A Review on Comparative Analysis of Seismic Performance: Framed Tube Structures versus Shear Walls in Reinforced Concrete Buildings of Varying Heights

Sourabh. S. Sutar [1], Rahul. D. Patil[2]

[1] *P.G. Student, Structural Engineering, Department of Civil Engineering, Rajarambapu institute of Technology, Rajaram Nagar, Dist.Sangli, MS, India,415414,*

[2] *Associate Professor, Department of Civil Engineering, Rajarambapu institute of Technology, Rajaram Nagar, Dist.-Sangli, MS, India,415414*

***Abstract*— In this study, compares the seismic behavior of reinforced concrete (RC) structure with framed tube structure and shear wall for different stories. The aim of this research is to evaluate the performance of these structural systems under effect of seismic and wind loads using the structural ETABS software. The implications of these findings are that the framed tube structure can be a suitable alternative for high-rise buildings in seismic zones. The main conclusions and recommendations of this research are that the framed tube structure should be designed with adequate stiffness and strength to avoid excessive deformation and failure, and that further studies are needed to investigate the effect of different parameters such as soil-structure interaction, material properties and loading patterns on the seismic behavior of these structures. For the analysis purpose the building of different stories taken. Storey displacements were evaluated for both lateral load resisting systems. The analysis of structure by using Response Spectrum Method. The results show that the framed tube structure has better seismic resistance than the shear wall in terms of displacement, drift ratio, base shear and ductility of the structure.**

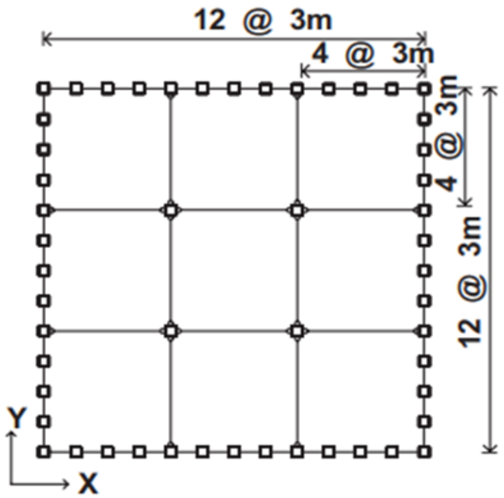
Keywords: ***Seismic, framed tube structure, shear wall, response spectrum, lateral load resistance, ETAB.***

I. INTRODUCTION

The cost of land increases in most nations as the population grows, therefore tall buildings have been expanding and their number of stories have increased to between 150 and 200, and they will continue to do so for high rise towers. High-rise buildings are subjected to significant lateral loads due to wind and seismic forces. These loads can cause large deformations and stresses in the structure, affecting its stability and performance. Structures must withstand lateral forces as well as vertical loads since they can cause serious damage. It is crucial to stop the harmful effects that are coming from earthquakes since ground shaking, ground displacement, fire, and flood are only a few of the outcomes that the earthquake and wind loads might create. Therefore, it is essential to design high-rise buildings with efficient structural systems that can resist these loads and provide adequate safety and serviceability. Seismic design's primary goal is to withstand lateral forces during an earthquake, which reduces the chance that people in the earthquake zone get injuries. For lateral Resistance in many high-rise constructions, tube system is advised in the structural engineering. It provides a high resistance against lateral and seismic forces The framed tube structure was developed by the famous structural engineer Fazlur Rahman Khan in 1960 [1]. The entire building act as a huge tube. Which is act as cantilever perpendicular to ground.

A. Framed Tube

One of the most widely used structural systems for high-rise buildings is the framed tube system, the building has closely spaced columns and deep spandrel beams rigidly connected together throughout the exterior frames [1]. The column spacing varies depending on the construction, but is typically 1.5–4.5 meter as shown in Fig. 1.1. The depths of spandrel beams can be between 0.5m to 1.2m. The entire building act as a huge tube. Which is act as cantilever perpendicular to ground. A hollow tube resists the majority of lateral loads, and an internal column resists gravity load. The framed tube system can be used for various floor plan shapes like square, rectangular, circular and free form. The advantage of this system is that it reduces the bending moments and shear forces in the columns and transfers them to the spandrel beams, which act as flanges of a vertical cantilever beam. The framed tube system also increases the torsional stiffness and reduces the shear lag effect in the structure.



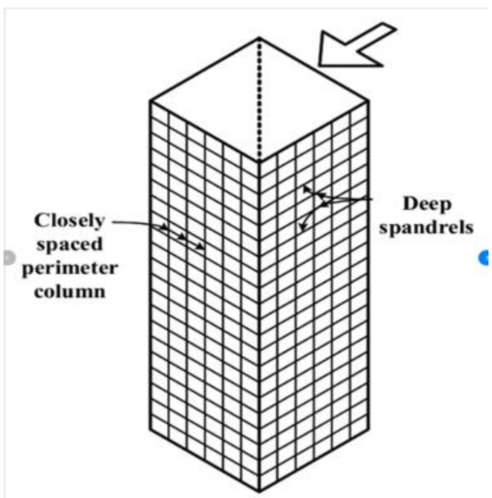


Fig. 1.1: - Framed tube Structure, (Taranath,1998) [2]

B. Shear Lag Effect

When a building with a tubular frame is subjected to lateral loads like a wind or earthquake, a phenomenon known as the hear lag effect in framed tube structures takes place. Due to the spandrel beams' bending, the corner columns experience a significantly higher axial load than the center columns. This results in a nonlinear distribution of axial stress along the flange and the web of the cross section of the building [3].

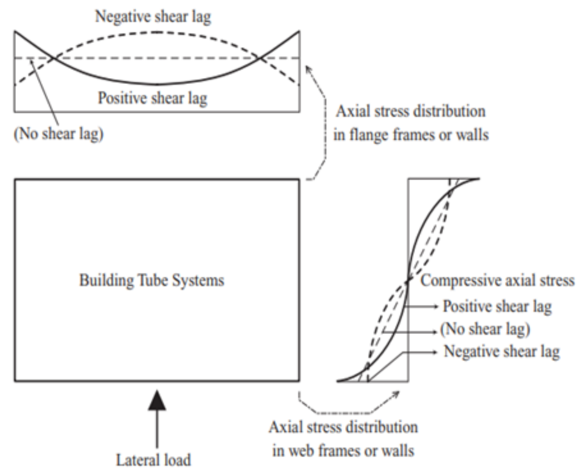


Fig. 1.2: - Shear Lag Behaviour [4]

C. Shear Wall

Shear walls are structural features that are meant to resist lateral forces acting on a building, such as wind and earthquake loads. They are commonly used in high-rise buildings to provide stiffness and stability in the direction parallel to their plane. Shear walls can be formed of a variety of materials, including reinforced concrete, steel, wood, or masonry, and can come in a variety of shapes, sizes, and combinations. The performance of shear walls is determined by various parameters, including their position, geometry, reinforcement, openings, coupling, and interaction with other structural components.

The aim of this research paper is to compare the seismic behavior of reinforced concrete (RC) structure with framed tube structure and shear wall for different stories.

II.LITERATURE REVIEW

The research works published by several researchers in the various journals have been reviewed and are presented in the following section:

Nassani and Dia Eddin [6] In this article, structural studies were performed using ETAB software to compare the structural response of several types of lateral load-resisting systems, such as moment-framed structures, shear wall systems, dual systems, and framed tube systems, to seismic and wind loads. The structure has 28 levels and a total size of 625 m2 (25m x 25m). The findings of this investigation revealed that displacements in all structural systems were analysed for all lateral load-resisting systems. According to the study, the displacements from the frame tube system for all lateral loads were significantly reduced as compared to other structural systems, giving the building a high stiffness against lateral loads.

Jinkoo Kim [7] In this research, nonlinear static and dynamic analysis was used to evaluate the seismic performance of framed and braced tubular structures. According to the findings of this study, tubular constructions have great earthquake resistance but lower stiffness and strength when compared to tube structures with diagonal braces. When compared to framed tube constructions, braced tube structures have higher strength but lower overall ductility.

Reem Hatem Ahmed [8] In this study, the ETABS software is used to investigate the lateral load resistance of a frame tube system and a bundled tube system. For the purpose of analysis, an 8-story steel building with a plan size of 80m x 80m was examined. As a result, the time period for the bundled tube system was less than that of the framed tube system. The base shear for a bundle tube system is greater than for a framed tube system. This is because the bundled tube system is stiffer than the framed tube system. Because a bundle tube system attracts more lateral force, its base shear value is greater than that of a framed tube system. The steel weight for the bundled tube system is likewise slightly higher (0.70 to 0.80) than for the framed tube system.

Mir M. Ali [9] In this paper, the evolution of tall buildings' structural systems and the technological driving force behind tall building developments are described. Furthermore, tall buildings are classified based on the various types of structural systems. In addition to height-based classifications, a system-based broad categorization has been proposed in the past. Various structural systems within each new classification group have been described, with an emphasis on innovations. The evolution of structural systems in connection with architectural forms and aesthetics has been documented, from the traditional rigid frame to the more contemporary re-formed "out-of-the-box" systems.

James C. Anderson [10] This research conducts an analytical and experimental study to evaluate the usage of high-strength concrete (8 000–10 000 psi) in high-rise framed tube structural systems located in seismically prone areas. The results show that displacement demands from observed strong ground movements are less than what crucial beam-to-column joints in the planned structure can supply. Through well-distributed plastic hinging in the spandrel girders, the structural system provides excellent lateral stiffness, redundancy, and energy absorption. Based on the outcomes Displacement (rotation) demands of 0.8 and 1.2% on critical joints due to two strong motion earthquakes are well below the rotation capacity of the half-scale test specimens, which reached 6.5% rotation before starting to unload. Based on these findings, it appears that this structural system has a lot to offer for earthquake-resistant tall structure design.

Myoungsu Shin [11] This paper presents modelling, analysis, and design for a 55-story hotel building recently planned for New York City, USA. The researched building's lateral force resistance was developed using a shear wall, moment frame structure, and framed tube structure, with tube action credited to the connection of the walls and frames. A full-story belt wall system encircling the whole perimeter of the structure at approximately mid-height was also installed. Because of the existence of tube action, maximum story drift is lowered by roughly 30 and 20%, respectively, in tube buildings with belt walls.

R. Kamgar [12] In this study, a simple approximate approach for calculating the natural frequency of tall buildings is devised. Timoshenko's beam model, which takes shear and flexural deformation into account, was utilized to construct framed tube structures. By defining equilibrium equations of forces operating on an infinite element, a dynamic model of Timoshenko's beam can be obtained. The fundamental frequency of the structure was calculated using ETABS V9.0.0 and compared to the result obtained from the proposed method, indicating that the percentage of error was minimal and acceptable. In the basic stages of structural design, the proposed method can be used as an alternative procedure to analyse the natural frequency of framed tubes.

III.CONCLUSION

From the study of literature review following conclusions are drawn:

- there are various types of tube structure. Most of the studies are carried out on tube-in-tube structure for resist the lateral load. In tube in tube structure interior planning limitations due to presence of inner tube.

- In this study We can analyse the high rise building by using framed tube structure for resist lateral load like earthquake load and wind load. The Framed tube buildings leave the interior floor plan relatively free and enhancing the net usable floor area. The reduction of material makes the buildings economically much more efficient.
- There is ample opportunity to investigate the behaviour of RC structures with shear walls and framed tube structures for increasing numbers of storeys under seismic loads. The seismic analysis of structure by using ETAB software.

REFERENCES

[1] Ali. Mir M and Kyoung Sun Moon (2007). " Structural Developments in Tall Buildings: Current Trends and Future Prospects". Architectural Science Review. Volume 50.3, pp 205-223.

[2] Jinkoo Kim and Junhee Park (2007). " Seismic Performance of Tubular Structures with Buckling Restrained Braces". The Structural Design of Tall and Special Buildings. DOI: 10.1002/tal.420.

[3] Sharadrao Patil and Uttam Kalwane (2015). " Shear Lag in Tube Structures ". International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 3. ISSN 2348 – 7968.

[4] M Shin, Thomas H.-K. Kang, James M. LaFave (2010). " Design and behaviour of a reinforced concrete high-rise tube building with belt walls The Structural Design of Tall and Special Buildings DOI: 10.1002/tal.661.

[5] F. Khan and N. Amin, `Analysis and design of framed tube structures for tall concrete buildings', Struct. Eng.,51, (1973).

[6] Nassani D. E., (2020), "Lateral Load Resisting Systems in High-Rise Reinforced Concrete Buildings". European Journal of Science and Technology, No. 20, 397-403.

[7] Jinkoo K., Junhee P. S. and Kyung-Won M. (2009), "Seismic Performance of Tubular Structures with Buckling Restrained Braces.", Struct. Design Tall Spec. Build. 18, 351–370.

[8] Ahmed R. H, Shaikhli H. I., Wail A. M. (2021). "Study of different tubular systems on the lateral load resistance." Periodicals of Engineering and Natural Sciences ISSN 2303-4521 Vol. 9, No. 2, 672-681.