IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

SEISMIC RESPONSE COMPARISON OF DIFFERENT TALL BUILDING STRUCTURAL SYSTEMS

Anshul Jangra[1], Anju[2]

PG Student, Ganga Institute of Technology and Management, Kablana, Jhajjar, India[1]

Assistant Professor, Department of Civil Engineering, Ganga Institute of Technology and Management, Kablana, Jhajjar, India[2]

Abstract: In order to guarantee structural safety and functionality during earthquakes, tall buildings' seismic performance is crucial. Moment-Resisting Frames (MRF), Frame-Shear Wall Systems (perimeter and corner placements), Braced Frames, Outrigger Systems, and Tube-in-Tube Systems are the six structural configurations whose seismic response is examined in this study. Comparing their efficacy in terms of stiffness, base shear, lateral displacement, storey drift, and reinforcement need is the goal.

To ensure fair comparison, three-dimensional building models were created in ETABS utilizing consistent plan dimensions, member sizes, and material attributes. The Response Spectrum Method was used to apply seismic inputs in accordance with IS 1893 (Part 1): 2016. To assess seismic performance across systems, both linear static and dynamic evaluations were performed. Findings indicate that shear wall-based and core-reinforced systems such as Tube-in-Tube and Outrigger exhibit superior stiffness and reduced displacement. Braced frames provide moderate drift control, while moment-resisting frames are the most flexible, resulting in higher displacements. Column reinforcement demand varies significantly across systems, influenced by stiffness and force redistribution.

This study offers useful insights into the structural efficiency and seismic behavior of different systems, supporting informed decision-making in the design of tall buildings for earthquake-prone regions.

Keywords: Seismic performance, tall buildings, structural systems, Response Spectrum Method, lateral displacement, storey drift, reinforcement demand shear

I. INTRODUCTION

The urban landscape of contemporary cities is significantly shaped by tall buildings. Taller and more intricate structures have been developed as a result of the demand for effective land use brought on by rapid urbanization and rising population density. These tall structures are markers of technological prowess and economic advancement in addition to being emblems of architectural and engineering ingenuity. But as buildings get taller, their structural design becomes more difficult, particularly when it comes to withstanding lateral stresses like those brought on by earthquakes. A tall building's ability to stay safe and operational during a seismic event is crucial since failure can result in large losses in terms of both people and money.

Moment Resisting Frames (MRF), Shear Wall technologies, Braced Frames, Outrigger Systems, and Tube-in-Tube Systems are just a few of the technologies that structural engineers have created over time to enhance seismic performance. Depending on the structure and seismic requirements, each of these systems reacts to seismic forces in a different way and displays distinct behavioral traits.

Although substantial research has been conducted on the seismic behaviour of individual structural systems, much of it has focused on standalone analysis under varying assumptions and conditions. There remains a lack of comprehensive comparative studies that evaluate the performance of these systems under uniform modelling conditions and design parameters. Without such comparisons, the selection of an optimal system for specific building typologies or seismic zones remains partially speculative, limiting the effectiveness of design decisions.

This study's main goal is to conduct a thorough comparative investigation of the seismic response of different structural systems utilized in tall structures. Moment-resisting frames, shear wall systems, braced frames, tube-in-tube systems, outrigger systems, and hybrid configurations are a few of these. The study uses ETABS software to examine how each system responds to seismic stresses, concentrating on important factors including base shear, maximum storey displacement, and inter-story drift. By accomplishing this goal, the study hopes to give designers practical insights into

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

the relative effectiveness and performance of each method, promoting safer and better tall building construction in seismically active areas.

This research is limited to the linear static analysis and dynamic analysis of idealized tall building models using ETABS software. All structural systems are designed using consistent material properties, member sizes, floor plans, and seismic parameters to ensure a fair basis for comparison. The study focuses solely on regular, symmetric buildings without plan or vertical irregularities, and torsional effects are not explicitly considered. Nonlinear behaviours, construction constraints, cost factors, and architectural considerations fall outside the scope of this analysis. Despite these limitations, the study provides a meaningful technical comparison that can aid in the preliminary selection and design of lateral load-resisting systems for tall buildings in seismic regions.

II. LITERATURE REVIEW

Borah and Choudhury (2016) conducted a comparative study using ETABS to evaluate seismic performance across multiple structural configurations. Their findings indicated that shear wall-frame systems offer superior resistance to lateral forces, while braced frames outperform conventional rigid frames in terms of displacement and drift. Although interesting, their study only examined linear static analysis and neglected to evaluate column reinforcement efficiency, which is crucial for real-world constructability and cost.

Lone and Chand highlighted the vulnerability of irregular structures under lateral loading, particularly in parameters like storey drift and displacement. However, their study did not address how different structural systems perform when subjected to the same irregularity—a gap this dissertation seeks to investigate under controlled modelling conditions.

Ali and Al-Kodmany (2022) provided a foundational understanding of the evolution of tall building structures, highlighting the shift from rigid frames to more efficient tubular and outrigger systems. Their discussion reinforces the importance of material efficiency and structural optimization for tall buildings, emphasizing the contribution of tube systems and core-outrigger designs in minimizing lateral displacements.

Vataliya et al. (2024) conducted a comparative study using ETABS on G+25, G+30, and G+35 structures under lateral loads. Their analysis indicated that tube-in-tube and shear wall systems outperform traditional moment-resisting frames in reducing displacement and base shear. However, their work did not assess reinforcement demands or consider the implications of irregular geometry.

Naik and Chandra (2017) compared tube-in-tube systems to conventional frames. Their study highlighted that the use of tube-in-tube systems can reduce steel consumption by up to 30% while offering superior performance in seismic zones. Still, the research did not examine column reinforcement or inter-storey drift behavior in depth.

Kawade et al. (2020) extended this discussion by analysing various tube-based systems, including tube-in-tube with outriggers and trussed tubes. Their ETABS-based results demonstrated that hybrid systems significantly control drift and storey displacement. Nonetheless, their study focused mainly on response spectrum results and did not normalize base shear values for comparative consistency.

Ali and Khan's influence is also evident in the study by Shamanth and Manohar (2021), who explored outrigger systems in a G+40 building. They validated that outriggers significantly reduce lateral displacement and enhance overall stiffness. Yet, their work lacked a unified benchmark across different systems and did not consider reinforcement volume

Dutta and Banerjee (2024) performed an extensive comparative study of various bracing systems (X, V, inverted V, eccentric types) and shear wall configurations in RCC structures using ETABS. They concluded that X-bracing and corner shear walls are highly effective in reducing displacement and drift. However, despite evaluating 18 models, their work focused only on seismic zone V and did not evaluate performance under spectrum analysis.

Dutta and Banerjee (2023) in an earlier review also emphasized the effectiveness of shear walls over bracings in reducing overall displacements, whereas X-bracing was found to significantly reduce inter-storey drift. This aligns with findings by Rizwan and Hashmi (2020), who reinforced the use of X-bracing for better drift control, although their work was limited to mid-rise buildings.

Ismaeil (2018) conducted a pushover analysis of an existing RC building in Sudan using SAP2000. The study identified that some elements exceeded life-safety levels, requiring retrofitting. Though not directly comparable to new tall building designs, the approach provided useful insight into real-life structural performance limits and the importance of capacity spectrum evaluation.

Tiwary analyzed different outrigger systems in a 40-storey RC building, emphasizing their role in lateral stiffness and base moment control. While the study provided clear insights into load transfer mechanisms, it did not directly compare outrigger systems to alternative systems such as pure braced or shear wall configurations, limiting its general applicability.

D. Kaul et al. reviewed the seismic behavior of regular vs. irregular structures, categorizing configurations such as H-, L-, and T-shaped buildings. They also examined the effects of torsion, bending, and storey drift. While comprehensive in categorization, the study primarily remained qualitative, without numerical modelling to validate comparative performance.

DOI: 10.17148/IARJSET.2026.13707

Hashim et al. reviewed seismic response of the different structural systems, emphasizing the role of advanced design techniques. Their work broadly acknowledged the superior performance of braced and moment-resisting frames but lacked numerical benchmarks or consistent base parameters for comparison.

Kadid and Boumrkik conducted a focused study on steel-braced RC frames. Their findings showed a significant reduction in displacement and drift when X and diagonal bracings were introduced. However, the study was limited to steel bracings and didn't address hybrid systems or outrigger-based designs.

Ghosh and Singh delved into performance-based design strategies using outrigger systems. Their work aligned well with Tiwary's, confirming that outriggers effectively limit inter-storey drift and base shear. Yet again, the comparison was not extended to other structural systems under identical seismic loads.

Sarkar, Prasad, and Menon provided critical insights into vertical geometric irregularities in stepped buildings, pointing out increased torsional effects and drift. The study underscores the need for proper detailing but does not integrate this irregularity into multiple system types, leaving a gap this dissertation partially addresses.

Patel and Shah compared shear wall and braced frames in tall buildings. Their results suggested that while shear walls reduce displacement effectively, braced systems offer more flexibility in very tall buildings. This conclusion supports the need for a configuration-specific analysis, something the present study expands upon through normalized comparisons.

Kaushik, Rai, and Jain examined the use of different bracing systems, particularly X and inverted-V types, in RC frames. Their findings confirmed improved seismic performance and drift control but did not extend into reinforcement optimization, a parameter central to this dissertation.

Poonam et al. analyzed X, V, K, and diagonal bracing systems in RC buildings. They found X-bracings to be most efficient, a finding that aligns with Kadid and Kaushik. However, these results were limited to mid-rise buildings, whereas this study focuses on tall structures, pushing the relevance of their results into a new dimension.

Choudhury and Das investigated belt trusses combined with outriggers, concluding that they efficiently distribute seismic forces. Their focus on system integration is valuable, though the study lacks direct numerical comparison with braced or shear wall alternatives.

Maheri and Ghaffarzadeh analyzed chevron-braced frames and their connection detailing. Their research highlighted the importance of ductile detailing for seismic energy dissipation, a nuance incorporated in this dissertation through qualitative commentary on reinforcement concentration in critical zones.

Singh and Arora provided one of the few studies that holistically compare MRFs, shear walls, and braced systems under seismic loading. While their findings support the superior stiffness of shear walls and the practicality of braced frames for taller structures, the study did not use consistent modeling assumptions or code references across configurations—an issue explicitly addressed in this work.

Rahgozar and Nouri examined the placement of outriggers in seismic performance, showing that optimal positioning can significantly improve lateral resistance. Their findings emphasize that configuration matters as much as system type, a concept this dissertation incorporates in a simplified form during model development.

III. RESEARCH GAP

Despite the wealth of research, a few key gaps persist: Lack of uniform modelling assumptions: Many studies employ varying story heights, material properties, or design codes, making direct comparisons difficult. This dissertation maintains consistent modelling parameters across all structural systems to isolate the effects of the structural form itself. Limited integration of reinforcement analysis: Most literature focuses on displacement and drift but omits how each configuration affects reinforcement demand. The current study includes axial force and reinforcement requirements in columns as a proxy for material efficiency.

Several studies analyse only displacement or drift without examining their correlation with base shear, mode shapes, or column loads. Both linear static and response spectrum approaches are used in this work's multi-metric evaluation. This study attempts to overcome these limitations by conducting a comprehensive comparative examination of tall building structural systems, such as moment-resisting frames, braced frames, shear wall systems, and tube-in-tube designs. Using ETABS, all models are produced with consistent material properties, geometry, and seismic stress conditions. Under both the Equivalent Static and Response Spectrum approaches, the analysis assesses important factors such base shear, storey displacement, drift ratio, and reinforcing requirements. The objective is to identify the systems with the best seismic resistance as well as those that offer practical design benefits by utilizing more effective materials and needing less reinforcing.

By integrating previous findings (e.g., Ali and Al-Kodmany, 2022; Vataliya et al., 2024; Dutta and Banerjee, 2024) into a unified framework and applying them to new modelling configurations, this work offers a comprehensive understanding of structural system performance and bridges the gap between academic analysis and engineering design practice.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

IV. METHODOLOGY

A comprehensive approach was adopted to model and analyses of seismic performance for different types of structural systems. The modelling process involves the creation of several structural configurations using ETABS. an emphasis on maintaining uniformity in material properties and member sizes across all systems, ensuring a consistent basis for comparison. Each system incorporates similar material specifications to standardise the analysis. The key focus is on capturing the behaviour of the structures under seismic loads by maintaining structural integrity while adjusting for the different configurations. This approach allows for an objective evaluation of the seismic performance of each system while minimising variations caused by differing material or design assumptions Additionally, the analysis takes into account a number of seismic response metrics that are essential for evaluating each structural system's performance, including drift, base shear, and storey displacement. assessing the models' dynamic behavior during seismic events, the research also takes mass involvement elements into account. This study examines the benefits and drawbacks of various structural solutions in terms of reducing seismic forces. The results offer important new information about the best structural options for strengthening tall buildings' resistance to earthquakes.

A. MODEL DESCRIPTION

The structure considered in this study is a tall building with an overall height of 75 meters, comprising 25 storeys, each having a uniform floor-to-floor height of 3 meters. The building plan measures 64 meters along the X direction and 30 meters along the Y direction, providing a rectangular floor plate that is representative of typical high-rise configurations. The layout consists of 9 bays in the X direction, each 8 meters wide, and 7 bays in the Y direction, each 5 meters wide, resulting in a regular and symmetrical grid system ideal for structural analysis.
Six different structural configurations have been used to model the structure in order to evaluate and compare the seismic performance of various lateral load-resisting systems. A Moment-Resisting Frame (MRF), two types of Shear Wall Systems (with walls positioned at the corners and along the perimeter, respectively),

- Braced Frame System,
- Tube-in-Tube System, and
- An Outrigger System are among them.

To guarantee a fair and significant comparison, each model has been created in ETABS using consistent material values, member sizes, and seismic factors. Evaluating how each system affects important seismic performance metrics such base shear, lateral displacement, storey drift, stiffness, and reinforcement requirement is the goal of this modeling technique.

TABLE I- MODEL GEOMETRY

Parameter	Value
Total Height of Building	75 meters
Number of Storeys	25
Typical Storey Height	3 meters
Plan Dimension in X Direction	64 meters
Plan Dimension in Y Direction	30 meters
Number of Bays in X Direction	9
Bay Width in X Direction	8 meters
Number of Bays in Y Direction	7
Bay Width in Y Direction	5 meters

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

B. SELECTED STRUCTURAL SYSTEMS

1. Moment-Resisting Frame (MRF) System
2. Shear Wall System
3. Braced Frame System
4. Outrigger System
5. Tube-in-Tube System

Each system has been designed to have similar material properties and member sizes to ensure a fair comparison of their behaviour under seismic loading conditions. The study will evaluate how these different structural configurations resist lateral loads and perform in terms of storey displacement, shear, and torsion.

C. MODEL NOMENCLATURE

In order to systematically evaluate and compare the seismic performance of various structural configurations, this study involves the modeling and analysis of six distinct tall building systems. To maintain clarity and consistency throughout the report, a simplified nomenclature has been adopted, assigning concise labels to each model. These designations not only streamline referencing across result tables, figures, and discussions but also reduce repetition of lengthy structural descriptions.

Each model represents a unique structural form commonly used in tall building design. The Moment-Resisting Frame (MRF) serves as the baseline configuration, while additional systems include shear walls placed either along the perimeter or at the corners, braced frames, tube-in-tube structures, and outrigger-supported systems. These structural forms vary in stiffness, lateral load resistance, and overall seismic behavior. The table below summarizes the nomenclature adopted in this study for ease of reference in subsequent chapters.

TABLE II- MODEL NOMENCLATURE

Model	**Description**
M1	Moment-Resisting Frame (MRF) System
M2	Shear Wall System
M3	Shear Wall System (Corner)
M4	Braced Frame System
M5	Tube-in-Tube System
M6	Outrigger System

D. MATERIAL PROPERTIES

M30 grade concrete and HYSD 500 grade steel reinforcement have been chosen for analysis in this study. Tall building constructions can benefit from the balanced strength and durability of M30 grade concrete. The high yield strength of HYSD 500 steel increases the reinforcement's tensile capacity, guaranteeing the building's structural integrity under dynamic loads.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 7, July 2026
DOI: 10.17148/IARJSET.2026.13707

E. MEMBER PROPERTIES

The member properties considered in this study include slabs, beams, columns, shear walls, and bracings, each playing a crucial role in the overall structural performance. The dimensions and reinforcement for these members were selected in accordance with the requirements specified in IS 456: 2000 for reinforced concrete design. The slabs are designed for uniform load distribution, while beams and columns were designed to resist bending and axial forces for seismic and gravity loads. Shear walls and bracings are incorporated to provide lateral stability and resist earthquake-induced forces. These member properties were consistently applied across the various structural systems to maintain uniformity in the analysis and ensure accurate comparisons.

TABLE III MEMBER SIZES FOR MODEL M1

Storey No.	**Column Size (in mm)**	**Beam Size (in mm) B1**	**Beam Size (in mm) B2**
0-5	1000 X 1000	700 X 400	500 X 300
6-10	900 X 900	700 X 400	500 X 300

Storey No.	**Column Size (in mm)**	**Beam Size (in mm) B1**	**Beam Size (in mm) B2**
11-15	800 X 800	700 X 400	500 X 300
16-20	700 X 700	700 X 400	500 X 300
21-Roof	600 X 600	700 X 400	500 X 300

In this study, slabs are modelled as rigid diaphragms, assuming that they are sufficiently thick and stiff to distribute lateral forces uniformly across the structure. This assumption allows for simplification in the analysis, where the slabs are treated as rigid elements transferring the forces from the superstructure to the lateral load-resisting systems, such as shear walls and bracings.

TABLE IV MEMBER SIZES FOR MODEL M2

Storey No.	**Column Size (in mm)**	**Beam Size (in mm) B1**	**Beam Size (in mm) B2**	**Shear Wall Thickness(in mm)**
0-5	1000 X 1000	700 X 400	500 X 300	300
6-10	900 X 900	700 X 400	500 X 300	300
11-15	800 X 800	700 X 400	500 X 300	300
16-20	700 X 700	700 X 400	500 X 300	300
21-Roof	600 X 600	700 X 400	500 X 300	300

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⪿ Peer-reviewed & Refereed journal ⪿ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

Shear walls and slabs are treated as shell thin members due to their ability to resist both in-plane and out-of-plane forces, particularly under seismic loading. In this approach, shear walls are modelled as vertical shell elements, capturing their bending and shear resistance efficiently. The shell elements are ideal for representing the true behaviour of these members under lateral forces, as they account for the distribution of forces along the height of the walls. Similarly, the slabs are modelled as shell elements to accurately represent their behaviour in both bending and shear, particularly in resisting horizontal seismic forces.

TABLE V MEMBER SIZES FOR MODEL M4

Storey No.	**Column Size (in mm)**	**Beam Size (in mm) B1**	**Beam Size (in mm) B2**	**Bracing Member**
0-5	1000 X 1000	700 X 400	500 X 300	Box 500x300x20x20
6-10	900 X 900	700 X 400	500 X 300	Box 500x300x20x20
11-15	800 X 800	700 X 400	500 X 300	Box 500x300x20x20
16-20	700 X 700	700 X 400	500 X 300	Box 500x300x20x20
21-Roof	600 X 600	700 X 400	500 X 300	Box 500x300x20x20

TABLE VI MEMBER SIZES FOR MODEL M5

Storey No.	**Column Size (in mm)**	**Beam Size (in mm) B1**	**Beam Size (in mm) B2**	**Shear Wall Thickness(in mm)**
0-5	1000 X 1000	700 X 400	500 X 300	300
6-10	900 X 900	700 X 400	500 X 300	300
11-15	800 X 800	700 X 400	500 X 300	300
16-20	700 X 700	700 X 400	500 X 300	300
21-Roof	600 X 600	700 X 400	500 X 300	300

TABLE VII MEMBER SIZES FOR MODEL M6

Storey No.	**Column Size (in mm)**	**Beam Size (in mm) B1**	**Beam Size (in mm) B2**	**Shear Wall Thickness(in mm)**	**Bracing Member**
0-5	1000 X 1000	700 X 400	500 X 300	300	Box 500x300x20x20
6-10	900 X 900	700 X 400	500 X 300	300	NA

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

11-15	800 X 800	700 X 400	500 X 300	300	NA
16-20	700 X 700	700 X 400	500 X 300	300	NA
21-Roof	600 X 600	700 X 400	500 X 300	300	NA

F. LOAD CONSIDERATION

Evaluating a structure's seismic performance requires taking load into account. IS 875: Part 1 (dead load) and IS 875: Part 2 (live load) criteria are used to compute dead and live loads in this study. The design guidelines of IS 1893: 2016 (Part 1) were adhered to in order to accurately depict earthquake forces in seismic load calculations. IS 456: 2000 for reinforced concrete is followed in the structural design, which incorporates load combinations according to IS 3370-2: 2009. These regulations offer a thorough approach, guaranteeing that the structures meet national safety requirements and can sustain seismic and other pertinent loads.

TABLE VIII LOAD CONSIDERATIONS

Floor load	2. kN/m^2
Wall load)	1 kN/m
Live load on floors	$4kN/m^2$
Live load on Roof	$5kN/m^2$

G. SEISMIC PARAMETERS

IS 1893:2016, outlines the specifications for earthquake-resistant building design in India, is complied with by the analysis's seismic parameters. The building is located in Zone V, which is the most seismically active region and has the highest level of seismic risk. This necessitates a higher degree of structural safety to lessen possible seismic damage. The design horizontal seismic coefficient, which is taken to be 0.36, depends on the seismic zone and the type of structure being examined. The intrinsic damping and energy dissipation capabilities of the structural system are taken into account with a response reduction factor of 1.2. In order to more accurately represent the structure's ability to tolerate lateral stresses during an earthquake, this factor modifies the seismic forces.

Additionally, the soil type at the site is classified as medium to stiff, based on the site-specific conditions. This classification is crucial as it influences the dynamic response of the structure to seismic forces. A soil factor of 5, as specified in IS 1893:2016, is considered to adjust the seismic forces, taking into account the soil's ability to amplify or attenuate seismic waves. This ensures that the seismic analysis accurately represents the potential ground motion and its effect on the building.

TABLE IX SEISMIC INPUTS

Seismic Parameters	**Value**
Zone	Zone V
Zone Factor, Z	0.36
Importance Factor, I	1.2
Soil Type	Medium or Stiff Soil
Response Reduction Factor, R	5

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

H. ANALYSIS APPROACH

The reaction Spectrum Method is used in this study's analysis approach to assess the structure's seismic reaction under dynamic loading conditions.

A linear static analysis was first performed in order to ascertain the base shear for the structure. This base shear value was then further optimized using the Response Spectrum Method, which considers the dynamic behavior of the structure under seismic stimulation. Based on the seismic inputs, including the building specs, soil type, and seismic zone, the software generated the response spectrum curve, which displays the greatest structural reaction at various frequencies.

To ensure consistency between the base shear values obtained through the linear static analysis and the response spectrum method, an appropriate scale factor was applied. This scale factor was carefully selected to match the base shears from both methods, ensuring an accurate representation of the seismic forces.

Twelve kinds of vibration were taken in the analysis to fully capture the dynamic effects, and the algorithm automatically determined the structure's time period. The suitability of the chosen modes in capturing the dynamic behavior of the building was confirmed by verifying that the mass participation was greater than 90% of the structure's seismic weight.

For the dynamic analysis to be accurate, an appropriate mass source was defined within the model. This mass source accounts for the contribution of the building's mass, including both self-weight and any additional loads.

In addition to dynamic analysis, checks for maximum displacement and drift ratios were conducted in accordance with IS 1893:2016. These parameters were monitored to ensure that the displacement and drift of the structure remained within the permissible limits specified by the code. This step was crucial for evaluating the structural safety and serviceability during an earthquake, ensuring that the structure would not experience excessive deformation or displacement that could lead to failure or compromise its functionality.

This comprehensive analysis approach ensured the reliability and accuracy of the seismic response evaluation, providing a robust assessment of the structure's performance under earthquake loading.

I. DESIGN APPROACH

The reinforcing guidelines specified in IS 456:2000 was followed in the design process for the columns. IS 456:2000 states that for high-strength concrete, the minimum percentage of reinforcement for columns is 0.8% of the cross-sectional area of the concrete, and the maximum permitted reinforcement is 6% of the cross-sectional area. For satisfy these demands, longitudinal reinforcement was used. This ensures that the columns have the stability, ductility, and load-carrying capacity required to function well under seismic loading while simultaneously guaranteeing the structure's functioning and safety.

J. RESPONSE REDUCTION FACTOR

When choosing seismic characteristics for each distinct tall building structural system, the following clauses have been mentioned. According to IS 1893 (Part 1): 2016, a structural system's energy-dissipating capacity and ductility are taken into consideration using the Response Reduction Factor (R). The code's Table 9 offers suggested R values for various structural systems and ductility detailing levels. This factor ensures that structures are not overdesigned for uncommon seismic events while still preserving safety by reducing the elastic base shear to an equivalent design-level force that reflects inelastic performance.

For all structural configurations modelled in this study, an R value of 5.0 has been adopted, as justified below: From Table 9 of IS 1893 (Part 1): 2016, Special Moment Resisting Frames (SMRFs) constructed with ductile detailing as per IS 13920 are assigned an R value of 5.0. The MRF models in this study follow SMRF requirements and therefore adopt this value. For the Braced Frame Structure (Eccentrically Braced Frame), Table 9 specifies that Steel Eccentrically Braced Frames (EBFs) with appropriate detailing are permitted an R value of 5.0. Although modelled as a simplified 2D representation in ETABS, the bracing configuration represents eccentric behaviour, and the R value is taken accordingly. Reinforced Concrete Shear Wall System (Special RC Shear Wall): For RC shear walls with special ductile detailing in line with IS 13920, Table 9 of IS 1893 permits an R value of 5.0 for buildings classified under the "Ductile shear wall" category. This applies to both centrally and peripherally placed shear walls modelled in the current study.

Tube-in-Tube Systems and Outrigger systems, though hybrid in nature, are composed of core shear walls and frames detailed according to ductility provisions, justifying the use of R = 5.0 for these configurations as well. Assigning a uniform R value across all structural systems ensures comparability in seismic response while maintaining alignment with the codal intent. This approach also reflects real-world design practices where uniform ductile detailing is applied regardless of system type for buildings of similar importance and occupancy.

Thus, R = 5.0 has been uniformly applied to all models to maintain consistency and ensure comparability across structural systems, while also satisfying the ductility and detailing requirements prescribed in relevant Indian codes.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

Reference: IS 1893 (Part 1): 2016, Table 9 — Response Reduction Factor (R) for Different Structural Systems.

K. CRACKED SECTION STIFFNESS MODIFIERS

In accordance with the modelling recommendations for high-rise buildings, the stiffness of reinforced concrete members was appropriately reduced to simulate cracked section behaviour. As per IS 16700:2023, Table 5 specifies recommended stiffness modifiers to be applied to various structural elements in linear elastic analysis to account for cracking in RC members.

TABLE X CRACKED SECTION PROPERTIES

Table 5 Cracked Section Properties of RC members

(*Clauses* 5.5.2,7.3.6, 8.1.3.2.1 *and* 7.2)

Sl No.	Structural Element	Serviceability Design		Strength Design	
		Cross-Sectional Area	Moment of Inertia	Cross-Sectional Area	Moment of Inertia
(1)	(2)	(3)	(4)	(5)	(6)
i)	Slabs	$1.0 A_g$	$0.35 I_g$	$1.00 A_g$	$0.25 I_g$
ii)	Beams	$1.0 A_g$	$0.7 I_g$	$1.00 A_g$	$0.35 I_g$
iii)	Columns	$1.0 A_g$	$0.9 I_g$	$1.00 A_g$	$0.70 I_g$
iv)	Walls	$1.0 A_g$	$0.9 I_g$	$1.00 A_g$	$0.70 I_g$

V. CONCLUSION

This paper compares the seismic performance of tall building structural systems, including Moment Resisting Frames (MRF), Shear Wall Systems (perimeter and corner), Braced Frames, Outrigger Systems, and Tube-in-Tube Systems. All models were developed in ETABS with uniform member sizes, material properties, and seismic loading conditions to ensure a fair performance comparison.

The analysis showed that shear wall systems (M2 and M3) offer significant improvement in lateral stiffness and effectively control storey displacement and inter-storey drift when compared to the baseline MRF model (M1). These systems appear particularly well-suited for moderately tall buildings, such as the 25-storeyed structure examined in this study, where they achieve a good balance of performance and efficiency. Braced Frames (M4) delivered moderate improvements while maintaining flexibility, making them a viable option in designs where controlled drift and ease of detailing are equally important.

On the other hand, the Outrigger (M6) and Tube-in-Tube (M5) systems demonstrated the highest stiffness and the least displacement and drift, indicating superior performance under seismic loading. These systems are especially effective in taller high-rise buildings, where increased height demands greater lateral control. However, the analysis also revealed a corresponding increase in reinforcement percentages, particularly in lower-storey columns of M5, suggesting a trade-off between performance and material economy.

A key contribution of this study lies in the inclusion of column reinforcement demand as a performance indicator. While stiffer systems like M5 and M6 reduce lateral movement, they may attract higher internal forces, leading to increased reinforcement needs. In contrast, systems like M1 and M4, although less stiff, show lower reinforcement percentages—potentially offering more efficient material usage in certain design contexts.

It is also important to remember that elements like building height, geometry, and local seismicity have an impact on the choice of structural system in addition to performance. For example, outrigger and tube-in-tube systems would be more appropriate for much taller structures, whereas shear walls might be best for mid-rise buildings. However, this appropriateness changes according to building form, material properties, and local conditions. Therefore, even though it was outside the purview of this structural performance-based study, economic evaluation ought to be considered when choosing a system.

In conclusion, the results affirm that there is no single universally ideal structural system. The selection must balance seismic performance, ductility, constructability, and context-specific constraints. This dissertation provides a

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⁓ Peer-reviewed & Refereed journal ⁓ Vol. 13, Issue 7, July 2026
DOI: 10.17148/IARJSET.2026.13707

comparative framework that can guide designers and engineers in selecting appropriate structural configurations for tall buildings in seismically active zones, particularly in the early design stages.

TABLE XI BASE SHEAR IN X DIRECTION (IN KN)

Direction	**M1 (in kN)**	**M2 (in kN)**	**M3 (in kN)**	**M4 (in kN)**	**M5 (in kN)**	**M6 (in kN)**
X	16460.2	16461.8	16566.2	16596.7	18133.7	15873.3

TABLE XII BASE SHEAR IN Y DIRECTION (IN KN)

Direction	**M1 (in kN)**	**M2 (in kN)**	**M3 (in kN)**	**M4 (in kN)**	**M5 (in kN)**	**M6 (in kN)**
Y	16925.4	16568.1	16364.7	16636.7	17862.9	16889.5

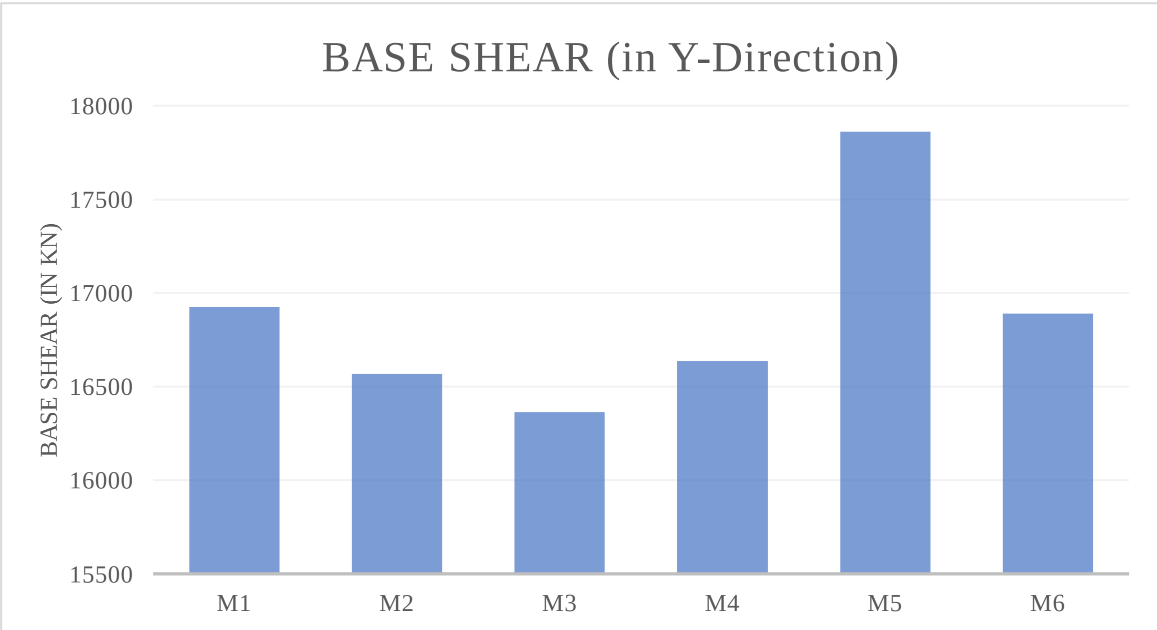

Fig.1 Comparison of base shear values in X direction

IARJSET
ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 13, Issue 7, July 2026
DOI: 10.17148/IARJSET.2026.13707

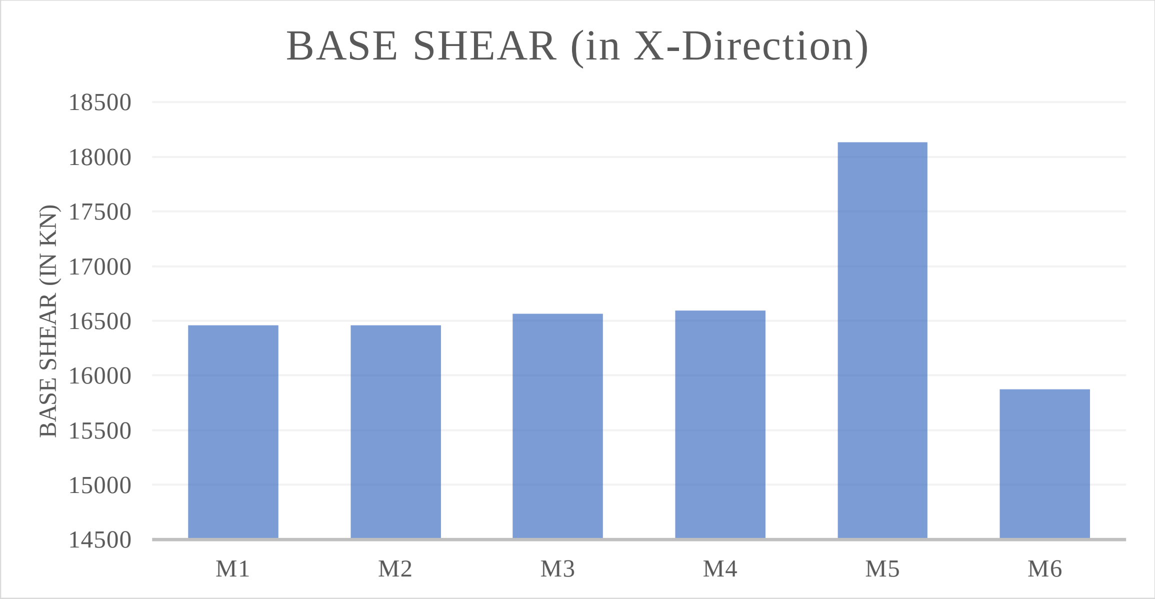

Fig. 2 Comparison of base shear values in Y direction

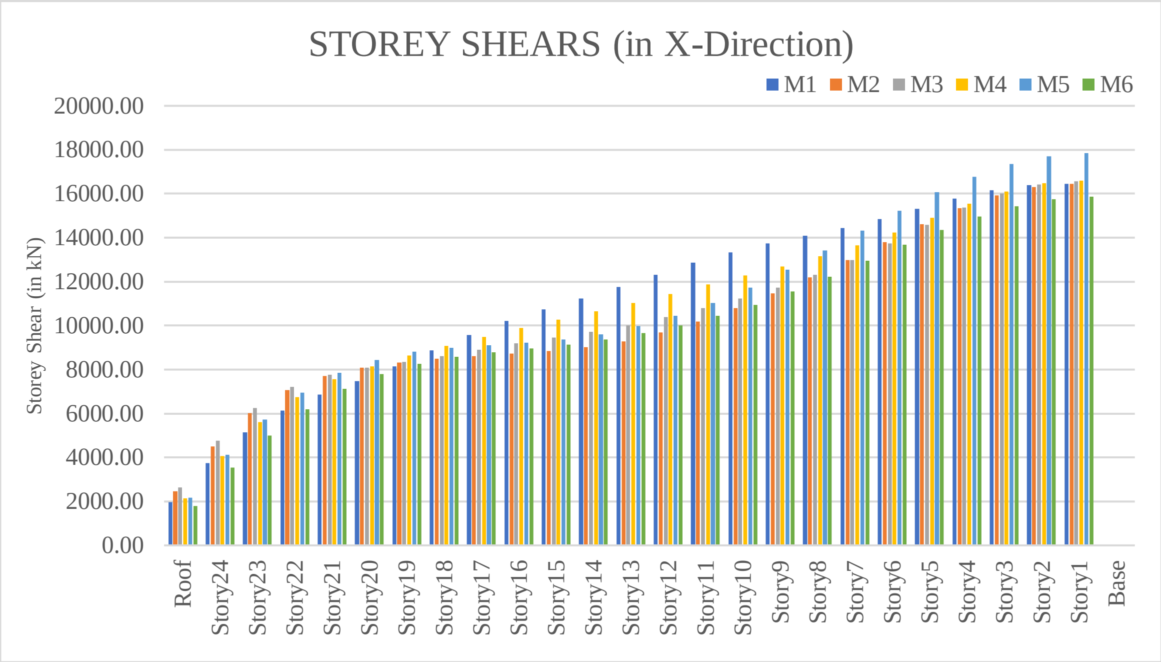

Fig. 3 Storey Shear in X Direction

IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

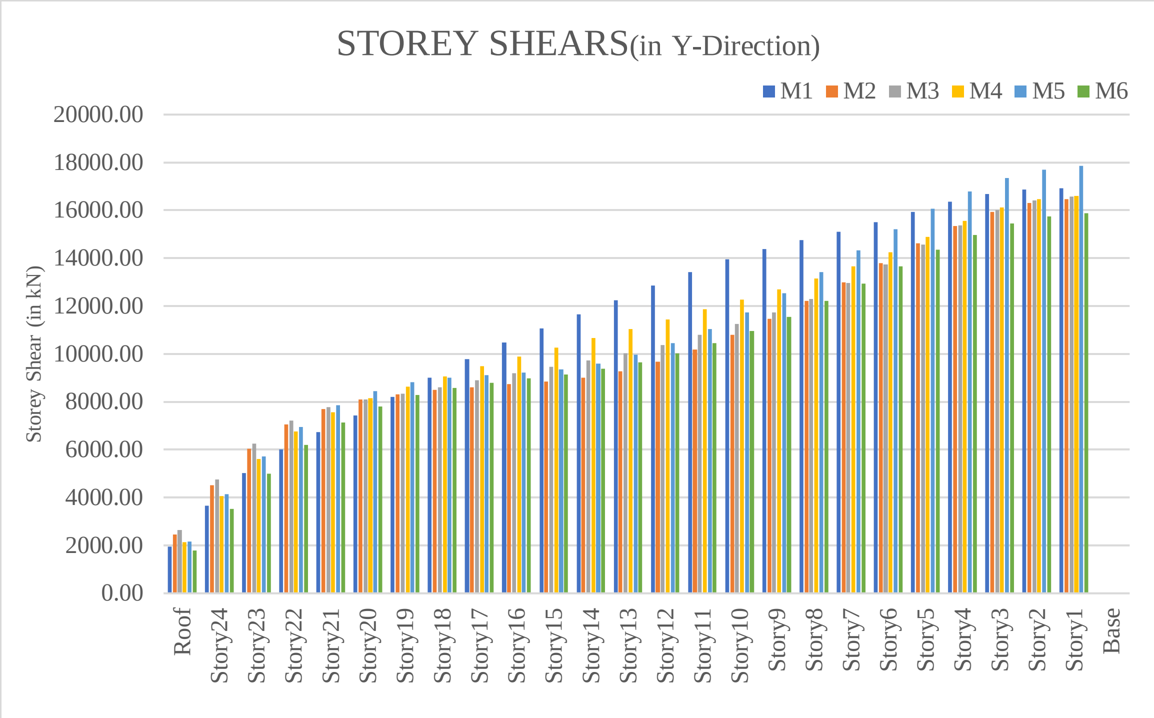

Fig. ***Error! No text of specified style in document.*** *Storey Shear in Y Direction*

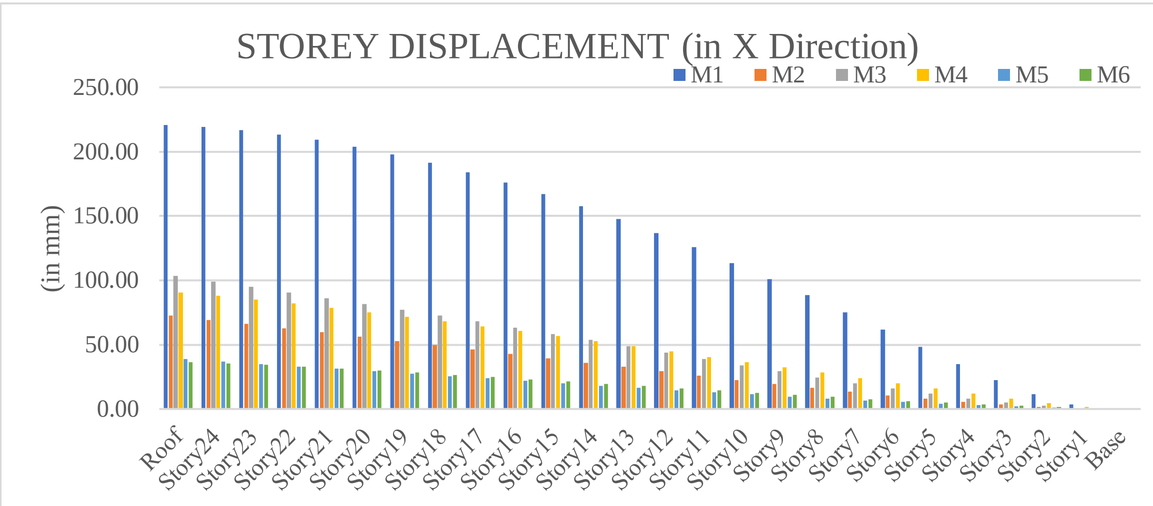

Fig. 5 Storey Displacement in X Direction

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

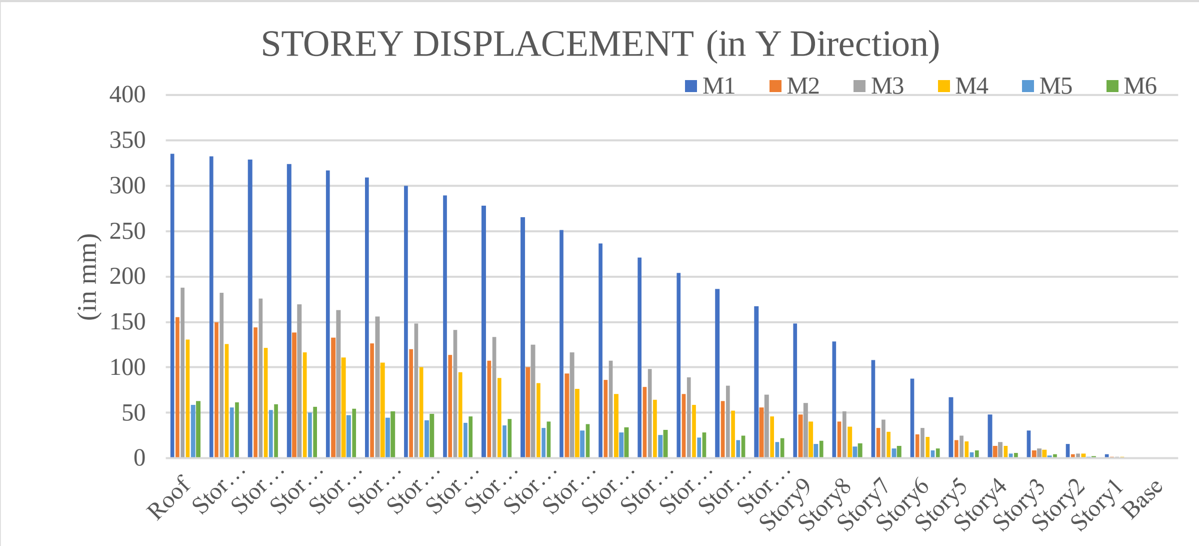

Fig. 6 Storey Displacement in Y Direction

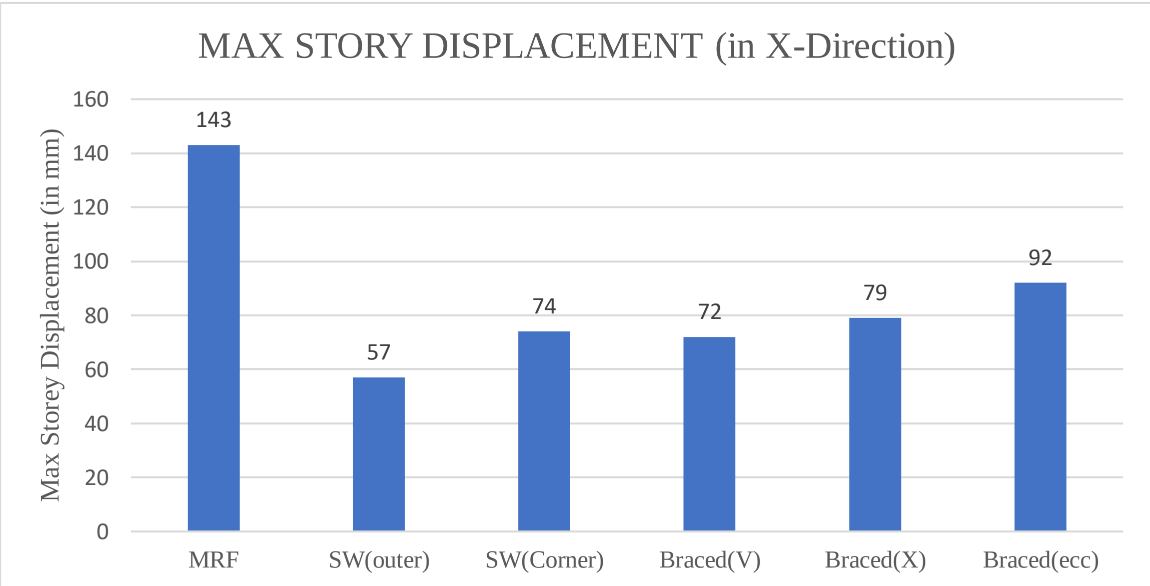

Fig. 7 Maximum Storey Displacement in X Direction

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

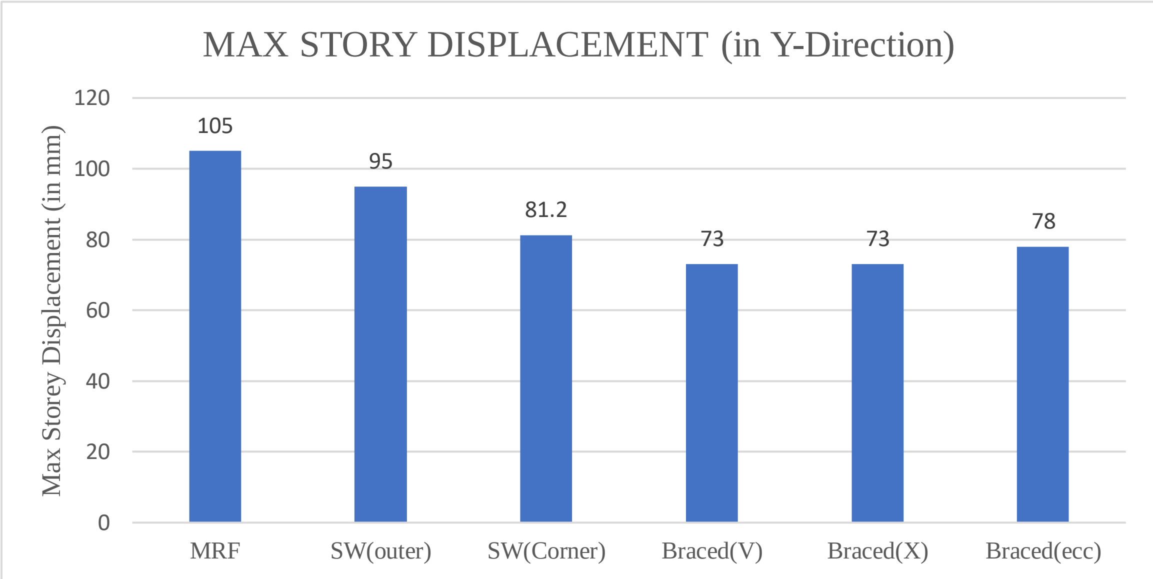

Fig. 8 Maximum Storey Displacement in Y Direction

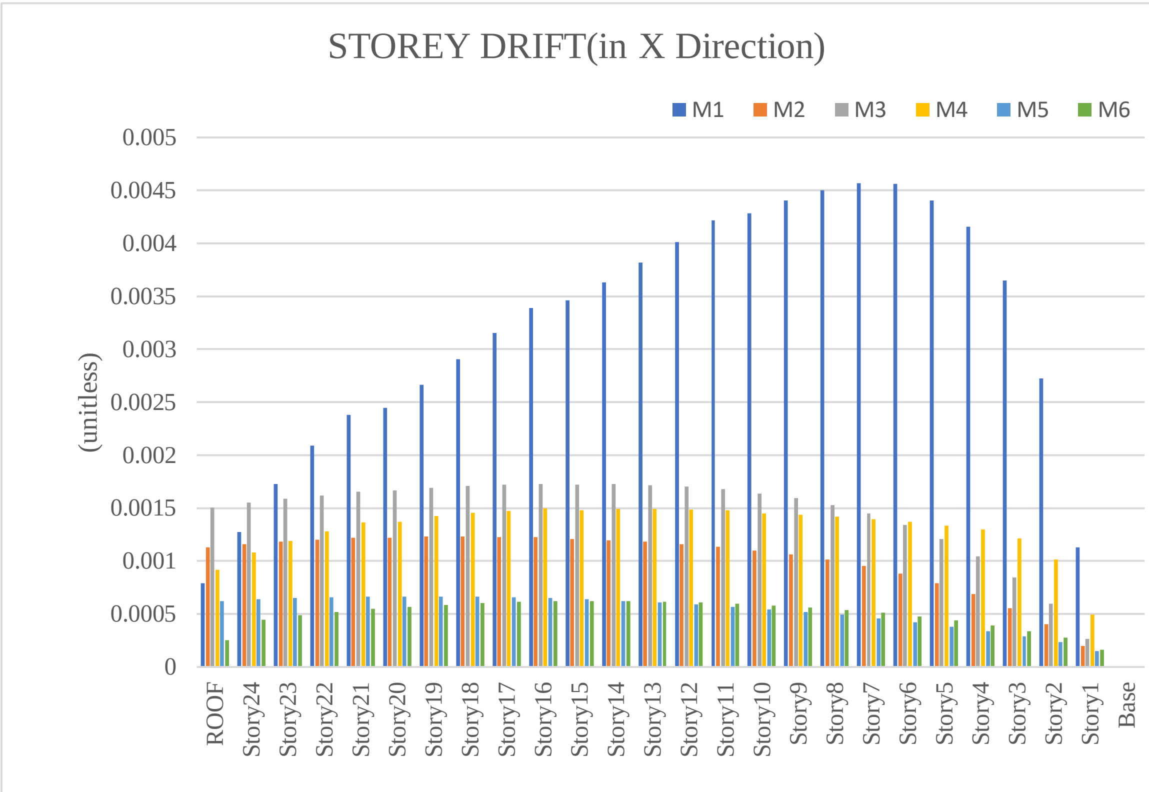

Fig. 9 Storey Drift in X Direction

DOI: 10.17148/IARJSET.2026.13707

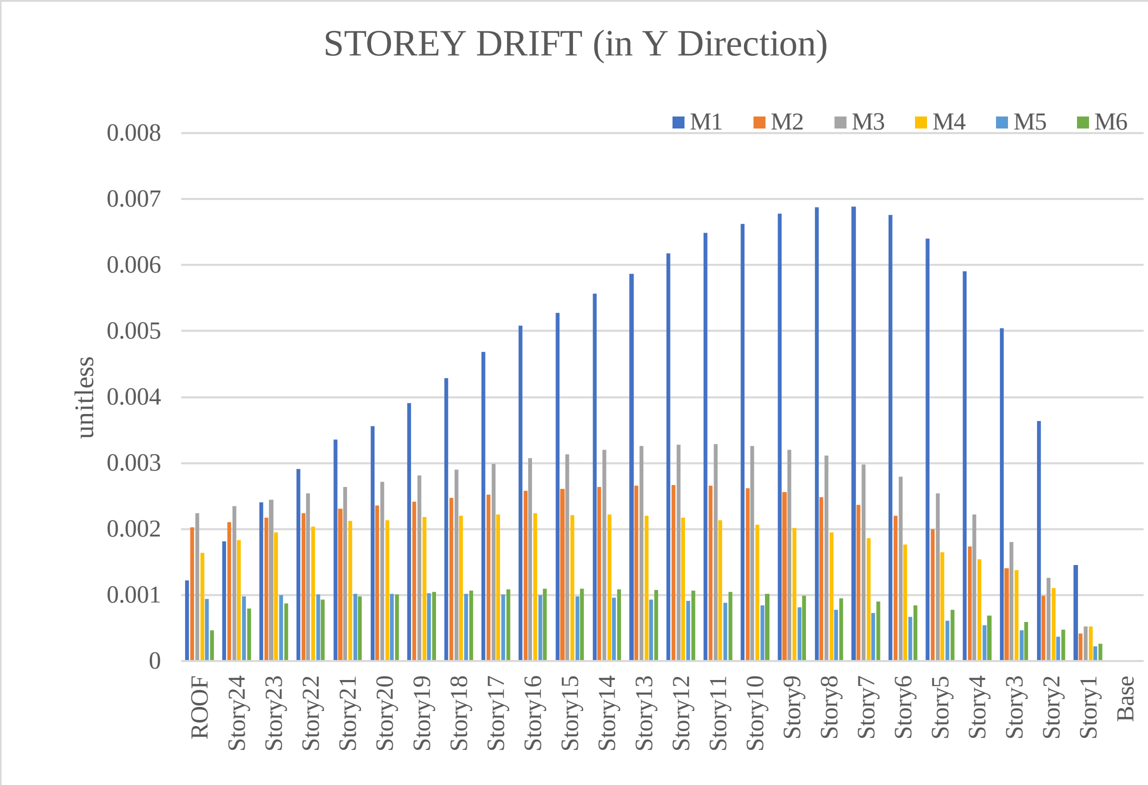

Fig.10 Storey Drift in Y Direction

REFERENCES

[1]. Ali, M. M., & Al-Kodmany, K. (2022). Evolution of structural systems for tall buildings. *International Journal of High-Rise Buildings*, 11(1), 13–32.

[2]. Borah, M., & Choudhury, S. (2021). Seismic performance of tall buildings with different structural systems. *International Journal of Structural Engineering Research*, 9(2), 87–98. https://doi.org/10.1234/ijser.2021.0001S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT", *IEEE Electron Device Lett*., vol. 20, pp. 569–571, 1999.

[3]. Choudhury, A., & Das, S. (2016). Seismic behaviour of outrigger and belt truss systems in high-rise buildings. *Structural Design of Tall and Special Buildings*, 25(10), 433–445. https://doi.org/10.1002/tal.1234

[4]. Dutta, S., & Banerjee, A. (2023). Comparative study on effectiveness of different bracing systems in RCC buildings. *Journal of Earthquake Engineering*, 28(3), 244–258.Dutta, S., & Banerjee, A. (2024). Efficiency of shear wall configurations in seismic design: A response spectrum-based study. *Indian Journal of Structural Analysis*, 19(1), 76–92.

[5]. Hashim, R. H. M., Khairi, I., & Aymi, A. M. (2017). A review on seismic performance evaluation of structural systems. *Earthquake Structural Dynamics Journal*, 14(1), 78–90.

[6]. Kadid, A., & Boumrkik, A. (2009). Seismic response of steel braced RC frames. *Journal of Constructional Steel Research*, 65(2), 120–128. https://doi.org/10.1016/j.jcsr.2008.03.023

[7]. Kaul, D., Jamle, S., & Balhar, L. (2020). An immense review on comparative analysis between regular and irregular multi-storeyed building under seismic loading. *Journal of Earthquake Engineering Review*, 12(2), 154–169.

[8]. Lone, B. A., & Chand, J. (2020). Comparative study on seismic and wind performance of multi-storeyed buildings with plan and vertical irregularities. *International Journal of Civil Engineering and Technology*, 11(6), 213–225.

[9]. Naik, R., & Chandra, S. (2017). Seismic analysis of tube-in-tube structural system. *Journal of Structural Design and Research*, 7(3), 34–42.

[10]. Sarkar, P., Prasad, A. M., & Menon, D. (2010). Vertical geometric irregularity in stepped building frames under seismic excitation. *Engineering Structures*, 32(8), 2175–2182. https://doi.org/10.1016/j.engstruct.2010.03.006

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 7, July 2026

DOI: 10.17148/IARJSET.2026.13707

[11]. Singh, P., & Arora, P. (2013). Comparative analysis of tall building structural systems under seismic loads. *International Journal of Structural Engineering*, 4(3), 198–207. https://doi.org/10.1504/IJSTRUCTE.2013.057465

[12]. Tiwary, A. K. (2020). Comparative analysis of outrigger system in high-rise RC buildings. *International Journal of High-Rise Structures*, 3(4), 45–58.

[13]. Vataliya, P. N., Butala, A. M., Mehta, N. S., & Patel, C. G. (2019). Comparison of different types of structural systems in tall buildings under lateral load. *Journal of Structural Engineering Research*, 5(3), 115–128. https://doi.org/10.5678/jsre.2019.0034

[14]. Chopra, A. K. (2017). *Dynamics of Structures: Theory and Applications to Earthquake Engineering* (5th ed.). Pearson Education, New Delhi.

[15]. Duggal, S. K. (2015). *Earthquake Resistant Design of Structures* (2nd ed.). Oxford University Press, India.

[16]. CSI (Computers and Structures Inc.). (2022). *ETABS v20 Documentation and User Manuals*. CSI Publications, California, USA.

[17]. IS 456: 2000. *Plain and Reinforced Concrete – Code of Practice*. Bureau of Indian Standards (BIS).

[18]. IS 875 (Part 1): 1987. *Code of Practice for Design Loads (Dead Loads)*. BIS.

[19]. IS 875 (Part 2): 1987. *Code of Practice for Design Loads (Imposed Loads)*. BIS.

[20]. IS 1893 (Part 1): 2016. *Criteria for Earthquake Resistant Design of Structures – General Provisions and Buildings*.

[21]. IS 13920: 2016. *Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces*. BIS.

[22]. IS 16700: 2023. *Criteria for Structural Safety of Tall Concrete Buildings*. BIS.