Mr. Arun Kumar, 2025, 13:4
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology
An Open Access Journal

Comparative Seismic Performance of High-Rise RC Buildings with Shear Walls and Bracing Systems Using Response Spectrum Method

Mr. Arun Kumar[1], Dr. Bhagyashree Naik[2]
[1]M.Tech. Research Scholar Department of Civil Engineering School of Engineering Eklavya University, Damoh (M.P.)
[2]Associate Professor Department of Civil Engineering School of Engineering Eklavya University, Damoh (M.P.)

Abstract- The seismic performance of high-rise reinforced concrete (RC) buildings is a critical concern in earthquake-prone regions. This paper investigates the comparative seismic behavior of a twelve-storey RC building (42 m height, 15 × 20 m plan) modeled in STAAD.Pro. The study considers three structural configurations: (i) bare frame, (ii) braced frame with X-type steel bracings, and (iii) shear-wall frame with 250 mm RC shear walls. Seismic loading is applied using the Response Spectrum Method (RSM) as per IS 1893:2016, along with two historical ground motion records—Imperial Valley (1940) and San Francisco (1906). Key response parameters examined include the fundamental time period, base shear, inter-storey drift, and top-storey displacement. Results indicate that shear walls significantly enhance structural stiffness, reducing displacements and drifts, with corner placement yielding optimum performance. Bracings moderately improve seismic response and offer economical retrofitting potential but are less effective than shear walls. The findings provide practical guidance for engineers in selecting lateral load-resisting systems for high-rise RC buildings in seismic zones.

Keywords: Seismic design; Reinforced concrete buildings; Shear walls; Bracing systems; STAAD.Pro; Response Spectrum Method; Inter-storey drift.

I. INTRODUCTION

Earthquakes are among the most destructive natural hazards, responsible for large-scale structural failures and socio-economic losses worldwide. In regions of high seismicity, the vulnerability of the built environment is amplified when structural systems are not adequately designed to resist earthquake-induced forces. High-rise reinforced concrete (RC) buildings, in particular, are increasingly preferred in rapidly urbanizing cities due to limited land availability and escalating land costs. However, their height, slenderness, and dynamic characteristics make them especially prone to seismic actions, where lateral forces often govern design over gravity loads. Thus, the seismic design of tall RC buildings has emerged as a critical research and engineering challenge.

In India, the seismic risk is especially significant, as nearly 59% of the landmass falls under moderate to severe seismic zones (III to V) as per the Indian seismic code IS 1893:2016. Major urban centers such as Delhi, Guwahati, Srinagar, and cities across the Himalayan belt lie in high-risk zones. Historical events—including the 2001 Bhuj earthquake (Mw 7.6), which resulted in over 20,000 fatalities, and the 2015 Nepal earthquake, which caused widespread structural damage in northern India—have repeatedly demonstrated the vulnerability of conventional RC buildings without sufficient lateral load-resisting systems. The recurrence of such disasters underscores the urgent need for effective seismic-resistant design strategies in Indian high-rise construction.

The behavior of RC frames under seismic loading is dominated by lateral displacements, inter-storey drift, torsional effects, and resonance with ground motions. Bare frames, although economical and architecturally flexible, are inherently flexible and susceptible to excessive drift and collapse during strong ground shaking. To mitigate these deficiencies, additional stiffening systems—such as shear walls and steel bracings—are widely used.

Shear walls, functioning as vertical cantilevers, significantly increase stiffness and strength, thereby reducing storey drift and top displacement. Bracing systems, on the other hand, provide an economical means of improving ductility and can be easily retrofitted in existing frames. Both systems, however, have distinct advantages and limitations: while shear walls enhance stiffness at the expense of architectural flexibility, bracings are lighter and more economical but less effective in displacement control.

Numerous studies have addressed the role of shear walls and bracings in improving seismic performance. For example, Chandurkar and Pajgade (2013) demonstrated that corner shear walls greatly reduce lateral displacements, while Viswanath (2010) highlighted the effectiveness of X-bracing in reducing drift. However, much of the available literature is fragmented, with studies focusing either on shear walls or bracings, often under a single seismic input such as codal spectra.

Comprehensive comparative studies involving both systems, especially under multiple earthquake ground motions, remain limited. Furthermore, there is a lack of systematic investigations that consider practical parameters—such as placement of stiffening elements and their relative efficiency in reducing time period, drift, and displacement—in the context of Indian seismic design provisions.

This research addresses these gaps by conducting a comparative analysis of high-rise RC buildings with bracing and shear wall systems using STAAD.Pro. A 12-storey RC building is modeled under three different lateral load-resisting configurations: bare frame, braced frame with X-type steel bracings, and shear-wall frame with various wall placements. Seismic inputs include the IS 1893:2016 design spectrum, as well as two real earthquake records (Imperial Valley 1940 and San Francisco 1906). Key performance indicators—fundamental time period, base shear, inter-storey drift, and top-storey displacement—are evaluated to assess the effectiveness of different stiffening systems. The findings provide practical insights into the selection of appropriate lateral load-resisting systems for high-rise RC buildings in seismic regions, with specific relevance to Indian conditions.

II. RESEARCH SIGNIFICANCE

The significance of this study lies in addressing a persistent gap in seismic design practice: the absence of systematic comparative evaluations of bracing and shear wall systems in high-rise RC buildings under multiple seismic inputs. While numerous studies have individually examined these systems, most are limited to single structural configurations or rely solely on codal response spectra. This restricts their applicability to real-world conditions where ground motions vary widely in intensity, frequency content, and duration.

By analyzing a 12-storey RC building with three stiffening strategies—bare frame, X-type bracing, and RC shear walls—under both codal spectra and historical earthquake records, this study provides a more holistic understanding of structural performance. The comparative assessment of key response parameters—fundamental time period, base shear, inter-storey drift, and top-storey displacement—enables a clearer identification of the strengths and limitations of each stiffening system.

For the Indian context, where 59% of the landmass falls in seismically active zones and high-rise construction is expanding rapidly, the outcomes of this research have both technical and practical relevance. Engineers can use the findings to make informed decisions on the optimal placement and selection of stiffening systems, balancing seismic safety, serviceability, and economy. The results also provide useful insights for retrofitting existing RC buildings, where cost constraints often limit the use of shear walls, making bracing systems a practical alternative.

More broadly, this research contributes to advancing performance-based seismic design approaches in India, moving beyond codal compliance toward resilient and sustainable structural solutions.

III. METHODOLOGY

The present study adopts a systematic review methodology aimed at consolidating and critically evaluating existing research on the seismic performance of high-rise buildings with different lateral load resisting systems. The review emphasizes shear walls, steel bracings, and hybrid systems, as these are the most widely adopted strategies in modern seismic design practice. The methodological approach ensures that the selection, categorization, and analysis of literature are transparent, replicable, and comprehensive.

Structural Description and Assumptions

The study analyzes a 12-storey unsymmetrical reinforced concrete building (42 m high, plan 15 m × 20 m) modeled in STAAD.Pro as a three-dimensional space frame. The work is divided into three parts: Bare frame analysis under three ground motions, Braced frame analysis, Shear wall frame analysis.

The structure was analyzed using the Response Spectrum Method as per IS 1893:2016, which accounts for higher mode effects and provides a realistic dynamic response compared to the equivalent static method.

The building has 3 bays along X (5 m each) and 4 bays along Z (5 m each). Key material and load specifications include M30 concrete, 0.45 × 0.25 m columns, 0.40 × 0.25 m longitudinal beams, 0.35 × 0.25 m transverse beams, 0.10 m slab thickness, unit weight of concrete 25 kN/m^3, and live load 3.5 kN/m^2. The site lies in Seismic Zone IV with hard soil conditions and a damping ratio of 5%.

Figures (3.1 and 3.2) and Table 3.1 present the plan, 3D model, and detailed specifications.

Table 3.1 Specifications of the Building Model
Specification Data

Specification	**Data**
Number of Storeys	12
Storey Height	3.5 m
Overall Building Height	42 m
Plan Dimension (X × Z)	15 m × 20 m
Number of Bays along X	3
Number of Bays along Z	4
Bay Length along X	5 m
Bay Length along Z	5 m
Concrete Grade	M30
Column Size	0.45 m × 0.25 m
Longitudinal Beam Size	0.40 m × 0.25 m
Transverse Beam Size	0.35 m × 0.25 m
Slab Thickness	0.10 m
Unit Weight of Concrete	25 kN/m³
Live Load	3.5 kN/m²
Seismic Zone	Zone IV
Soil Condition	Hard Soil
Damping Ratio	5%

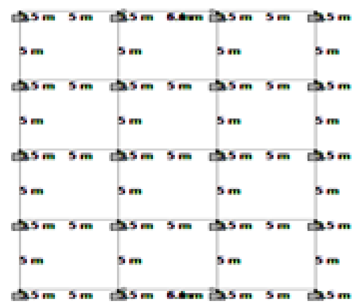


Figure3.2 Plan of the building

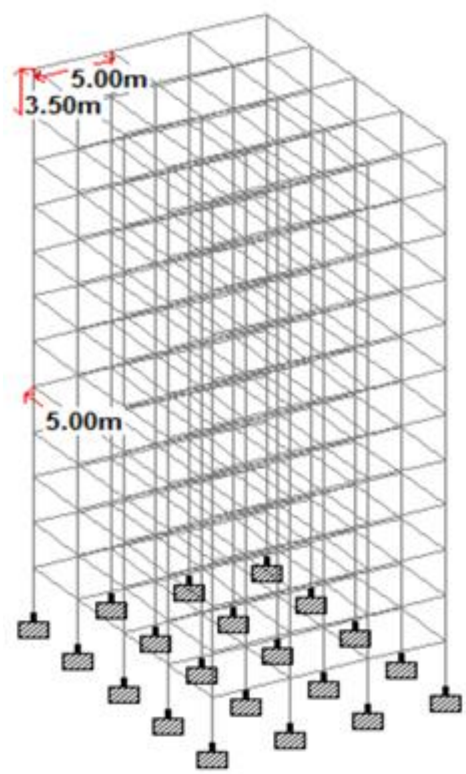


Figure 3.3 Model of the building

Seismic Input Data

The seismic input data for the present study has been adopted in accordance with the provisions of IS 1893:2016 (Part 1): Criteria for Earthquake Resistant Design of Structures. This standard specifies the design response spectrum, seismic coefficients, and drift limitations for reinforced concrete (RC) buildings located in different seismic zones of India. To capture both codal compliance and realistic ground motion effects, three types of seismic inputs were considered in this research:

1. IS Code Compatible Response Spectrum (2016, Zone IV, Hard Soil)
2. Imperial Valley Earthquake Record (1940)
3. San Francisco Earthquake Record (1906)

This approach ensures that the analysis accounts for both the theoretical spectrum defined in Indian codes and the practical response obtained from actual earthquake records.

IS 1893:2016 Response Spectrum Parameters

For the IS code-compatible analysis, the following seismic parameters were adopted:

Seismic Zone (Z)	IV (Zone factor = 0.24)
Importance Factor (I)	1.0 (ordinary residential/commercial building)
Response Reduction Factor (R)	5.0 (special moment-resisting frame)
Damping Ratio (ξ)	5% of critical damping for RC structures
Soil Condition	Hard Soil (Type I as per IS 1893-2016)

The design horizontal seismic coefficient was calculated using:

$$A_h = \frac{Z}{2} \cdot \frac{I}{R} \cdot \frac{S_a}{g}$$

where Sa/g is the average response acceleration coefficient obtained from the response spectrum curves provided in IS 1893:2016.

MATLAB-Derived Time Periods of the Bare Frame

The natural time periods of the 12-storey bare frame up to the 12th mode were computed using MATLAB and are presented in Table 3.2. These periods served as input for generating response spectra for the selected ground motions.

Table 3.2 Time Periods of Bare Frame (MATLAB Calculation)

Mode	Time Period(s)
1	2.4297
2	0.8145
3	0.4943
4	0.3592
5	0.2860
6	0.2409
7	0.2112
8	0.1909
9	0.1769
10	0.1674
11	0.1613
12	0.1579

Imperial Valley Earthquake (1940)

The Imperial Valley earthquake record was processed to generate a response spectrum using MATLAB. The corresponding spectral acceleration values (Sa/g) were converted into acceleration values by multiplying with 9.81 m/s^2. The results for the first 12 modes of the bare frame are presented in Table 3.3.

Table 3.3 Time Period vs. Acceleration for Imperial Valley Ground Motion

Time Period(s)	Sa/g	Acceleration(m/s^2)
2.4297	1.61E+00	1.58E+01
0.8145	2.31E+00	2.27E+01
0.4943	2.14E+00	2.10E+01
0.3592	1.47E+00	1.44E+01
0.2860	2.11E+00	2.07E+01
0.2409	1.89E+00	1.85E+01
0.2112	1.47E+00	1.44E+01
0.1909	1.10E+00	1.08E+01
0.1769	1.12E+00	1.10E+01
0.1674	9.86E-01	9.67E+00

0.1613	8.31E-01	8.15E+00
0.1579	7.78E-01	7.64E+00

San Francisco Earthquake (1906)
Similarly, the San Francisco earthquake ground motion record was used to generate a response spectrum. The time period vs. acceleration values for the bare frame are shown in Table 3.4.

Table 3.4 Time Period vs. Acceleration for San Francisco Ground Motion

Time Period (s)	Sa/g	Acceleration (m/s²)
2.4297	1.03E+00	1.01E+01
0.8145	1.20E+00	1.18E+01
0.4943	1.23E+00	1.21E+01
0.3592	2.09E+00	2.05E+01
0.2860	3.13E+00	3.07E+01
0.2409	2.90E+00	2.85E+01
0.2112	2.12E+00	2.08E+01
0.1909	1.68E+00	1.64E+01
0.1769	1.63E+00	1.60E+01
0.1674	1.98E+00	1.94E+01
0.1613	2.28E+00	2.24E+01
0.1579	2.47E+00	2.42E+01

By adopting both codal and real earthquake response spectra, the study ensures that the seismic performance of the building is evaluated under a wide range of conditions—from the idealized design spectrum prescribed in IS 1893:2016 to realistic ground motion scenarios from historically significant earthquakes. This hybrid approach strengthens the reliability and applicability of the results.

Structural Modelling
To evaluate different lateral load resisting systems, several analytical models of the 12-storey RC building were developed in STAAD.Pro with identical geometry, materials, and loading. The models differed only by the addition of bracings or shear walls, with the bare frame serving as a reference.
Bare Frame Model: Conventional RC moment-resisting frame without stiffening elements, expected to show maximum displacements and minimum base shear.

Braced Frame Models: Four variations using ISA 60×40×6 steel bracings:
- Bracing A: Along X-direction.
- Bracing B: Along Z-direction.
- Bracing C: At corner bays (torsional control).
- Bracing AB: Along both X and Z directions.

Shear Wall Models: Four variations with 250 mm thick RC shear walls provided over full height:
- Shear Wall A: Along X-direction.
- Shear Wall B: Along Z-direction.
- Shear Wall C: At corners.
- Shear Wall AB: Along both X and Z directions.

Analysis Procedure
The seismic performance of the 12-storey RC building was analyzed in STAAD.Pro using the Response Spectrum Method (RSM) as per IS 1893:2016 (Part 1). This linear dynamic approach estimates maximum responses by combining modal contributions.

- Model Preparation: The bare frame was modeled with fixed supports and rigid floor diaphragms.
- Seismic Parameters: Zone IV (Z = 0.24), Importance factor (I = 1.0), R = 5.0 (SMRF), 5% damping, and hard soil were adopted. Seismic mass included self-weight, 2.5 kN/m² dead load, and 3.5 kN/m² live load.
- Load Cases & Combinations: Dead, live, and earthquake loads were applied with IS 1893:2016 combinations such as 1.5(DL+LL), 1.2(DL+LL±EL), etc.
- Response Spectrum Input: Spectra were applied for (i) IS 1893:2016 Zone IV, (ii) Imperial Valley 1940, and (iii) San Francisco 1906 earthquakes. MATLAB-generated spectra were used where required.
- Analysis Process: Modal properties were extracted, seismic response was computed for each mode, and modal contributions were combined using the Complete Quadratic Combination (CQC) method.
- Results Extracted: Fundamental time period, base shear, inter-storey drift, and roof displacement.

Parameters for Evaluation
- Four key response parameters were selected for evaluating seismic behavior across bare, braced, and shear wall models:

- Fundamental Time Period (T): Indicates stiffness and flexibility. Computed in STAAD.Pro and validated against IS 1893:2016 empirical formula:
- $T_a = 0.075h^{0.75}$
- where h = building height in meters.
- Base Shear (Vb): Represents overall seismic demand. RSM values were compared with Equivalent Static Method as per IS 1893:2016. Codal requirement: RSM base shear ≥ 80% of static base shear.
- Inter-Storey Drift (Δ): Relative lateral displacement between two floors. Limited to 0.004h (IS 1893:2016). Used to assess serviceability and potential damage.
- Top-Storey Displacement: Roof deflection under seismic loads. No direct codal limit, but excessive values imply discomfort or instability. Compared across all structural systems.

IV. RESULTS AND DISCUSSION

The seismic response of a 12-storey RC building was studied for three configurations—bare frame, braced frame, and shear wall frame—using the Response Spectrum Method in STAAD.Pro. Three seismic inputs were considered: IS 1893:2016 compatible spectrum, Imperial Valley (1940), and San Francisco (1906) ground motions. The performance was evaluated in terms of fundamental time period, base shear, inter-storey drift, and top-storey deflection.

Fundamental Time Period

The fundamental time period reflects the natural vibration characteristics of the structure. The bare frame exhibited the longest period (3.51 s), indicating high flexibility and low stiffness. Bracing systems produced only marginal reductions, with values close to the bare frame. In contrast, shear walls substantially reduced the time period, particularly with corner placement (1.70 s), demonstrating their superior contribution to lateral stiffness.

Shear walls, especially at corners, significantly improve structural rigidity compared to bracing systems.

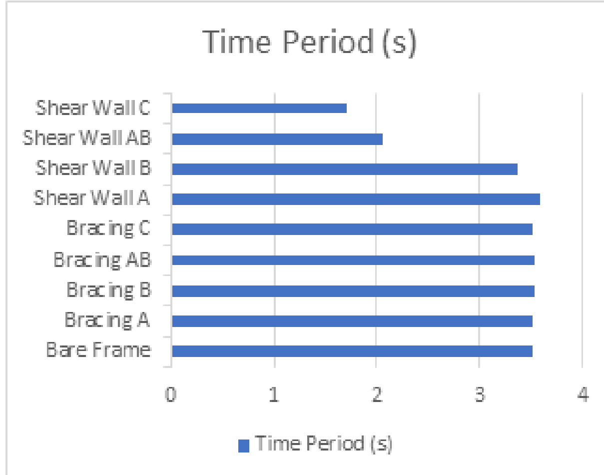


Figure 4.1 Variation of time periods with various structural configuration

Response under IS 1893 Spectrum

- **Base Shear:** Bare frame attracted the least base shear (568.9 kN in X), while Shear Wall C recorded the highest (1228.0 kN in X), reflecting the principle that stiffer systems attract larger forces.

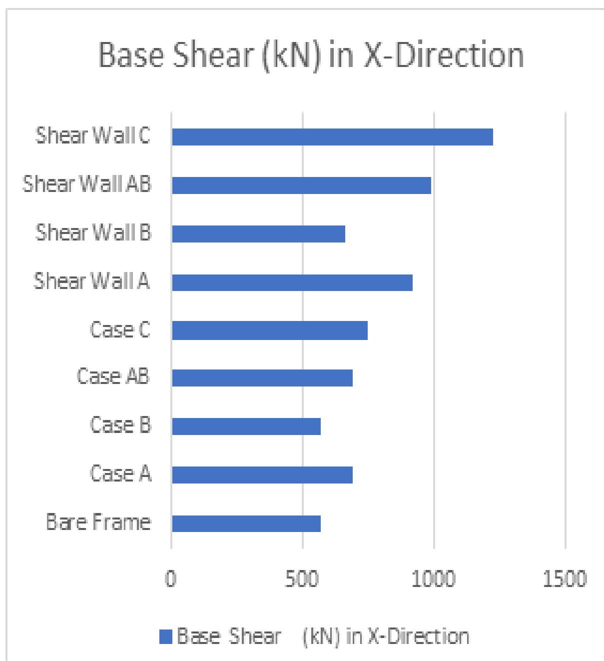


Figure 4.2 Variation of Base shear for ground motion in X direction as per IS code

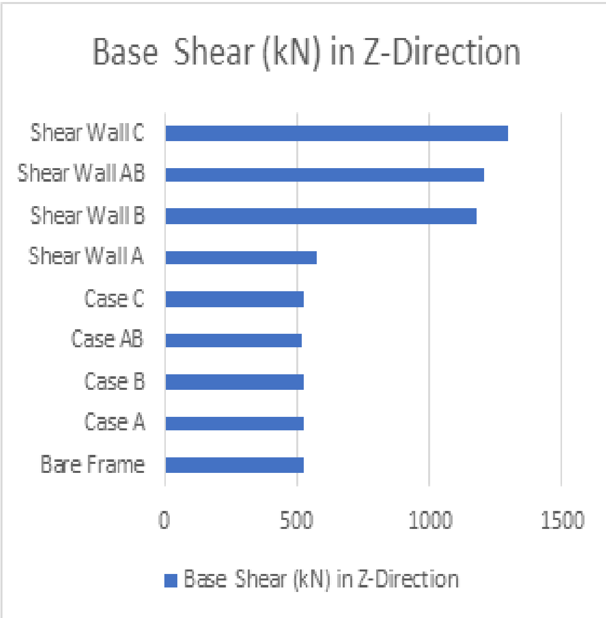


Figure 4.3 Variation of Base shear for ground motion in X direction as per IS code

- **Inter-Storey Drift:** Bare frame exceeded codal limits. Bracings reduced drift moderately, but shear walls—especially Shear Wall C—maintained drift well within permissible values.

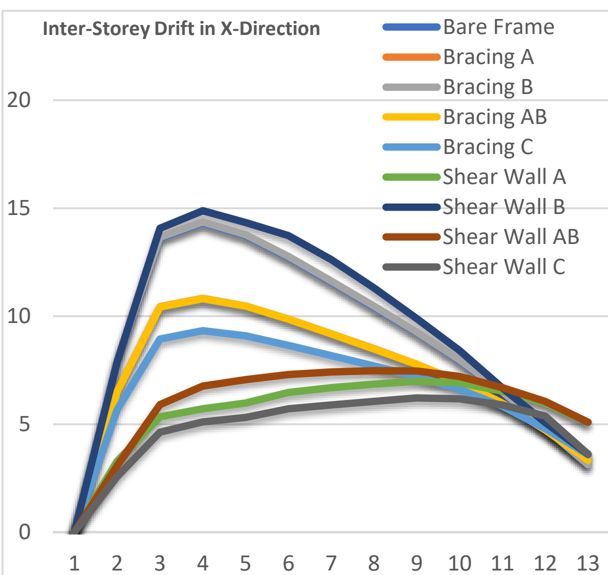


Figure 4.4 Variation of Inter-Storey Drift for ground motion in X direction as per IS Code

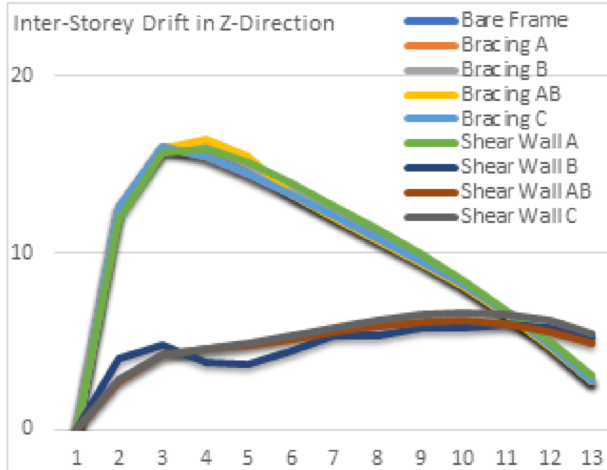
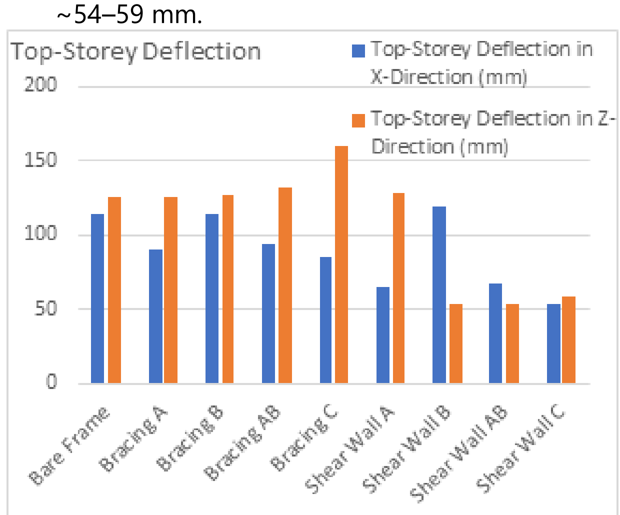


Figure 4.5 Variation of Inter-Storey Drift for ground motion in Z-direction as per IS Code

- **Top-Storey Deflection:** Bare frame displaced up to 126 mm. Bracing C reduced deflection moderately, while Shear Wall C restricted it to ~54–59 mm.



Shear walls are highly effective in drift and displacement control, ensuring compliance with IS code requirements.

Response under Imperial Valley Earthquake

Base Shear: Bare frame again attracted the lowest forces. Bracing C increased base shear moderately, while shear walls—particularly corner placement—produced the maximum values, confirming higher stiffness.

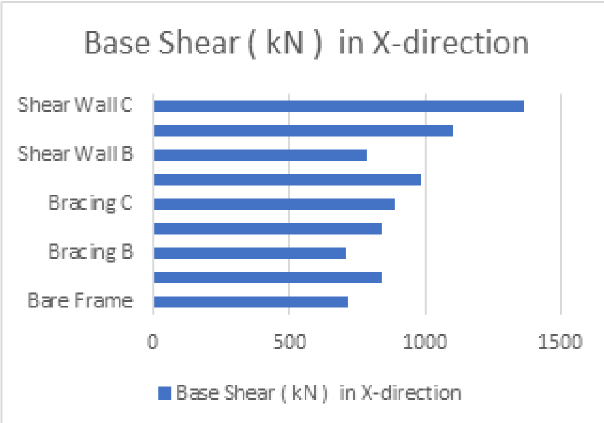


Figure 4.9 Variation in Base shear for ground motion in X direction as per Imperial Valley Earthquake

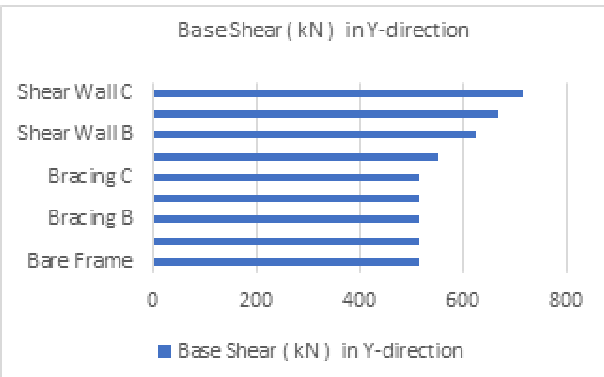


Figure 4.10 Variation in Base shear for ground motion in Y direction as per Imperial Valley Earthquake

Inter-Storey Drift: Bare frame exceeded limits. Bracing C gave some improvement in X-direction but limited benefit in Z. Shear Wall C reduced drifts to within safe levels in both directions.

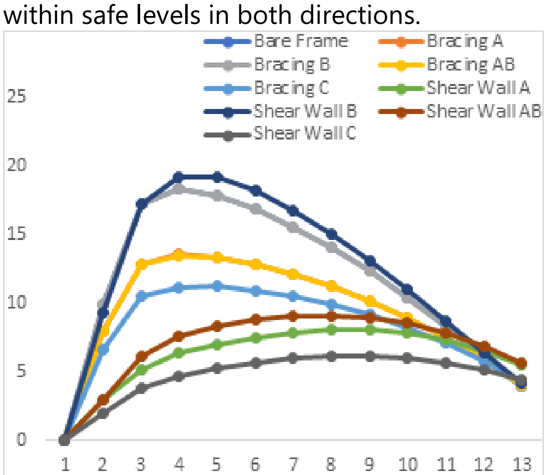


Figure 4.11 variation in Inter-Storey Drift (mm) for Ground Motion in X-Direction as per Imperial Valley Earthquake

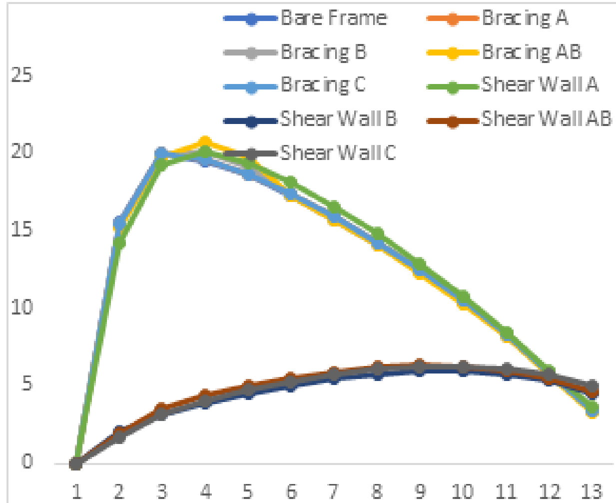


Figure 4.12 Variation in Inter-Storey Drift (mm) for Ground Motion in Z-Direction as per Imperial Valley Earthquake

Top-Storey Deflection: Bare frame displaced ~128 mm at roof. Bracing C reduced this to ~62 mm, while Shear Wall C limited it further to ~32–34 mm.

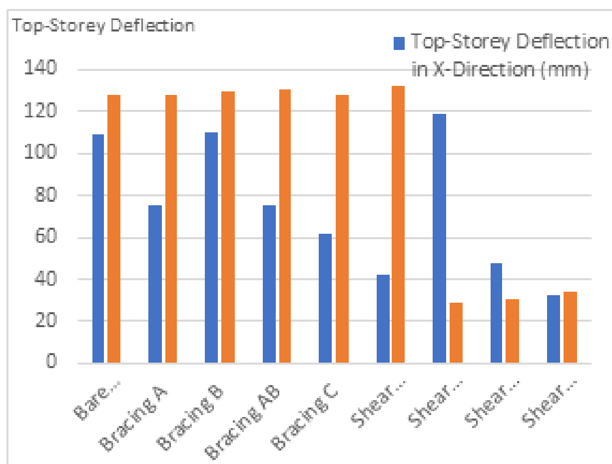


Figure 4.13 Variation in Top-Storey Deflection in X-Direction and Z-Direction As per Imperial Valley Earthquake

Key Insight: Bracings enhance stiffness directionally, but only shear walls provide reliable drift control across both directions.

Response under San Francisco Earthquake

Base Shear: Similar trends were observed. Bare frame had the lowest values, bracings increased stiffness modestly, while shear walls—especially at corners—recorded the highest forces.

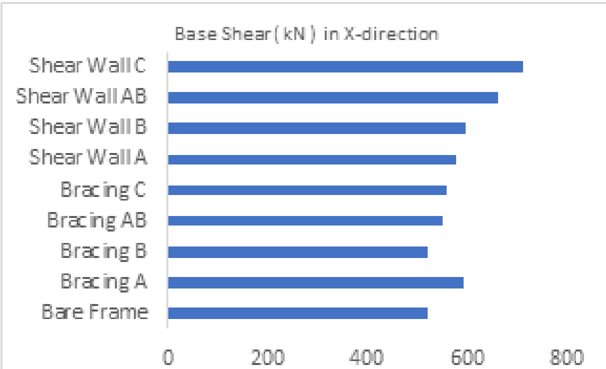


Figure 4.16 Base shear for ground motion in X direction as per San Francisco Earthquake

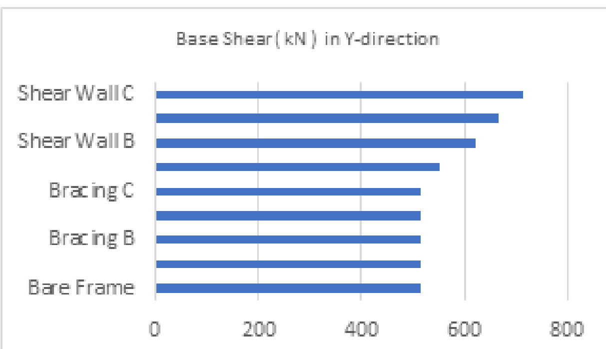


Figure 4.17 Base shear for ground motion in Z direction as per San Francisco Earthquake

Inter-Storey Drift: Bare frame showed excessive drift beyond IS limits. Bracing C reduced drift but not adequately in Z-direction. Shear Wall C maintained drift well below codal limits.

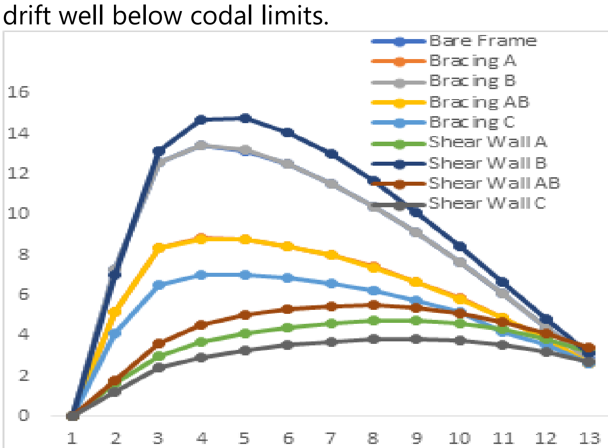


Figure 4.18 Variation of Inter-Storey Drift (mm) for Ground Motion in X-Direction as per San Francisco Earthquake

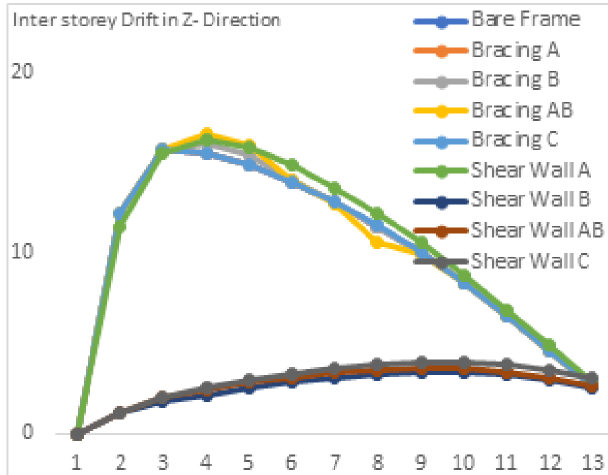


Figure 4.19 Variation of Inter-Storey Drift (mm) for Ground Motion in Z-Direction as per San Francisco Earthquake

Top-Storey Deflection: Bare frame displaced over 128 mm at roof. Bracing C reduced it to ~62 mm, while Shear Wall C restricted it to ~32–34 mm, demonstrating superior control.

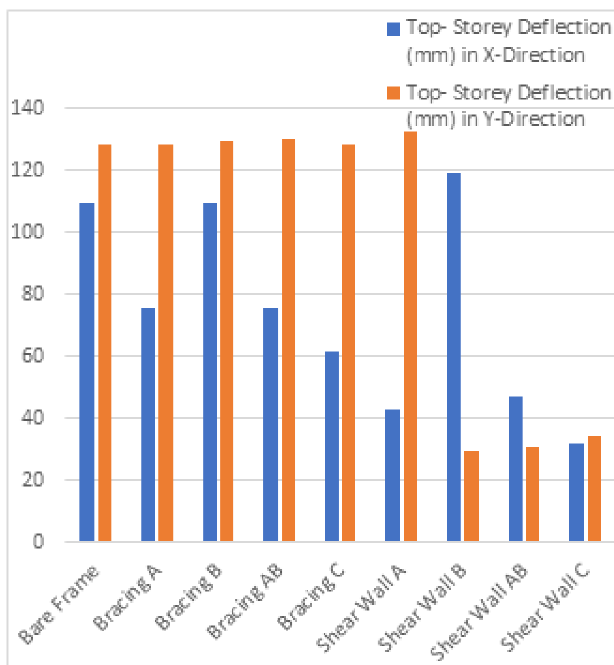


Figure 4.20 Top-Storey Deflection in X-Direction and Z-Direction As per San Francisco Earthquake

Key Insight: Even under severe earthquake records, shear walls consistently outperform bracings in drift and deflection control.

Comparative Discussion

Across all seismic inputs, the bare frame consistently displayed the poorest performance, with maximum drifts and deflections exceeding code limits. Bracings offered moderate improvements, particularly with corner placement (Bracing C), but failed to ensure compliance in all directions. Shear walls consistently delivered the best performance, with corner placement (Shear Wall C) providing the shortest time period, highest stiffness, minimum drift, and lowest deflection. While bracings are cost-effective for retrofitting, shear walls—especially at corners—are the most reliable system for new high-rise RC buildings in seismic zones.

V. CONCLUSION

This study presented a comparative seismic analysis of a 12-storey RC building under three structural configurations: bare frame, braced frame, and shear wall frame. The analysis was performed using the Response Spectrum Method in STAAD.Pro under IS 1893:2016 spectrum, Imperial Valley (1940), and San Francisco (1906) earthquake records.

The key findings are summarized as follows:

- The bare frame exhibited the longest fundamental time period, lowest base shear, and highest drifts and deflections, confirming its inadequacy as a seismic-resistant system for high-rise buildings.
- The braced frames demonstrated moderate improvement in stiffness, reducing time period and displacements to some extent. Bracing C (corner bracing) consistently provided the best performance among braced systems, but in several cases, drift values still approached or exceeded codal limits, especially in the Z-direction.
- The shear wall frames achieved significant reductions in time period, drift, and top-storey deflection. Shear Wall C (corner placement) emerged as the most effective configuration, consistently ensuring compliance with codal drift limits across all ground motions.
- A trade-off was observed: while shear walls attracted higher base shear due to increased stiffness, this was offset by their superior control of displacements and improved global stability.

Overall, the study concludes that shear walls—particularly when symmetrically placed at building corners—are the most efficient lateral load-resisting system for high-rise RC buildings in seismic zones. Bracing systems, although less effective, remain viable for economical retrofitting solutions.

VI. FUTURE SCOPE

The present study is based on linear elastic response spectrum analysis. To advance the understanding and practical application of seismic-resistant systems in RC buildings, future research should focus on:

- Nonlinear dynamic analysis: Time-history and pushover analyses to capture inelastic behavior and evaluate ductility demands.
- Soil–structure interaction: Incorporating foundation flexibility and soil effects to obtain more realistic seismic responses.
- Plan and vertical irregularities: Studying torsional effects and irregular geometries commonly encountered in modern construction.
- Hybrid systems: Exploring combinations of bracings and shear walls to optimize both stiffness and economy.
- Experimental validation: Conducting shake-table or hybrid simulation experiments to verify numerical predictions.
- Cost-benefit assessment: Evaluating the economic feasibility of different stiffening systems in real construction projects.
- Such investigations will further strengthen performance-based seismic design approaches, contributing to safer, more resilient, and sustainable high-rise construction in earthquake-prone regions.

REFERENCES

1. Chandurkar, P. P., & Pajgade, P. S. (2013). Seismic Analysis of RCC Building with and without Shear

Wall. International Journal of Modern Engineering Research, 3(3), 1805–1810.
2. Viswanath, K. G. (2010). Seismic Analysis of High-Rise Building with and without Bracing. International Journal of Engineering Research and Applications, 2(3), 1185–1190.
3. Chavan, S. S., & Jadhav, H. S. (2014). Seismic Analysis of RCC Building with Different Bracing Systems. International Journal of Engineering Research and Applications, 4(6), 29–34.
4. Esmaili, O., Samadzad, S., & Mahdizadeh, M. (2008). Study of Structural Aspects of High-Rise Buildings in Tehran with RC Shear Walls and Bracings. Asian Journal of Civil Engineering (Building and Housing), 9(5), 511–532.
5. Akbari, R., Farahmand Azar, B., & Hosseini, S. M. (2015). Seismic Fragility Assessment of RC Frames with Steel Bracing Systems. Journal of Constructional Steel Research, 114, 43–56.
6. Kappos, A. J., & Manafpour, A. (2000). Seismic Design of RC Buildings Using Inelastic Analysis and Performance Criteria. Engineering Structures, 23(4), 369–386.
7. Yamada, M., Yoshimura, M., & Shibata, H. (1992). Deformation and Fracture Characteristics of Lateral Load Resisting Systems in Multi-Storey Buildings. Earthquake Engineering and Structural Dynamics, 21(8), 715–731.
8. Najam, F. Ahmed (2018). A modified response spectrum analysis procedure to determine nonlinear seismic demands of high-rise buildings with shear walls. The Structural Design of Tall and Special Buildings, 27(1).
9. Allavarapu, D. Bharat & Narendra Babu, P. (2023). Comparative Seismic Analysis of Concrete and Steel Structures With Shear Wall Using Etabs. IJERT, Volume 12, Issue 11.
10. Maheshwari, R. (2024). Comparative Seismic Analysis of G+20 RC Framed Structure Building for with and without Shear Walls. Journal of the Civil Engineering Forum, 10(3), 257-266.
11. Lei Zhao et al. (2024). Experimental Investigation on the Seismic Performance of Novel Prefabricated Composite RC Shear Walls with Concrete-Filled Steel Tube Frame (CCRCSW-CFST). Buildings, 14(9), article 2673.
12. Fei-Fei Sun & Guo-Qiang Li (2024). Test and Parametric Analysis on Performance Improvement of Non-buckling Corrugated Steel Shear Walls. In STESSA 2024 (11th International Conference on Behaviour of Steel Structures in Seismic Areas). Lecture Notes in Civil Engineering, Vol. 520.
13. Xiaoming Ma, Yi Hu, Xinyuan Cheng, Liqiang Jiang, Yun Li & Hong Zheng (2022). Seismic Performance of Flat Steel Plate Shear Walls with Atmospheric Corrosion. Buildings, 12(11), 1881.
14. Asfaw Belay & Temesgen Wondimu (2023). Seismic performance evaluation of steel and GFRP reinforced concrete shear walls at high temperature. Journal of Engineering and Applied Science, 70:4.
15. Ashraf Osman & Ahmed E. Farouk (2023). The use of steel X-bracing combined with shear link to seismically upgrading reinforced concrete frames. Journal of Engineering and Applied Science, 70, Article 150.
16. W. L. Cao, S. D. Xue, J. W. Zhang (2022). Seismic Performance and Mechanical Mechanism of Steel-Enhanced Damping Concrete Core Wall with Concealed Steel Plate Bracings under Oblique Loading. Advances in Civil Engineering.
17. Mehmet Alpyürür & Hakan Ulutaş (2024). Comparison of Performance Analysis Results with Developed Site-Specific Response Spectra and Turkish Seismic Design Code: A Case Study from the SW Türkiye Region. Buildings, 14(5), 1233.
18. Nayak, A., Hulagabali, A. M., Solanki, C. H., Dodagoudar, G. R. (2024). Response Spectrum Analysis of High-Rise Reinforced Concrete Framed Structure Resting on Raft and Pile Foundation System. In Innovation in Smart and Sustainable Infrastructure, Vol. 2. Lecture Notes in Civil Engineering, Vol. 485.
19. Kent, J., Zhong, C., & Christopoulos, C. (2023). Steel flexure and shear yielding base-mechanism for enhanced seismic resilience of RC core wall high-rise structures. Earthquake Spectra, 39(1).
20. Zhao, L., et al. (2024). Experimental Investigation on the Seismic Performance of Novel Prefabricated Composite RC Shear Walls with Concrete-Filled Steel Tube Frame (CCRCSW-CFST). Buildings, 14(9), Article 2673.