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Short Communication

Impact of Lateral Loads on High Rise RC Framed Structure with Reference to Drift with and without Shear Wall: A Critical Review

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Geometry & Detailing of Shear Walls

The Geometry and Detailing of Shear Walls: Shear walls typically feature a rectangular cross-section, with one dimension significantly larger than the other. Although four-sided cross-sections are common, L- and U-shaped configurations are also employed. Small, deep reinforced concrete shafts serving as shear walls are used in elevator systems. Shear walls may consist of one or two parallel layers, known as curtains, with both vertical and horizontal reinforcement commonly present. The minimum required steel reinforcement in both horizontal and vertical directions is 0.0025 times the cross-sectional area. In certain cases, it may be necessary to distribute vertical reinforcement uniformly across the wall's cross-section.

Function of Shear Walls: Shear walls must possess sufficient lateral strength to counteract horizontal earthquake forces. As shear walls acquire weight, they transfer horizontal forces to other sections of the structural system below them. The load network includes shear walls, floors, base walls, slabs, and footings. Shear walls also contribute to lateral stability, preventing the roof or floor from swaying side to side. Shear walls with adequate stiffness prevent members from sliding off their supports in the floor and roof framing. Additionally, properly stiffened buildings sustain less damage to their functionality.

Requirements of Structural Elements in High-Rise Buildings: The interaction between wind and seismic forces on multi-story structures is a crucial aspect of design. Developing a robust framework for high-rise structures involves monitoring their dynamic response by adding appropriate structural elements, such as shear walls with tube frameworks. Additionally, in recent decades, the use of reinforced concrete in shear wall end regions has increased to ensure these walls perform in a ductile manner, supporting load reversals without losing strength.

Distinguishing Between Columns and Shear Walls: Shear walls consist of columns and components that resist compression and shear. These vertical structural elements resist lateral forces within the wall plane due to shear and bending. Shear walls are often designed with equal lengths and widths for structural integrity. They are vertically aligned and bear the downward loads from earthquakes to the foundation.

Wind Speed and Drift: Similar to displacement, the study found that wind speed has an effect on drift. The maximum drift observed was 0.019085 (likely in inches) on the Y-axis, occurring at story 10, when subjected to a wind speed of 260 km/h. Conversely, the minimum drift recorded was 0.0021 (likely in inches) on the X-axis, happening at story 1, under a wind speed of 150 km/h. This implies that higher wind speeds result in larger drift values.

Percentage Increase: The study also calculated the percentage increase in displacement or drift when comparing the effects of wind speeds. The maximum percentage of increment was found to be 46.2% for a wind speed of 260 km/h compared to a wind speed of 150 km/h. This indicates that, when wind speed is increased from 150 km/h to 260 km/h, there is a 46.2% increase in displacement or drift, underscoring the sensitivity of the building's response to higher wind speeds.

These findings emphasize the importance of considering wind load effects in building design, especially in regions prone to high wind speeds. Engineers and architects must account for these factors to ensure the structural integrity and safety of tall buildings in windy conditions.

The information you've provided from Mahdi Hosseini et al.'s study in 2022 highlights their research on reinforced concrete shear wall buildings and their seismic performance analysis. Here are the key points from this study[3].

Analysis of Shear Wall Buildings: The study focuses on reinforced concrete shear wall buildings and their behavior under seismic loads. It appears that the researchers followed the procedures outlined in IS codes (likely referring to Indian Standard codes) to conduct their analysis.

Regular Shaped Structures: The study specifically considers regular-shaped structures. Regularity in the architectural and structural layout of a building can have a significant impact on its seismic performance. Irregularities in the structure can lead to higher seismic forces and drift.

Dual Frame System with Shear Wall: The researchers appear to have examined a dual frame system with a shear wall structure. Such a system typically combines two different lateral load-resisting systems in a building design, often for enhanced seismic performance.

Importance of Drift: The study underscores the importance of considering drift in high-rise structures subjected to earthquake loads. Drift refers to the lateral displacement or movement of a building's floors or stories during an earthquake. Even a small amount of drift can be critical in high-rise buildings as it can affect occupant comfort, structural integrity, and overall safety.

Seismic Performance Evaluation: The primary focus of the research seems to be the evaluation of the seismic performance of the building model. This involves assessing how well the building can withstand seismic forces and how it behaves during an earthquake.

Mahdi Hosseini et al.'s study emphasizes the significance of considering drift, especially in tall structures, when evaluating their seismic performance. It suggests that engineers and designers should account for drift effects due to earthquake loads in the design and analysis of high-rise buildings with shear wall systems to ensure their safety and functionality during seismic events.

Storey Displacement: The study found that the model with flag walls exhibited the minimum storey displacement compared to other models. This suggests that flag walls can help minimize lateral movement and sway of the building during various loading conditions.

Maximum Shear Force: The

inclusion of flag walls also had a positive impact on the maximum shear force experienced by the structure. The model with flag walls showed a 29.88% reduction in maximum shear force compared to a model without them. Lower maximum shear forces are desirable as they indicate a more robust structural design.

Base Shear: While the study noted that the self-weight of the flag walls led to a slight increase in base shear (approximately 1%), the model with flag walls still had the maximum base shear value compared to all other models. This suggests that flag walls contribute to the overall lateral stability of the structure.

Lateral Force: The model with flag walls exhibited lesser lateral force values compared to all other models. Lower lateral forces can help reduce structural stresses and improve overall safety during lateral loading events.

The information you've provided from Naveen Kumar et al.'s study in 2019 presents key findings and conclusions related to the analysis of buildings with shear walls and their comparison with RCC (Reinforced Concrete Cement) buildings without shear walls. Here are the major conclusions drawn from their research[4].

Order of Increasing Values: The study observed that there is a consistent pattern of increasing values in terms of storey displacement and storey drift for different seismic zones. These values were compared across Zone II, Zone III, Zone IV, and Zone V in both the X and Y directions.

Comparative Analysis with Shear Walls: The study's analysis suggests that multistoried buildings with shear walls exhibit comparatively lower storey displacements when compared to RCC buildings without shear walls. This implies that the presence of shear walls has a beneficial effect on reducing the lateral displacement of the building during seismic events.

Economical and Effective: The research concludes that providing shear walls in high-rise buildings is both economical and effective. This indicates that the cost incurred in constructing shear walls is justified by the benefits they provide in terms of reducing displacement during earthquakes and wind loads.

Reduction in Displacements: One of the key findings is that shear walls, when provided at adequate locations in a building, significantly reduce displacements caused by both earthquake and wind forces. This reduction in displacements is critical for maintaining structural integrity and occupant safety.

Study highlights the advantages of incorporating shear walls in high-rise buildings, emphasizing their effectiveness in reducing storey displacement and storey drift during seismic events. These findings have implications for the design and construction of tall structures, particularly in regions prone to seismic activity or strong winds[4].

In The conclusions from Shrinivas et al.'s study in 2019 provide valuable insights into the impact of shear walls and different design parameters on high-rise buildings. Here are the key takeaways from their research[6].

Shear Wall Location: Placing shear walls in the outermost perimeter of a high-rise building has a significant impact on reducing storey displacement and storey drift. This indicates that the strategic placement of shear walls can enhance the structural stability of the building.

Model 6 Performance: Among the different models considered in the study, Model 6 exhibited superior performance in terms of maximum top storey displacement and storey drift. This superior performance is attributed to the increased stiffness and stability of this particular model.

Extension of Shear Wall: In Model 6, an extra 6 meters (one bay) of shear wall was added at the corners of the building to achieve storey displacement within permissible limits. This modification led to improved structural behavior, emphasizing the role of shear walls in controlling displacement.

Reduction in Displacement and Drift: The introduction of shear walls to Model 6 resulted in a substantial reduction in both top storey displacement and storey drift. Specifically, top storey displacement and storey drift were reduced by up to 79% and 40%, respectively, when compared to the bare frame without shear walls.

Impact of Openings: After introducing different sizes of openings, it was observed that the maximum size of opening that can be provided while maintaining top storey displacement within acceptable limits is 2x2 meters. This finding highlights the importance of carefully designing and placing openings in high-rise buildings.

Safety and Structural Integrity: Although there was a relative increase in top storey displacement and drift (up to 36% and 12%, respectively) when comparing Model 6 to Model 10, it is emphasized that the structure remained within permissible safety limits. The introduction of shear walls played a crucial role in minimizing displacement and drift, thereby enhancing structural integrity and safety.

Equivalent Static vs. Response Spectrum Analysis: When comparing the results of Equivalent Static analysis and Response Spectrum analysis, it was observed that the base shear remained the same. However, there was a reduction of up to 20% in top storey displacement and drift when using Response Spectrum analysis. This suggests that Response Spectrum analysis can provide a more accurate assessment of structural behavior under dynamic loads.

In summary, Shrinivas et al.'s study underscores the importance of shear walls in high-rise building design, particularly in terms of reducing displacement and drift. It highlights the significance of shear wall location, extension, and careful consideration of openings to optimize structural performance and safety. Additionally, the study emphasizes the benefits of Response Spectrum analysis for a more realistic evaluation of dynamic behavior.

The findings from Mohammed Aejaz Ahmed et al.'s study in 2019 provide important insights into the effectiveness of shear walls in reducing lateral displacement and drift in high-rise buildings subjected to both wind and earthquake loads. Here are the key conclusions drawn from their research[1].

Shear Wall Effectiveness: Shear walls, when provided along both longitudinal and transverse directions in a building, are effective in reducing lateral displacement values in the respective directions. This suggests that shear walls play a crucial role in enhancing the structural stability of tall buildings by mitigating lateral displacements.

Differences Between Wind and Earthquake Loads: The study highlights that wind and earthquake loads produce different effects on building behavior. Specifically, earthquake loads result in less inter-storey drift compared to wind loads.

This implies that shear walls are particularly effective in minimizing the effects of earthquake-induced lateral displacements.

Inter-Storey Drift in Tall Buildings: The research findings indicate that inter-storey drift ratios in tall buildings are relatively small, and there are no significant apparent issues with the main force-resisting system of the structure. This suggests that shear walls, when properly designed and placed, can effectively control inter-storey drift even in tall structures.

Shear Wall Placement: Maximum reduction in drift values is observed when shear walls are provided at the corners of the building. This placement strategy appears to be highly effective in minimizing lateral displacements and drift, further emphasizing the importance of shear wall location.

Independent Design for Wind and Earthquake Forces: The study underscores the importance of independently designing buildings to withstand critical forces from both wind and earthquake loads. This means that engineers and designers should consider the unique characteristics of each type of load when developing structural solutions.

Shear Force and Moment Considerations: During seismic analysis, it is noted that the total shear force and moment at the base of a building can vary depending on the direction of the loads. Loads acting normal to the shorter side of the building may result in greater shear forces and moments than loads in the other direction. This insight emphasizes the need for a comprehensive structural analysis that accounts for load direction.

Composite Structures for High-Rise Buildings: The study suggests that composite structures represent an effective solution for high-rise buildings. Composite structures typically combine different materials, such as steel and concrete, to optimize structural performance. This conclusion highlights the versatility of composite systems in achieving stability and safety in tall buildings.

Research underscores the role of shear walls in reducing lateral displacement and drift in high-rise buildings, particularly in earthquake-prone regions. The study emphasizes the need for careful design and placement of shear walls, as well as independent consideration of wind and earthquake forces in structural design. Additionally, the potential benefits of composite structures are highlighted for high-rise building applications[1].

Focused on the wind analysis of high-rise buildings and compared two different lateral load-resisting systems: the outrigger system and the diagrid system in the context of a 108-meter tall building. Here are the key findings and conclusions from this research[8].

Objective and Methodology: The primary objective of the study was to evaluate the performance of high-rise buildings under wind loads. The analysis was carried out using the gust factor approach, following the guidelines outlined in IS: 875 (Part-3)-1987, which provides standards for wind loads in India.

Lateral Load-Resisting Systems: The study compared two distinct lateral load-resisting systems–outrigger and diagrid. These systems are used to enhance the structural stability of tall buildings and mitigate the effects of lateral loads, such as wind forces.

Analysis Variables: Various parameters and variables were considered in the analysis, including the angle of inclination and the location of the outrigger. These variables were modified to assess their impact on structural performance.

Material Consumption: One of the key findings was related to material consumption. The study revealed that the outrigger structural system required 17% more material compared to the diagrid system. This suggests that the diagrid system may be more resource-efficient, which can be an important consideration in construction projects.

Time Period: The research found that the time period for the diagrid structural system was significantly shorter compared to the outrigger system. A shorter time period indicates that the diagrid system is stiffer and can provide better structural efficiency.

Economic Feasibility: Based on the findings related to material consumption and time period, the research concluded that the diagrid system is more economical. This means that it may offer cost savings during construction while still providing robust structural performance.

Architectural Planning: The study also highlighted the feasibility of using the diagrid system in architectural planning for high-rise buildings. The diagrid's unique structural design can be integrated into the architectural aesthetics of a building while maintaining structural efficiency.

Structural Efficiency: The diagrid structural system was found to offer higher structural efficiency for high-rise buildings. This efficiency can translate into better performance under lateral loads, including wind forces.

Tausif J. Shaikh's research suggests that the diagrid structural system is a cost-effective and structurally efficient solution for high-rise buildings, particularly when compared to the outrigger system. The study emphasizes the importance of considering factors like material consumption and time period in the selection of lateral load-resisting systems for tall buildings. Additionally, the unique architectural possibilities offered by the diagrid system make it an attractive choice for designers and architects.

The study ranked the lateral load-resisting systems based on their effectiveness and cost-efficiency. The outrigger system with belts at strategic positions, shear walls at the middle periphery, and inverted V-shape bracing systems were identified as highly effective options for enhancing the lateral stability of high-rise buildings. These findings can guide structural engineers and architects in selecting the most suitable lateral load-resisting system for their specific design requirements and project constraints[2].

Highlighted the importance of reinforced concrete bearing walls as a critical structural element for resisting lateral loads. Their modeling approach and experimental validation contributed to a better understanding of the behavior of these walls and their role in maintaining the stability and safety of buildings subjected to lateral forces. This information is valuable for structural engineers and designers when planning and constructing buildings to withstand various types of loads[3].

Conclusion

Based on the comprehensive literature review, several conclusions can be drawn regarding the use of lateral load-resisting systems in high-rise buildings:

Steel bracings are suitable for buildings with 10 to 20 storeys, while shear walls are effective for structures with 20 to 35 storeys. Shear walls, however, have a higher structural weight, which may be uneconomical for buildings with fewer storeys.

Diagrid systems are the most efficient and economical choice for high-rise buildings exceeding 35 storeys. They offer flexibility in interior space planning and building elevation, making them well-suited for seismic and wind load resistance.

In summary, the choice of lateral load-resisting system depends on the building's height and structural requirements. Proper selection and design of these systems are crucial for ensuring the safety and stability of high-rise structures under lateral loads.

Based on the information you've shared, it's evident that the studies generally emphasize the importance of shear walls and other structural elements in reducing displacement, drift, and other effects caused by lateral loads, such as wind and earthquakes, in tall buildings. Here are some key conclusions and findings from the studies you've mentioned:

Wind and Earthquake Loads: Different studies highlight the differences in the effects of wind and earthquake loads on tall buildings. Earthquake loads tend to produce less inter-story drift compared to wind loads.

Shear Wall Placement: The location of shear walls within a building has a significant impact on reducing displacement and drift. Placing shear walls at the corners or periphery of the building is effective in minimizing these effects.

Effectiveness of Shear Walls: Shear walls are found to be effective in reducing lateral displacement, base shear, and storey drift in tall buildings. They increase the stiffness of the structure and minimize damage to structural elements.

Comparative Studies: Many studies compare the performance of different lateral load-resisting systems, including shear walls, bracing, moment-resisting frames, and diagrid systems. These comparisons often consider parameters such as displacement, drift, base shear, and cost-effectiveness.

Material Consumption: Some studies analyze the material consumption of different lateral load-resisting systems. Shear walls may have higher structural weight but can be effective in controlling displacement.

Time Period: Shear walls and other systems affect the time period of the building's response to lateral loads. Different configurations of shear walls can lead to variations in time period.

Stiffness: Shear walls are noted for increasing the stiffness of a building, which is beneficial in reducing the effects of lateral loads.

Optimization: Some studies emphasize the importance of optimizing shear wall placement for cost-effectiveness and safety. Placing shear walls at specific locations can enhance structural performance.

Diagrid Systems: Diagrid structural systems are highlighted as effective and efficient in resisting lateral loads and providing flexibility in interior design.

Software and Modeling: Many of these studies use software like ETABS for modeling and analysis of building structures under lateral loads.

It's important to note that these findings and conclusions are based on the specific studies and research papers you've referenced. The effectiveness of shear walls and other lateral load-resisting systems can depend on various factors, including building design, location, local building codes, and the severity of the lateral loads. Engineers and architects typically consider these factors when designing tall buildings to ensure their safety and stability[5,7].

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