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# Comparative Performance Assessment of Shear Wall and Diagrid Systems in an Octagonal Tall High-Rise Building under Seismic and Wind Loads

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**Abstract**

*The increasing demand for high-rise structures due to rapid urbanization necessitates the adoption of efficient lateral load-resisting systems to ensure structural safety, stability, and serviceability. This study presents a comparative evaluation of the seismic and wind performance of a Ground plus Fifty-storey high-rise building with an octagonal plan, incorporating different structural configurations such as shear wall arrangements and a diagrid system. A total of six analytical models, including a conventional bare frame, four shear wall configurations, and a perimeter diagrid system, were developed and analyzed using STAAD.Pro in accordance with relevant Indian Standards. The structural response was assessed in terms of lateral displacement, base shear, bending moment, and axial force under both seismic and wind loading conditions. The results indicate that the bare frame model exhibits maximum lateral displacement of approximately 2154 mm under seismic loading and 954 mm under wind loading, reflecting its low stiffness. The introduction of shear walls significantly improves structural performance, with optimally placed corner shear walls reducing seismic displacement by nearly 73% and wind displacement by about 71%. The diagrid system demonstrates enhanced overall efficiency, achieving a reduction of approximately 63% in seismic displacement and 37% under wind loading, along with improved control over bending moments and axial forces. Furthermore, shear wall configurations show higher base shear values (up to 3.18% increase), indicating increased stiffness and load resistance, while the diagrid system provides a more uniform load distribution and reduced torsional effects. The study highlights that while shear walls are highly effective in controlling displacement, the diagrid system offers a balanced performance in terms of stiffness, strength, and structural efficiency.*

**Keywords:** High-rise building, Diagrid system, Shear wall, Seismic analysis, Wind analysis, STAAD.Pro

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## INTRODUCTION

The rapid growth of the urban population and continuous expansion of metropolitan cities have significantly increased the demand for high-rise structures. Owing to the scarcity of land and increasing land prices, vertical development has become essential in modern construction practices. As the height of buildings increases, the influence of lateral loads, such as earthquakes and wind forces, becomes more critical than that of gravity loads in structural design [1, 2].

Tall buildings are highly vulnerable to lateral forces because of their slenderness and flexibility.

 

Excessive lateral displacement, inter-storey drift, and torsional effects can lead to structural damage or even collapse under extreme loading conditions. Therefore, the selection of an efficient lateral load-resisting system is crucial to ensure the safety, stability, and serviceability of high-rise buildings [3, 4].

Conventional moment-resisting frame systems are often insufficient for very tall buildings because of their limited stiffness. To overcome this limitation, advanced structural systems, such as shear walls, braced frames, tubular systems, outrigger systems, and diagrid systems, have been developed and widely implemented in modern structural engineering [5-7].

Among these, shear walls are one of the most widely used and effective systems for resisting lateral load. Shear walls provide high in-plane stiffness and strength, enabling significant reductions in story drift and lateral displacement. The effectiveness of shear wall systems depends on their location, geometry, and interactions with other structural components. Proper placement, especially at corners or along the building perimeter, enhances the structural performance and reduces torsional effects [8-10].

In recent years, diagrid structural systems have emerged as innovative and efficient solutions for tall buildings. The diagrid system consists of diagonally arranged structural members forming a triangulated framework that eliminates the need for conventional vertical columns along the exterior. This system resists both gravity and lateral loads primarily through axial forces, resulting in improved stiffness and material efficiency [11, 5].

Research studies indicate that diagrid structures provide better performance than conventional systems in terms of stiffness, load distribution, and reduction in material consumption. Advanced configurations, such as double-layer diagrid systems, further improve the seismic performance by enhancing energy dissipation and reducing deformation [8, 12].

Wind loads play a significant role in the design of high-rise buildings because wind-induced vibrations can affect both the structural safety and occupant comfort. Similarly, seismic forces produce dynamic responses that depend on the mass, stiffness, and damping characteristics of the structure. Therefore, it is essential to evaluate the structural performance under both wind and earthquake loading conditions [13, 2].

Recent studies (2023–2025) have emphasized the importance of optimizing shear wall placement and diagrid configurations. It has been observed that increasing the shear wall ratio improves the torsional resistance and reduces the lateral displacement, whereas innovative diagrid systems significantly enhance the stiffness and overall seismic performance of high-rise structures [8-10, 14].

In this study, a Ground plus Fifty-storeyhigh-rise building with an octagonal plan configuration was analyzed using six different structural models, including a bare frame, various shear wall arrangements, and a diagrid system. The objective was to compare their performance in terms of lateral displacement, base shear, axial forces, and bending moments under seismic and wind-loading conditions. The findings aim to identify the most efficient structural system for tall buildings subjected to combined lateral load.

**Diagrid Structural System**

The diagrid structural system is an advanced structural framework widely adopted in modern high-rise buildings because of its superior efficiency and architectural flexibility. The term “diagrid” is derived from the combination of the words diagonal and grid, referring to a network of diagonal members arranged in a triangulated configuration along the building perimeter. Unlike conventional framed structures, diagrid systems eliminate the need for vertical perimeter columns, thereby enhancing both the structural performance and aesthetic appeal [5].

In a diagrid system, the primary load-resisting elements are diagonal members that form a series of interconnected triangular modules. These diagonal members carry both gravity and lateral loads mainly through axial forces, rather than bending moments. This axial load transfer mechanism significantly improves structural efficiency, reduces material consumption, and enhances stiffness compared with traditional moment-resisting frames [11, 15].

The efficiency of a diagrid structure is largely influenced by parameters such as the angles of the diagonal members, module size, and building height. Typically, the optimal angle of diagrid members ranges between 60° and 70°, which provides a balance between shear rigidity and bending resistance. As the building height increases, the optimal angle also increases to enhance the structural performance [11].

Diagrid systems offer several practical advantages, including reduced structural steel usage, elimination of interior columns, and improved architectural flexibility. The absence of vertical columns allows open floor plans and better utilization of interior space. Additionally, the external diagrid framework enhances the visual appearance of buildings, making them architecturally distinctive [4].

Recent advancements in diagrid technology, including double-layer and hybrid diagrid systems, have further improved their performance under dynamic-loading conditions. These systems exhibit enhanced energy dissipation capacity and better resistance to seismic forces, making them a preferred choice for high-rise construction in seismic regions Figures 1-11 [8, 12].

**Shear Wall**

Shear walls are among the most effective structural elements used to resist lateral loads in high-rise buildings. These are vertical structural components designed to withstand the horizontal forces generated by wind and earthquake loads. Shear walls act as cantilever members fixed at the foundation level and extend throughout the height of the building, providing significant stiffness and strength to the structure [1, 2].

In modern construction, reinforced concrete (RC) shear walls are widely used because of their high load-carrying capacity and durability. These walls are strategically positioned within the building layout, typically at the core, corners, or along the perimeter, to ensure maximum resistance to lateral forces. The proper placement of shear walls is crucial, as it directly influences the structural performance, particularly in controlling lateral displacement and minimizing torsional effects [9, 10].

The primary function of shear walls is to safely transfer lateral loads to the foundation. Under seismic loading, shear walls resist forces through a combination of shear and flexural actions, whereas under wind loading, they help reduce the sway and vibration of the structure. Due to their high in-plane stiffness, shear walls significantly reduce inter-storey drift, thereby enhancing the structural stability and serviceability [3].

**Figure 1.** Diagrid structure.

 

**Figure 2.** RC Shear wall.

Shear walls can be classified according to their shape, material, and behavior. The common types include rectangular shear walls, flanged walls, coupled shear walls, and core-type shear walls. Among these, core shear walls are widely used in high-rise buildings because they efficiently integrate with elevator shafts and service cores, providing both structural and functional benefits [4].

**Problem Statement**

The rapid increase in urban populations and the limited availability of land have led to the construction of high-rise buildings, which are highly susceptible to lateral loads such as earthquakes and wind forces. As the height of a structure increases, its vulnerability to lateral displacement, storey drift, and torsional effects also increases, making structural safety and performance critical concerns.

Conventional structural systems, such as moment-resisting frames, often fail to provide sufficient stiffness and strength for extremely tall buildings. This results in excessive deformation and reduced serviceability under dynamic loading. Therefore, the selection of an efficient lateral load-resisting system is essential to ensure stability, safety, and economy in design.

Shear walls are widely used to enhance stiffness and reduce lateral displacement; however, their effectiveness depends on their location, configuration, and interaction with the structural system. Improper placement may lead to stiffness irregularities and inefficient load distributions. In contrast, the diagrid structural system has emerged as an innovative solution that improves structural efficiency and reduces material usage. Despite its advantages, its performance compared to conventional shear wall systems under combined seismic and wind loading conditions requires further investigation.

Additionally, limited comparative studies are available for very tall buildings (such as 50-storey structures) with different configurations of shear walls and diagrid systems. There is a need to evaluate and identify the most efficient structural system that provides optimal performance in terms of lateral displacement, base shear, bending moment, and overall stability.

Hence, this study aims to analyze and compare the performance of different structural systems, including shear wall configurations and diagrid systems, for a high-rise building subjected to seismic and wind loads to determine the most effective and economical design approach.

**Objectives**

The primary objectives of the present study are outlined as follows:

1. To conduct the structural analysis of a 50-storey high-rise building in accordance with IS 1893 and IS 875 provisions.

 

2. To evaluate the seismic performance of the 50-storey structure located in seismic Zone III.
3. To perform dynamic analysis using the Response Spectrum Method for a multi-storey building (50 floors)**.**
4. To assess the behavior of the tall building under wind loading conditions.
5. The effect of shear walls placed at different locations in a high-rise structure**.**
6. To investigate the performance of the building when a diagrid system is provided along the full perimeter**.**
7. To compare the structural responses, such as the axial force, bending moment, twisting moment, base shear, and lateral displacement, for different configurations.
8. To determine the most efficient structural system and optimal shear wall placement for improved performance,

## LITERATURE REVIEW

### Introduction

A literature review plays a vital role in understanding previous research related to the performance of high-rise buildings under seismic and wind loads. Various studies have been conducted to evaluate the effectiveness of different lateral load-resisting systems, such as shear walls and diagrid structures. This section presents a summary of the significant research contributions in this field.

**[8] Cheng, Y. (2025):** This study investigates the multidirectional seismic behavior of reinforced concrete shear wall systems in high-rise buildings. It focuses on how the orientation and placement of shear walls influence the structural response under earthquake loading. The results indicate that properly aligned shear walls significantly reduce the lateral displacement and torsional effects. The research highlights that symmetrical placement improves load distribution and enhances the global stiffness. It also emphasizes that the irregular positioning of shear walls can lead to uneven stress distribution and increased structural vulnerability. Advanced analytical methods were used to evaluate parameters such as the base shear and inter-storey drift. The study concluded that an optimized shear wall configuration plays a crucial role in improving the seismic performance and ensuring the structural safety of tall buildings.

**[9] Uysal, Y. (2025):** This study examined the effect of the shear wall ratio on the seismic performance of reinforced concrete structures. It evaluates the impact of varying the proportion of shear walls on lateral stiffness and displacement. The findings show that increasing the shear wall ratio reduces the storey drift and enhances the structural stability. However, the study also notes that excessive stiffness may attract higher seismic forces, making the design uneconomical. The uniform distribution of shear walls is an important factor in minimizing torsional irregularities. This research uses parametric analysis to assess the structural response to earthquake loading. It was concluded that an optimal balance between stiffness and flexibility is necessary to achieve efficient seismic performance in high-rise buildings.

**[10] Liu, C. (2025):** This study focused on the performance of advanced diagrid structural systems, particularly double-layer configurations in tall buildings. It evaluates how the diagrid geometry and member arrangement influence the structural behavior under lateral loads. The results indicate that double-layer diagrid systems provide higher stiffness and reduced displacement compared with conventional systems. The study highlights that the axial force transfer in diagonal members improves the efficiency and reduces the bending moments. It also shows that diagrid systems offer better energy dissipation under seismic loads. This study emphasizes the importance of selecting an optimal diagonal angle for maximum performance. Overall, the study concludes that diagrid systems are highly effective in improving the stability and efficiency of modern high-rise structures.

**[14] Yi, J. (2024):** This study analyzed the seismic performance of super-high-rise buildings using different structural systems. It focuses on the role of shear walls in controlling the structural response to earthquake forces. The findings indicate that shear walls significantly reduce lateral displacement and improve stiffness compared with conventional frame systems. This study used dynamic analysis techniques to evaluate parameters such as the base shear and storey drift. This also highlights that proper detailing of shear walls is essential to ensure ductile behavior during seismic events. The results demonstrate that buildings with well-designed shear wall systems exhibit better stability and safety. The study concluded that shear walls are essential components for enhancing the seismic resistance of high-rise structures.

**[12] Roshani, Mohammad (2023):** This study investigates the seismic resilience of diagrid structures using performance-based design approaches. This study examines how the triangulated configuration of diagrid systems improves load distribution and structural redundancy. The results demonstrated that the diagrid structures effectively resisted both gravity and lateral loads through axial action. This study highlights that this system reduces the risk of progressive collapse and enhances the energy dissipation capacity. This also indicates that diagrid structures provide better control over lateral displacement than conventional systems. The research demonstrates that diagrid systems require less material while maintaining high strengths and stiffness. The study concluded that diagrid structures are efficient and reliable for high-rise buildings in seismic regions.

**[3] Mele, Ernesto; Toreno, Giovanni; De Luca, Angelo (2014):** This study examined the structural behavior of diagrid systems in tall buildings. It focuses on how diagonal members contribute to the load resistance and improve the structural efficiency. The findings indicate that diagrid systems primarily transfer loads through axial forces, thereby reducing the bending moments in the structural members. This study highlights that selecting an optimal diagonal angle is essential for achieving maximum performance. It also shows that diagrid systems reduce the need for internal columns, thereby allowing greater architectural flexibility. This study demonstrates that these systems provide improved stiffness and better load distribution. The study concluded that diagrid structures are an effective solution for high-rise buildings because of their strength, efficiency, and aesthetic advantages.

### Key Findings from Literature

From the review of previous studies, the following observations can be made:

1. Shear walls significantly enhance stiffness and reduce lateral displacement.
2. Diagrid systems improve structural efficiency by resisting loads through axial action.
3. Hybrid systems (shear wall + diagrid) provide superior performance compared with individual systems.
4. The location and configuration of shear walls play a crucial role in structural behavior.
5. Diagrid angle and geometry greatly influence structural efficiency.
6. Both systems are effective in resisting seismic and wind loads in high-rise structures.

### Research Gap

Based on the literature review, the following research gaps are identified:

1. Limited studies are available for very tall buildings (50-storey structures).
2. Comparative evaluation under both wind and seismic loads simultaneously is insufficient.
3. Optimization of shear wall location along with diagrid configuration requires further investigation.
4. Most studies have focused on shear walls or diagrids individually, whereas combined analyses are limited.

## METHODOLOGY

### General

This study focuses on evaluating the structural performance of a high-rise building under seismic and wind loads using different lateral load-resisting systems (LLRSs). A systematic approach was adopted to analyze and compare various structural configurations. The methodology involves modeling, loading, analysis, and comparison of results to identify the most efficient structural system.

 

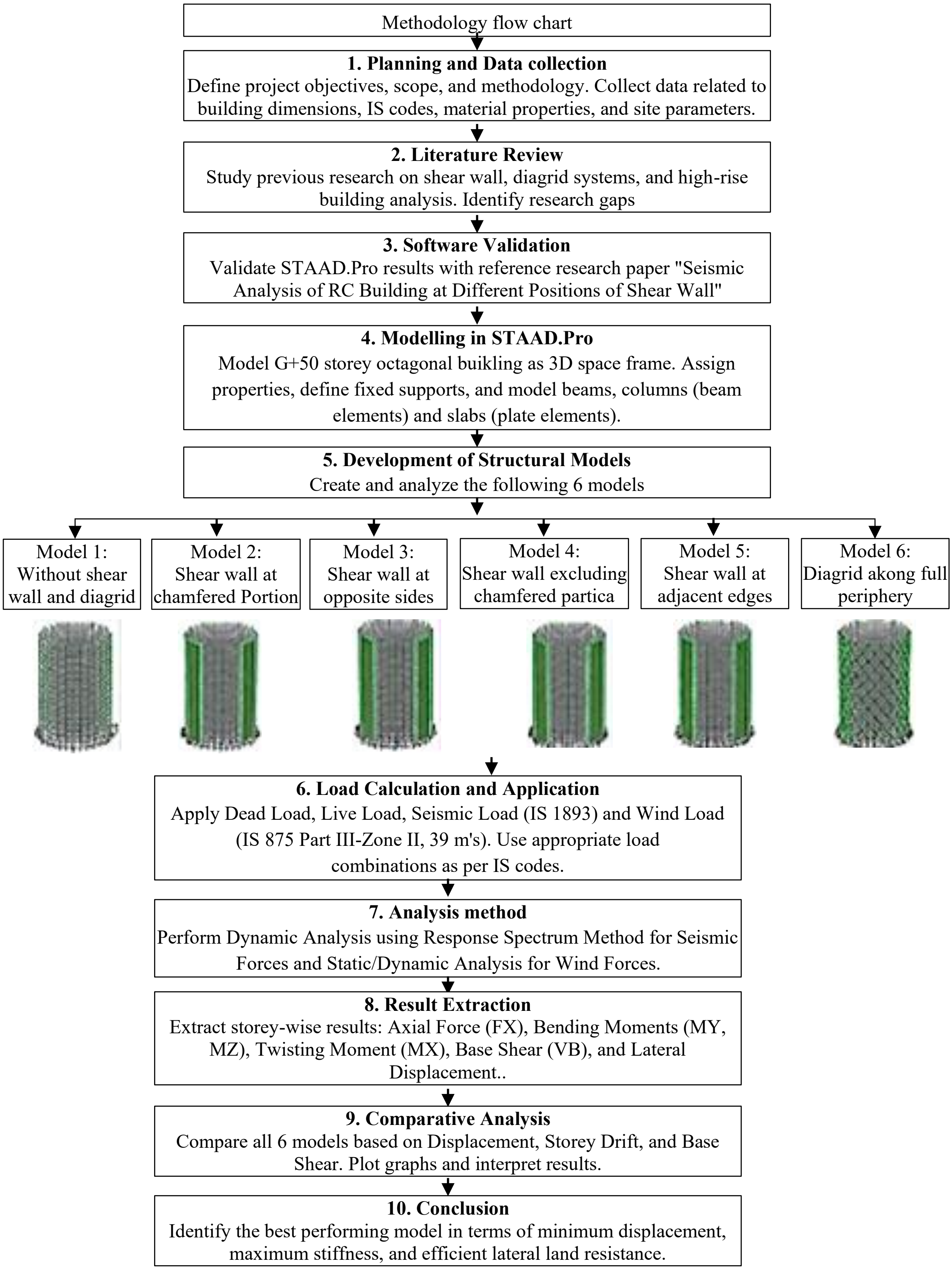


**Figure 3.** Methodology.

## Study Model Description

A 50-storey high-rise building was considered for the analysis. The building was modeled with an octagonal plan configuration to study the effect of geometric complexity on the structural performance. Six different structural models were developed to evaluate the influence of shear walls and diagrid systems.

 

**Model 1:** Bare frame structure (octagonal plan) without shear walls or a diagrid system
**Model 2:** Octagonal building with shear wall located at the central core
**Model 3:** Octagonal building with shear walls placed at opposite sides
**Model 4:** Octagonal building with shear walls positioned at the corners
**Model 5:** Octagonal building with shear walls along adjacent edges
**Model 6:** Octagonal building with a diagrid system provided along the full perimeter

**Software Used**

The structural analysis is carried out using STAAD.Pro for modeling, analysis, and result extraction This software is widely used for analyzing complex high-rise structures under different loading conditions.

**Building Specification for Seismic Analysis and Wind Analysis shown in Table 1**

**Table 1.** detailed specifications for seismic and wind analysis.

| S.N. | Parameters | Dimensions |
|---|---|---|
| 1 | Storey height for ground floor | 10800 mm |
| 2 | Storey Height | 3500 mm |
| 2.1 | Octagonal plan of dimensions | 40,000 mm × 40,000 mm |
| 3 | Column Sizes<br>1 to 10 storey<br>11 to 20 storey<br>21 to 30 storey<br>31 to 40 storey<br>41 to 50 storey<br>Other columns<br>Outer circle<br>Inner circle | <br>1.7 m X 1.7 m<br>1.4 m X 1.4 m<br>1.2 m X 1.2 m<br>0.95 m X 0.95 m<br>0.75 m X 0.75 m<br><br>1.25 m Dia.<br>1 m Dia. |
| 4 | Beam size | 0.23 m X 0.75 m |
| 5 | Depth of Slab | 0.2 m |
| 6 | Thickness of Wall | 0.23 m |
| 7 | Thickness of shear wall | 0.2 m |
| 8 | Size of diagrid | 0.2 m X 0.4 m |
| 9 | Unit weight of concrete | 25 kN/$m^3$ |
| 10 | Grade of Concrete | $M_{50}$ |
| 11 | Grade of steel | $Fe_{415/500}$ |
| 12 | Floor Finish | 1.5 kN/$m^2$ |
| 13 | Dead load from slab | 5 kN/$m^2$ |
| 14 | Weight of wall | 17 kN/$m^2$ |
| 15 | Weight of parapet wall | 5 kN/$m^2$ |
| | **For Seismic Analysis** | |
| 16 | Type of soil | Medium |
| 17 | Seismic zone | III |
| 18 | Importance factor | 1.5 |
| 19 | Response reduction factor | 5 |
| 20 | Damping ratio | 5 % |
| | **For Wind Analysis** | |
| 21 | Wind zone | II |
| 22 | Basic wind speed | 39 m/s |
| 23 | Exposure category | C |
| 24 | Building natural frequency | 2 Hz |

**2-D Rendering View of Ground plus Fifty-storey Models shown in figure 3(a-f)**

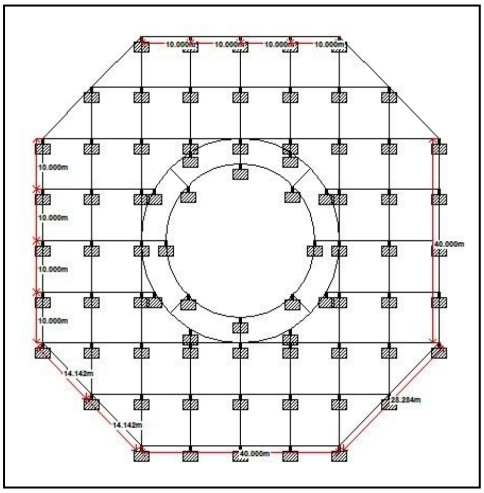


**Figure 3 (a).** Model 1- Bare frame structure without shear wall and diagrid systems.

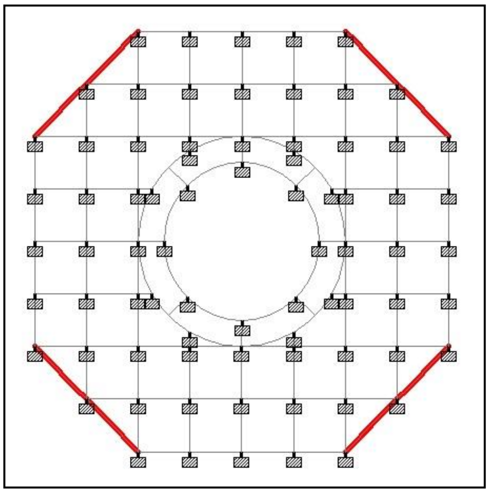

**Figure 3 (b).** Model 2- Building with shear walls located at chamfered corners

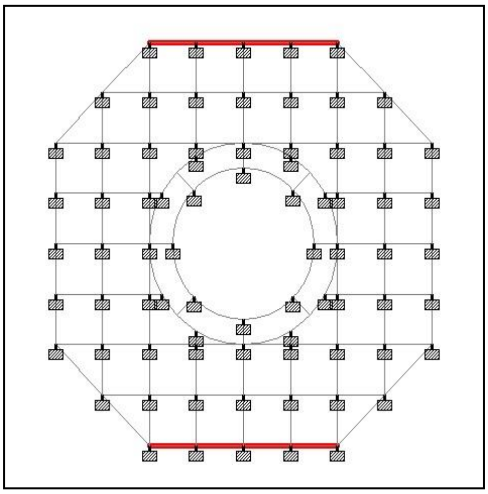

**Figure 3 (c).** Model 3- Building with shear wall on opposite sides in X-direction

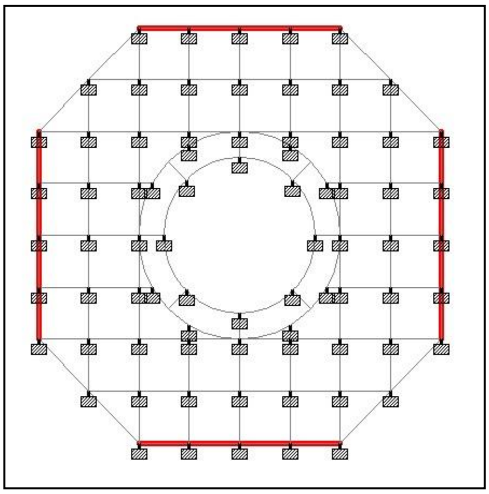

**Figure 3 (d).** Model 4- building with shear wall on opposite sides excluding chamfered portion

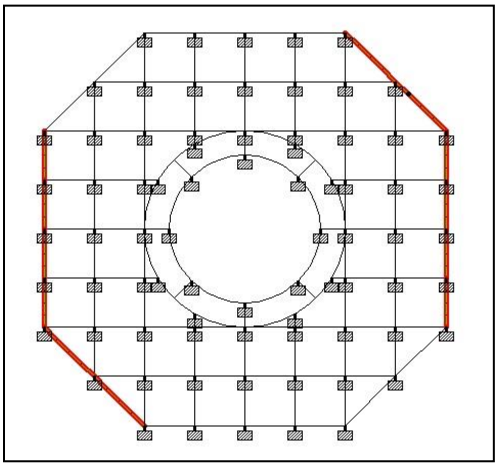

**Figure 3 (e).** Model 5- building with shear wall on opposite two adjacent edges.

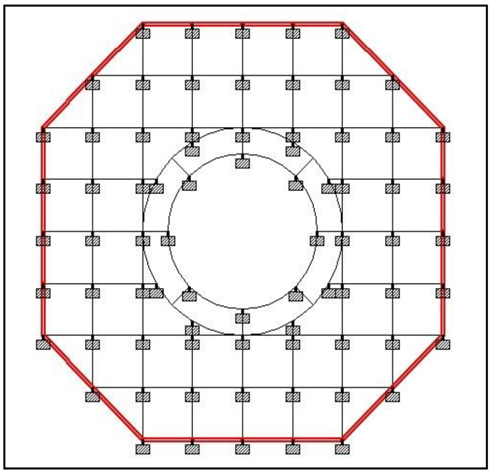

**Figure 3 (f).** Model 6- Building with diagrid along complete periphery.

 

**3-D Rendering View of Ground plus Fifty-storeyModels shown in 3(g-l)**

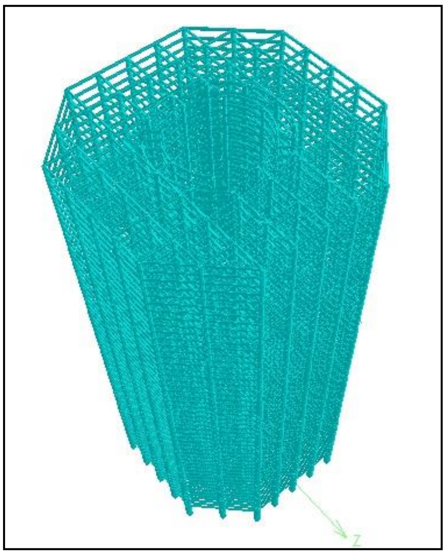

**Figure 3 (g).** 3-D Rendering view of model- 1

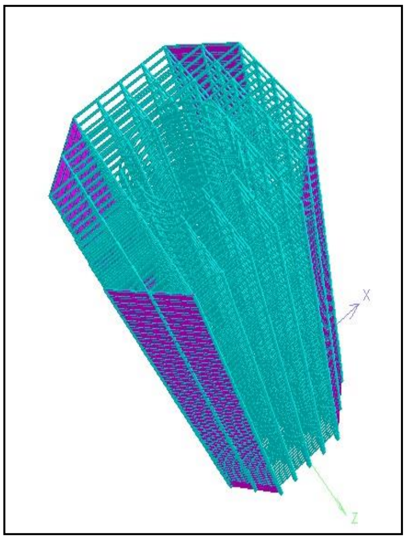

**Figure 3 (h).** 3-D Rendering view of model- 2

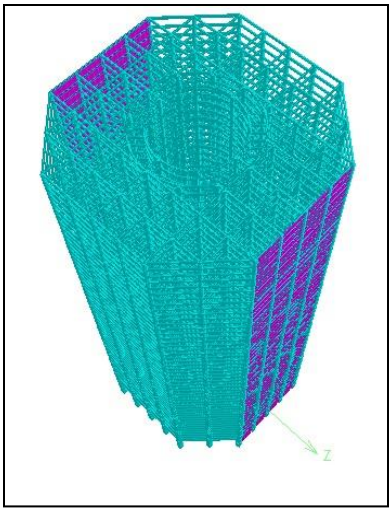

**Figure 3 (i).** 3-D Rendering view of model 3

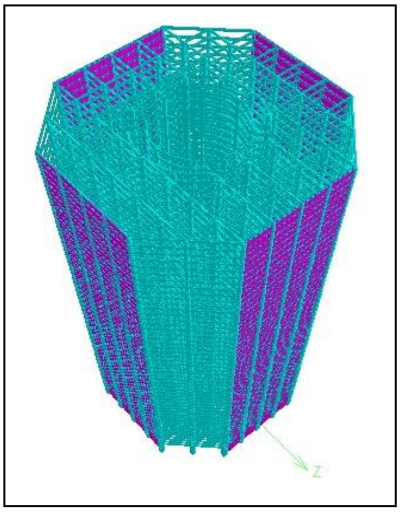

**Figure 3 (j).** 3-D Rendering view of model 4

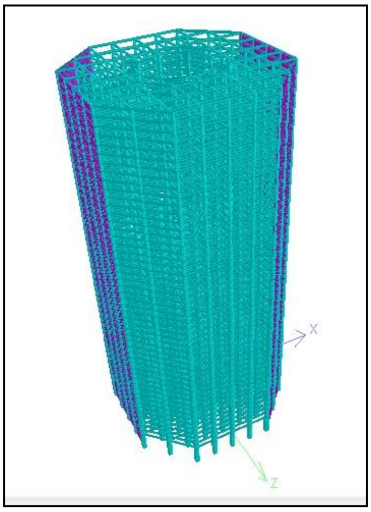

**Figure 3 (k).** 3-D Rendering view of model 5

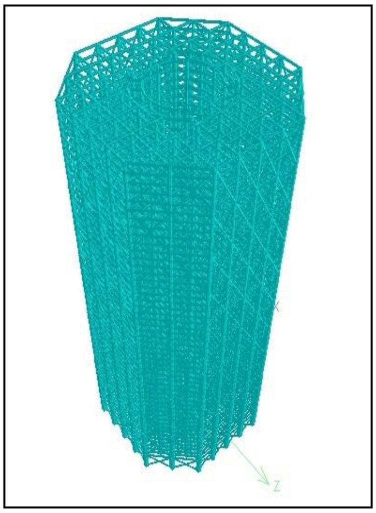

**Figure 3 (l).** 3-D Rendering view of model 6

 

## RESULTS AND DISCUSSION

### General

The structural analysis of the 50-storey high-rise building was carried out using STAAD. Pro under seismic and wind-loading conditions. Six different models were analyzed to evaluate the effects of the shear wall configuration and diagrid system on the structural performance. The results were compared based on key parameters, such as the axial force, bending moment, twisting moment, base shear, and lateral displacement.

### Lateral Displacement

Lateral displacement is one of the most critical parameters in the analysis of high-rise buildings because it directly reflects the stiffness and stability of the structure under lateral loads. In the present study, lateral displacement values were obtained for all six models under both seismic and wind-loading conditions.

#### *Displacement under Seismic Load*

The analysis of the result values indicates that the lateral displacement increases progressively with height for all models, which is the expected behavior in tall structures. The maximum displacement occurred at the top story (50th level).

- **Model 1 (Bare Frame)** exhibited the highest displacement = 2154 mm**),** indicating the lowest stiffness.
- **Model 2 (Core Shear Wall)** reduces displacement to **879 mm**.
- **Model 3** shows a slightly higher displacement (**2193 mm**) owing to the less effective shear wall placement.
- **Model 4 and Model 5** show further improvement, with values of approximately **573 mm and 1300 mm**, respectively.
- **Model 6 (Diagrid)** shows significantly reduced displacement (~802 mm)**.**

*Percentage Reduction (Compared to Model 1):*

- **Model 2:** ~59% reduction
- **Model 4:** ~73% reduction (Best shear wall case)
- **Model 6:** ~63% reduction

This clearly shows that properly placed shear walls (Model 4) **and** diagrid system significantly improve the stiffness.

#### *Displacement under Wind Load*

From Result Value, a similar trend is observed under wind loading:

- Model 1 shows maximum displacement = 954 mm
- Model 2 reduces it to 458 mm
- Model 3 shows higher displacement = 941 mm
- Model 4 gives the lowest displacement = 280 mm
- Model 5 shows moderate performance = 609 mm
- Model 6 gives 600 mm displacement

*Percentage Reduction (Compared to Model 1):*

- Model 2: ~52% reduction
- Model 4: ~71% reduction (Best overall)
- Model 6: ~37% reduction

### Base Shear (VB)

#### *General*

The base shear represents the total lateral force transferred to the foundation owing to seismic and wind loads. It is a key parameter that indicates the overall load-resisting capacity of a structure. In this study, base shear values were obtained for all six models and compared to evaluate the effects of different structural systems Figure 4, 5.

 

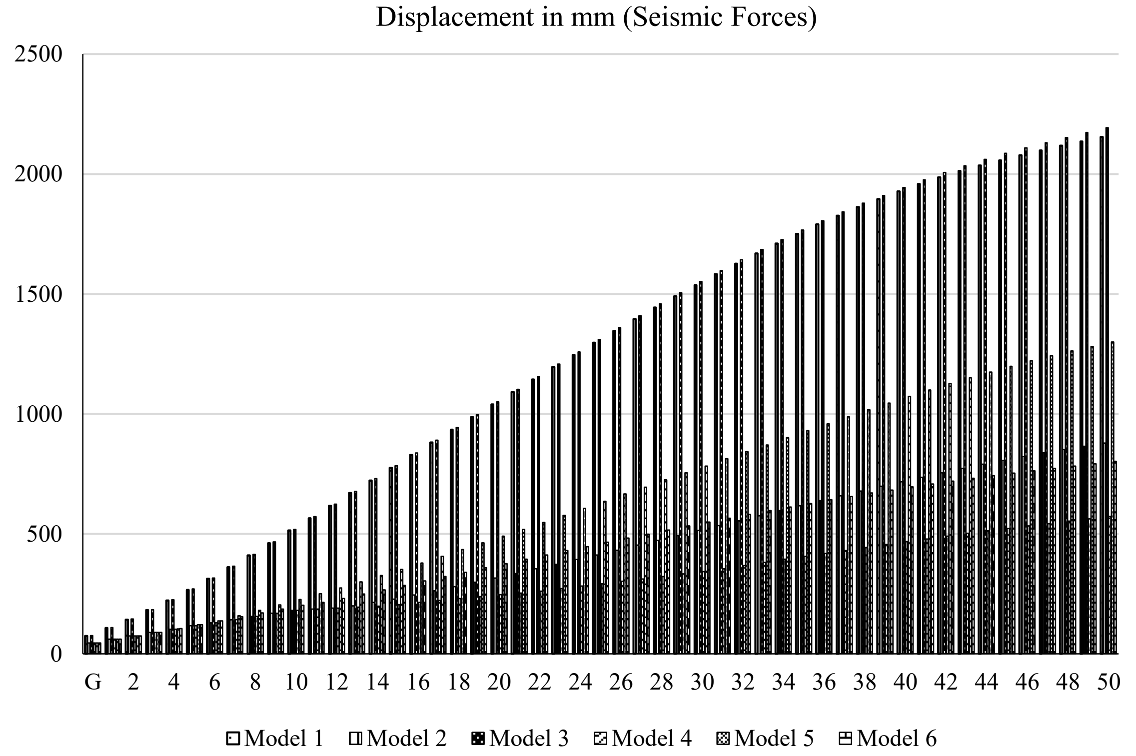


**Figure 4**. Maximum values of lateral displacement considering seismic forces.

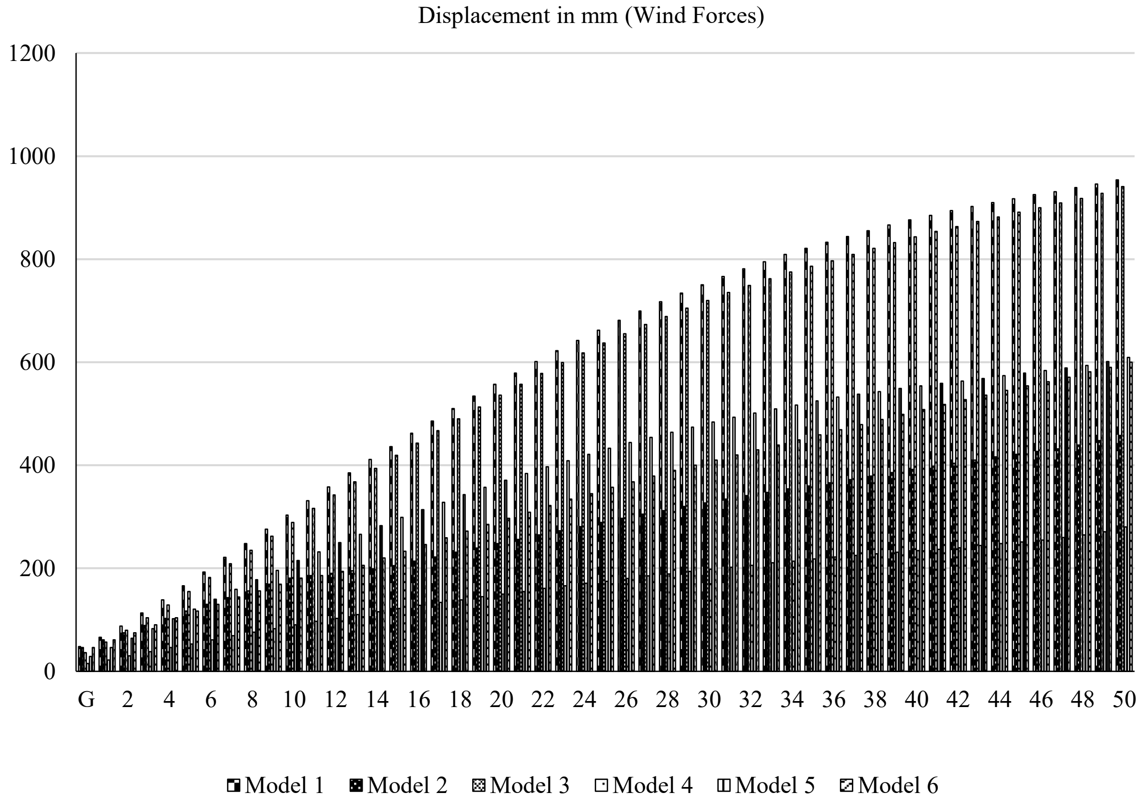


**Figure 5.** Maximum values of lateral displacement considering wind forces.

***Base Shear under Seismic Load***

From Table 2 and Figure 6, the maximum base shear values for all the models are summarized as follows:

 

**Table 2.** Maximum values of base shear ($V_B$) considering seismic forces.

| Model | Base Shear in kN |
|---|---|
| 1 | **38370.80** |
| 2 | 39235.18 |
| 3 | 38980.58 |
| 4 | **39590.31** |
| 5 | 39411.73 |
| 6 | 38546.70 |

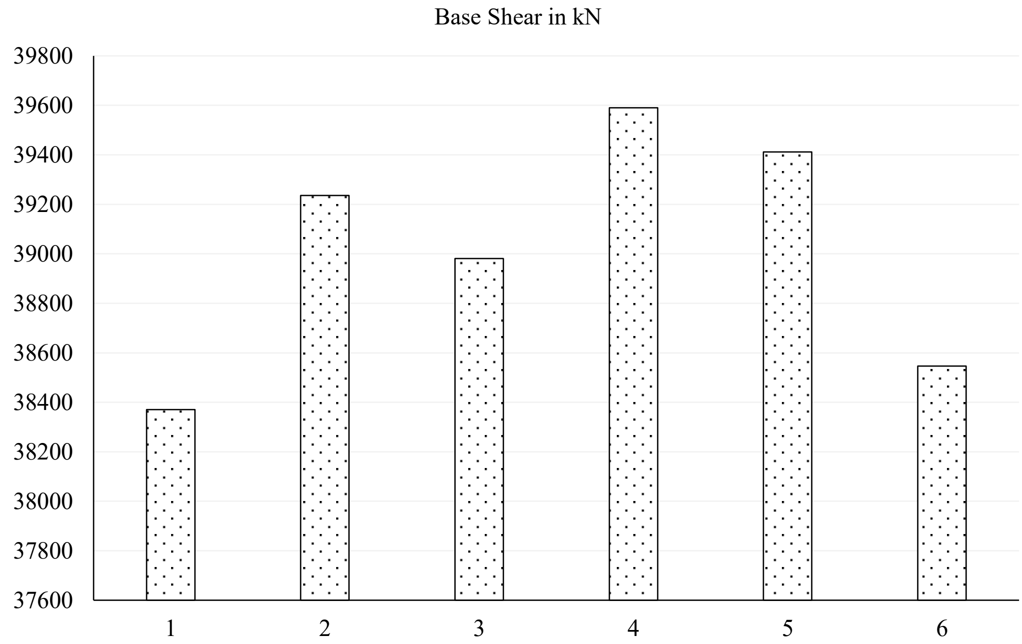


**Figure 6.** Maximum values of base shear ($V_B$) considering seismic forces.

The data suggests that:

- Model 4 (Corner Shear Wall) shows the maximum base shear = 39590.31 kN
- Model 1 (Bare Frame) shows comparatively lower base shear
- Model 6 (Diagrid) has moderate base shear

A higher base shear indicates that the structure has greater stiffness and attracts more seismic force, which is a desirable characteristic for resisting lateral loads.

*Percentage Increase (Compared to Model 1):*

- Model 2: ↑ ~2.25%
- Model 3: ↑ ~1.59%
- Model 4: ↑ ~3.18% (Maximum)
- Model 5: ↑ ~2.71%
- Model 6: ↑ ~0.46%

***Base Shear under Wind Load***

From Table 3, The base shear values under wind loading are observed to be comparable in trend; however, slight variations may occur depending on the load combinations and dynamic response characteristics.

 

**Table 3.** (W) Maximum values of base shear ($V_B$) considering wind forces.

| Model | Base Shear in kN |
|---|---|
| 1 | **38370.80** |
| 2 | 39235.18 |
| 3 | 38980.58 |
| 4 | **39590.31** |
| 5 | 39411.73 |
| 6 | 38546.70 |

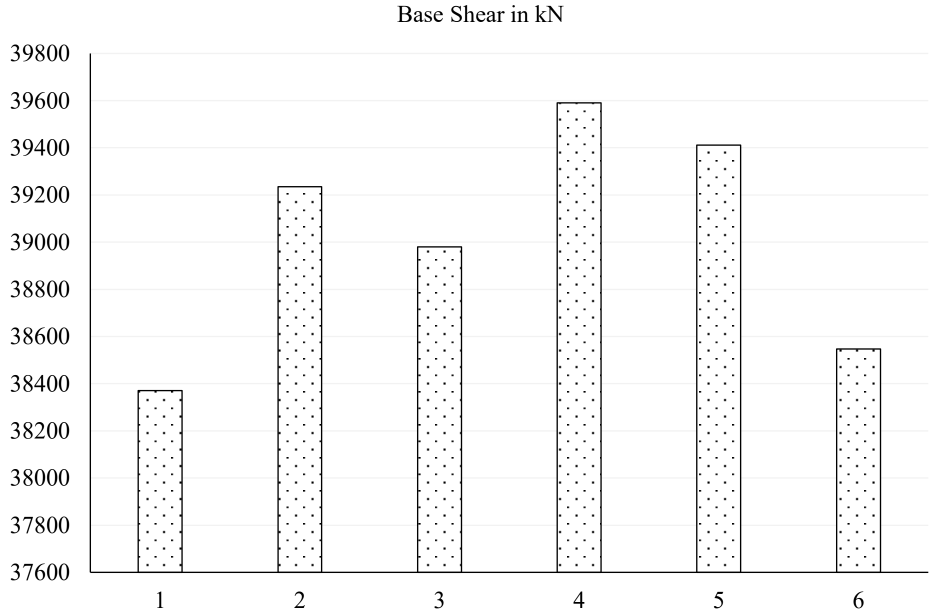


**Figure 7.** (W) Maximum values of base shear ($V_B$) considering wind forces.

- Model 4 shows the highest base shear
- Model 1 shows the lowest value among all models

This confirms that Model 4 has the highest stiffness and load-resisting capacity**.**

**Bending Moment (MZ)**

***General***

The bending moment is a critical parameter in structural analysis because it governs the design of beams and columns. In high-rise buildings, bending moments are primarily induced by lateral loads, such as earthquakes and wind forces. In this study, the bending moment values (MZ) were evaluated for all models at different storey levels.

***Bending Moment under Seismic Load***

The results show that the bending moment is maximum at the **ground storey** and gradually decreases towards the upper storeys Figure 8.

- **Model 1 (Bare Frame)** shows the maximum bending moment = 18500 kN·**m** at the ground level.
- **Model 2 and Model 3** show a significant reduction due to shear wall presence
- **Model 4** shows controlled bending due to proper shear wall placement
- **Model 5** shows moderate performance
- **Model 6 (Diagrid)** reduces bending considerably due to axial load transfer

 

Minimum bending moment is observed in Model 6 at 41st storey (~824 kN·m)

*Percentage Reduction at Ground Storey (Compared to Model 1):*
- Model 2: ~68% reduction
- Model 3: ~68% reduction
- Model 4: ~67% reduction
- Model 5: ~40% reduction
- Model 6: ~54% reduction

***Bending Moment under Wind Load***

From Result, a similar trend is observed:
- **Model 1** shows maximum bending moment = **12200 kN·m**
- **Model 2, 3, 4** show significant reduction
- **Model 6** shows fluctuating but generally reduced bending values
- Minimum bending moment occurs in upper storeys

Maximum value is again observed at **ground storey**, indicating maximum demand at base.

*Percentage Reduction at Ground Storey (Wind Load):*
- Model 2: ~59% reduction
- Model 3: ~65% reduction
- Model 4: ~62% reduction
- Model 5: ~48% reduction
- Model 6: ~21% reduction

**Axial Force (FX)**

***General***

The axial force is an important parameter that represents the vertical load carried by structural members, such as columns and walls. In high-rise buildings, the axial force is maximum at the lower stories and decreases gradually towards the top owing to the reduction in cumulative gravity loads. In this study, the axial force values were evaluated for all models under seismic and wind loading conditions Figure 9.

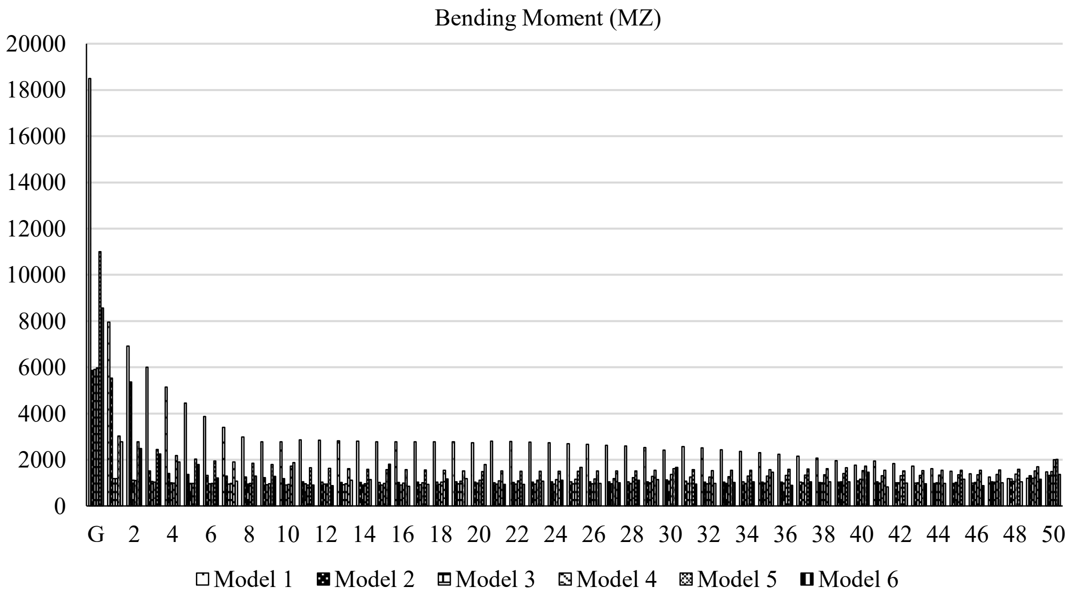


**Figure 8.** (S) Maximum values of bending moment ($M_Z$) considering seismic forces.

***Axial Force under Seismic Load***

From Result, The results highlight that:

- The axial force is maximum at ground storey (G) and decreases continuously with an increase in height Figure 10.
- **Model 5** shows the maximum axial force = 142000 kN at ground level.
- **Model 1, 3, and 4** show similar values around 105000 kN**.**
- **Model 2** shows slightly higher value = 115000 kN**.**
- **Model 6 (Diagrid)** shows comparatively lower axial force = 104000 kN**.**

*Percentage Variation at Ground Storey (Compared to Model 1):*

- Model 2: ~9.5% increase
- Model 5: ~35% increase (Maximum)
- Model 6: ~1% decrease

***Axial Force under Wind Load***

From Table 2 and Figure 11 similar behavior is observed:

- Maximum axial force occurs at **ground storey**
- **Model 1 and Model 5** show highest values (~105000 kN)
- **Model 3 and Model 4** showed reduced axial forces (~83900 kN and 82800 kN, respectively).
- **Model 6** shows the **lowest axial force = 77600 kN**

*Percentage Reduction (Compared to Model 1):*

- **Model 3:** ~20% reduction
- **Model 4:** ~21% reduction
- **Model 6:** ~26% reduction (Minimum)

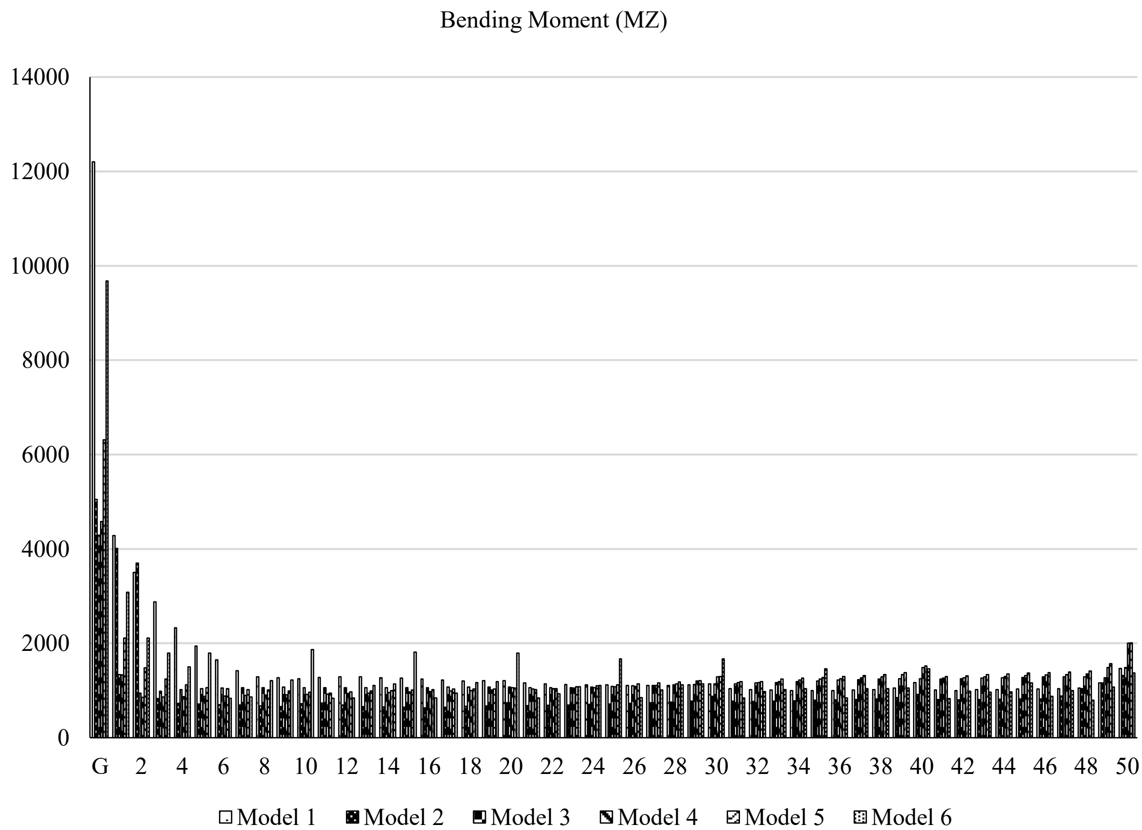


**Figure 9.** (W) Maximum values of bending moment ($M_Z$) considering wind forces.

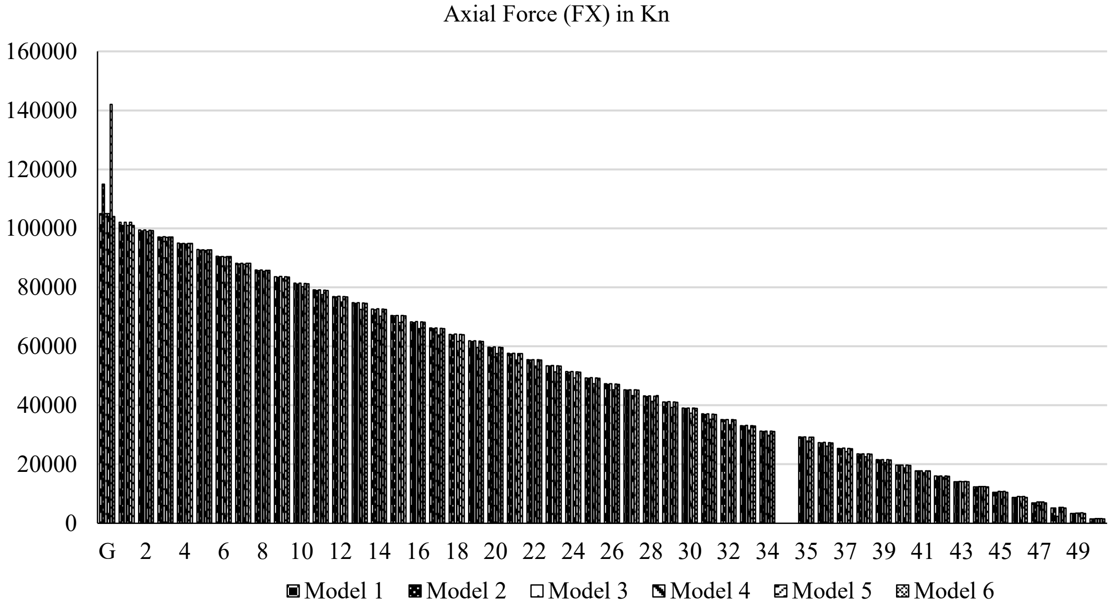


**Figure 10.** Maximum values of axial force ($F_X$) considering seismic forces.

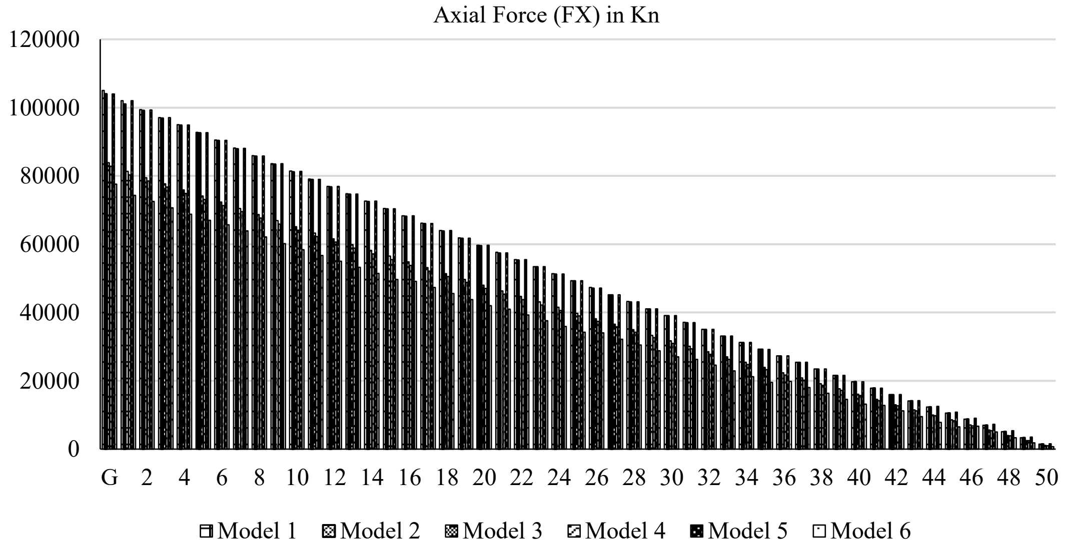


**Figure 11.** Maximum Values of axial force ($F_X$) considering wind forces.

## DISCUSSION

The comparative evaluation of the six structural models provides a clear insight into the influence of different lateral load-resisting systems on the behavior of high-rise buildings under seismic and wind loading.

A consistent trend observed across all models was the progressive increase in lateral displacement with building height, which is typical for slender structures subjected to lateral forces. However, the magnitude of the displacement varies significantly depending on the structural configuration. The bare frame model exhibited excessive displacement, indicating inadequate stiffness for tall building applications. In contrast, the introduction of shear walls and diagrid systems substantially improved stiffness and reduced lateral deformation.

Among the shear wall configurations, the model with corner shear walls demonstrated superior performance. This improvement can be attributed to the effective distribution of stiffness along the building perimeter, which minimizes torsional effects and enhances resistance to lateral loads. However, the inefficient placement of shear walls, as observed in some configurations, resulted in higher displacement and less effective load transfer, highlighting the importance of strategic positioning.

The diagrid system exhibits a different structural behavior compared to conventional systems. Instead of relying on bending resistance, the diagrid primarily transfers loads through the axial forces in its diagonal members. This mechanism leads to a significant reduction in the bending moments and improves the overall structural efficiency. Additionally, the diagrid system exhibited better control over the torsional response, which is a critical factor in high-rise structures with complex geometries, such as octagonal plans.

The variation in the base shear values among the models reflects the differences in the structural stiffness. Models with higher stiffness, particularly those incorporating shear walls, tend to attract greater seismic forces, resulting in an increased base shear. This behavior is consistent with the fundamental structural dynamics, where stiffer systems experience higher force demand but lower deformation. However, the diagrid system achieves a balanced response by maintaining moderate base shear while effectively controlling the displacement and internal forces.

The bending moment distribution across the height of the building indicates the maximum demand at the base, which gradually decreases towards the top. The significant reduction in the bending moments observed in the shear wall and diagrid systems confirmed their effectiveness in resisting lateral loads. In particular, the diagrid system reduces bending by converting lateral loads into axial forces, thereby improving the structural performance and reducing the material demand.

The variation in the axial force further highlights the efficiency of the different systems. Higher axial forces observed in certain shear wall configurations suggest a concentration of loads, whereas the diagrid system exhibits a more uniform distribution. This uniformity contributes to improved load sharing among the structural members and reduces the likelihood of localized overstressing.

A comparison between the seismic and wind effects indicated that seismic loading governed the design of the structure in this study. Seismic forces generate higher displacements and internal forces than wind loads, emphasizing the need for careful seismic design, especially in moderate-to-high seismic zones. However, wind effects remain important for serviceability considerations, particularly regarding occupant comfort and structural vibrations.

Overall, the discussion highlights that no single structural system is optimal. Shear walls provide excellent stiffness and displacement control when properly located, whereas the diagrid system offers a more efficient and balanced structural response by optimizing the load transfer mechanisms. Therefore, the selection of an appropriate system should consider not only the structural performance but also factors such as architectural requirements, material efficiency, and construction feasibility.

## CONCLUSION

Based on the analysis results and detailed discussion, the following conclusions can be drawn.

1. The distribution of the axial force varied significantly among the models. The maximum axial force is observed in Model 5, whereas the diagrid system (Model 6) exhibits comparatively lower values under seismic loading. A reduction in the axial force of approximately 26 percent at the ground story, gradually decreasing to approximately 5% at higher levels, indicates a more efficient and uniform load transfer mechanism in the diagrid configuration.
2. The torsional response of the structure was effectively controlled by introducing a diagrid system. A substantial reduction of nearly 67% in the twisting moment at the lower storeys and up to 85% at the top storey is achieved compared with Model 5, demonstrating the ability of the diagrid system to minimize torsional irregularities and enhance overall stability.

3. The evaluation of lateral displacement confirmed that Models 1, 2, and 3 exceeded the permissible limits specified in IS 1893 (Part 1) (0.004 times the building height). In contrast, the inclusion of shear walls at optimal locations, particularly in Model 4, significantly reduced the displacement and ensured compliance with the codal limits under both seismic and wind loading conditions.
4. The building model incorporating the perimeter diagrid system (Model 6) demonstrated the most balanced structural behavior under seismic loading. This system achieves an efficient combination of a reduced bending moment, controlled axial force, minimized torsion, and adequate base shear, thereby enhancing the overall structural performance of high-rise buildings.
5. Under wind loading conditions, the configuration with shear walls placed on opposite sides (Model 4) performed most effectively. This arrangement provides improved resistance against lateral forces, resulting in reduced displacement, bending moment, and base shear compared with other models.
6. A comparative assessment of the loading effects indicated that seismic forces govern the structural design of buildings, producing higher values of displacement, internal forces, and moments than wind loads. This emphasizes the necessity of a detailed seismic evaluation in the design of tall structures, particularly in moderate to high seismic zones.

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