Impact of Shear Wall Placement on Lateral Load Performance of Building Frames

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Abstract:
This study investigates the impact of shear wall placement on the lateral load performance of G+15 building frames, focusing on two ETABS models with different shear wall configurations: corner-placed shear walls and side-placed shear walls. Both models are analyzed under seismic loads in Seismic Zone V, which represents the highest earthquake risk category in India. Key structural parameters such as base shear, lateral displacement, overturning moment, drift, and time period are evaluated to compare the effectiveness of each shear wall configuration in enhancing seismic resistance. The placement of shear walls plays a crucial role in a building's ability to resist lateral loads by increasing stiffness and reducing sway. Corner-placed shear walls concentrate lateral resistance at the edges, potentially affecting the torsional behavior of the structure, whereas side-placed shear walls distribute resistance more uniformly along the sides. The results from the ETABS analysis reveal significant differences in performance metrics, such as base shear and lateral drift, which highlight the influence of shear wall location on the structural behaviour during seismic events. This comparative analysis aims to guide engineers and designers in optimizing shear wall placement for mid- to high-rise buildings to ensure better seismic performance and safety. It provides insights into the benefits and limitations of each configuration, helping to develop more resilient building designs suitable for seismic-prone regions.
Keywords: Corner shear walls, Side shear walls, ETABS, lateral load performance, Seismic Zone V, base shear, drift, torsion, overturning moment, structural design.

1. INTRODUCTION

The structural integrity and safety of buildings in seismic zones depend significantly on their ability to withstand lateral loads, particularly those induced by earthquakes. Among the various design strategies employed to enhance the lateral load performance of building frames, the placement of shear walls has emerged as a critical factor. Shear walls are vertical structural elements designed to resist lateral forces through their inherent stiffness and strength, making them essential in mitigating the effects of seismic activity. This study focuses on a G+15 building model subjected to seismic loads, analyzing the performance implications of corner-placed and side-placed shear walls within the context of seismic zone V, characterized by a high risk of intense seismic events.

In seismic zone V, the placement of shear walls can significantly influence the overall stability and drift control of a structure. Corner-placed shear walls provide a more robust framework by creating a centralized core that effectively distributes lateral forces across the structure, minimizing deformation and enhancing energy dissipation during seismic events. This configuration is particularly advantageous in resisting torsional movements that can arise during earthquakes. On the other hand, side-placed shear walls may offer greater design flexibility and spatial efficiency; however, they can lead to increased torsional effects and uneven force distribution, which may compromise the building's stability.

The performance of these two configurations can be quantitatively assessed using ETABS software, which allows for advanced modeling of complex structural behaviors under seismic loading conditions. The analysis will involve simulating various earthquake scenarios to evaluate key performance indicators, including lateral drift, base shear, and overall stability. The corner-placed shear wall is anticipated to demonstrate superior performance in terms of reduced lateral drift and increased energy dissipation, thereby enhancing the building's resilience to seismic forces. In contrast, the side-placed shear wall may exhibit higher lateral drift and reduced overall stability, highlighting the importance of strategic design considerations in seismic-prone areas.

Furthermore, this study will explore the implications of each shear wall configuration on the overall serviceability and safety of the building. Factors such as occupant comfort, potential for damage, and the building's post-earthquake functionality will also be examined. By comparing the two configurations, the research aims to provide a comprehensive understanding of how shear wall placement affects the lateral load performance of building frames. The findings are expected to contribute valuable insights for

engineers and architects, aiding in the development of more effective and resilient structural designs that can withstand the challenges posed by seismic events. Ultimately, this study seeks to enhance the safety and resilience of urban structures in seismic zones, ensuring that they can endure the forces of nature while providing a safe environment for their occupants.

Fig. 1. Shear Walls in Building

1.1 Advantages of Corner and Side-Placed Shear Walls

A. Corner-Placed Shear Walls

1. Torsional Resistance: Corner-placed shear walls are highly effective in countering torsional forces generated by uneven seismic loads.
2. Enhanced Rotational Stability: They help to diminish overturning moments, thereby improving the overall stability of taller structures.
3. Suitability for Irregular Layouts: This configuration is advantageous for buildings with non-standard shapes, as it prevents significant rotational displacements.

B. Side-Placed Shear Walls

1. Uniform Load Distribution: Side-placed shear walls facilitate a more even distribution of lateral loads across both horizontal axes.

2. Improved Drift Control: Their placement aligns better with key structural components, resulting in more effective management of inter-story drift.
3. Architectural Flexibility: This arrangement allows for greater design freedom in interior space planning, as it frees up corner areas.
4. Optimized Seismic Response: Side placement is beneficial for symmetrical buildings, where the lateral load paths can be predicted and managed effectively.

1.2 Disadvantages of Corner and Side-Placed Shear Walls

A. Corner-Placed Shear Walls

1. Localized Stiffness Concentration: They may create uneven stiffness distribution, potentially leading to localized stress concentrations within the structure.
2. Design Constraints: Their requirement for placement at structural corners can limit architectural flexibility.
3. Higher Base Shear Values: Due to their increased stiffness, corner-placed shear walls may attract slightly greater seismic forces.

B. Side-Placed Shear Walls

1. Reduced Torsional Resistance: This configuration is less effective at counteracting twisting forces, which can increase vulnerability to torsional irregularities.
2. Increased Drift During Extreme Events: Side-placed shear walls might experience higher displacements when the structure is subjected to severe lateral loads.
3. Alignment Challenges: If the shear wall does not align well with the load paths, its efficiency can diminish during significant earthquake events.

1.3 Aim

The primary aim of this project is to conduct a comparative study of G+10 buildings with oblique and Y-shaped columns in the context of Seismic Zone V, which represents the most severe seismic conditions in India. The objective is to analyze how these unconventional column geometries influence the building's seismic response in terms of displacement, drift, base shear, and overturning moments.

This research aims to provide insights into the dynamic behavior of these structures by leveraging advanced modeling software such as ETABS to perform static and dynamic analysis. The project seeks to determine which column type offers better structural stability and resistance to lateral forces, thus ensuring both safety and performance under high seismic demands. Additionally, the study strives to optimize the design in terms of material efficiency and cost-effectiveness while maintaining compliance with Indian seismic codes (IS 16700).

The findings from this project will not only contribute to safer design practices but also provide architectural flexibility, helping structural engineers and architects choose suitable column configurations that meet both performance-based design objectives and aesthetic goals. This comparative study aims to serve as a practical reference for future high-rise construction projects in seismic-prone regions.

1.4 Objectives

i. **Modeling and Analysis:** Create and analyze G+15 structural models featuring both corner-placed and side-placed shear walls using ETABS software.

ii. **Seismic Behavior Evaluation:** Assess the seismic performance based on metrics such as base shear, displacement, drift, time period, and modal mass participation.

iii. **Comparative Performance Analysis:** Examine the performance differences between the two configurations under earthquake loads, particularly in the context of Seismic Zone V.

iv. **Compliance with Seismic Codes:** Verify that both structural designs adhere to Indian seismic standards, specifically IS 1893:2016 and IS 16700:2017, applicable to high-rise buildings.

v. **Advantages and Limitations Assessment:** Identify the strengths and weaknesses of each shear wall placement strategy to determine the most effective design for high-rise structures.

vi. **Overturning Moment Resistance Analysis:** Evaluate the capacity of different shear wall placements to resist overturning moments during seismic events.

2. LITERATURE REVIEW

1. In the article **“Orientation and Location of Shear Walls in RC Buildings to Control Deflection and Drifts”** by Ashikur Rahman Simona, Ferdows Kabir Hridoya, M. Fahim Siddiquea, and Sanjid Ahmed Safata (2023), the authors address the critical issue of managing deflections and drifts resulting from lateral loads, such as wind and seismic forces, in the construction of high-rise buildings. The improper placement of shear walls can lead to eccentricities in buildings, which in turn may cause torsional effects. This study aims to identify the optimal orientation and location of shear walls in reinforced concrete (RC) buildings to mitigate these issues. The researchers modeled a 10-story RC building using ETABS, examining various shear wall positions, including central, side, inner, peripheral, corner, and combinations of center and edge placements. The framed structure was subjected to lateral and gravity loads according to BNBC 2020, with analytical results compared to a bare frame model in terms of storey shear, drift, displacement, stiffness, torsional irregularity, and time period.
The findings indicate that incorporating shear walls can significantly reduce lateral displacements and storey drift while enhancing the overall stiffness of the structure. Comparisons between models with shear walls at the center and those with shear walls at both the center and edges reveal that effective shear wall placement should consider both short and long directions. Additionally, shear walls positioned symmetrically, away from the building’s center of mass, demonstrate greater effectiveness, particularly those placed at the periphery.

2. The study titled **“Optimization of the Effective Location of Reinforced Shear Wall for High-Rise RCC Structure (G+19)”** by Kavya Kodali and Dr. C. Ravi Kumar Reddy (2021) focuses on identifying the optimal diagonal angle for steel diagrid structures to enhance resistance against lateral loads, based on the aspect ratios of buildings. Results indicate that diagrid structures featuring uniform diagonal angles between 50° and 70° provide the best performance in resisting both lateral and gravity loads for building aspect ratios ranging from 1.6 to 0.55. The study reveals that diagrid structures consistently outperform conventional building designs across all seismic zones in India. The research culminates in the identification of the optimum angle for complete module diagrid structures with various aspect ratios, although further investigation is needed to understand the behavior of incomplete module diagrid systems in taller buildings, as the number of stories correlates directly with the primary module height.
To evaluate the seismic response of different configurations, four building models were proposed: Model-1 (G+19 structure without shear walls), Model-2 (L-type shear wall), Model-3 (U-type shear wall), and Model-4 (rectangular shear wall), all analyzed in zones 4 and 5 with medium soil conditions. A linear dynamic response spectrum analysis was conducted using the response spectrum functions outlined in IS 1893 (Part 1): 2016. The study explores the relationships between story displacements, drift ratios, stiffness, and base shear to mitigate the seismic response of building models equipped with shear wall systems of varying thickness.

3. In the paper **“Impact of Shear Wall Location on the Response of RC Framed Building”** by Ashish Shrestha, Bikal Kandel, Mandip Shrestha, and Basanta Adhikari (2023), the authors investigate how the positioning of shear walls affects the response of RC framed buildings. Shear walls provide significant stiffness against lateral forces, enhancing the structure's resilience during seismic events. The research emphasizes the importance of shear wall location in effectively countering seismic forces on buildings. The methodology involved experimental research, where various alternatives (ALT-1, ALT-2, ALT-3, ALT-4) were created to determine the most advantageous shear wall position.
The analysis utilized finite element software ETABS for the linear dynamic evaluation and design of an 11-story building. Results indicate that the introduction of shear walls significantly reduces lateral sway and storey drift, with central placement yielding the most favorable outcomes. This study provides valuable insights for the Engineering Department of OCEM, students, researchers, and professionals regarding the influence of shear wall location on the response of RC framed buildings. While the research

focuses on symmetrical structures, it notes that the optimal orientation and placement of shear walls may differ in asymmetrical designs. The authors identify a significant opportunity for further research on shear wall placement in unsymmetrical structures and suggest extending the study to higher-story buildings across various seismic zones, as they consider essential factors like storey shear, drift, and displacement.

3. METHODOLOGY

The methodology for this project involves a systematic approach to analyze the impact of shear wall placement on the lateral load performance of G+15 building frames in Seismic Zone V. The first step entails the development of two distinct structural models using ETABS software: one with corner-placed shear walls and the other with side-placed shear walls. Each model will incorporate typical architectural features and material properties relevant to high-rise construction.

Once the models are established, the next phase involves applying seismic load parameters in accordance with IS 1893:2016. A response spectrum analysis will be conducted to evaluate how each model behaves under various seismic conditions that are representative of Zone V. Key performance indicators such as base shear, lateral displacement, inter-story drift, fundamental time period, and modal mass participation will be meticulously recorded during this analysis.

The results from the corner-placed and side-placed shear wall configurations will then be compared to assess their respective performances under earthquake-induced lateral loads. This comparative analysis will highlight the strengths and weaknesses of each design in terms of stability, drift control, and overall seismic response. Furthermore, the models will be evaluated for compliance with Indian seismic design codes (IS 1893:2016 and IS 16700:2017) to ensure that they meet safety standards for high-rise buildings.

Finally, an examination of the overturning moment resistance provided by each shear wall placement will be conducted to understand its implications for the overall structural integrity. The findings from this comprehensive study will be compiled into a detailed report that outlines the methodology, analysis, and recommendations for optimal shear wall placement in high-rise structures, contributing valuable insights to the field of seismic design.

4. MODELING AND ANALYSIS

4.1 Material Properties and Section Properties:

Concrete grade: M25
Steel grade: FE415, FE500
Structural Steel grade: FY250

4.2. Load calculations:

Dead load and live load calculation on slab (As Per IS 875- 2015 Part-1 & Part-2 clause 3.1 Table 1):
Dead load calculation (from IS 875 part 1):
Dead Load = 1.5 KN/m^2
Live Load = 3 KN/m^2

4.3 Earthquake load (IS-1893-Part: 1-2016):

In this project, seismic load considerations are essential due to the building's placement in Seismic Zone V, which poses a high risk of earthquakes. The importance factor (I) for this analysis is set at 1.2, reflecting the structure's significance concerning occupancy and usage, ensuring it is adequately designed to endure potential seismic forces. Furthermore, the response modification factor (R) is established at 5, accounting for the energy dissipation capabilities inherent in the building's structural system, which reduces the design seismic forces compared to the maximum anticipated loads. The site is classified as Soil Type II, indicating stiff soil conditions that influence the site period and, consequently, the design seismic force.

4.5. Modeling in ETABS 2020- version 20.0.0

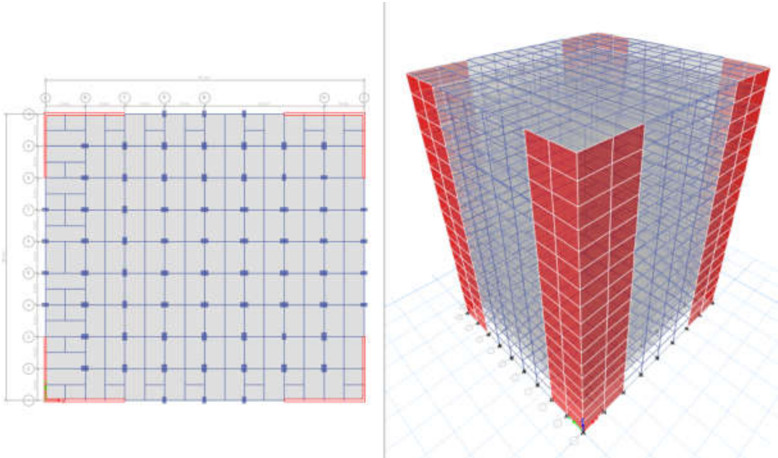

Fig. 2. Plan and 3D View of G+15 Corner Placed Shear Walls Structure Modelled in Etabs

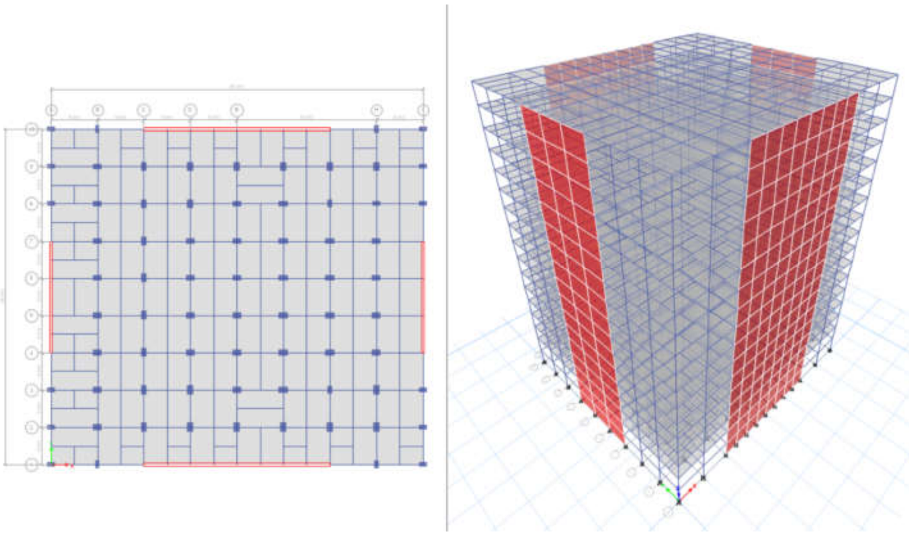

Fig. 3. Plan and 3D View of G+15 Side Placed Shear Walls Structure Modelled in Etabs

5. RESULTS AND DISCUSSION

5.1 Displacement :

The analysis of displacement responses during seismic events reveals notable differences between the G+15 building structures with corner-placed shear walls and those with shear walls positioned at the sides. For the G+15 building featuring corner-placed shear walls, the recorded displacements were 76.92 mm in the EQ-X direction and 82.077 mm in the EQ-Y direction. These values indicate that while the corner placement effectively contributes to torsional resistance, it also results in slightly higher displacements in both axes compared to the side-placed configuration. The increased displacements in the corner placement may be attributed to the eccentricity created by the shear walls, which, while enhancing the overall stability of the building, can also lead to larger lateral movements under seismic loads.

In contrast, the G+15 building with shear walls located at the sides exhibited lower displacements, measuring 53.99 mm in the EQ-X direction and 86.733 mm in the EQ-Y direction. The reduced displacement in the EQ-X direction highlights the effectiveness of side-placed shear walls in achieving a more uniform distribution of lateral forces throughout the structure. Although the side-placed shear walls resulted in higher displacements in the EQ-Y direction compared to the corner configuration, their overall performance demonstrates better drift control and a more predictable seismic response. This comparative analysis underscores the importance of shear wall placement in optimizing lateral load performance, indicating that while corner-placed shear walls provide significant torsional resistance, side-placed configurations can offer enhanced stability and reduced displacements during seismic events.

Table 1. Maximum Horizontal Displacement

Structure Type	Displacement in EQ-X (mm)	Displacement in EQ-Y (mm)
G+15 Corner Placed Shear Wall Building	76.92	82.077
G+15 Shear Wall at Sides of Building	53.99	86.733

5.2 Drift :

The storey drift analysis for the G+15 buildings equipped with corner-placed shear walls versus those with side-placed shear walls reveals significant differences in lateral displacement responses across various floors during seismic events in Seismic Zone V. The data shows that the corner-placed shear wall configuration exhibits a gradual increase in storey drift from the ground floor to the terrace. For instance, at the terrace level, the drift is recorded at 0.001621 mm in the EQ-X direction and 0.001559 mm in the EQ-Y direction. This increasing trend is also observed at the lower stories, with notable values such as 0.001841 mm at Story 11 in EQ-X and 0.001908 mm in EQ-Y. The higher drift values indicate that while corner-placed shear walls enhance torsional stability, they can also lead to increased lateral movement under seismic loading, particularly in the upper stories.

Conversely, the building with shear walls placed at the sides demonstrates a more favorable performance in terms of drift control, particularly in the EQ-X direction, where the maximum drift recorded at the terrace is 0.001118 mm. The storey drift remains relatively consistent across the various levels, with values like 0.001146 mm at Story 15 and only 0.000795 mm at Story 1. Although the side-placed shear walls exhibit higher drift values in the EQ-Y direction compared to the corner configuration, the overall storey drift is significantly lower in the EQ-X direction, suggesting better load distribution and stability. The results indicate that the side placement of shear walls allows for more uniform resistance to lateral loads, effectively minimizing the drift across all stories. This comparative study highlights the crucial role of shear wall placement in managing lateral movements during seismic events, emphasizing that while corner-placed shear walls provide enhanced torsional resistance, side-placed shear walls offer improved drift control and overall structural stability.

Table 2. Drift in structure due to lateral force

Storey	G+15 Building with Corner Placed Shear Wall Located in Seismic Zone V		G+15 Building Placed Shear Wall at Sides of Building all Located in Seismic Zone V	
	EQ-X	**EQ-Y**	**EQ-X**	**EQ-X**
Terrace	0.001621	0.001559	0.001118	0.001509
Story15	0.001646	0.001591	0.001146	0.001569
Story14	0.001706	0.001679	0.001201	0.001682
Story13	0.001766	0.001769	0.001238	0.001788
Story12	0.001811	0.001846	0.001266	0.001886
Story11	0.001841	0.001908	0.001284	0.001972
Story10	0.001853	0.001951	0.001291	0.00204
Story9	0.001845	0.001973	0.001285	0.002086
Story8	0.001814	0.001968	0.001263	0.002104
Story7	0.001759	0.001934	0.001224	0.00209
Story6	0.001676	0.001868	0.001167	0.002038
Story5	0.001564	0.001766	0.001091	0.001944
Story4	0.00142	0.001625	0.000994	0.001803
Story3	0.001238	0.001438	0.000875	0.001608
Story2	0.00103	0.001212	0.000743	0.001353
Story1	0.000795	0.000942	0.000628	0.001092
GF	0.000492	0.000551	0.000454	0.000646

5.3 Overturning Moment :

The comparison of the overturning moment in G+10 buildings with oblique columns and Y-shaped columns located in seismic zone V shows significant differences. The building with oblique columns experiences an overturning moment of 364913 kNm in the EQ-X direction and 346679 kNm in the EQ-Y direction. On the other hand, the building with Y-shaped columns demonstrates higher values, with 536938 kNm in EQ-X and 499788 kNm in EQ-Y. This indicates that the Y-shaped column building has greater overturning moments, primarily due to increased lateral force resistance and the altered load path enabled by the Y-shaped geometry.

In terms of percentage differences, the overturning moment in the EQ-X direction for the Y-shaped column building is approximately 47.2% higher than that of the oblique column structure. Similarly, the EQ-Y direction exhibits a 44.1% increase. These differences highlight the structural behavior under seismic forces, with Y-shaped columns providing enhanced stiffness and stability but also attracting higher seismic forces, resulting in larger overturning moments. This comparison emphasizes the importance of selecting an appropriate column configuration to balance structural performance with efficiency in seismic zones.

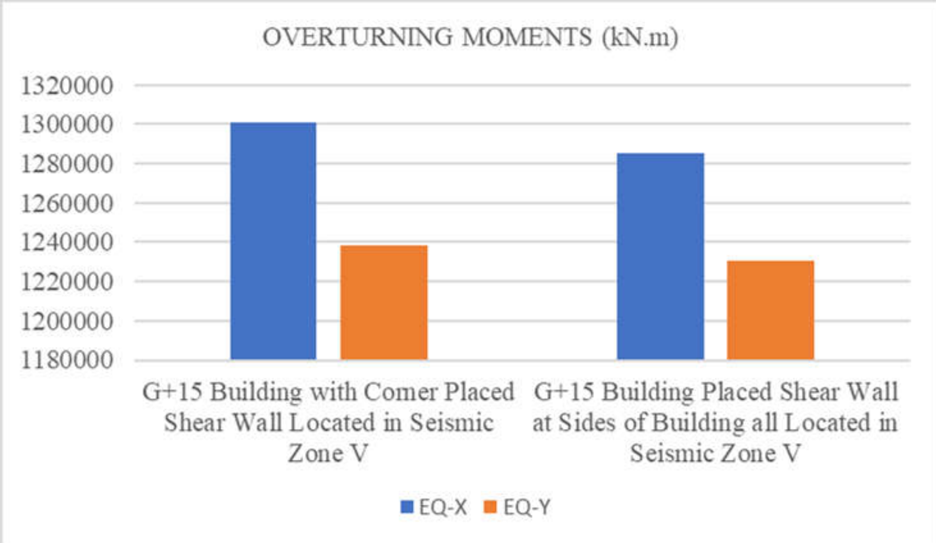

Fig. 4. Overturning moment comparison

5.4 Time Period and Modal Mass Participation-

Table 3. Time Period and Modal Mass Participation in Building

Mode No.	G+15 Building with Corner Placed Shear Wall Located in Seismic Zone V				G+15 Building Placed Shear Wall at Sides of Building all Located in Seismic Zone V			
	Time Period	**UX**	**UY**	**RZ**	**Time Period**	**UX**	**UY**	**RZ**
1	1.397	0.0001	0.7326	0.0004	1.452	0.000008917	0.7433	0.0003
2	1.292	0.715	0.0001	0.0016	1.081	0.7157	0.00002152	0.0072
3	0.836	0.0015	0.0004	0.7023	0.844	0.0069	0.0003	0.7102

The time period and modal mass are essential parameters in structural dynamics, particularly for buildings located in high seismic zones such as Zone V. The time period reflects the natural oscillation frequency of the building: a longer time period indicates greater flexibility, while a shorter time period points to increased stiffness. On the other hand, the modal mass quantifies the distribution of effective mass participating in each mode of vibration along the principal directions (UX, UY, and rotational about the vertical axis, RZ). Both parameters significantly affect the building's seismic performance.

In Mode 1, the building with corner-placed shear walls has a time period of 1.397 seconds, whereas the building with side-placed shear walls has a time period of 1.452 seconds, showing a 3.93% increase in flexibility for the side-placed configuration. However, in Mode 2, the time period for the corner-placed shear wall building is 1.292 seconds, while that for the side-placed shear wall configuration is 1.081 seconds, indicating a 16.34% reduction in flexibility for the side-placed system. In Mode 3, the time periods are nearly identical, with 0.836 seconds for the corner-placed walls and 0.844 seconds for the side-placed walls, with a minor 0.96% increase in the latter. These results suggest that the placement of shear walls has varying effects on the building's stiffness across different modes. While the side-placed configuration introduces more flexibility in the first mode, it behaves stiffer in the second mode.

The modal mass describes the extent of mass participation in different vibration modes along the X (UX), Y (UY), and rotational Z (RZ) directions. In Mode 1, the corner-placed wall system shows negligible mass participation in the UX direction (0.0001) but significant participation in the UY direction (0.7326), indicating a tendency for the building to sway primarily along the Y-axis. In contrast, the side-placed shear wall configuration has even lower participation in the UX direction (0.000008917) but a similar UY response (0.7433). The rotational mass participation (RZ) is slightly reduced for the side-placed walls (0.0003) compared to the corner configuration (0.0004), suggesting that the latter introduces a slightly higher resistance to torsional effects.

In Mode 2, both configurations show substantial mass participation in the UX direction, with nearly identical values (0.715 for corner-placed walls and 0.7157 for side-placed walls), indicating both systems are highly responsive along the X-axis. However, the UY mass participation for the corner-placed walls is minimal (0.0001), whereas it is slightly higher (0.00002152) for the side-placed walls. Additionally, the rotational mass participation (RZ) is more prominent in the side-placed configuration (0.0072) compared to the corner configuration (0.0016), indicating better rotational stability.

In Mode 3, the mass participation in the UX and UY directions remains very low for both systems, with corner walls contributing 0.0015 and 0.0004, respectively, while side-placed walls have values of 0.0069 and 0.0003. However, the rotational mass (RZ) is nearly the same, with 0.7023 for the corner-placed walls and 0.7102 for the side-placed walls, reflecting similar torsional behavior in this mode.

5.5 Base Shear :

Table 4. Base in structure due to earthquake

	G+15 Building with Corner Placed Shear Wall Located in Seismic Zone V	G+15 Building Placed Shear Wall at Sides of Building all Located in Seismic Zone V
Base shear EQX (kN)	32638	32459
Base shear EQY (kN)	30961	30792

Base shear is the total horizontal force exerted at the base of a structure during an earthquake, and it is a critical factor for designing buildings in seismic zones. It represents how much of the seismic energy is transferred to the foundation. In this comparison, the base shear values are provided for two configurations of a G+15 building in Seismic Zone V—one with corner-placed shear walls and the other with shear walls positioned along the sides.

For seismic loading along the X-axis (EQX), the building with corner-placed shear walls experiences a base shear of 32,638 kN, while the structure with side-placed walls shows a slightly lower value of 32,459 kN. This difference translates to a 0.55% reduction in base shear for the side-placed configuration. Similarly, under seismic forces along the Y-axis (EQY), the corner shear wall system records a base shear of 30,961 kN, whereas the side-placed shear wall configuration yields 30,792 kN, indicating a 0.55% decrease in the base shear for the latter configuration.

The small reduction in base shear for the side-placed wall system suggests that it provides slightly better distribution of seismic loads, possibly due to enhanced lateral stiffness along the primary axes. This can improve the overall dynamic response, as the lateral walls might offer more uniform resistance to ground motion. However, both configurations demonstrate nearly identical performance, with a marginal difference in their ability to transfer seismic forces to the foundation. The similarity in base shear values highlights that both configurations are effective for earthquake resistance, although the choice of shear wall placement may affect other structural aspects, such as torsional stability and deformation control.

	G+15 Building with Corner Placed Shear Wall Located in Seismic Zone V	G+15 Building Placed Shear Wall at Sides of Building all Located in Seismic Zone V
Base shear EQX (kN)	32638	32459
Base shear EQY (kN)	30961	30792
Dead Load (kN)	393930.31	391661.68

Live Load (kN)	46080	46080
% of earthquake (EQX)	0.080	0.080
% of earthquake (EQY)	0.07636	0.07637

Table 7. Base shear in Structure Due to Earthquake

5.6Analysis of Base Shear

- **Base Shear EQX:**
  - The G+15 building with corner-placed shear walls exhibits a base shear of 32638 kN, while the building with side-placed shear walls shows a slightly lower base shear of 32459 kN.
  - This indicates that the corner-placed shear wall configuration experiences a marginally higher lateral force during seismic loading. This can be attributed to the structural dynamics of corner placements, which may induce greater torsional effects and lateral movements.
- **Base Shear EQY:**
  - For the Y-direction, the corner-placed configuration has a base shear of 30961 kN, compared to 30792 kN for the side-placed configuration.
  - Similar to the X-direction analysis, the corner-placed shear wall building experiences a slightly higher base shear. The variations in lateral forces can be associated with the differences in the distribution of mass and stiffness along the structure.

➢ **Percentage of Earthquake Forces**

- The percentage of earthquake forces in both configurations is comparable:
  - For the X-direction, both buildings experience approximately 8.0% of the total applied forces from seismic activity.
  - In the Y-direction, the corner-placed shear wall building experiences about 7.636%, while the side-placed configuration experiences 7.637%.

5. 7 Implications for Structural Behaviour

- **Structural Response:**
  - The slightly higher base shear values for the corner-placed shear wall configuration indicate that this design might require additional reinforcement to adequately resist the increased lateral forces. It could lead to higher demand on the foundation and lower stories due to the greater overturning moments and shear forces generated.
- **Seismic Design Considerations:**
  - The overall differences in base shear highlight the importance of shear wall placement in optimizing seismic performance. While both configurations are relatively close in performance, the corner-placed shear walls may require enhanced detailing to handle the additional lateral forces, particularly in high seismic zones.

while the differences in base shear between the two configurations of G+15 buildings are minor, they are significant enough to influence design decisions. The corner-placed shear wall configuration experiences slightly higher lateral forces, which can affect its overall seismic performance. The percentage of earthquake forces for both configurations indicates that they are designed effectively to handle the demands of seismic activity in Zone V. Further dynamic analysis and detailed design considerations should be made to ensure adequate performance and safety in both configurations.

6. CONCLUSION

Based on the current study and reviewed literature, the following conclusions can be drawn:

i. The base shear in the EQ-X direction is 32,638 kN for the corner-placed shear wall design and 32,459 kN for the side-placed configuration, reflecting a minimal difference of 0.55%. Similarly, in the EQ-Y direction, the values are 30,961 kN for the corner design and 30,792 kN for the side placement, again showing a slight 0.55% variation. Both systems demonstrate similar lateral force resistance, indicating that either configuration can effectively withstand seismic forces.

ii. For EQ-X, the overturning moment is 1,301,093 kN-m for the corner-placed walls and 1,285,166 kN-m for the side-placed design, reflecting a 1.2% reduction in the side configuration. In the EQ-Y direction, the corner configuration achieves 1,238,233 kN-m, while the side arrangement yields 1,230,653 kN-m, with a 0.6% lower overturning moment. While both provide good stability, the corner configuration offers slightly higher resistance to overturning forces.

iii. With an allowable displacement limit of 72 mm (H/500, where H = 36 m), the corner-placed shear wall configuration records 76.92 mm in the EQ-X direction, exceeding the limit by 6.83%. On the other hand, the side-placed configuration stays within the limit, with a displacement of 53.99 mm. In the EQ-Y direction, the corner-placed structure displaces 82.08 mm, and the side-placed design records 86.73 mm—both surpassing the permissible limit by 13.4% and 20.4%, respectively. Although the side-placed configuration performs better in EQ-X, both exceed limits in EQ-Y.

iv. The maximum allowable inter-story drift, based on H/250 for a 3.2 m story height, equals 0.0128. Across all stories, the drift for both configurations remains within the allowable limit, ensuring that both designs control deformation effectively under seismic loads.

v. The fundamental time period for the corner-placed wall building is 1.397 seconds, while the side-placed design shows a slightly higher value of 1.452 seconds, indicating marginally reduced stiffness in the latter. Both configurations exhibit similar modal mass participation along the UX and UY directions, ensuring comparable dynamic performance.

vi. Both shear wall configurations provide reliable seismic performance. The corner-placed design offers superior resistance to overturning moments and achieves lower displacement in certain cases. However, the side-placed configuration remains within the displacement limit in the EQ-X direction but performs less favorably in the EQ-Y direction. Both designs control drift effectively, staying within the allowable limits across all stories.

vii. Since both configurations perform closely across most structural parameters, the final choice may depend on architectural preferences, construction feasibility, or site conditions. Both designs are suitable for seismic zones, but additional attention must be given to controlling displacements, particularly in the EQ-Y direction, to ensure optimal performance.

Authors contribution

Sauarabh D. Bharat[1]: Conducted primary research, including comprehensive literature reviews and analysis. Authored the manuscript and crafted all figures.

Dr. Atul B. Pujari [2], Dr. Santos K. Patil[3] & Abhijeet R. Undre[4]: Provided guidance and mentorship throughout the research process.

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