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# A Literature Review on 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 present paper gives an overview of different research work to be done regarding the study of RC frame multi-story 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.***
***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.

This review paper focuses on the research work of various scholar's doing the analysis of structures equipped with various lateral force-resisting systems to evaluate their effectiveness and contribution to earthquake resistance.

## II. LITERATURE REVIEW

Research on various structural systems for tall buildings began in the mid-20th century, driven by the need to build taller, safer, and more efficient structures in rapidly urbanizing cities. The development of these systems has been guided by advancements in materials. There is some latest work is reviewed below-

Bhuta, D. C., & Pareekh, U. (2016). The research compares lateral load-resisting systems in tall buildings: shear walls, outriggers, and diagrid systems. Using dynamic analyses like response spectrum and time history with ETABS, it evaluates displacement, drift, base shear, and time period. Diagrid systems showed minimal displacement, while outriggers effectively reduced drift, enhancing stability against seismic forces.

Shah, M. I et al., (2016). The study compares diagrid and conventional structural systems for tall buildings, analysing performance under lateral loads using ETABS. Diagrids showed superior efficiency in stiffness, displacement control, and steel usage, especially in taller buildings. The results highlight diagrids as a structurally and aesthetically superior option for modern high-rise construction.

Dharanya, A. et al., (2017). The study examines the seismic performance of multi-storey residential buildings reinforced with shear walls and cross bracings.

Using ETABS software and equivalent static analysis, it compares lateral stability, base shear, displacement, and drift. Results show shear walls significantly enhance stability and minimize displacement, outperforming bracings in high-seismic areas like Bhuj, India.
Sandeep, G. S., & Patil, G. (2017). The study compares seismic performance of flat slab and conventional slab structures in various seismic zones using response spectrum analysis. It evaluates lateral displacement and storey drift for 5, 10, and 15-story buildings. Results show conventional slabs have greater lateral stiffness, while flat slabs can be adopted based on storey drift suitability.
Thapa, A., & Sarkar S. (2017). The study compares the seismic behaviour of multi-storied RCC buildings with and without shear walls under dynamic loading. Analysing G+5, G+10, and G+15 models via static and response spectrum methods, it finds that shear walls improve lateral stiffness and reduce displacements. Their effectiveness grows with building height, enhancing earthquake resistance significantly.
Ajaykumar G. Shah et al., (2019) The study analyses tall buildings with diagrid structural systems using ETABS 2017, focusing on different module sizes (4, 6, 8 storeys) across buildings up to 60 storeys. Results show that 4-storey modules offer superior stiffness, lower displacement, and better drift control, making them optimal for resisting lateral loads like wind and earthquakes.
Pradhana, R. A. et al., (2019). The study analyses flat slab and conventional slab systems in a multi-storey building under seismic loads using ETABS and SAP2000. It compares factors like base shear, stiffness, fundamental period, and storey drift. Findings reveal flat slabs reduce weight but have higher drifts, while conventional slabs offer greater stiffness and seismic resistance.
Shravani A. Bhale, Pandit M. Shimpale et al (2019). The study investigates the seismic performance of diagrid structural systems. Using response spectrum analysis via ETABS software, it compares a 16-storey diagrid building with a conventional RCC structure. Parameters such as storey displacement, drift, shear, and time period reveal diagrid structures exhibit superior stiffness, efficiency, and resistance to seismic forces.
Raut, R., & Dahake, H. (2020) The study compares outrigger systems in tall buildings to improve lateral stability. Analysing different models, it examines story drift, displacement, and time period using seismic data. Results show that buildings with outrigger systems experience reduced lateral displacement, making them more effective in resisting seismic and wind forces compared to conventional structures.
Tejas H K et al., (2020) analyzes outrigger systems in tall buildings using ETABS 2015. Comparing core-only, single, and double-outrigger models, it shows outriggers significantly enhance stability against lateral forces, reduce displacement, and improve structural performance vital for modern high-rise design in disaster-prone areas.
Yogesh Dudhe, Dr. Swati Ambadkar (2020). The study compares four structural systems—Beam Column, Shear Wall, Tube, and Diagrid—for a G+16 high-rise in seismic zone IV using ETABS. Among them, the Diagrid System showed superior performance with least displacement and drift, highest stiffness, and shortest time period, making it most efficient for earthquake-resistant high-rise construction.
Ajit Kurey et al., (2021). The study compares Tube-in-Tube and Bundled Tube systems in a G+20 high-rise building using ETABS. Results show both systems perform within safety limits, but the Bundled Tube system has better shear lag performance and more uniform stress distribution. It also shows slightly higher base shear but reduced story drift overall.
Aleena Raechal George, Dr.R. Umamaheswari (2021). This study analyses a 10-storey RCC building in seismic zones 2 and 5, comparing models with and without shear walls. Results show that placing shear walls, especially at corners, significantly increases base shear and stiffness while reducing displacement and drift. Corner placement is identified as the optimal shear wall position.
Babhulkar S. et al., (2021) The paper compares diagrid and conventional structures under seismic loads using STAAD Pro. Diagrid systems, with diagonal columns, enhance structural efficiency, reduce displacement and material use, and perform better in earthquakes. Though construction is complex, diagrids offer significant aesthetic and economic benefits for high-rise buildings over traditional framed designs.
Hussin Ahmad Hasrat (2021). The study reviews lateral load resisting systems—shear walls, outriggers, braced frames, diagrids, and tubular systems for high-rise buildings under wind and seismic loads. Findings show shear walls suit medium-rise structures, diagrids excel in high-rises, and tubular systems offer rigidity and efficiency. Mixed systems often provide optimal performance across scenarios.
Shital Borkar et al., (2021) The study compares flat slab and conventional slab structures using ETABS 2015, focusing on seismic performance in multistory buildings. While flat slabs offer architectural and height advantages, they may underperform seismically without shear walls. Conventional slabs show better seismic resistance, highlighting the need for careful column design in flat slab systems.

Bhat, A. F., & Kumar, V. (2022). The study investigates the deflection and drift behaviour of multi-storeyed buildings with shear walls and core walls using ETABS. Three building models were analysed under lateral and seismic loads. Results indicate shear walls and core walls effectively minimize deflection and drift, especially when placed at the building's centre for stability.

Kumar Vanshaj et al., (2022) focuses on comparing a G+20 steel structure with and without X and inverted V bracings using STAAD.pro. It highlights improved seismic performance, reduced displacement and drift, and enhanced stability with bracing. The study supports bracing systems as effective, economical solutions for earthquake-resistant steel buildings.

Mayuri Borah and S Choudhury (2022). The study analyses seismic performance of 20-storey buildings in Guwahati using five structural systems via ETABS 2016. All systems met code criteria, but shear wall systems showed best performance with minimal displacement and high base shear. Outrigger and hybrid systems were overly stiff, making them less suitable for mid-rise buildings.

Mohammed Mudabbir Ahmed et al., (2022) The study compares seismic performance of 30-storey buildings using three structural systems Special Moment Resisting Frame with Shear Wall, Braced Frame System, and Outrigger Core Belt Truss System under Zone V conditions. Analyses revealed all systems met IS 1893:2016 standards, with Outrigger Core Belt Truss System performing best in all key parameters.

Rishav Jaiswas and Ankit Mahajan (2022). The study compares five 10-storey building models using different lateral load systems. ETABS analysis shows the hybrid model with a shear wall at the core and diagrid on the exterior performs best. It offers reduced displacement, drift, and time period, with increased base shear and stiffness, enhancing seismic performance.

Wani, S. et al., (2022). The study analyses G+9 steel buildings using 45°, 63.43°, and variable-angle diagrid systems. Compared to conventional frames, diagrids showed reduced displacement, drift, and steel usage. The 45° diagrid proved most economical, while the variable-angle type had the least displacement, making diagrids ideal for efficient high-rise construction in seismic zones.

Grant Oduor et al., (2023). The study analyses seismic performance of braced tube, diagrid, tube-in-tube, and shear wall-frame systems for 12-, 24-, and 36-story buildings in Nairobi using ETABS. Diagrid and tube-in-tube systems showed highest lateral stiffness, with diagrids best controlling accelerations and drifts. Diagrid systems are recommended for seismic-resistant high-rise design.

Prajakta Vadagave and Parasharam Sawant (2023). The study compares four G+28 high-rise building models using various outrigger systems. Analysis via ETABS shows that the belt truss outrigger system significantly reduces bending moment, shear force, axial force, and storey displacement. Results confirm that incorporating outriggers especially with belt trusses enhances lateral stability and seismic performance of tall structures.

Ali, S. et al., (2024). The study investigates the seismic performance of tall buildings with full and half outrigger systems, analysing G+40 models under lateral loads using ETABS. Results show eight vertically connected half outriggers significantly reduce displacement (47.85%) and drift (57.57%), improving structural stability. Optimal outrigger placement minimizes lateral forces and enhances safety.

## III. GAP OF STUDY

Comparative Study Across Varying Seismic Zones -Many studies focus on seismic performance in a specific zone, such as Zone IV or V, but a broader comparative analysis across multiple seismic zones is lacking.

Hybrid Structural Systems-While individual systems like diagrids, tube-in-tube, and outriggers have been analyzed, limited research is available on their combined effect when used together in a single high-rise structure.

Optimization of Structural Components-Few studies discuss the optimal placement and sizing of elements like shear walls, outriggers, or diagrid modules to enhance seismic efficiency.

Performance in Different Soil Conditions-Most analyses consider ideal soil conditions, whereas research on seismic behavior considering varying soil profiles (soft, medium, and hard) is relatively scarce.

Life Cycle Cost Analysis-While performance-based comparisons exist, studies evaluating long-term economic feasibility and maintenance costs of different lateral force-resisting systems remain underexplored.

Experimental Validation-Most studies rely on ETABS or SAP2000 software-based simulations, with limited experimental testing or real-case validation under seismic conditions.

## IV. CONCLUSIONS

No single structural system is universally optimal. The choice depends on building height, seismic zone, architectural constraints, and performance objectives.

For high-rise buildings in high seismic zones, diagrids, bundled tubes, and outrigger-belt truss systems emerge as the most effective. For mid-rise structures, shear wall and hybrid configurations offer the best balance of performance, cost, and construction practicality.

## 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 Plan 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. Andalasian 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

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[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