doi.org/10.22214/ijraset.2022.43212>
- [7] Bhuta, D. C., & Pareekh, U. (2016). Comparative study on lateral load resisting system in tall building. International Journal of Science Technology & Engineering, 2(11), 320-327. Retrieved from <https://www.ijste.org/>
- [8] Borkar, S., Dabhekar, K., Khedikar, I., & Vaidya, N. (2021). Comparative study of flat slab structure and conventional slab structure. IOP Conference Series: Materials Science and Engineering, 1197, 012072. <https://doi.org/10.1088/1757-899X/1197/1/012072>
- [9] Dharanya, A., Gayathri, S., & Deepika, M. (2017). Comparison study of shear wall and bracings under seismic loading in multi-storey residential building. International Journal of ChemTech Research, 10(8), 417–424.
- [10] Dudhe, Y., & Ambadkar, S. (2020). Comparative analysis of different lateral load resisting system for high rise building. <https://doi.org/10.22214/ijraset.2020.6255>
- [11] George, A. R., & Umamaheswari, R. (2021). Comparative Study on RCC Framed Structures with and Without Shear Wall at Seismic Zones II and V. International Research Journal of Engineering and Technology (IRJET), 8(7), 2822–2826. Retrieved from [IRJET](<https://www.irjet.net>).
- [12] Hasrat, H. A. (2021). Comparative Study of Various High Rise Building Lateral Load Resisting Systems for Seismic Load & Wind Load: A Review. International Research Journal of Engineering and Technology (IRJET), Volume 08, Issue 01, Pages 291–297.
- [13] IS: 456 (2000), 'Code of practice for Plain and Reinforced Concrete (fourth revision)', Bureau of Indian Standard, New Delhi.
- [14] IS: 875 Part 1, 2 and 5 (1987), 'Code of practice for Design Load (other than earthquake) for Buildings and Structures', Bureau of Indian Standard, New Delhi.
- [15] IS: 1893 Part I (2016), 'Code of practice for Criteria for Earthquake Resistance Design of Structure: General provisions and Building', Bureau of Indian Standard, New Delhi.
- [16] IS: 4326 (1993), 'Code of practice for Earthquake Resistant Design and Construction of Buildings (Second Revision)', Bureau of Indian Standard, New Delhi.
- [17] IS: 13920 (1993), 'Code of practice for Ductile detailing of Reinforced Concrete Structures Subjected to Seismic Forces', Bureau of Indian Standard, New Delhi.
- [18] Jaiswal, R., & Mahajan, A. (2023). Comparative analysis of building with shear wall and diagrid structure. IOP Conference Series: Earth and Environmental Science, 1110, 012033. <https://doi.org/10.1088/1755-1315/1110/1/012033>
- [19] Kurey, A., Hanjage, S., Chause, M., Gawande, S., & Kondekar, A. R. (2021). Comparative Study of Tube in Tube System and Bundled Tube System for High Rise Building. International Journal of Creative Research Thoughts (IJCRT), Volume 9, Issue 6, ISSN: 2320-2882. Available at: [IJCRT](<https://www.ijcrt.org>).
- [20] Mayuri Borah and S Choudhury, "Seismic Performance of Tall Buildings with Different Structural Systems" 2022, International Conference on Advances in Structural Mechanics and Applications (ASMA-2021), National Institute of Technology Silchar, India. from [ResearchGate](<https://www.researchgate.net/publication/363662695>)
- [21] Mohammed Mudabbir Ahmed and Khaja Musab Manzoor, A Comparative Study on the Seismic Performance of Multi-storey Buildings with Different Structural Systems IOP Conference Series: Earth and Environmental Science, 1026(1), 012020. <https://doi.org/10.1088/1755-1315/1026/1/012020>
- [22] Oduor, G., Abuodha, S., & Mumenya, S. (2023). A Comparative Study of the Dynamic Earthquake Behavior of Braced Tube, Diagrid, Tube-in-tube, and Shear Wall-frame Structures. Andalusian International Journal of Applied Science, Engineering, and Technology, Volume 03, Issue 01, Pages 67-79. DOI: [10.25077/aijaset.v3i01.72](<https://doi.org/10.25077/aijaset.v3i01.72>)
- [23] Pradhana, R. A., Pratama, M. M. A., Santoso, E., & Karjanto, A. (2019). Structural performance of multi-storey building using flat slab and conventional slab to seismic loads (Case study: Faculty building of Sport Science in Universitas Negeri Malang, Indonesia). IOP Conference Series: Materials Science and Engineering, 669(1), 012053. <https://doi.org/10.1088/1757-899X/669/1/012053>
- [24] Raut, R., & Dahake, H. (2020). Comparison of outrigger system in tall buildings. JES Journal of Engineering Sciences, 11(7), 332-336. Retrieved from <https://www.jespublication.com>
- [25] Sandeep, G. S., & Patil, G. (2017). Comparative Study of Lateral Displacement and Storey Drift of Flat Slab and Conventional Slab Structures in Different Seismic Zones. International Journal of Civil Engineering and Technology, 8(7), 567–580. Retrieved from <http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=7>
- [26] Shah, A. G., Patel, V. B., & Patel, S. B. (2020). Parametric Study of Tall Structures with Diagrid. Journal of Emerging Technologies and Innovative Research (JETIR), Volume X, Issue X, ISSN: 2349-5162. Available at: [ResearchGate](<https://www.researchgate.net/publication/342550519>)
- [27] Shah, M. I., Mevada, S. V., & Patel, V. B. (2016). Comparative study of diagrid structures with conventional frame structures. International Journal of Engineering Research and Applications, 6(5, Part 2), 22–29. Retrieved from <https://www.researchgate.net/publication/302928668>
- [28] Thapa, A., & Sarkar, S. (2017). Comparative study of multi-storied RCC building with and without shear wall. International Journal of Civil Engineering, 6(2), 11-20. Retrieved from <https://www.researchgate.net/publication/316619653>
- [29] Thejas H K, Laxmi S, & Abhilash D T. (2020). Comprehensive Analysis of Outrigger Building System. International Journal of Civil Engineering and Technology (IJCIET), 11(1), 25-31. Available at: [IAEME](<http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=11&IType=1>)
- [30] Vadagave, P., & Sawant, P. (2023). Comparative Study of High Rise Building with Outrigger and Shear Wall. International Research Journal of Modernization in Engineering Technology and Science (IRJMETS), Volume 05, Issue 09, Pages 1135–1145. <https://doi.org/10.56726/IRJMETS44690>
- [31] Vanshaj, K., Singh, H. K., & Mishra, A. (2022). Comparative Study of High Rise Steel Structure with and without Bracing System. International Research Journal of Modernization in Engineering Technology and Science, 4(3), 1781-1786. Available at: [IRJMETS](<https://www.irjmets.com>).



- [32] Wani, S. S., Kokate, P. G., Londhe, A. S., Malge, S. B., & Potdar, A. N. (2022). Comparative analysis of diagrid structural system. International Journal of Civil Engineering and Architecture Engineering, 3(1), 33–40. Retrieved from <https://www.researchgate.net/publication/361323665>



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