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Comparative Study on Seismic and Wind Response of G+12 Residential RCC Frame Building with and Without Shear Walls Using Staad Pro

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Abstract- In recent years, rapid urbanization, population growth, and limited land availability in urban areas have led to a significant increase in the construction of multi-storey and high-rise buildings. As the height of buildings increases, the structural behavior becomes more complex, and the impact of lateral loads such as earthquake and wind forces becomes highly critical. Conventional Reinforced Cement Concrete (RCC) frame structures are mainly designed to resist vertical loads; however, they may not effectively resist lateral forces in tall buildings. This can result in excessive displacement, higher storey drift, and reduced structural stability, leading to potential structural damage during extreme conditions. To address these challenges, shear walls are introduced as important structural elements. Shear walls are vertical reinforced concrete components that provide high stiffness and strength, helping the structure resist lateral loads efficiently. They play a vital role in reducing displacement, controlling drift, and improving overall stability and safety. Their effectiveness depends on proper design and placement within the structure. The present study focuses on the comparative analysis of a G+12 RCC residential building with and without shear walls under seismic and wind loads using STAAD Pro software. The structural performance is evaluated based on parameters such as storey displacement, storey drift, base shear, bending moment, shear force, axial force, and structural stiffness. The results indicate that the building without shear walls shows higher displacement and drift, while the building with shear walls demonstrates a significant reduction (about 40–50%) and maintains values within permissible limits, indicating improved stability. Additionally, shear walls improve the distribution of internal forces, reducing bending moments and ensuring more uniform axial force distribution. Although the base shear increases in the shear wall structure due to higher stiffness, it reflects better load-resisting capacity. Overall, the structure with shear walls performs significantly better under lateral loads compared to the conventional RCC frame structure. The study concludes that shear walls are essential for improving the safety, stability, and performance of multi-storey RCC buildings, especially in seismic and wind-prone regions.

Keywords: Shear Wall, RCC Building, STAAD Pro, Seismic Load, Wind Load, Storey Drift, Displacement, Structural Analysis, High-Rise Building, Response Spectrum Method

I. INTRODUCTION

The construction industry has witnessed rapid growth in recent years due to increasing population, urbanization, and the demand for modern infrastructure. In urban areas, where land availability is limited and expensive, vertical development in the form of multi-storey and high-rise buildings has become a common and necessary solution. Residential buildings, commercial complexes, and office structures are now being constructed with greater heights to accommodate the growing needs of society. However, as the height of buildings increases, the structural behavior becomes more complex, and the effect of lateral loads such as earthquake and wind forces becomes highly significant. Traditionally, buildings were designed mainly to resist vertical loads such as dead load and live load. However, with the advancement in construction practices and the increase in building height, lateral loads have become a major concern in structural design. Earthquakes generate dynamic forces that act on the structure and can cause severe damage if not properly considered.

Similarly, wind forces act continuously on tall structures and can cause sway, vibration, and discomfort to occupants. Therefore, it is essential to design buildings that can safely resist both vertical and lateral loads. Reinforced Cement Concrete (RCC) frame structures are widely used in modern construction due to their strength, durability, and cost-effectiveness. These structures consist of beams, columns, slabs, and foundations, which together form a rigid frame capable of carrying loads. However, RCC frame structures alone may not provide sufficient resistance against lateral forces in high-rise buildings. This can lead to excessive displacement, storey drift, and structural instability. To improve the performance of buildings under lateral loads, additional structural elements such as shear walls are introduced. Shear walls are vertical reinforced concrete elements that provide high stiffness and strength to the structure, helping it resist horizontal forces effectively. They reduce lateral displacement, improve stability, and enhance the overall safety of the building. The placement and design of shear walls play a crucial role in determining the structural performance. With the development of advanced technology, structural analysis has become more accurate and efficient. Software tools like STAAD Pro are widely used by engineers to model, analyze, and design structures under various loading conditions. These tools allow detailed analysis using methods such as static and dynamic analysis, providing reliable results. The design and analysis of structures are carried out according to Indian Standard codes such as IS 456:2000, IS 875, and IS 1893 (Part 1):2016, which ensure safety and uniformity in construction practices. In recent years, many researchers have studied the behavior of RCC buildings under seismic and wind loads, with special focus on the use of shear walls. These studies have shown that shear walls significantly improve the performance of structures by reducing displacement and increasing stiffness. However, there is still a need for detailed comparative studies that evaluate the behavior of buildings with and without shear walls under combined loading conditions. Therefore, this study focuses on the comparative analysis of a G+12 RCC residential building with and without shear walls under seismic and wind loads using STAAD Pro. The aim is to understand the structural behavior, evaluate key performance parameters, and identify the most effective structural system for ensuring safety, stability, and efficiency in high-rise buildings.

II. METHODOLOGY

BUILDING DETAILS:

The building considered in this study is a G+12 multi-storey residential RCC structure. The selection of this building type is based on the increasing demand for vertical construction in urban areas due to land scarcity and population growth. The building is assumed to be symmetrical in plan with uniform geometry, which helps in eliminating torsional irregularities and ensures better comparison between models. The structural components such as beams, columns, slabs, and shear walls are designed with realistic dimensions as per standard engineering practice.

Table 3.1: Building Data

Sr. No.	Parameter	Value
1	Type of Structure	Residential Building
2	Number of Storeys	G + 12
3	Storey Height	3.0 m
4	Total Height	39 m
5	Plan Dimensions	20 m × 20 m
6	Beam Size	300 mm × 450 mm
7	Column Size	450 mm × 450 mm
8	Slab Thickness	150 mm
9	Shear Wall Thickness	200 mm
10	Type of Frame	RCC Moment Resisting Frame

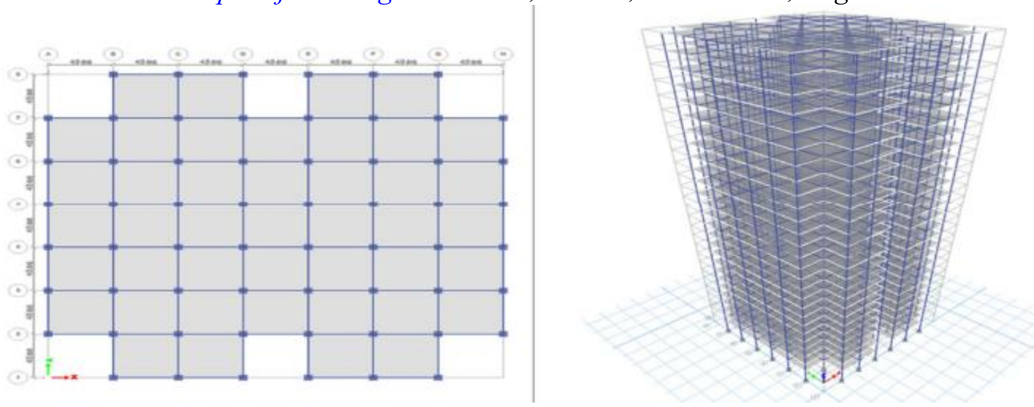

Figure 3.1: Plan of Structure without Shear wall

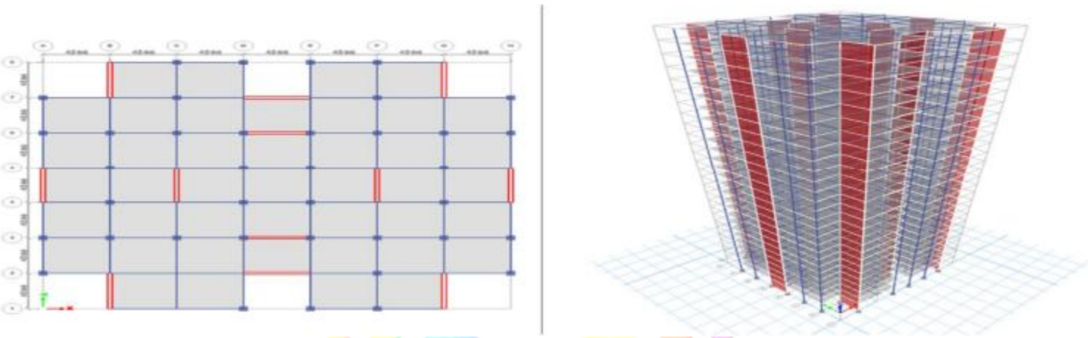

Figure 3.1: Plan of Structure with Shear wall

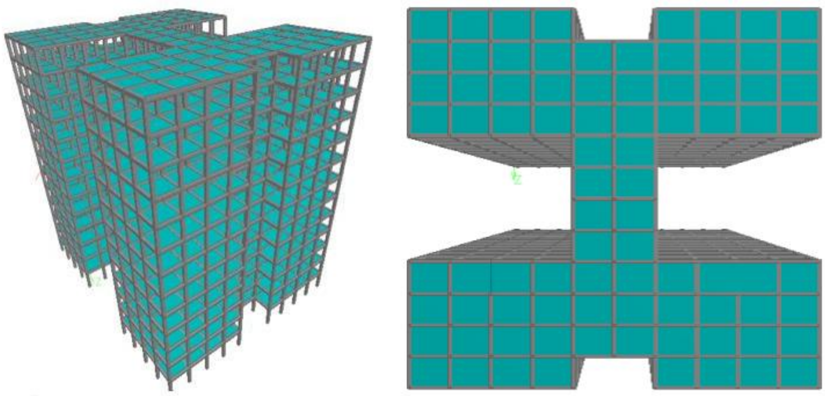

Figure 3.3: 3D view of G+12 RC Building

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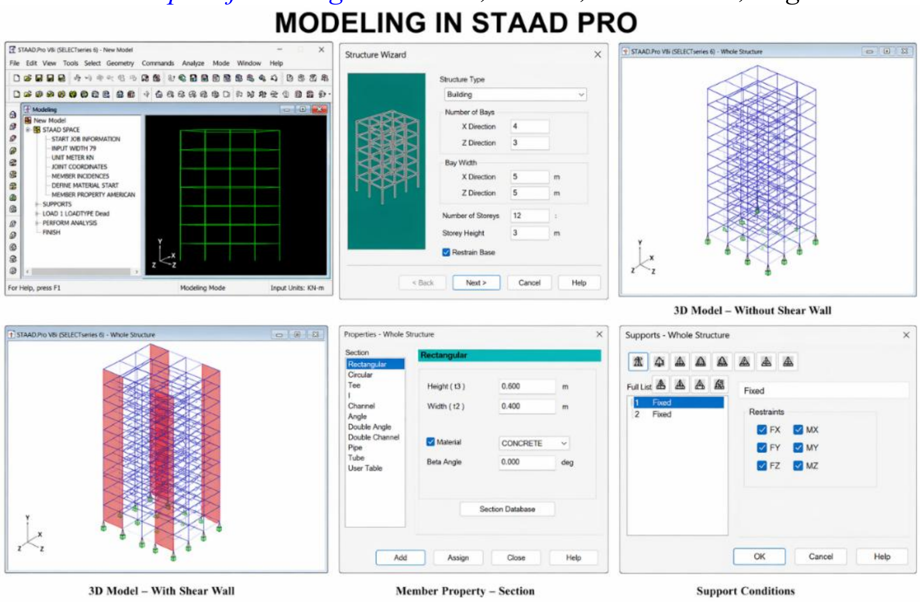

Figure 3.4: G+12 RC Building Modeling Steps in STAAD Pro

III. RESULTS AND DISCUSSION

STOREY DISPLACEMENT:

Table 4.1: Storey Displacement (mm)

Storey Level	Without Shear Wall (mm)	With Shear Wall (mm)
12 (Top)	120	65
11	112	60
10	104	55
9	96	50
8	88	45
7	78	40
6	68	35
5	58	30
4	48	25
3	38	20
2	25	12
1	12	6
Ground	0	0

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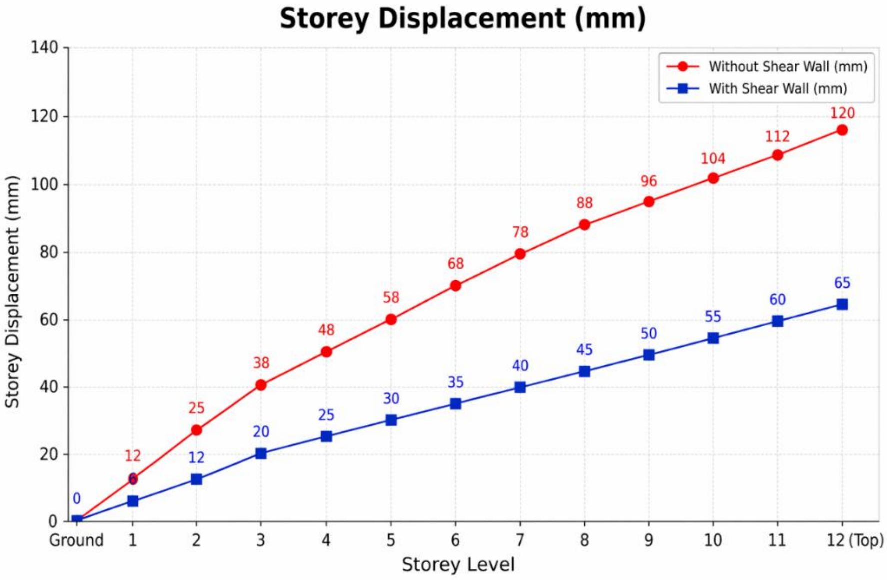


Graph 4.1: Storey Displacement (mm)

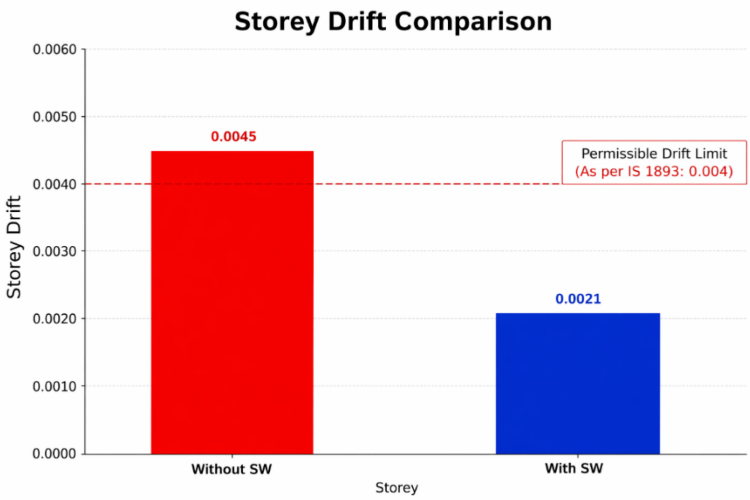
Discussion

- The displacement is maximum at the top storey and gradually reduces towards the base.
- The building without shear wall shows significantly higher displacement due to lower stiffness.
- The structure with shear wall shows reduction of displacement by approximately 40–50%.
- This clearly indicates that shear walls provide higher lateral stiffness and control excessive movement.

STOREY DRIFT:

Table 4.2: Storey Drift

Storey	Without SW	With SW
Max Drift	0.0045	0.0021



Graph 4.2: Storey Drift

4.3.2 Discussion

- The drift value for the building without shear wall exceeds permissible limits.
- The building with shear wall satisfies IS code requirements.
- Shear walls significantly reduce inter-storey deformation.
- Reduced drift ensures:
    - Structural safety

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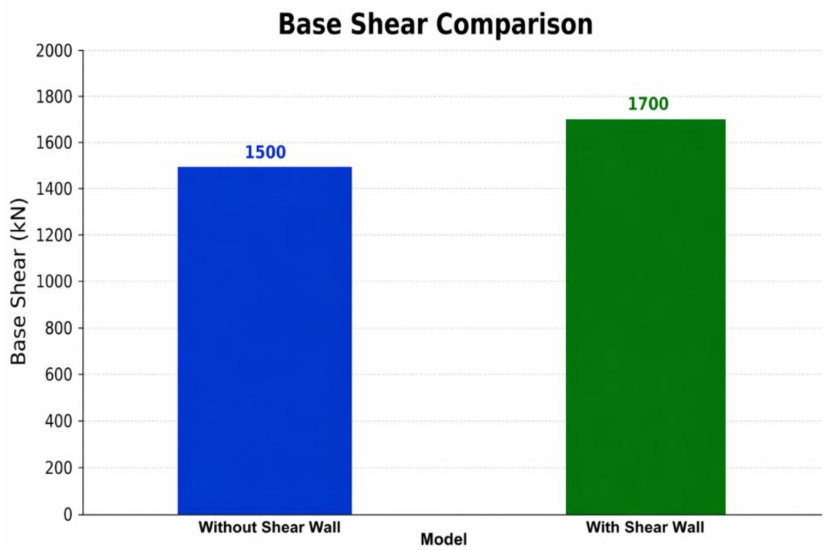
- Better serviceability
- Prevention of collapse

BASE SHEAR:

Table 4.3: Base Shear Comparison

Model	Base Shear (kN)
Without Shear Wall	1500
With Shear Wall	1700



Graph 4.3: Base Shear Comparison

Discussion

- Base shear is higher in shear wall structure.
- This is because:
  - Increased stiffness attracts more seismic force
- However, higher base shear is beneficial because:
  - Structure can resist more load
  - Better force distribution

BENDING MOMENT:

Table 4.4: Bending Moment Comparison

Member	Without SW (kNm)	With SW (kNm)
Beam	220	180
Column	350	280

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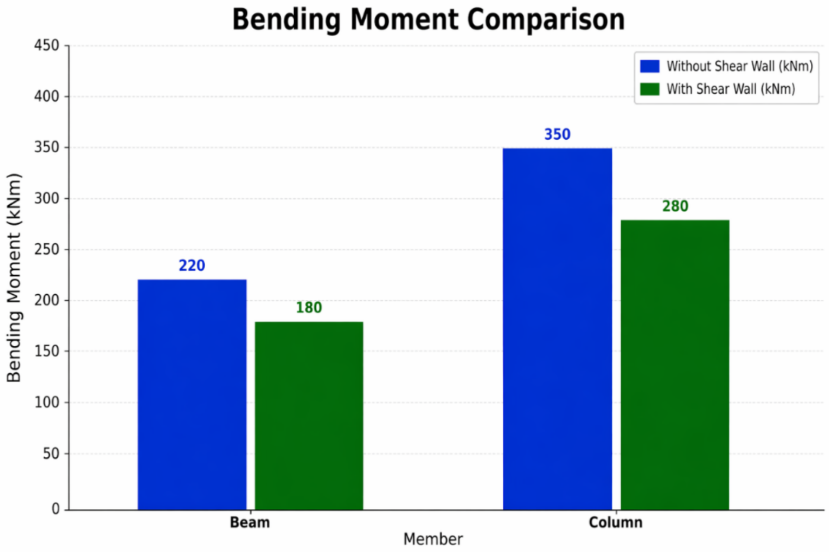


Graph 4.4: Bending Moment Comparison

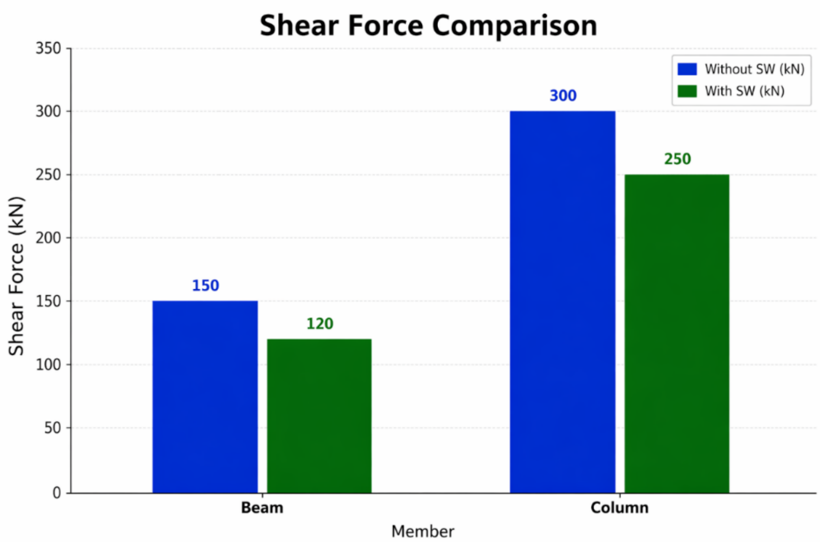
Discussion

- Bending moment values are reduced in shear wall structure.
- This happens because:
  - Shear walls share the lateral load
- Reduced bending moment leads to:
  - Safer design
  - Reduced reinforcement requirement

SHEAR FORCE:

Table 4.5: Shear Force Comparison

Member	Without SW (kN)	With SW (kN)
Beam	150	120
Column	300	250



Graph 4.5: Shear Force Comparison

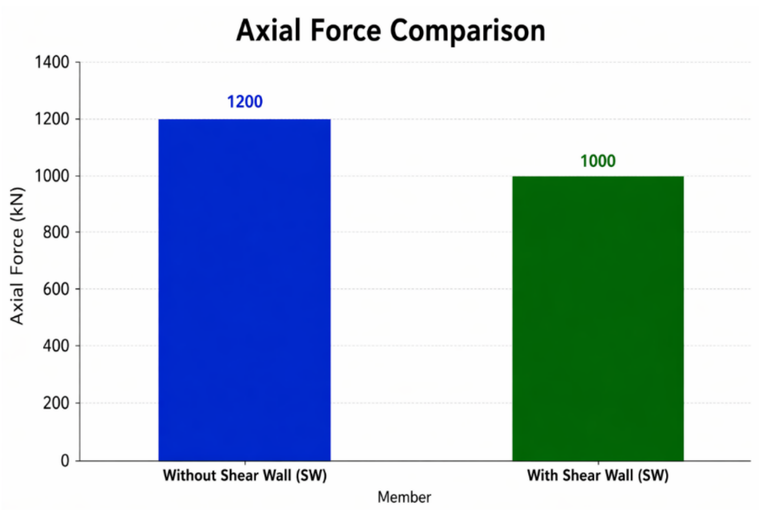
Discussion:

- Shear forces are slightly lower in the shear wall model.
- This indicates improved load distribution.

AXIAL FORCE:

Table 4.6: Axial Force Comparison

Member	Without SW (kN)	With SW (kN)
Column	1200	1000



Graph 4.6: Axial Force Comparison

Discussion:

- Axial forces are more uniformly distributed in shear wall structure.
- Reduces risk of:
  - Column failure
  - Buckling

CONCLUSION

Based on the comparative analysis of the G+12 RCC building with and without shear walls under seismic and wind loads, it is concluded that lateral loads significantly influence the behavior of multi-storey structures, and conventional RCC frames alone are insufficient for effective resistance. The inclusion of shear walls greatly enhances structural performance by increasing stiffness, reducing storey displacement by about 40–50%, and maintaining storey drift within permissible limits as per IS 1893. Although base shear is higher in shear wall structures due to increased stiffness, it indicates better load-resisting capacity and safe transfer of forces to the foundation. Additionally, shear walls reduce bending moments, shear forces, and uneven axial load distribution, leading to a safer and more economical design. Overall, shear wall systems provide better stability, serviceability, and durability, making them highly suitable for high-rise buildings in seismic and wind-prone areas, and their use is strongly recommended despite a slight increase in initial construction cost.

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