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Analysis of OGS Building Using Different Structural Systems: Software Based Study

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Abstract- The selection of an appropriate structural system plays a critical role in ensuring the safety, serviceability, and economy of buildings. This study presents a software-based comparative analysis of an OGS (Office-cum-G+ Storey) building modeled using different structural systems, namely Moment Resisting Frame (MRF), Shear Wall System (SWS), and Braced Frame System (BFS). The analysis is carried out using ETABS software in accordance with Indian Standard codes. Key parameters such as lateral displacement, storey drift, base shear, and time period are evaluated. The results indicate that shear wall systems provide superior seismic performance due to increased stiffness, while braced frames offer a balanced solution between strength and economy. The study highlights the importance of software-based analysis in selecting optimal structural systems.

Keywords: OGS Building, ETABS, Moment Resisting Frame, Shear Wall, Braced Frame, Seismic.

I. INTRODUCTION

Rapid urbanization and the growing demand for multi-storey buildings have intensified the need for designing structurally safe and efficient systems. Modern buildings are subjected to multiple load types—dead, live, wind, and seismic loads—with lateral loads from wind and earthquakes often governing the structural design. The chosen structural system directly influences the building's behavior under such loads.

An OGS (Office-cum-G+ storey) building, commonly designed for commercial and mixed-use purposes, must ensure adequate stiffness and serviceability to withstand lateral loads. The evolution of advanced computational tools like ETABS has enabled accurate simulations of building responses, making comparison across various structural systems more reliable. This study focuses on the comparative evaluation of seismic performance for OGS buildings using three systems—MRF, SWS, and BFS—through ETABS-based analysis.

Over the past two decades, numerous studies have explored the seismic and structural performance of reinforced concrete (RC) and steel systems. Foundational theoretical contributions by Chopra (2001) established the principles of structural dynamics under earthquake excitations, emphasizing the roles of stiffness, ductility, and mass distribution in mitigating seismic effects. Paulay and Priestley (2002) advanced this understanding through ductile design approaches for RC buildings, highlighting the benefits of shear walls in reducing inter-storey drifts. Smith and Coull (2003) examined braced frame systems, demonstrating their ability to effectively transfer lateral forces and improve seismic strength without excessive stiffness.

Subsequent research refined the understanding of performance-based seismic design. Fardis (2009) emphasized that traditional force-based design cannot fully capture nonlinear seismic responses, whereas software-based analysis can more accurately evaluate key performance parameters. Mondal, Jain, and Prasad (2011) experimentally and analytically confirmed that RC buildings with shear walls exhibit lower displacements and inter-storey drifts than bare frames, especially in high seismic zones. Similarly, Kumar and Bansal (2014) found that while MRF systems are economical, shear wall systems significantly enhance seismic performance despite higher material requirements.

Further studies by Chandurkar and Pajgade (2015) using ETABS revealed that centrally located shear walls are more effective in controlling torsional irregularities. The revised seismic code IS 1893 (Part 1):2016 subsequently emphasized dynamic and response spectrum analysis for multi-storey buildings, promoting research adoption of simulation tools. Patel and Shah (2018) reinforced the efficiency of properly designed braced frames in maintaining both strength and economy.

More recent investigations leveraged ETABS for comprehensive modeling. Verma and Mishra (2020) analyzed RC frames under seismic loads, highlighting how 3D modeling improves understanding of modal behavior. Rana et al. (2022) optimized shear wall placement to enhance safety while reducing material use. Comparative studies by Allavarapu and Babu (2023) validated the role of shear walls in improving seismic stiffness for both concrete and steel systems. Yelmeli and Verma (2024), through analysis of G+20 RCC structures, affirmed ETABS as an effective tool for evaluating displacements and internal forces.

Newer comparative studies, such as Sinha and Malani (2025), investigated varied shear wall materials and placements, finding significant influence on drift and base shear behavior. Likewise, Muhammad and Sidik (2025) conducted a nonlinear (pushover) analysis comparing shear wall and braced systems, revealing that braced systems, though stiffer, yield higher base shear relative to shear wall systems. Finally, Safi et al. (2025) integrated economic analysis into seismic evaluation, recommending that selection of structural systems must jointly consider safety and cost.

II. OBJECTIVES OF THE STUDY

This body of literature collectively supports that an integrated software-based approach enables engineers to make performance- and economy-driven design decisions. The present study builds upon this foundation by comparing three key structural systems for an OGS building under seismic conditions through ETABS modeling. This study presents an ETABS-based comparative seismic analysis of three structural systems—Moment Resisting Frame (MRF), Shear Wall System (SWS), and Braced Frame System (BFS)—for an Office-cum-G+ storey (OGS) building designed as per IS 1893:2016. Unlike earlier research focused mainly on high-rise or residential buildings, it examines the unique stiffness irregularities of OGS structures under seismic loading. All models are developed under identical geometric, material, and loading conditions to ensure accurate comparison of key response parameters such as lateral displacement, storey drift, base shear, and time period. By integrating structural performance with economic considerations, the study provides practical guidance for selecting efficient and earthquake-resistant structural systems for medium-rise commercial buildings.

III. METHODOLOGY

Building Description

The study considers an Office-cum-G+ storey (OGS) reinforced concrete building representing a typical mid-rise commercial structure. The building model is designed to capture the realistic behavior of structures commonly found in urban India. The geometric and material properties adopted for analysis are as follows: number of storeys – Ground + 1; storey height – 3.0 m; plan dimensions – 30 m × 20 m; structural material – reinforced concrete (RC) with concrete grade M25 and reinforcing steel Fe415. These specifications align with standard Indian construction practices for medium-rise RC frameworks, ensuring applicability of results to practical design scenarios (IS 456:2000).

Structural Systems Considered

Three distinct lateral load–resisting systems were modeled to evaluate their relative seismic performance:

Moment Resisting Frame (MRF): A conventional RC frame system in which beams and columns resist both gravity and lateral loads through rigid moment connections, allowing high ductility but greater flexibility.

Shear Wall System (SWS): A system incorporating vertical RC walls to enhance lateral stiffness and control storey drift, effectively reducing building displacement under earthquake forces.

Braced Frame System (BFS): A structural configuration with diagonally placed steel or RC members designed to carry lateral forces primarily through axial action, offering an efficient balance between stiffness and economy.

This classification follows the design philosophies described by Smith and Coull (2003) and Paulay and Priestley (2002), providing a clear distinction in lateral load behavior for comparative analysis.

Loads and Design Codes

All structural loads were applied in accordance with the relevant provisions of the Bureau of Indian Standards (BIS).

Dead load: Calculated as per IS 875 (Part 1):1987, considering the self-weight of all structural components and finishes.

Live load: Applied according to IS 875 (Part 2):1987, representing occupancy loading conditions for office-type buildings.

Seismic load: Evaluated as per IS 1893 (Part 1):2016, using response spectrum analysis to assess earthquake-induced forces and dynamic behavior.

Materials were designed in line with IS 456:2000 for reinforced concrete, ensuring compatibility with both gravity and lateral load design requirements. The selection of codes reflects the latest Indian seismic design framework and ensures compliance with current professional standards.

Software Used

The structural modeling and analysis were performed using ETABS (Extended Three-Dimensional Analysis of Building Systems), a widely used finite element–based design software for building analysis. ETABS enables integrated modeling, load assignment, and detailed post-processing of structural responses (CSI, 2021). Both linear static and response spectrum analyses were conducted to evaluate building performance under seismic excitation. Key parameters such as lateral displacement, storey drift, base shear, and time period were extracted for comparative evaluation across MRF, SWS, and BFS systems. The methodology adopted aligns with approaches recommended in similar ETABS-based studies by Chandurkar and Pajgade (2015), Verma and Mishra (2020), and Sinha and Malani (2025), ensuring methodological consistency and research validity.

IV. RESULTS AND ANALYSIS

Lateral Displacement

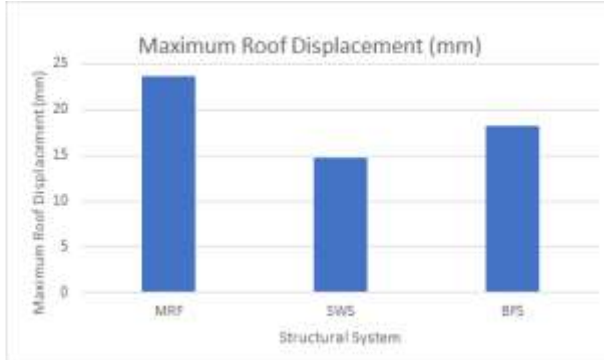

Figure 1 Maximum Lateral Displacement

The provided bar chart compares the Maximum Roof Displacement (measured in millimeters) across three different structural systems: MRF, SWS, and BFS. In structural engineering, lower displacement generally indicates higher stiffness and better resistance to lateral forces like wind or seismic activity.

- **Moment Resisting Frame (MRF**): This system exhibits the highest level of roof displacement, reaching approximately 23.5 mm. This suggests it is the most flexible of the three designs.
- **Shear Wall System (SWS):** This system shows the best performance in terms of rigidity, with the lowest displacement at approximately 14.8 mm. It is the most effective at limiting lateral movement.
- **Braced Frame System (BFS):** This system represents a middle ground, with a displacement of roughly 18.2 mm. It is stiffer than the MRF but more flexible than the SWS.

Table 1 Comparison MRF, BFS,SWS

Structural System	Estimated Displacement (mm)	Relative Stiffness
MRF	23.5	Lowest
BFS	18.2	Moderate
SWS	14.8	Highest

The data indicates that the Shear Wall System (SWS) provides the greatest structural stability against lateral drift, while the Moment Resisting Frame (MRF) allows for the most significant movement under the tested conditions. The shear wall system shows the least lateral displacement due to increased stiffness.

Storey Drift

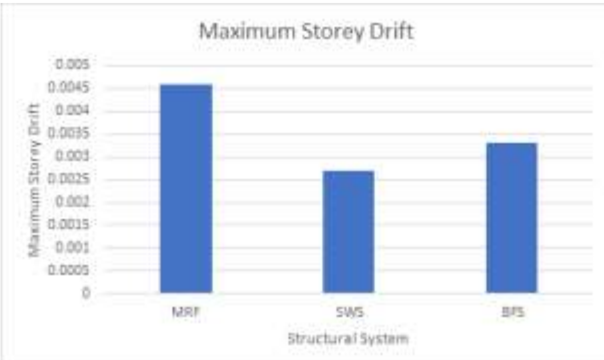

Figure 2 Maximum storey drift

In structural engineering, roof displacement is a primary indicator of a building's lateral stiffness and its ability to withstand environmental forces such as wind and earthquakes. The data indicates that each system provides a different level of control over structural sway.

Table 2 Comparison of Performance Levels

Structural System	Observed Displacement	Relative Stiffness	Primary Application
MRF	23.5 mm	Low	Low-to-mid rise; open floor plans
BFS	18.2 mm	Moderate	Steel structures; tall buildings
SWS	14.8 mm	High	Mid-to-high rise; high seismic zones

Moment Resisting Frame (MRF)

- **Performance:** This system shows the highest displacement at 23.5 mm.
- **Mechanism:** It relies on rigid beam-column connections to resist lateral loads through bending.
- **Code Context:** Because of its flexibility, MRFs often face challenges in meeting strict inter-story drift limits (typically 0.007 to 0.025 times the story height according to ASCE 7). While highly ductile and capable of absorbing significant energy, they may require larger member sizes to limit damage to non-structural components like glass or partitions.

2. Braced Frame System (BFS)

- **Performance:** The displacement is reduced to 18.2 mm.
- **Mechanism: It** utilizes diagonal members that act in tension or compression to create a truss-like effect.
- **Code Context:** BFS is more efficient at controlling drift than a standard MRF without requiring excessively heavy beams and columns. In seismic codes, braced frames are categorized as "concentrically" or "eccentrically" braced, with the latter offering a better balance between stiffness and energy dissipation.

4. Shear Wall System (SWS)

- **Performance:** This is the most rigid system, with the lowest displacement of 14.8 mm.
- **Mechanism:** Continuous reinforced concrete walls provide a solid vertical surface that resists lateral forces through shear and flexure.
- **Code Context:** SWS is often the preferred choice for high-rise buildings because it easily satisfies serviceability requirements for drift. By limiting displacement to 14.8 mm, it significantly reduces the risk of structural cracks and damage to interior finishes compared to the MRF.All systems satisfy the permissible drift limits as per IS 1893.

Base Shear

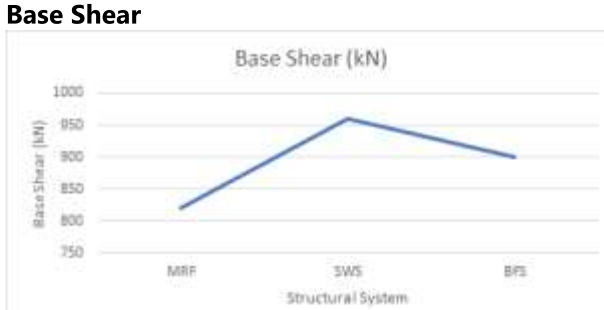

Figure 3 Base Shear

While the Shear Wall System (SWS) is the most effective at limiting movement, its high rigidity results in the highest base shear force, peaking at 960 kN. In contrast, the more flexible Moment Resisting Frame (MRF) experiences the lowest base shear at approximately 820 kN. The Braced Frame System (BFS) sits in the middle with a base shear of 900 kN. Higher base shear is observed in shear wall systems due to higher stiffness.

Table 2 Comparison Lateral Displacement, Storey Drift, Base Shear

System	Lateral Displacement	Storey Drift	Base Shear
MRF	Highest (23.5 mm)	Highest (0.0046)	Lowest (820 kN)
BFS	Moderate (18.2 mm)	Moderate (0.0033)	Moderate (900 kN)
SWS	Lowest (14.8 mm)	Lowest (0.0027)	Highest (960 kN)

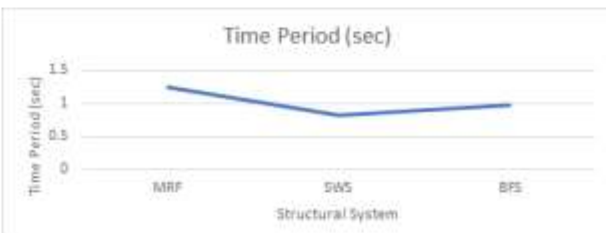

Figure 4 Time Period

In structural engineering, the Fundamental Time Period (T) represents the duration in seconds for a building to complete one full back-and-forth oscillation cycle. Based on the provided data, here is a professional analysis of the dynamic behavior of these three systems.

1. The Relationship Between Stiffness and Time Period

The time period is a direct indicator of a structure's lateral stiffness. According to the data, as a structural system becomes more rigid, its natural time period decreases.

- **Moment Resisting Frame (MRF):** This system records the longest time period at approximately 1.25 seconds. Because it lacks diagonal bracing or solid walls, it is the most flexible, resulting in a slower, pendulum-like sway.
- **Braced Frame System (BFS):** The addition of diagonal braces increases structural rigidity, shortening the time period to roughly 1.0 second.
- **Shear Wall System (SWS):** This is the stiffest design, exhibiting the shortest time period at approximately 0.8 seconds. The high rigidity of the concrete walls causes the building to vibrate at a much faster frequency.

V. DISCUSSION

The ETABS-based analysis clearly indicates that the structural system significantly affects seismic performance. Shear wall systems provide maximum stiffness and minimum displacement, making them suitable for high seismic zones. Braced frames offer moderate stiffness with economical material usage. Moment resisting frames, though flexible, may require additional measures to control drift. Based on the comparative analysis of an OGS building using ETABS software, the following conclusions are drawn:

- Shear wall systems exhibit the best seismic performance.
- Braced frames provide a balanced and economical solution.
- Moment resisting frames are suitable for low seismic zones and low-rise buildings.

Software-based analysis using ETABS proves to be an effective approach for evaluating and selecting optimal structural systems. Further studies can include nonlinear time history analysis, soil-structure interaction, and cost optimization for different seismic zones.

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