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# "Comparative Analysis of Various Lateral Load Resisting Systems in Multistorey Buildings"

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***Abstract*** - *_In this research, we explore three distinct types of lateral load resisting systems: outrigger braced systems, diagrid systems, and shear wall systems. The outrigger bracing system serves as a solution to mitigate excessive drift and displacement in high-rise buildings. It comprises outrigger bracings or outrigger trusses that connect the central core of the building to the peripheral columns, while the peripheral columns are interconnected through belt trusses. The study involves the modeling of a conventional structural model with a reinforced concrete central core and various models incorporating outriggers at different heights, including the top, top and 0.75H, top and 0.5H, and top, where H represents the total height of the building*

*The primary objective of this research is to identify the optimal location for the outrigger system and determine the most cost-effective lateral load resisting system. Through comprehensive analyses and evaluations, we aim to uncover valuable insights regarding the performance of these systems.*

*Based on the results obtained from the diverse analyses conducted, it has been determined that the ideal location for the outrigger bracing system in high-rise buildings is at the top and mid height of the structure. This particular location exhibits the least top displacement and drift, highlighting its effectiveness in controlling lateral movements. Furthermore, outrigger structures demonstrate superior rigidity compared to conventional structures, diagrid systems, and shear wall systems.*

*Notably, the outrigger models positioned at the top and 0.5H showcase the most significant reduction in storey displacement, base shear, and slab stresses among the analyzed models. These findings contribute to the understanding of the advantages associated with the implementation of outrigger bracing systems in high-rise construction projects.*

***Key Words:*** *Outrigger braced system, Diagrid Structure, Response Spectrum Method, Storey Shear, Node Displacement. Stresses in Slab and beam.*

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## I. INTRODUCTION

Due to population growth and limited available land, there has been a significant increase in the demand for high-rise buildings. Technological advancements and engineering techniques have enabled the construction of tall structures with precision and safety. To meet aesthetic demands and cope with limited land availability, there is a trend towards taller and more slender buildings.

Tall buildings are susceptible to lateral loads induced by wind and seismic forces, making it crucial to design them to withstand these forces. Designing high-rise buildings requires meeting strength and stiffness requirements while effectively controlling lateral displacements and drift caused by wind and seismic loads to prevent structural and non-structural damage. Over time, various structural systems have emerged to address these challenges.

Research has shown that shear walls, when used alone, are effective up to a certain height but become uneconomical compared to the benefits they provide. Therefore, there is a need for a more efficient structural system that offers increased stiffness and strength to high-rise buildings while considering economic factors. The outrigger bracing system is a cost-effective solution for controlling drift and provides additional stiffness to tall buildings without significant additional steel costs.

Diagrid structural systems have gained popularity in the construction of tall buildings due to their structural efficiency and architectural potential. Diagrid systems, commonly constructed using steel members, have been widely adopted in recent years. In this study, a concrete diagrid structure with vertical geometric irregularity is analyzed and compared to a conventional concrete building. Diagrid structures consist of diagonal members formed by the intersection of various construction materials such as metals, concrete, or wood beams. Steel diagrid structures offer a time- and cost-effective solution.

## II. OBJECTIVES OF STUDY

The objectives of this study are as follows:

1. To compare the outrigger structural system with other lateral load resisting systems, including the Diagrid system and the Shear wall system, by conducting dynamic analyses.
2. To investigate the response of these systems in terms of their performance, lateral displacement, and economic considerations by varying the location of outrigger bracings with belt trusses along the height of the structure.
3. To determine the optimal location for the outrigger system based on its performance, specifically in terms of minimizing lateral displacement and considering economic factors.
4. To compare the results obtained from the outrigger system with those from the conventional framed structural system, Diagrid structural system, and Shear wall system. This comparison will be based on storey drift, storey shear, and top storey displacement.
5. To compare the moment in the peripheral columns of the outrigger system models with that of the conventional models, Diagrid Model, and shear wall model.

## III. METHODOLOGIES

In this study, the software Staad Pro is utilized to model various structural configurations, including conventional frames with central cores, conventional frames with central cores and outrigger systems, diagrids, and shear walls. The preliminary member sections are assumed for the models.

The height of all the models is set to 20 stories, and the seismicity level is considered as Zone IV.

To determine the optimal location for the outrigger system, one outrigger is fixed at the top of the structure, while the other outrigger's position is varied along the height at 0.5H and 0.75H, where H represents the height of the structural model.

The obtained results are compared using linear dynamic analysis, specifically the Response Spectrum Analysis. Various parameters such as displacement, inter-storey drift, moment, base shear, time period, and axial force in the peripheral column are evaluated and compared among the different models. This analysis provides insights into the performance of each lateral load resisting system and helps in determining their effectiveness in controlling structural response under seismic forces.The data used in this study is summarized below:

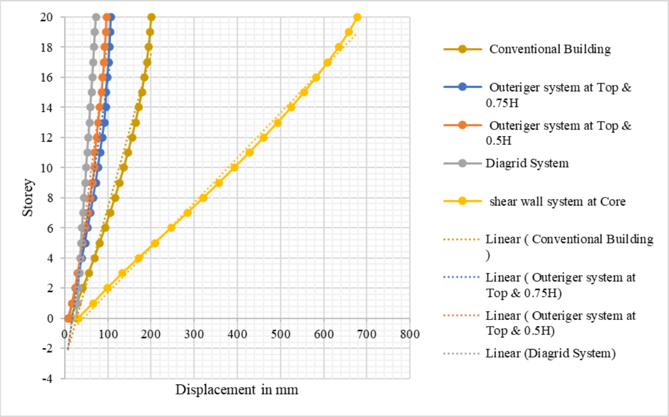
*The structural parameters for the 20-storey building considered in this study are as follows:*

- *Number of storeys: 20 storeys*
- *Plan area: 20 meters by 30 meters*
- *Storey height: 3 meters*
- *Spacing of columns: 5 meters*
- *Grade of concrete: M25*
- *Grade of steel: Fe415*
- *Size of columns: 500 millimeters by 500 millimeters*
- *Size of cantilever beams: 2000 millimeters by 500 millimeters*
- *Slab thickness: 200 millimeters*
- *Shear wall thickness: 150 millimeters*

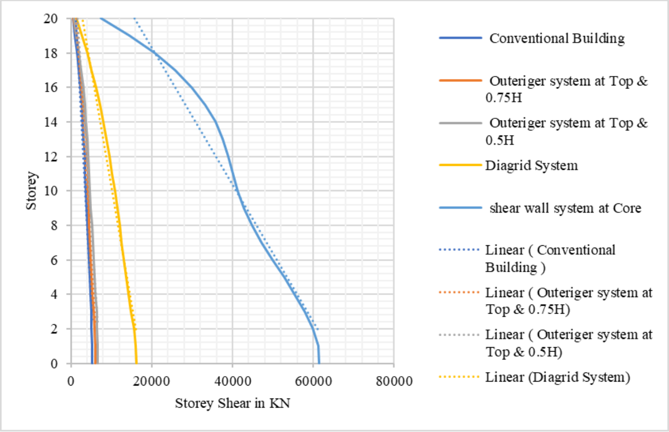
*These parameters define the dimensions and material properties of the building components, including columns, beams, slabs, and shear walls. They play a crucial role in the structural behavior and performance of the building under different loading conditions.*

## IV. RESULTS

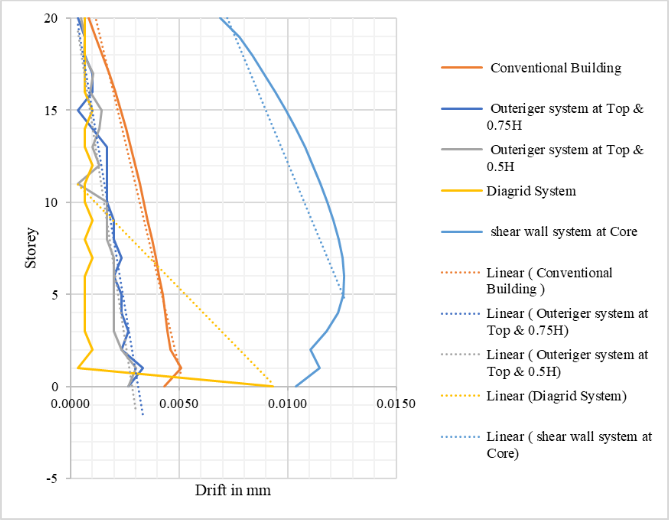
Graph 1 Storeys Vs Displacement



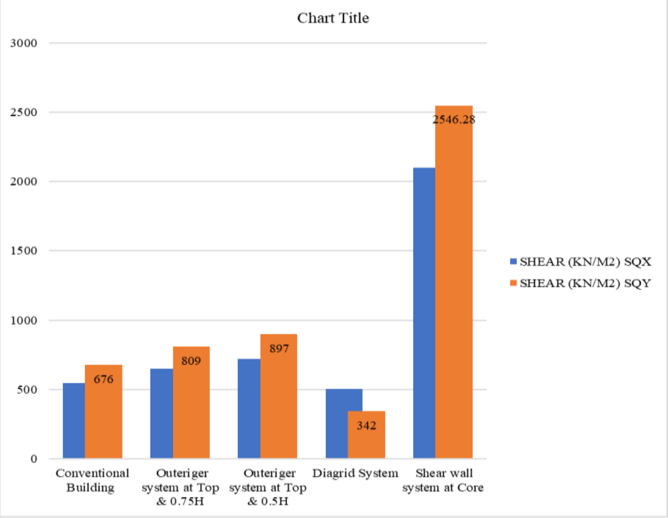
Graph 2 Storey Shear in different load resisting system



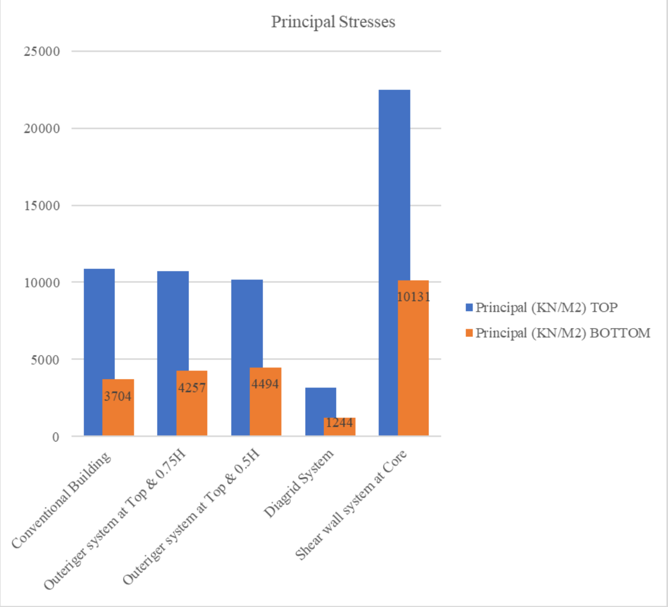
Graph 3 Storey Drift in different load resisting system



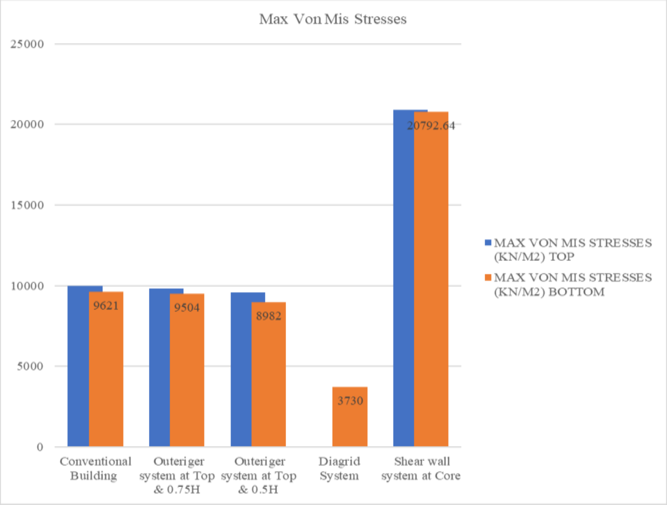
Graph 4 Center Shear Stresses Vs Different types of Building



Graph 5 principal stresses Vs Different types of building for Seismic Analysis



Graph 6 Max Von Mis stresses in Slab



## V. CONCLUSION

The following conclusions have been derived from this study:

1. The optimal location for the outrigger system is determined to be at the top and 0.5 times the height of the structure. This configuration significantly reduces lateral displacement and drift.
2. When using the Response Spectrum Method, the lateral displacement for the 20-storey structural models with outriggers at the top and 0.75H is reduced by 47%, while for the 0.5H position it is reduced by 52%. The diagrid structural system demonstrates a reduction of 64% in lateral displacement, whereas the shear wall system exhibits an increase of 238%.
3. The outrigger models at the top and 0.5H, along with the Diagrid Structural System, produce the best results in terms of reducing lateral displacement.
4. The maximum storey drift for the 20-storey structural models with outriggers at the top and 0.5H, as well as the Diagrid system, is decreased by 42% and 20%, respectively, when compared to the conventional model.
5. The base shear for the 20, 40, and 60-storey structural models with outriggers at the top and 0.5H is increased by 35% compared to the conventional model.
6. The incorporation of the outrigger bracing system effectively reduces the moment in the central core, with the peripheral columns playing a significant role in resisting the moment. The peripheral columns form a tension-compression couple, enhancing the structure's ability to withstand lateral loads more effectively.

These conclusions demonstrate the advantages of utilizing outrigger systems and the Diagrid Structural System in high-rise buildings, showcasing their effectiveness in reducing lateral displacement, drift, and moment while improving overall structural performance.

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