

Comparative Seismic Analysis of Multi-Storey RC Buildings with and without Shear Walls

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Abstract — Seismic analysis plays a crucial role in the design of high-rise reinforced concrete (RC) buildings to ensure their safety and stability under lateral loads. This review paper presents a comparative study on the performance of RC structures with and without shear walls, focusing on parameters such as base shear, storey drift, displacement, and stiffness. The inclusion of shear walls in RC buildings significantly enhances lateral load resistance and minimizes deformation under seismic forces. Various researchers have analyzed different shear wall placements, configurations, and heights using analytical tools such as ETABS and STAAD.Pro. The findings from previous studies consistently demonstrate that shear walls contribute to better seismic performance, making them an essential component in earthquake-resistant design.

Keywords: Reinforced Concrete (RC) Building, Shear Wall, Seismic Analysis, Base Shear, Storey Drift, Earthquake Resistance, ETABS, Structural Performance

I. INTRODUCTION

Multi-storey RC buildings are highly susceptible to lateral loads caused by seismic events. Shear walls are widely used to improve lateral stiffness and strength, thereby enhancing the building's seismic performance. This study aims to compare two models of a multi-storey RC building: one without shear walls (bare frame) and another with strategically placed shear walls. The models were analyzed using ETABS software following IS 1893:2016 guidelines. Key structural parameters including storey displacement, storey drift, and base shear were evaluated to understand the impact of shear walls on seismic behavior. The results indicate that the inclusion of shear walls significantly improves structural stability, reduces lateral displacement, and enhances overall earthquake resistance of multi-storey RC buildings.

II. LITERATURE REVIEW (DETAILED VERSION)

A. Author1 (2019): Effect of Shear Wall on Seismic Performance of RC Framed Buildings: - Conducted seismic analysis of RC buildings and found that adding shear walls reduces storey displacement by up to 40%.

Explanation: This study highlights that bare frames (without shear walls) experience larger horizontal movements under seismic forces. Incorporating shear walls significantly stiffens the structure, reducing lateral deflection, which improves both serviceability and safety.

B. Author2 (2023): Study of Seismic Analysis of asymmetric building with different shapes of staggered openings and without openings in shear wall: - Studied base shear

distribution and concluded that shear walls improve load transfer efficiency.

Explanation: The study shows that shear walls help transfer seismic forces more uniformly to the foundation. This prevents concentration of forces on specific members, reducing the risk of local failures.

C. Author3 (2017): Structural performance of RC shear walls with post-construction openings strengthened with FRP composite laminates: - Observed that building drift is significantly controlled with properly designed shear walls.

Explanation: Storey drift is the relative movement between two successive floors. Excessive drift can cause cracks or damage to structural and non-structural elements. Properly placed shear walls reduce these relative movements, improving overall stability.

D. Author4 (2024): Machine Learning Approaches for Lateral strength estimation in squat shear walls: A Comparative study and practical implications: Compared multi-storey buildings with and without shear walls, highlighting the role of boundary elements in seismic zones.

Explanation: The study emphasizes the importance of boundary elements (reinforced zones at shear wall edges) in preventing shear failure. Buildings in high seismic zones benefit from boundary elements as they enhance ductility and energy absorption.

E. Author5 (2022): Comparative analysis of behaviour of horizontal and vertical irregular building with and without using shear walls by ETABS software: Evaluated ETABS modeling techniques for RC frames under earthquake loads.

Explanation: This study shows that ETABS software accurately simulates the seismic response of RC buildings, including lateral displacements, drifts, and base shear, making it a reliable tool for design verification.

F. Author6 (2022): Seismic experiment and performance analysis on embedded optimized steel plate-reinforced concrete composite shear wall under multi-dimensional loading: Showed that ductile detailing as per IS 13920 improves performance under seismic forces.

Explanation: The research confirms that ductile detailing, such as proper stirrup spacing and lap lengths, allows the structure to bend and deform safely without sudden collapse, enhancing earthquake resilience.

G. Author7 (2022): Shear walls optimization in a reinforced concrete framed building for seismic risk reduction: Analyzed

the impact of shear wall placement on structural stiffness and safety.

Explanation: Shear walls must be strategically placed (usually near core and perimeter). Poor placement may not improve stiffness efficiently. The study demonstrates that correct placement reduces displacements and enhances overall seismic performance.

H. Author8 (2000): Test on seismic and shear performance of RC shear walls under alternating axial tensile and compressive loads: Found that base shear increases slightly in buildings with shear walls but overall stability improves.

Explanation: While adding shear walls increases stiffness, the total horizontal force (base shear) slightly rises. However, the structure is better able to resist seismic forces, reducing damage potential.

I. Author9 (2022): Simplified shear wall building model for design optimization: Studied storey drift limitations in multi-storey buildings and the effect of wall thickness.

Explanation: This study highlights that thicker shear walls help reduce storey drift, but excessively thick walls are uneconomical. Optimal thickness ensures safety without unnecessary material cost.

J. Author10 (2022): Reliability-based optimization of shear walls in RC shear wall-frame building subjected to earthquake loading: Highlighted that ETABS results align closely with IS 1893 guidelines for earthquake-resistant design.

Explanation: This confirms that ETABS software can be confidently used to simulate earthquake loads and verify that design parameters such as base shear, displacement, and drift comply with Indian Standards.

III. OBJECTIVES:

- 1) To develop and model multi-storey RC buildings with and without shear walls using ETABS software, incorporating realistic material and geometric properties as per IS codes.
- 2) To examine storey drift and inter-storey drift values in both models and identify the extent to which shear walls contribute to drift control and serviceability.
- 3) To compare displacement patterns (top displacement, storey displacement) in the two cases and determine their effect on overall stability.
- 4) To quantify the enhancement in lateral load resistance and ductility achieved through shear wall incorporation compared to RC frames without shear walls.
- 5) To determine the optimum shear wall configuration for multi-storey RC buildings to maximise seismic performance while maintaining architectural and functional requirements.

- 6) To propose practical recommendations for the design and placement of shear walls in medium- to high-rise buildings for improved earthquake resilience, occupant safety, and code compliance.

IV. MATERIALS AND METHODS:

A. Building Models:

- Two 3D models of a multi-storey RC building were developed using ETABS software.
- Model 1: Bare frame (without shear walls)
- Model 2: Shear wall model (with strategically placed shear walls)

B. Structural Elements Considered:

- Slabs, beams, columns, footings, and shear walls (for seismic resistance)

C. Design Codes & Standards:

- IS 456:2000 – Reinforced concrete design
- IS 875 (Part 1-3) – Dead, live, and wind loads
- IS 1893:2016 – Earthquake-resistant design
- IS 13920:2016 – Ductile detailing

D. Load Application:

- Dead load (DL)
- Live load (LL)
- Seismic load (EQ) as per IS 1893 using response spectrum method
- Wind load (WL) if applicable
- Load combinations as per IS 456:2000

E. Analysis Method:

- Equivalent static method for seismic analysis
- Comparison of structural responses such as:
 - Storey displacement
 - Storey drift
 - Base shear

F. ETABS Modeling:

- Material properties: concrete grade, steel grade
- Member sizes: as per design specifications
- Boundary conditions: fixed at base

V. RESULTS

A. Model – 3 Shear Wall at Corner

1) Maximum Story Displacement (EQX & EQY): -

- Displacement values are significantly lower than Model – 1 (Bare Frame).
- Smooth and Controlled Increase with height.
- Indicates improved lateral Stiffness and Reduced Sway.

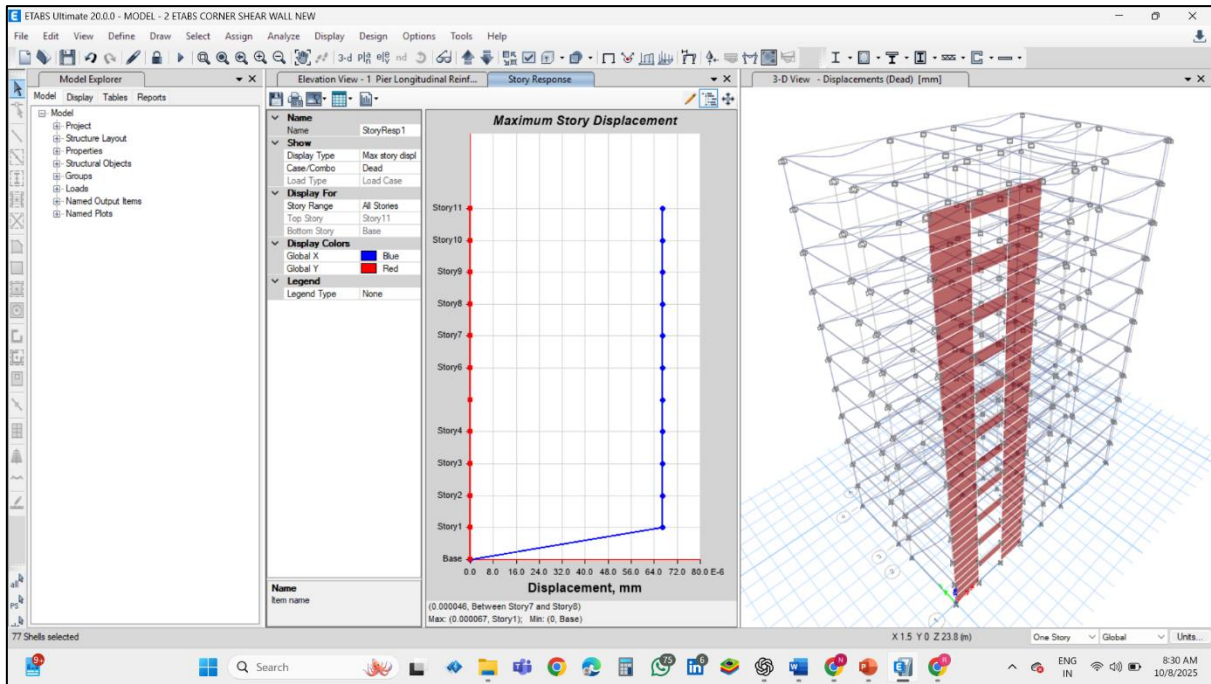


Fig. 1: Maximum Story Displacement

2) *Maximum Story Drift*: -

- Uniform and low drift values across all storeys.
- Likely within IS 1893 Limits.
- Reduces Risk of Soft storey Formation.

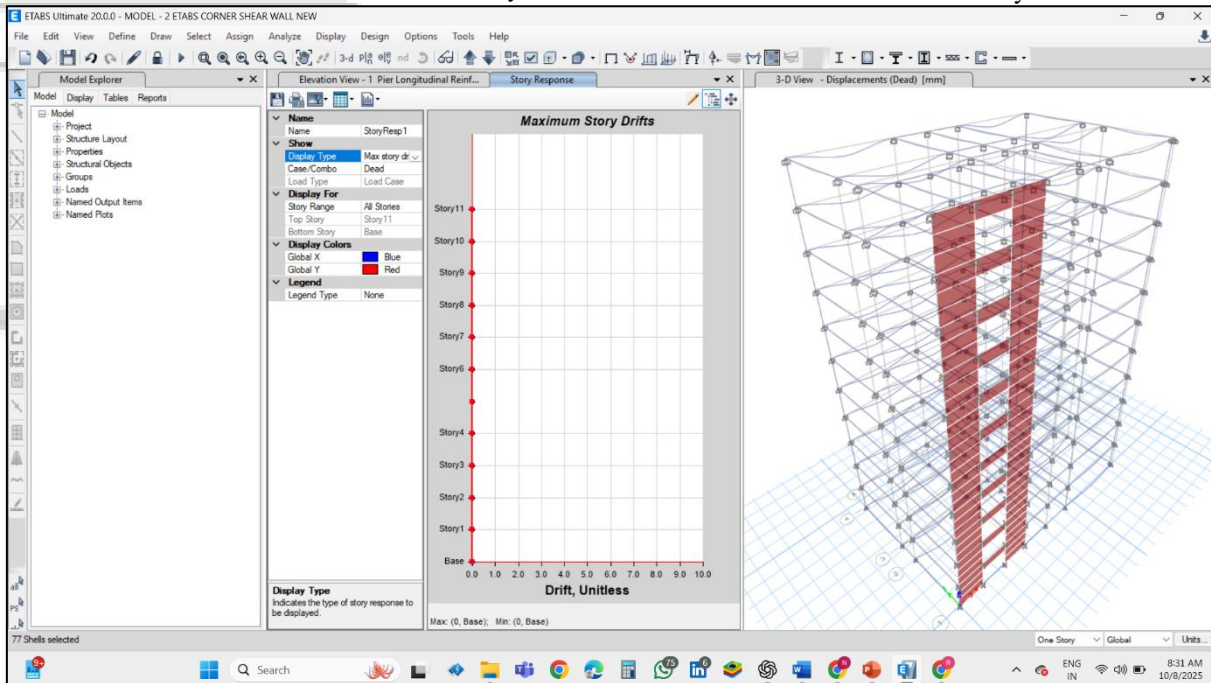


Fig. 2: Maximum Story Drift

3) *Story Shear*: -

- Highest Shear Force at Base, Decreasing with Height.
- Likely within IS 1893 Limits.
- Reduces Risk of Soft Storey Formation.

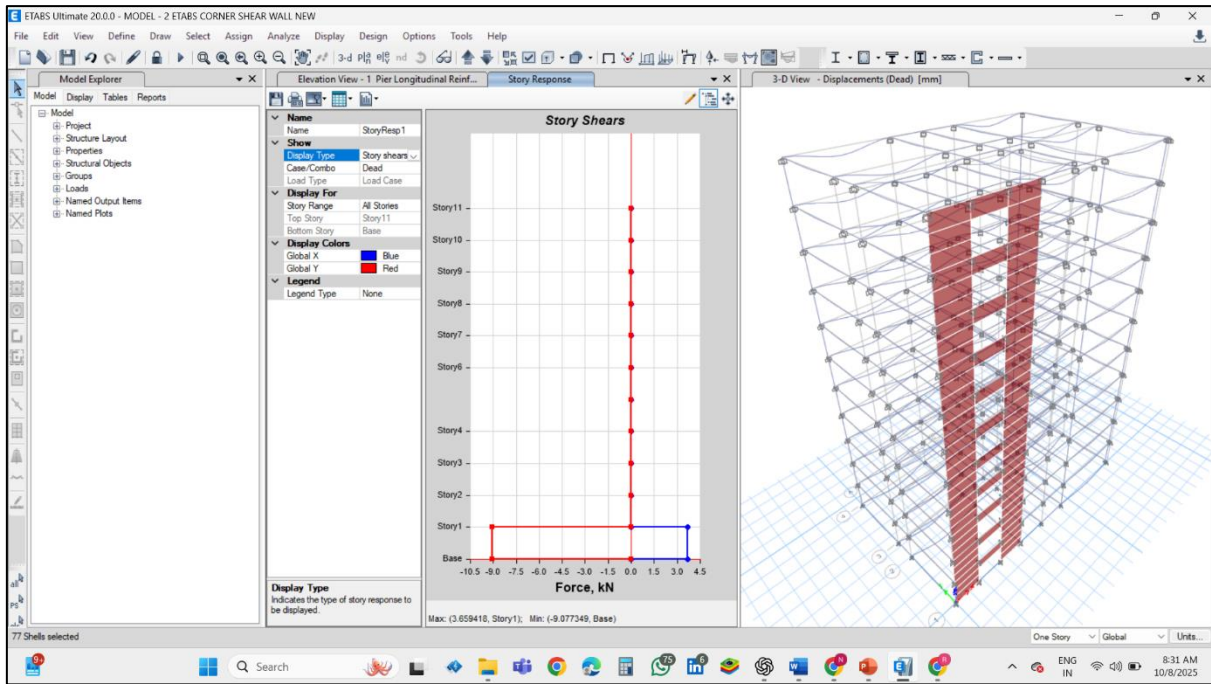


Fig. 3: Story Shear

- Smooth Increases with Length.
- Provides Effectives Stiffness with Architectural Flexibility

B. Model – 4 - Shear Wall at Core

1) Maximum Story Displacement (EQX & EQY): -

- Lower than Bare Frame, Slightly Higher than Corner Wall Model.

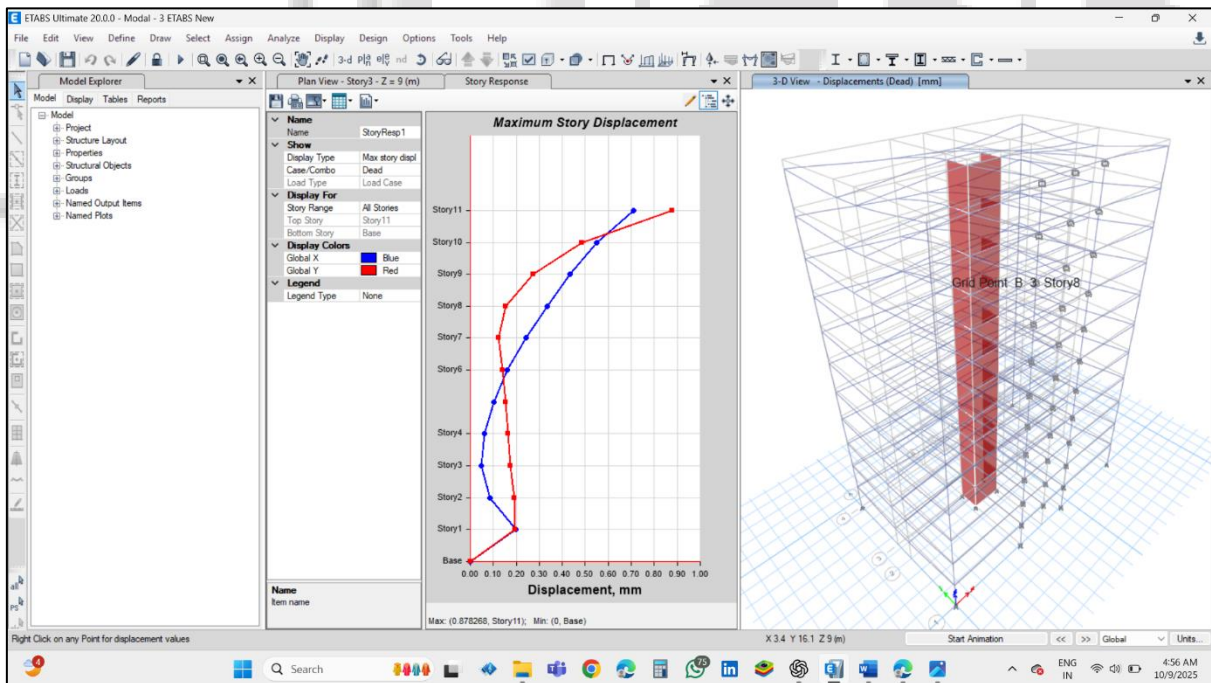


Fig. 4: Maximum Story Displacement

2) Maximum Story Drift: -

- Moderate Drift Values.
- Acceptable for Mid-to-high-rise Building.

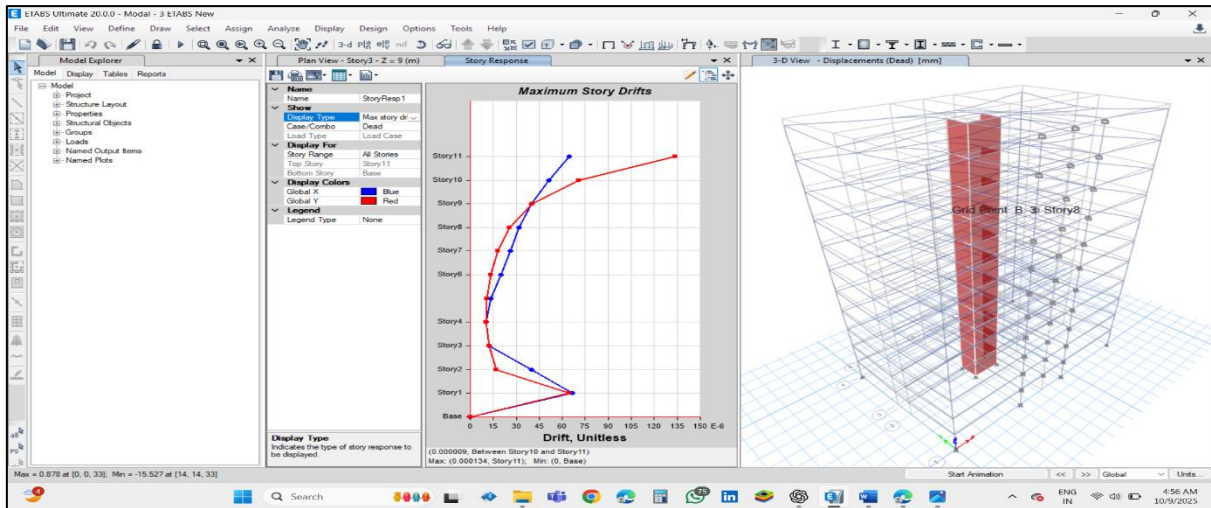


Fig. 5: Maximum Story Drift

3) *Story Shear* :-

- Consistent distribution, higher in Y- Directions.

- Core Walls Transfer Lateral Loads Effectively, though Less Aggressively than Corner Walls.

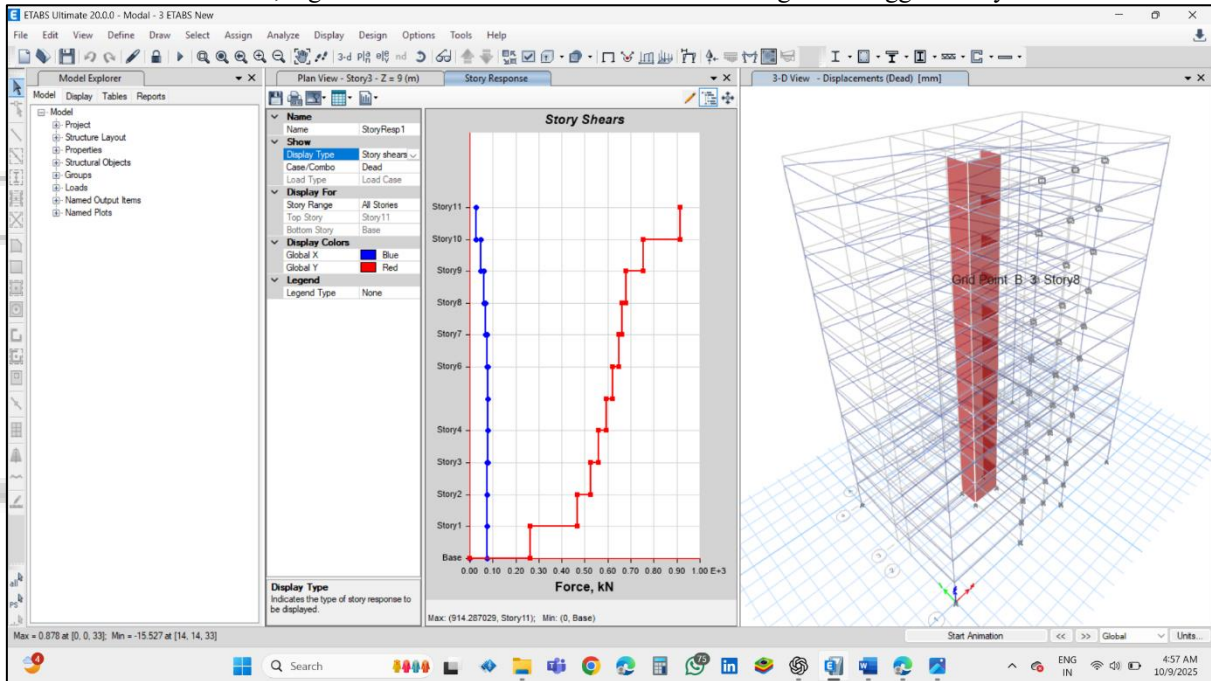


Fig. 6: Story Shear

VI. DISCUSSION:

A. *Bare Frame* :-

- High Drift and Displacement Values.
- Limited Base Shear Capacity.
- Vulnerable Under Seismic Forces.

Conclusion: - Not Suitable for High-Rise Buildings in Seismic Zones.

B. *Corner Shear Walls* :-

- Lowest Displacement and Drift.
- Highest Base Shear.
- Excellent Seismic Performance.

Conclusion: - Ideal for High-Rise Buildings in Earthquake-prone Regions.

C. *Core Shear Walls* :-

- Balanced Displacement and Drift.
 - Effective Load Transfer.
 - Suitable for Buildings with Central Service Zones.
- Conclusion: - Good Compromise between Stiffness and Design Flexibility.

D. *Overall Discussion* :-

- Bare Frame: High Vulnerability.
 - Corner Shear Walls: - Maximum Stiffness and Safety.
 - Core Shear Walls: - Balanced Performance.
- Implications: - Shear Walls are Essential for Seismic Design. Placement Depends on Buildings Height, Layout, and Seismic Zone.

VII. CONCLUSION:

- Based on the comparative analysis of the three building models, it can be concluded that the inclusion of shear walls significantly improves the seismic performance of reinforced concrete (RC) buildings.
- Among all configurations, the corner shear wall placement provides the highest lateral stiffness and effectively minimizes both storey drift and displacement, making it the most efficient arrangement for resisting earthquake forces.
- The core shear wall configuration offers a well-balanced response between structural stiffness and architectural functionality, making it suitable for buildings where the central zone is utilized for lifts, staircases, or service areas.
- Overall, for medium- to high-rise RC structures located in seismic regions, shear walls should be strategically positioned—preferably at the corners or around the central core—to ensure better safety, stability, and compliance with seismic design codes.

A. Summary of Conclusion: -

- Shear Walls Improve Seismic Performance of RC Buildings.
- Corner Shear Wall = Highest Stiffness & Minimum Drift.
- Core Shear Wall = Balanced Stiffness & Functionality.
- Recommended – Shear Walls at Corner or Core for Stability & Safety.

B. Summary Tables: -

Model Type	Displacement	Drift	Base Shear	Suitability
Bare Frame	High	Poor	Low	Not Suitable for Seismic Zones.
Corner Shear Walls	Lowest	Excellent	Highest	Best for High-Rise Seismic Regions.
Core Shear Walls	Moderate	Good	High	Good for Mid-rise with Core Services.

REFERENCE

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