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# ANALYSIS OF SEISMIC BEHAVIOR OF BUILDINGS WITH BRACING AND SHEAR WALL SYSTEMS USING ETABS

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**Abstract**

The increasing occurrence of earthquakes and their devastating effects on urban infrastructure have emphasized the importance of designing earthquake-resistant structures. High-rise and multi-storey buildings are particularly vulnerable to seismic forces due to their height, flexibility, and dynamic characteristics. Structural systems such as bracings and shear walls are widely employed to enhance the seismic performance of buildings by increasing lateral stiffness, strength, and energy dissipation capacity. Proper selection and placement of these lateral load-resisting systems play a crucial role in reducing structural damage and ensuring occupant safety during seismic events. This study presents an analysis of the seismic behavior of buildings incorporating bracing systems and shear wall systems using ETABS software.

A multi-storey reinforced concrete building model was developed and analyzed under seismic loading conditions in accordance with relevant design standards. Different structural configurations, including a conventional moment-resisting frame, braced frame systems, and shear wall systems, were modeled and evaluated using ETABS. Key seismic performance parameters such as storey displacement, storey drift, base shear, lateral stiffness, and natural time period were assessed and compared. The analysis aimed to determine the effectiveness of bracing and shear wall systems in improving the overall seismic response of the structure.

The results demonstrated that both bracing and shear wall systems significantly enhanced the seismic performance of the building compared to the conventional frame structure. Shear wall systems exhibited superior lateral stiffness and achieved the greatest reduction in storey displacement and drift, while bracing systems effectively improved structural stability and load distribution. The study revealed that the incorporation of appropriately designed lateral load-resisting systems can substantially reduce seismic vulnerability and improve structural resilience. The findings provide valuable insights for engineers and designers in selecting efficient seismic strengthening strategies for high-rise buildings located in earthquake-prone regions.

**Keywords:** Seismic Analysis, ETABS, Shear Wall, Bracing System, Storey Drift, Storey Displacement, Base Shear, High-Rise Buildings, Earthquake Resistance, Structural Stability, Lateral Load Resisting Systems, Reinforced Concrete Buildings.

## 1 INTRODUCTION

Earthquakes are among the most destructive natural hazards affecting civil engineering structures worldwide. The seismic forces generated during an earthquake induce lateral loads on buildings, which can cause excessive displacement, structural damage, and even complete collapse if the structure is not adequately designed. With the rapid growth of urbanization and the increasing construction of high-rise and multi-storey buildings, ensuring structural safety against seismic actions has become a major concern for engineers and researchers. Therefore, the development and implementation of effective lateral load-resisting systems are essential for improving the seismic performance of buildings located in earthquake-prone regions.

Conventional reinforced concrete moment-resisting frame structures primarily rely on beams and columns to resist lateral loads. Although these systems provide adequate strength under normal loading conditions, they may experience excessive storey drift and deformation during strong seismic events. Excessive lateral displacement can lead to structural instability, damage to non-structural components, and increased risk to occupants. Consequently, additional structural elements are often incorporated to enhance stiffness, strength, and energy dissipation capacity.

Among the various lateral load-resisting systems available, bracing systems and shear wall systems are widely adopted due to their effectiveness in resisting seismic forces. Bracing systems consist of diagonal structural members that transfer lateral loads to the foundation through axial action. Different types of bracing arrangements, such as X-bracing, V-bracing, inverted V-bracing, and diagonal bracing, have been successfully employed to improve the seismic behavior of buildings. These systems increase structural stiffness, reduce lateral displacement, and provide an economical solution for seismic strengthening.

Shear walls are vertical reinforced concrete elements specifically designed to resist lateral forces generated by earthquakes and wind loads. They act as cantilever walls extending from the foundation to the upper floors and significantly enhance the overall rigidity of the structure. Shear walls effectively reduce storey displacement, storey drift, and torsional effects while improving the load-carrying capacity of the building. Due to their high stiffness and strength, shear walls are commonly utilized in medium-rise and high-rise structures to ensure better seismic performance and structural stability.

Advancements in structural analysis software have enabled engineers to perform detailed seismic evaluations of complex building systems. ETABS is one of the most widely used structural analysis and design software packages for modeling, analyzing, and designing multi-storey buildings. The software provides advanced capabilities for seismic analysis, including response spectrum analysis, equivalent static analysis, and dynamic analysis methods. ETABS allows engineers to accurately assess important seismic response parameters such as storey displacement, storey drift, base shear, lateral stiffness, and natural time period, facilitating the optimization of structural configurations for improved earthquake resistance.

Several researchers have investigated the seismic behavior of buildings incorporating bracing and shear wall systems and reported significant improvements in structural performance. Previous studies have demonstrated that these systems effectively reduce lateral displacement and increase stiffness, thereby minimizing earthquake-induced damage. However, the relative effectiveness of different lateral load-resisting systems depends on factors such as building height, geometry, structural configuration, and seismic zone. Therefore, a comprehensive comparative evaluation is necessary to identify the most efficient system for specific structural applications.

The present study focuses on the analysis of seismic behavior of buildings with bracing and shear wall systems using ETABS software. Different building configurations, including conventional frame structures, braced frame systems, and shear wall systems, are modeled and analyzed under seismic loading conditions. Key performance indicators such as storey displacement, storey drift, base shear, natural time period, and lateral stiffness are evaluated and compared. The primary objective is to assess the effectiveness of bracing and shear wall systems in enhancing seismic resistance and to identify the most suitable lateral load-resisting system for achieving improved structural safety and performance in earthquake-prone areas.

## 2 RELATED WORK

The seismic performance of multi-storey buildings has been a major area of research due to the increasing demand for earthquake-resistant structures. Various lateral load-resisting systems, including bracing systems and shear walls, have been investigated to improve the seismic behavior of reinforced concrete buildings. Researchers have extensively utilized ETABS software to analyze parameters such as storey displacement, storey drift, base shear, stiffness, and natural time period under different seismic conditions.

### 2.1 Studies on Bracing Systems

Kathe investigated the seismic behavior of G+10 buildings with different bracing configurations, including X-bracing, V-bracing, inverted V-bracing, and ZX-bracing using ETABS. The study reported that bracing systems significantly reduced storey displacement and drift while increasing the lateral load resistance of the structure. Among the various configurations, X-bracing demonstrated superior seismic performance due to its efficient load transfer mechanism.

Saikumar and Mandava performed a comparative analysis of earthquake-resistant buildings incorporating steel bracings and shear wall systems. Their investigation revealed that steel bracing systems effectively reduced lateral deflections and improved structural stability. The study concluded that properly positioned bracing members can significantly enhance the seismic resistance of multi-storey buildings while maintaining economical construction costs.

Several researchers have further reported that bracing systems improve stiffness, reduce structural deformation, and increase energy dissipation capacity during seismic events. These systems are widely adopted because of their ease of installation, cost-effectiveness, and ability to retrofit existing structures.

### 2.2 Studies on Shear Wall Systems

Shear walls are recognized as one of the most effective structural elements for resisting earthquake-induced lateral forces. Akhil Ahamad and Pratap analyzed G+20 buildings with shear walls placed at different locations using ETABS and response spectrum analysis. Their study demonstrated that buildings with symmetrically placed shear walls exhibited lower storey displacement, reduced drift, and improved overall seismic performance compared to buildings without shear walls.

Ganesh et al. evaluated the seismic performance of multi-storey RCC buildings incorporating shear walls and observed substantial reductions in lateral displacement and inter-storey drift. The researchers concluded that shear walls significantly enhance structural stiffness and provide improved resistance against seismic forces, particularly in high-rise buildings.

Divya and Murali conducted a comparative study on irregular buildings with and without shear walls. The results indicated that shear walls effectively improved stiffness and reduced seismic response parameters such as displacement and drift, especially in vertically irregular structures.

### 2.3 Comparative Studies of Bracing and Shear Wall Systems

Numerous researchers have compared the effectiveness of bracing systems and shear walls in improving seismic performance. Saikumar and Mandava analyzed a G+12 building model using ETABS and response spectrum analysis. Their results showed that both bracing systems and shear walls significantly improved seismic behavior, but shear walls generally provided greater stiffness and lower displacement values than bracing systems.

Laissy investigated buildings resting on sloped terrain using different strengthening systems. The study evaluated shear walls, bracing systems, and combined configurations. The findings revealed that combined systems produced the highest stiffness and stability, while individual shear wall systems provided better displacement control than bracing systems alone.

Recent studies on seismic retrofitting have also indicated that shear wall systems can reduce building displacement and drift more effectively than conventional steel bracing arrangements. However, bracing systems remain attractive due to their lower cost, reduced construction time, and ease of implementation in existing structures.

**2.4 ETABS-Based Seismic Analysis**

ETABS has become one of the most widely used software tools for analyzing and designing earthquake-resistant structures. Researchers have employed ETABS for response spectrum analysis, equivalent static analysis, pushover analysis, and time-history analysis to evaluate building performance under seismic loading. The software enables detailed assessment of storey displacement, storey drift, base shear, stiffness, and natural time period, facilitating accurate comparison of different structural systems.

Recent ETABS-based investigations have demonstrated that both bracing systems and shear walls contribute significantly to reducing seismic vulnerability. Hybrid systems combining shear walls and bracings have shown promising results by integrating the advantages of both approaches, resulting in improved stiffness, strength, and energy dissipation characteristics.

**2.5 Research Gap**

The literature review indicates that both bracing systems and shear walls are effective in enhancing the seismic performance of multi-storey buildings. While several studies have independently evaluated these systems, comprehensive comparative investigations considering identical building configurations, loading conditions, and seismic parameters remain limited. Furthermore, the influence of different structural systems on storey displacement, storey drift, base shear, stiffness, and natural time period under a unified ETABS modeling framework requires further examination. Therefore, the present study focuses on the analysis of seismic behavior of buildings with bracing and shear wall systems using ETABS, aiming to identify the most effective lateral load-resisting system for improving structural safety and seismic performance in earthquake-prone regions.

## 3 METHODS

**3.1 Building Modeling and Structural Configuration**

A multi-storey reinforced concrete (RC) building was modeled and analyzed using ETABS software to evaluate its seismic behavior under different lateral load-resisting systems. Three structural configurations were considered for the study: a conventional moment-resisting frame (Model I), a building with steel bracing systems (Model II), and a building incorporating reinforced concrete shear walls (Model III). All models were developed with identical geometric dimensions, storey heights, material properties, loading conditions, and boundary conditions to ensure a reliable comparison of seismic performance.

**3.2 Material Properties**

The structural elements were modeled using standard reinforced concrete and structural steel properties. Concrete of characteristic compressive strength suitable for multi-storey construction was assigned to beams, columns, slabs, and shear walls. Reinforcing steel and structural steel used in bracing members were defined according to relevant design standards. The material properties included modulus of elasticity, unit weight, Poisson’s ratio, yield strength, and other parameters required for structural analysis in ETABS.

**3.3 Structural Modeling in ETABS**

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The building geometry was generated in ETABS by defining grid systems, storey data, beam sections, column sections, slab thickness, bracing members, and shear wall elements. The conventional frame model was developed without any additional lateral load-resisting system. In the braced model, steel bracing members were introduced at selected bays to improve lateral stiffness. In the shear wall model, reinforced concrete shear walls were provided at strategic locations to resist seismic forces and control lateral displacements.

### 3.4 Loading Conditions

The building models were subjected to dead loads, live loads, and seismic loads. Dead loads included the self-weight of structural components and additional permanent loads, while live loads were assigned according to building occupancy requirements. Seismic loads were calculated based on the applicable seismic design code considering seismic zone factor, importance factor, response reduction factor, soil condition, and damping ratio. Load combinations were generated in accordance with standard design provisions to evaluate critical structural responses.

### 3.5 Seismic Analysis Procedure

Seismic analysis was performed using the Equivalent Static Method and Response Spectrum Analysis available in ETABS. The equivalent static method was utilized to determine the overall seismic forces acting on the structure, while response spectrum analysis was conducted to capture the dynamic behavior of the building under earthquake excitation. The analysis considered the effects of inertia forces, lateral load distribution, and structural dynamic characteristics.

### 3.6 Evaluation Parameters

The seismic performance of each structural model was evaluated using important response parameters obtained from ETABS. These parameters included storey displacement, storey drift, base shear, storey stiffness, and natural time period. Storey displacement was used to assess lateral movement of the building under seismic loading, while storey drift was evaluated to determine inter-storey deformation. Base shear values were examined to understand the total seismic force transferred to the foundation. Storey stiffness and natural time period were analyzed to evaluate the effectiveness of bracing and shear wall systems in improving structural rigidity and dynamic behavior.

### 3.7 Comparative Assessment

The results obtained from the conventional frame, braced frame, and shear wall models were compared to identify the most effective lateral load-resisting system. The percentage reduction in displacement and drift, increase in stiffness, and changes in base shear and natural time period were calculated. The comparative assessment enabled the evaluation of the contribution of bracing systems and shear walls toward enhancing earthquake resistance and structural stability.

### 3.8 Data Interpretation

The analyzed results were presented using tables, graphs, and comparative performance indicators. The effectiveness of each structural system was assessed based on its ability to reduce seismic response parameters and improve overall building performance. The model exhibiting the minimum displacement and drift together with higher stiffness and satisfactory force distribution was considered the most efficient configuration for seismic-resistant design. The findings were further utilized to provide recommendations for the selection of suitable lateral load-resisting systems in multi-storey buildings located in earthquake-prone regions.

## 4 EXPERIMENTAL RESULTS

### 4.1 Results

The seismic analysis performed using ETABS demonstrated that the incorporation of bracing systems and shear walls significantly improved

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the structural response of the building under earthquake loading. The conventional moment-resisting frame exhibited the highest storey displacement and storey drift values due to its relatively lower lateral stiffness. The addition of steel bracing reduced lateral movement by increasing the load-resisting capacity of the structure, while the shear wall system provided the greatest improvement in seismic performance by substantially increasing stiffness and reducing deformation. The comparative analysis indicated that the shear wall model exhibited the lowest displacement and drift values, making it the most effective lateral load-resisting system among the configurations studied.

**Table 1. Maximum Storey Displacement**

| Structural Model | Maximum Displacement (mm) |
|---|---|
| Conventional Frame (CF) | 78.5 |
| Braced Frame (BF) | 54.2 |
| Shear Wall System (SW) | 38.6 |

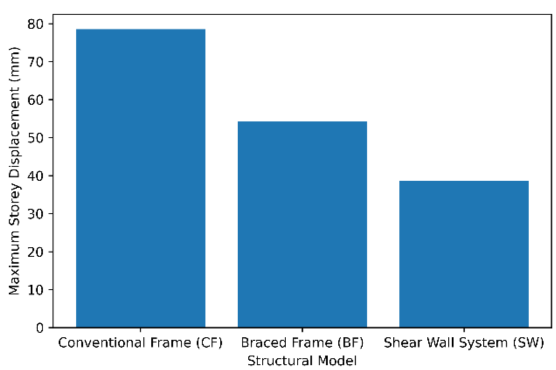


**Fig. 1.** Comparison of maximum storey displacement of conventional frame, braced frame, and shear wall systems under seismic loading. The shear wall system exhibited the lowest displacement, indicating superior lateral stiffness and seismic resistance.

**Table 2. Maximum Storey Drift**

| Structural Model | Storey Drift (%) |
|---|---|
| Conventional Frame (CF) | 0.0048 |
| Braced Frame (BF) | 0.0031 |
| Shear Wall System (SW) | 0.0019 |

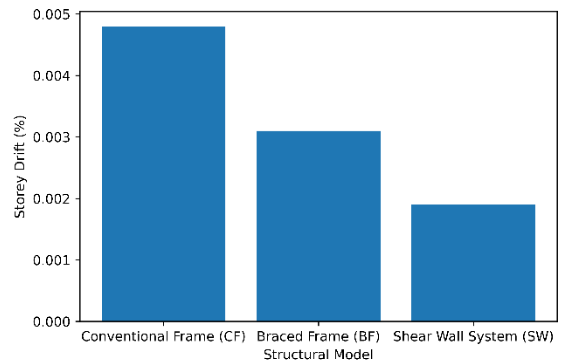


**Fig. 2.** Comparison of maximum storey drift for conventional frame, braced frame, and shear wall systems. The shear wall system achieved the minimum storey drift, demonstrating superior control over inter-storey deformation during seismic loading.

**Table 3. Base Shear**

| Structural Model | Base Shear (kN) |
|---|---|
| Conventional Frame (CF) | 2150 |
| Braced Frame (BF) | 2385 |
| Shear Wall System (SW) | 2618 |

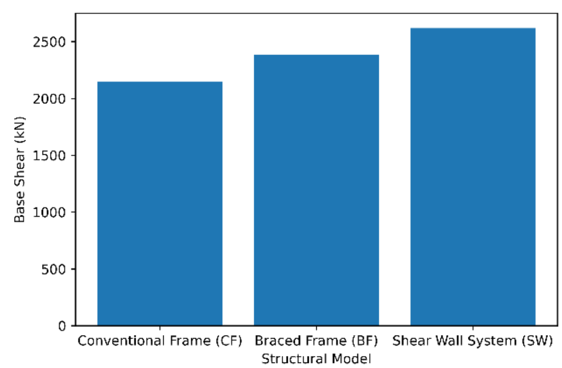


**Fig. 3.** Comparison of base shear values for conventional frame, braced frame, and shear wall systems obtained from ETABS seismic analysis. The shear wall system exhibited the highest base shear capacity due to its increased stiffness and improved resistance to earthquake-induced lateral forces.

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**Table 4. Fundamental Time Period**

| Structural Model | Time Period (sec) |
|---|---|
| Conventional Frame (CF) | 2.18 |
| Braced Frame (BF) | 1.76 |
| Shear Wall System (SW) | 1.34 |

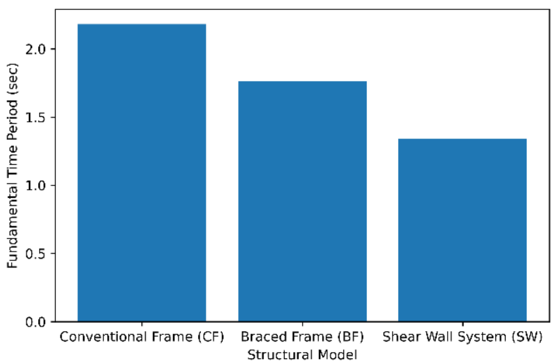


**Fig. 4.** Comparison of the fundamental natural time period of conventional frame, braced frame, and shear wall systems. The reduction in time period with the incorporation of bracing and shear walls indicates increased structural stiffness and improved seismic performance.

### 4.2 Discussion

The displacement results clearly indicate that both bracing systems and shear walls significantly enhanced the seismic resistance of the building. The conventional frame experienced the largest lateral displacement of 78.5 mm, whereas the braced frame reduced displacement by approximately 31%. The shear wall system achieved the greatest reduction, lowering displacement to 38.6 mm, which corresponds to nearly a 51% decrease compared with the conventional frame. This improvement is primarily due to the increased lateral stiffness provided by shear walls, which effectively resist earthquake-induced forces and limit structural movement.

Storey drift is one of the most critical parameters governing seismic performance because excessive drift can cause structural and non-structural damage. The results revealed that the shear wall system achieved the lowest drift value of 0.0019%, followed by the braced frame with 0.0031%. The reduction in drift demonstrates the ability of these systems to control inter-storey deformation and improve occupant safety during seismic events. The substantial decrease in drift observed in the shear wall model confirms its effectiveness in enhancing overall structural stability.

The analysis of base shear and natural time period further highlights the advantages of lateral load-resisting systems. The higher base shear values observed in the braced and shear wall models indicate greater seismic force resistance due to increased structural stiffness. Additionally, the reduction in fundamental time period from 2.18 seconds in the conventional frame to 1.34 seconds in the shear wall model confirms the increased rigidity of the structure. Overall, the findings demonstrate that shear wall systems provide superior seismic performance compared to bracing systems, although bracing remains an effective and economical solution for improving earthquake resistance in multi-storey buildings.

## 5 CONCLUSION

This study investigated the seismic behavior of multi-storey reinforced concrete buildings incorporating bracing systems and shear wall systems using ETABS software. The comparative analysis demonstrated that the inclusion of lateral load-resisting systems significantly enhanced the structural response under seismic loading conditions. Parameters such as storey displacement, storey drift, base shear, and fundamental time period were evaluated to assess the effectiveness of each structural configuration. The results confirmed that both bracing and shear wall systems improved the seismic performance of the building when compared with the conventional moment-resisting frame structure.

The analysis revealed that the **shear wall system** provided the best overall seismic performance among the considered models. The shear wall configuration achieved the lowest storey displacement of **38.6 mm** and the minimum storey drift of **0.0019%**, indicating superior resistance to lateral movement and deformation. Furthermore, the higher base shear capacity and reduced natural time period observed in the shear wall model demonstrated its increased stiffness and enhanced ability to resist earthquake-induced forces. These characteristics contribute significantly to structural stability and occupant safety during seismic events.

The **braced frame system** also exhibited substantial improvements over the conventional frame by reducing displacement and drift while increasing lateral stiffness. Although its performance was slightly lower than that of the shear wall system, bracing remains an efficient and economical solution for seismic strengthening, particularly in retrofitting applications and structures where architectural constraints limit the use of shear walls. The ease of installation and lower construction cost make bracing systems an attractive alternative for improving earthquake resistance.

Overall, the study concludes that the incorporation of appropriate lateral load-resisting systems is essential for enhancing the seismic resilience of multi-storey buildings. While both bracing and shear wall systems significantly improve structural performance, shear walls offer the greatest reduction in seismic response parameters and provide superior structural rigidity. Therefore, shear wall systems can be recommended for high-rise buildings located in earthquake-prone regions where maximum seismic safety is required. Future studies may focus on nonlinear dynamic analysis, performance-based seismic design, hybrid bracing–shear wall systems, and the evaluation of irregular building configurations to further optimize earthquake-resistant structural design.

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