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Comparative Study of RC Building with Bracing and Shear Wall

Badal Bansod[1], Prof. A.R. Nikhade[2]

[1]Post graduate student, Dept. of Civil Engineering, RTMNU University, Nagpur, India

[2]Assistant Professor, Dept. of Civil Engineering, RTMNU University, Nagpur, India

ABSTRACT

The most common applications for shear wall and steel bracing systems are in medium- to high-rise structures, which offer the stiffness, strength, and energy dissipation needed to withstand the lateral loads caused by wind and earthquakes. Shear walls and steel bracing have already been shown to be the most practical way to protect structures against earthquakes. These significant developments in earthquake engineering include the recently approved performance evaluation methodology and capacity design principles. Many existing RC buildings need to be retrofitted to fix their defects and support seismic loads. Existing RC buildings' seismic performance needs to be improved to meet the requirements of the new performance-based seismic design methodologies. This study looks at the seismic performance of an RC building that has been rebuilt with steel bracing and a shear wall. A twelve-story structure in zone 5 is subjected to an earthquake and wind load calculation. The efficiency of several steel bracing types with concrete shear wall construction.

Keywords: Seismic analysis, Bracings, Shear Wall, STAAD.PRO, Indian code IS 1893:2002.

1 INTRODUCTION

In the modern era, due to the rapidly increasing population and the continuous migration of people from rural to urban areas, the construction of high-rise buildings has become increasingly common. As the height of multi-storey buildings increases, ensuring structural stability becomes crucial. Stability is essential not only for the safety and well-being of occupants but also for protecting the building from potential damage or collapse. A stable structure must be capable of withstanding various types of loads, including gravity, wind, and seismic forces, without failure.

Natural disasters such as earthquakes, hurricanes, and floods can impose excessive lateral and vertical loads on buildings, leading to structural failure if not properly accounted for in the design. In regions categorized under high seismic risk—such as Seismic Zone 5 in India, which is the most severe earthquake-prone zone—buildings must be designed with enhanced lateral stability measures. Seismic Zone 5 demands special consideration in structural design due to the high probability of intense ground shaking.

To resist these lateral forces effectively, structural elements like shear walls and bracings are commonly employed. Shear walls are rigid vertical components that act as vertical diaphragms, transferring lateral loads (from winds and earthquakes) from floors, roofs, and exterior walls to the foundation. These walls significantly enhance the stiffness, stability, and strength of a building. They help reduce lateral sway and vibrations during seismic events, thereby minimizing structural and non-structural damage. Shear walls are also relatively easy to construct on-site and, due to their thinner profiles, contribute to a lighter overall structural weight.

Similarly, bracing systems—such as X-bracing, V-bracing, and K-bracing—are widely used to provide lateral load resistance. These systems consist of diagonal steel members placed within the bays of a frame, creating a triangulated configuration that can effectively transfer lateral forces to the foundation. Bracings are particularly effective in improving the lateral stiffness and ductility of a structure, making them suitable for use in high-rise buildings located in seismic-prone areas.

Numerous studies have been conducted on multi-storey buildings with and without shear walls and with different types of bracing systems, particularly in various seismic zones. Researchers have focused on identifying the most effective locations and configurations of shear walls and bracings to optimize performance under seismic and wind loads. In Seismic Zone 5, the implementation of shear walls and bracing systems is vital for minimizing structural deformation, reducing inter-storey drift, and preventing collapse during severe earthquakes.

1.1 STADD Pro

Staad Pro is a structural analysis and design software used by engineers and architects. It is widely used for designing buildings, bridges, towers and other structures. The benefit of using STAAD Pro is to reduce errors and improve accuracy in structural analysis and design. Staad Pro is a powerful tool for structural engineers, enabling them to create safe, efficient, and cost-effective designs. The importance of STAAD.Pro lies in its ability to accurately analyze structures under different loading conditions, such as dead loads, live loads, wind loads, and seismic loads, including those in high-risk areas. Designing buildings in STAAD.Pro is essential for modern structural engineering due to its accuracy, efficiency, and ability to handle complex structures

1.2 Bracing

Nowadays bracing systems are used in buildings to resist the earthquakes Bracing is a structural element used to enhance the stability and strength of a building by resisting lateral forces caused by wind, earthquakes, or dynamic loads. resist lateral loads, including wind and seismic forces. The use of bracing in buildings provides stability and rigidity it also helps to prevent the collapse of a building during an earthquake bracing systems help to:

1. Resist lateral loads: Bracing systems absorb and distribute lateral loads, reducing the stress on the structure.

2. Prevent collapse: Bracing systems help prevent collapse by providing additional support to the structure.

3. Reduce deflection: Bracing systems reduce the deflection of the structure under lateral loads.

Types of Bracing Systems:

1. V bracing:- V bracing consists of diagonal braces that form a V shape, typically connecting a horizontal beam to a vertical column or between structural members.

2. Diagonal Bracing: Diagonal members connect the beams and columns to form a diagonal bracing system.

3. X-Bracing: Two diagonal members intersect to form an X-shape, providing additional stability.

4. K-Bracing: A diagonal member connects the beam and column, forming a K-shape.

4. Eccentric Bracing: The bracing system is designed to resist lateral loads while allowing for some flexibility.

5. Concentric Bracing: The bracing system is designed to resist lateral loads while maintaining a fixed position.

In the bracing various material are used.

1. Steel: Steel bracing members are commonly used because of high strength-to-weight ratio.

2. Concrete: Concrete bracing members can be used for added stability and durability.

3. Fiber-Reinforced Polymer (FRP): FRP bracing members offer high strength, corrosion resistance, and low weight.

1.3 Shear Wall

A shear wall is a structural element that resists lateral loads, such as wind and seismic forces, by providing shear resistance. Shear walls help maintain the structural stability of a building by resisting lateral loads and providing support to the foundation. Shear walls are typically used in building design to:

1. Resist lateral loads: Shear walls help to resist lateral loads, reducing the stress on the structure.

2. Prevent collapse: Shear walls help to prevent collapse by providing additional support to the structure.

3. Reduce deflection: Shear walls reduce the deflection of the structure under lateral loads.

Types of Shear Walls:

1. Reinforced Concrete Shear Wall: A reinforced concrete wall with rebar reinforcement.

2. Masonry Shear Wall: A masonry wall with mortar and grout.

3. Steel Shear Wall: A steel wall with steel framing and sheathing.

4. Wood Shear Wall: A wood wall with wood framing and sheathing.

Benefits of Shear Walls used in building :

1. Improved structural integrity: Shear walls provide additional support to the structure.

2. Enhanced seismic resistance: Shear walls help to resist seismic forces.

3. Reduced damage: Shear walls reduce the damage caused by lateral loads.

2 LITERATURE REVIEWS

i.Author:- Ajay Kumar, Bikaram Nirala and Onkar Yadav- Issue year:- 2023

In this research work, the researchers analyzed four types of bracing systems—X, V, Diagonal, and Inverted V in two different buildings. The models were created using ETABS software. The study was conducted on G+8 and G+10 storey buildings under seismic loading conditions in Seismic Zone V. The researchers focused on comparing the storey displacement of the four bracing types with an unbraced frame.

At the end of the study, they compared the results of storey displacement and storey drift, and concluded that steel bracings can be effectively used for strengthening structures. Steel bracing is a beneficial solution for strengthening or retrofitting existing buildings. Among the different configurations, the Inverted V bracing system was found to be the most effective in reducing lateral displacement, offering greater lateral support compared to the unbraced frame and other bracing types.

ii.Author:- Keshi Janghel and Deepti Hazari – Issue Year:- 2023

In this paper, the researchers analyzed G+5 and G+9 buildings in Seismic Zones III and V using STAAD.Pro. They compared normal buildings with those having shear walls and bracings placed at different positions corners, center, and core—starting from specific heights above the ground. A total of 13 models were created. Key parameters studied included storey drift, displacement, peak storey shear, and Eigenvalues. Results showed that base shear increases with building height and structural stiffness. The highest base shear was observed in models with shear walls and bracings at corners, offering maximum safety. Displacement also increased when moving from lower to higher seismic zones, especially in models with shear walls.

iii.**Author:- Shivani B. Dasare, Prof. Mrs. Kariappa M.S. Issue Year:- July 2022**

In this paper, the researchers investigated G+6 and G+8 buildings with and without bracing, specifically focusing on X and V-type bracing systems. The study was conducted in Seismic Zone V with the application of wind loads. Bracings were positioned at the middle bays of the buildings, and all modeling and analysis were carried out using ETABS software. The objective was to evaluate parameters such as storey displacement, storey drift, stiffness, and maximum storey drift.

The study concluded that both X and V bracing systems effectively reduce the lateral movement of the building. The use of bracing increases the overall stiffness of the structure. Among the two, X-bracing was found to be more effective than V-bracing in minimizing lateral displacement and storey drift. Additionally, it was observed that as the building height increases (from G+6 to G+8), both displacement and drift values also increase. Bracing systems help transfer lateral loads to beams and columns, with X-bracing in reinforced concrete frames carrying a significant portion of the lateral load.

iv.Author:- Mohd Atif, Prof. Laxmikant Vairagade – Issue Year:- Aug, 2015

In this study, the researchers analyzed a G+15 building to evaluate the performance of different bracing systems and shear walls under seismic loading in Zone II, Zone III, Zone IV, and Zone V. The structural modeling was carried out using STAAD.Pro V8i software. Bracings and shear walls were applied at various positions in the building, such as the outer edges, corners, periphery, and interior. The types of bracings used included Diagonal, V-type, and X-type.

The study concluded that steel bracings can serve as an effective alternative to other strengthening or retrofitting techniques. The placement of shear walls and bracings significantly influences the seismic performance of the structure, with centrally located shear walls offering better results. Steel bracings help reduce flexural and shear demands on beams and columns by transferring lateral loads primarily through axial forces. Among all configurations, the X-bracing system was found to be the most effective in minimizing bending moments. Additionally, the use of steel bracings does not significantly increase the total weight of the building. The lateral displacement of the building was reduced by 35% to 45% using the X-type bracing system, making it the most efficient in controlling maximum displacement.

v.**Author:- Karnati Vijetha, Dr. B. Panduranga Rao -Issue Year:- July 2019**

In this research, the authors worked on three types of frame models. They analyzed a G+15 building using shear walls and braced frames placed at the outermost parts of the structure. The study was based on the seismic conditions of Vijayawada, which falls under Seismic Zone III. The main objective was to compare the seismic response of the structure. X-type bracing was used at different positions within the building for analysis.

The study concluded that shear walls significantly reduce lateral displacement. Providing shear walls at appropriate locations substantially decreases displacement due to earthquakes. The base shear of the structures increased notably, enhancing the building's stability against seismic loading. The natural time period of the structures was also significantly reduced after the placement of bracings and shear walls, compared to a normal unbraced structure. The capacity to resist lateral forces increased greatly with the addition of shear walls. Among all the models, lateral displacements were minimal in structures with shear walls. Based on the comparison and discussion, it was concluded that shear walls considerably improve the lateral stability of structures.

vi.Author:- Sachin V, Adarsh M Issue Year:- May 2023

In this research work, the authors considered a G+8 multi-storey building with shear walls and steel bracings. The analysis was carried out using ETABS software. The shear walls and X-type bracings were placed at the corners of the building for comparison.

The findings showed that both shear walls and steel bracings can effectively enhance the seismic performance of reinforced concrete (RC) multi-storey buildings. The seismic response is significantly improved when shear walls and bracings are placed at the corners compared to a bare frame structure. The natural time period of the designed structure was greatly reduced after the installation of steel bracings and shear walls. Using the X-type steel bracing system, the building's lateral displacement was reduced by 35% to 45%. Additionally, the X-type bracing reduced the maximum displacement and resulted in minimum possible bending moments compared to other bracing configurations.

vii.Author:- P. P. Chandurkar, Dr. P. S. Pajgade Issue Year:-July 2013

In this paper, the authors studied a G+9 building located in Seismic Zones II, III, IV, and V. The main objective of the analysis was to determine the optimal location for shear walls in multi-storey buildings. Four different models were created and analyzed using ETABS software:

- Model 1 – Bare frame structure (without shear walls)
- Model 2 – Dual system with one shear wall on each side
- Model 3 – Dual system with shear walls at the corners with length L=4.5 m
- Model 4 – Dual system with shear walls at the corners with length L=2

From the analysis, it was observed that in a 10-storey building, placing shear walls of shorter length (Model 4) at the corners is more economical and effective compared to other configurations. It was concluded that larger shear wall dimensions are not necessarily more effective in buildings of 10 storeys or fewer. The study also found that shear walls are both economical and efficient in high-rise buildings. Additionally, changing the position of shear walls affects the distribution of seismic forces, emphasizing the importance of placing them in proper locations. Proper placement of shear walls significantly reduces earthquake-induced displacements.

viii.Author:- Suchita Hirde and Ganga Tepugade Issue Year:- June 2014

In this study, the researchers conducted an analytical investigation on a G+20 multi-storey building with a soft storey located at various levels, including the ground floor. The analysis was performed using SAP2000 software, and eight different models were created using bracings, shear walls, and combinations of both. Shear walls were applied at different heights throughout the building.

After analysis, it was observed that plastic hinges developed in the ground-level soft storey columns, which is not acceptable for safe structural design. The provision of shear walls led to a significant reduction in lateral displacement. It was also noted that displacement decreases when the soft storey is placed at higher levels. After retrofitting, the base shear carrying capacity increased by 8.45% to 13.26%.

ix.Author:- Syed Ehtesham Ali, Mohd Minhaj Uddin Aquil Issue Year:- September 2014

In this paper, the main focus of the researcher was to determine the optimal location for shear walls in multi-storey buildings. For this analysis, a six-storey building located in Hyderabad and subjected to earthquake loading in Seismic Zone II was considered. Earthquake loads were calculated using the seismic coefficient method, as per IS 1893 (Part-I):2002. The analyses were performed using ETABS, and four models were created for this research:

- Model I: Structure without shear walls
- Model II: Structure with L-type shear walls
- Model III: Structure with shear walls along the periphery
- Model IV: Structure with cross-type shear walls

The analysis showed that, among all models, the lateral deflection of the columns in the building with L-type shear walls (Model II) was reduced the most compared to the other models. The shear force was maximum at the ground level for Model III, compared to Models II and IV. The shear force in Model IV was higher at the middle level than in Model III. The maximum bending moment occurred at the roof level for Model III. Based on these findings, the researcher concluded that a building with L-type shear walls (Model II) is more efficient than all other shear wall configurations.

x.Author:- Badri Adhikari, Tek Raj Gyawali, Rajendra Aryal- Issue Year:- 2022

In this paper, the researchers studied the seismic performance of RC frame buildings with regular and irregular plans. The models included rectangular, L-shaped, and U-shaped buildings, all with G+3 storeys, located in Seismic Zone V. The research focused on the use of bracing and shear walls at the corners of the building, comparing models with shear walls, bracing, and bare frame structures.

After analyzing all the models, they found that displacement was lower in the L-shaped and U-shaped buildings with shear walls or bracing at the corners, compared to the rectangular bare frame buildings. Similarly, the drift was also less in the L-shaped and U-shaped buildings with shear walls or bracing at the corners than in the rectangular bare frame building. Overall, the seismic performance of the L-shaped and U-shaped buildings with shear walls or bracing at each corner was better than that of the regular rectangular bare frame buildings.

xi.Author:- Kanchan Rana, Vikas Mehta Issue Year:- 2017

In this research, the focus was on determining the optimal location for shear walls. A 6-storey building located in Seismic Zone V was considered, and the analysis was conducted using STAAD Pro software. Four different models of the RCC building were proposed: one without shear walls and the others with shear walls placed at different positions.

The analysis found that the least storey drift in both the X and Z directions occurred when the shear wall was placed at the corners. The peak storey shear was highest when the shear wall was located at the center. The study concluded that the most effective location for the shear wall is at the corners, compared to all other locations.

xii.**Author:- Kumar Anupam, Mr. Md. Tasleem Issue Year:- 2021**

In this paper, the seismic behavior of a high-rise building using shear walls and bracing was analyzed. Four different models were created: one with a bare frame, one with shear walls, and others with X and inverted V bracing at the corners of the building to resist seismic loads. The study considered a G+16 multi-storey building located in Seismic Zone V, analyzed using ETABS-2018 software. The variations in displacement, storey drift, and storey shear of the models were studied.

The analysis results showed that shear walls significantly reduce displacement. The base shear of the structures increased considerably, making the structure more stable against seismic loading. The natural time period of the designed structures was greatly reduced after placing the bracings and shear walls compared to the normal structure. The capacity to resist lateral forces was significantly enhanced after placing shear walls. Based on the comparison of the structures and the discussion, it was concluded that shear walls improve the lateral stability of the structures. When comparing various parameters like story drift, story displacement, and story shear, the building with shear walls demonstrated better performance than both types of bracing.

xiii.Author:- M A Rahman, M Teguh, and F Saleh -Issue Year:- 2021

In this study, the researcher compared the seismic performance of a 10-storey building with shear walls and bracing systems. Three models were analyzed: Model 1 (bare frame), Model 2 (L-shaped shear walls), and Model 3 (X-bracing system). The analysis, conducted using SAP2000 software, focused on story drift, base shear, and displacement under earthquake forces.

The results showed that Model 2 (with shear walls) had the lowest lateral deflection and displacement, making it the most effective for earthquake resistance. Model 1 (without shear walls or bracing) had the highest drift and failed to meet drift limits, indicating the need for reinforcement. Model 3 (with X-bracing) also improved performance but was less effective than shear walls in reducing displacement and drift.

Base shear increased significantly in Model 2 compared to Model 1, indicating better resistance to seismic forces. The study concluded that shear walls offer the best solution for improving seismic stability, while bracing systems like X-bracing provide a viable alternative, especially where shear walls are not feasible.

Overall, the research emphasizes the importance of incorporating shear walls or bracing systems in multi-storey buildings located in seismic zones to ensure safety and reduce structural damage.

xiv.Author:- Abhishek Jain, Prof. Kavita Golghate Issue Year:- 2021

In this paper, the researcher compares different types of RCC bracing with shear walls in high-rise buildings. The structure modeling was done using ETABS software in Zone V.

For this study, five models were created:

- Model 1: Moment Resisting Frame
- Model 2: Moment Resisting Frame with RCC V-Bracing System
- Model 3: Moment Resisting Frame with RCC X-Bracing System
- Model 4: Moment Resisting Frame with X-Bracing along the X-direction and V-Bracing along the Y-direction
- Model 5: Moment Resisting Frame with Shear Wall System

The study examined the use and location of shear walls and RCC bracing systems (X-bracing and V-bracing), comparing seismic parameters like base shear and storey displacement. The analysis found that in high-rise buildings, parameters such as lateral strength and stiffness are critical. To enhance both, shear walls and RCC bracing systems are adopted.

Buildings with shear walls and RCC bracing systems have a higher base shear compared to those without, which increases the stiffness of the structure. The storey displacement of buildings is reduced with the use of shear walls and RCC bracing systems. The top storey displacement for Model 2 (RCC V-bracing system placed at the four corners of both transverse and longitudinal bays) is reduced compared to Model 3. Models 4 and 5 are the safest and show the least storey displacement.

The study also found that RCC bracing increases the primary strength of the structure. The most effective locations for the RCC X-bracing and RCC V-bracing systems are in Model 4. Therefore, the Moment Resisting Frame with X-Bracing along the X-direction and V-Bracing along the Y-direction (Model 4) is the safest and most economical of all the five models analyzed.

xv.Author:- Amit Kumar Gupta, Dr. V. Pandey -Issue Year:- 2019

In this research paper, various models of a 12-storey building in Zone IV were analyzed by changing the location of shear walls and bracings. The building models were created using STAAD Pro software. Five different models were studied with different positioning of shear walls and bracings in the building. The modeling was done to analyze seismic parameters such as bending moment, shear force, base shear, storey drift, and storey displacement.

The analysis results found that storey drift is significantly lower after inserting shear walls and bracings. Storey drift decreases remarkably in the case of shear walls. There is a reduction in storey deflection in the frame due to bracing and shear walls. The storey deflection is minimum when shear walls are used. The base shear is found to be higher in braced frames and even more so in shear-walled frames. The base shear is highest when shear walls are present. Bending moment and shear force demands on beams are significantly reduced by the introduction of bracing and shear walls. From the study, it is found that the frame model with shear wall at the corners (Shear Wall B) performs better and is more efficient than all other frame models.

3 CONCLUSION

Based on the analysis of various research works related to shear walls and bracing systems in multi-storey buildings, the following conclusions can be drawn:

1. Shear walls significantly reduce storey displacement and lateral deflection in multi-storey buildings under seismic loads.
2. X-bracing and V-bracing systems also improve structural performance but are generally less effective than shear walls.
3. Base shear increases with the use of both shear walls and bracing, indicating better resistance to seismic forces.
4. Story drift is minimized most effectively with the inclusion of shear walls, especially when placed at corners or centrally.
5. Natural time period is reduced when shear walls or bracings are applied, improving seismic stability.
6. Corner placement of bracing or shear walls often provides the most efficient seismic performance.
7. Model combinations (like X-bracing in X-direction and V-bracing in Y-direction) show better results than using a single bracing type.
8. RCC bracing systems increase both lateral strength and the primary stiffness of the structure.
9. Bracing systems offer an alternative where shear walls are not feasible, particularly in architectural or functional constraints.
10. Shear walls provide the best all-around performance, making them the preferred choice for seismic resistance in high-rise RC buildings.
11. A combination of shear walls and bracing yields the best seismic performance.
12. These systems ensure better stability and safety for high-rise buildings in seismic zones.

Most studies focus on bracings at corners, but this study investigates the effect of central placement of shear walls, which is less commonly analyzed, especially under both wind and seismic loads. These studies aim to investigate the structural analysis and design aspect of RC buildings with bracing and shear wall. Improve our understanding of how seismic behaviour and structural performance are affected when we use the bracing and shear wall.

For this study, we create 4 models

1. Normal Building (Without bracing and shear wall)
2. V-type bracing
3. X-type bracing
4. Shear wall

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