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Assessment of Different Types of Bracing System in Commercial Building under Seismic Response

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Abstract: *Tall buildings are susceptible to lateral movements and torsional deflections when subjected to earthquake loads. To counteract these effects and ensure structural stability, it's essential to enhance the building's lateral stiffness. Bracing the frame members is a widely employed method to achieve this goal. Bracing systems are designed to minimize lateral deflection by subjecting the frame members to tension and compression forces, akin to a truss system. This project focuses on a comprehensive review of literature concerning the behavior and analysis of various bracing structural systems. The reviewed articles explore different types of bracing systems, including K-bracing, V-bracing, inverted V-bracing, X-bracing, and single diagonal bracing. The consensus from the literature review indicates that implementing bracing systems effectively reduces the adverse effects of lateral loads on tall structures. The proposed project aims to build upon the insights gleaned from the literature review by investigating a mixed bracing system. By combining elements from different bracing configurations, the project seeks to optimize lateral stiffness and stability further. This approach acknowledges the diverse challenges posed by lateral loads in tall buildings and aims to address them comprehensively. Through rigorous analysis and experimentation, the proposed project endeavors to contribute to the body of knowledge surrounding bracing systems in tall buildings. By exploring the efficacy of a mixed bracing system, the project aims to offer practical insights and recommendations for enhancing the structural performance and resilience of tall buildings against lateral forces.*
Keywords *– K, V, inverted V, X, Single Diagonal Bracing.*

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I. Introduction

Tall buildings, officially defined as those over 50 meters by the Council for Tall Buildings and Urban Habitat, come in various categories. Skyscrapers, for example, are over 100 meters tall, while super tall buildings reach heights of 300 meters or more, and mega tall buildings exceed 600 meters. The demand for such towering structures stems from several factors, including limited land availability, increased need for commercial and residential space, economic growth, technological advancements, innovative building designs, cultural significance, and the desire for prestige associated with building tall.

High-rise buildings come in different structural forms, one of which is stiffened structures. A common example of this is the rigid frame system, often used in buildings subjected to lateral forces like wind and seismic pressures. These frames typically utilize structural steel components, capable of efficiently handling both tension and compression. The beams and columns within the frame bear the vertical load, while the stiffening system handles lateral forces.

However, incorporating these stiffening elements can pose challenges, particularly concerning facade design and the placement of openings. To address this, modern buildings, especially those adopting avant-garde or postmodern styles, often integrate rigidity as a prominent feature, whether internally or externally.

By effectively resisting lateral forces, these stiffening systems enhance structural efficiency compared to rigid frames alone.

The bracing system can be broadly categorized into two main types, depending on how they resist horizontal forces.

1. Vertical Bracing System:

This system involves stiffening or bracing along the lines of the columns, primarily in the vertical planes. It establishes paths for transferring horizontal forces at ground level. Frame buildings typically need a minimum of three vertical bracing planes, oriented perpendicular to each other in order to prevent twisting around the vertical axis.

2. Horizontal Bracing System:

In this system, reinforcement occurs within each floor, specifically in the horizontal planes. This setup facilitates the transfer of horizontal forces to the vertical bracing planes. Horizontal links are necessary at every level, although the floor system itself might offer adequate strength. However, additional reinforcement might be required for the roof.

II. Objective

This study focuses on evaluating and comparing the seismic performance of various bracing systems in a high-rise commercial building structure.

1. It includes the modeling of G+26 storey buildings using STAAD Pro with different bracing configurations (X, K, V, Inverted V, Single Diagonal, and Mixed Bracing Systems).
2. The building is assumed to be located in Seismic Zone III with medium soil conditions, in compliance with IS 1893 (Part 1): 2002 standards.
3. The analysis considers linear dynamic analysis through the Response Spectrum Method to simulate realistic seismic behavior.
4. The results are evaluated based on key structural response parameters such as storey displacement, storey shear, and base shear.
5. The study is limited to bracing systems made of ISMB 500 steel sections and assumes uniform material properties and loading conditions.
6. The outcomes are intended to guide structural engineers in selecting efficient bracing systems for seismic resilience in commercial buildings.

III. Methodology

Model Development: Seven building models were created using STAAD Pro software:
Model 1: BE1 – Regular Building (No Bracing Element)
Model 2: BE2 – Building with X- Bracing Element & Single Diagonal Bracing Element Model 3: BE3 – Building with K- Bracing Element & Single Diagonal Bracing Element Model 4: BE4 – Building V- Bracing & Inverted Diagonal Bracing Element
Model 5: BE5 – Building with V- Bracing Element & X- Bracing Element
Model 6: BE6 –V- Bracing Element & K-Bracing Element
Model 7: BE7 – Building with Inverted V Bracing Element & X- Bracing Element.

Input Data:
Building height: G+26 storeys
Storey height: 3.6 m
Plan dimensions: 45 m × 25 m
Materials: M25 Concrete, Fe550 Steel
Bracing: ISMB 500 sections
Seismic zone: Zone III
Soil type: Medium

Seismic Analysis: Performed using the Response Spectrum Method in accordance with IS 1893 (Part 1): 2002. Parameters such as time period, damping ratio, and zone factors were applied as per code.

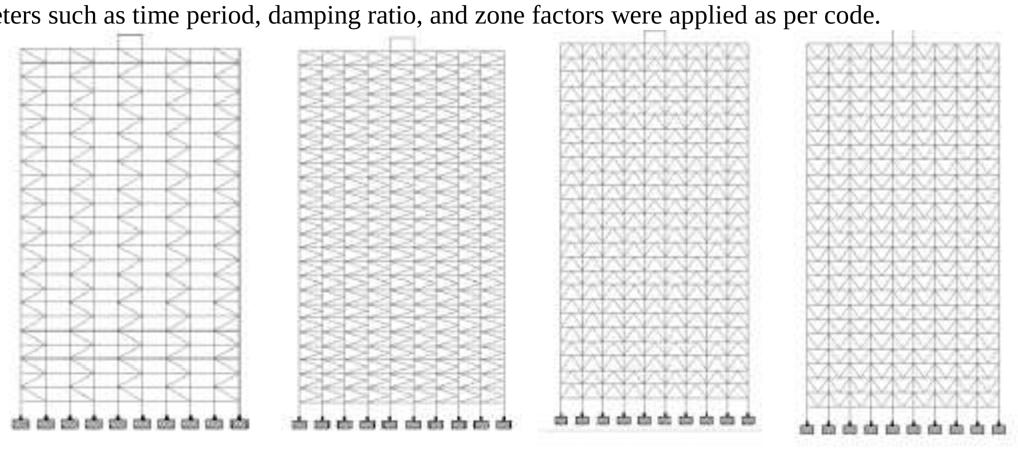

Figure 1 Different Bracing Modes (1 to 7)

Table 1 Data of the Model

S.no	Model ID	Value
1	No. of Story	G + 26 Stories
2	Plan Area	45Meters X 25 Meters
3	Story Height	3.6 Meters
4	Beam Size	800 millimeters X 1200 millimeter
5	Colum Size	1200 millimeters X 600 millimeters
	Bracing size	ISMB 500
6	Slab Thickness	160 millimeters
7	Grade of Concrete	M-25
8	Grade of Steel	Fe-550
9	Zone	Zone III

Details of Structural Models

For this study, a structural model with a height of 96.40-meter storeys is created, keeping the storey height consistent at 3.6 meters. The structural models are designed to have asymmetrical configurations in both directions by maintaining the same bay width. To comply with the guidelines of the IS code, the bay width is adjusted for models of different heights, ensuring that the slenderness ratio of the structural models remains within the specified limits. The detailed dimensions of the structural models are presented in Table 5.1.

4.3 Methods of Analysis

The structural models created in Staad Pro undergo linear dynamic analysis using the Response Spectrum Method (RSM). This analysis technique helps evaluate the response of the structures to seismic forces. Each of the five models, including the traditional shear wall configuration and the models with steel bracing systems, is analyzed using this method. The analysis provides valuable insights into the structural behavior and performance under seismic loads. Based on the analysis results, a comparative study is conducted to determine the optimal placement of the steel bracing system within the structure. This study helps identify the most effective location for the bracing system to minimize the structural response to seismic forces.

IV. Results and Discussion

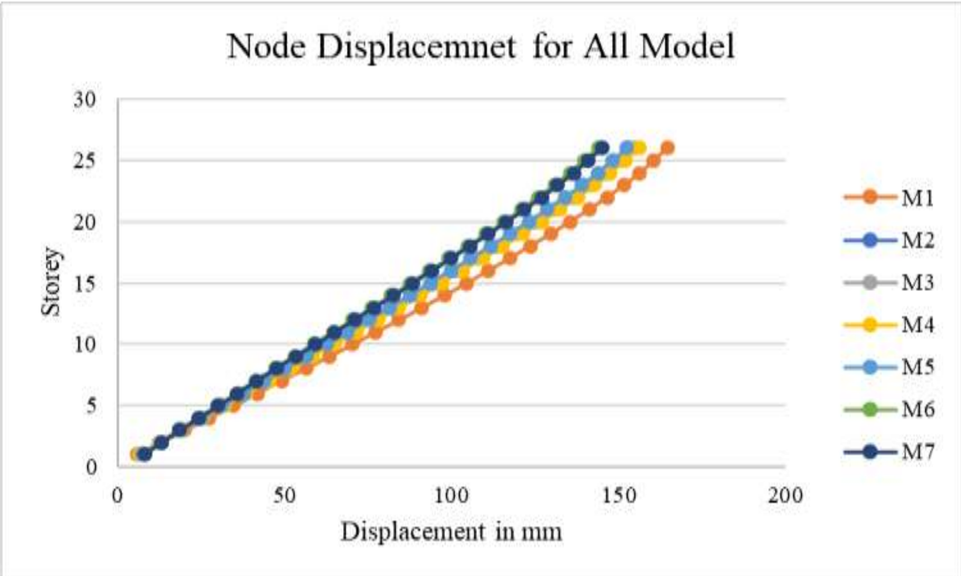

Figure 1: storey Vs Node Displacement

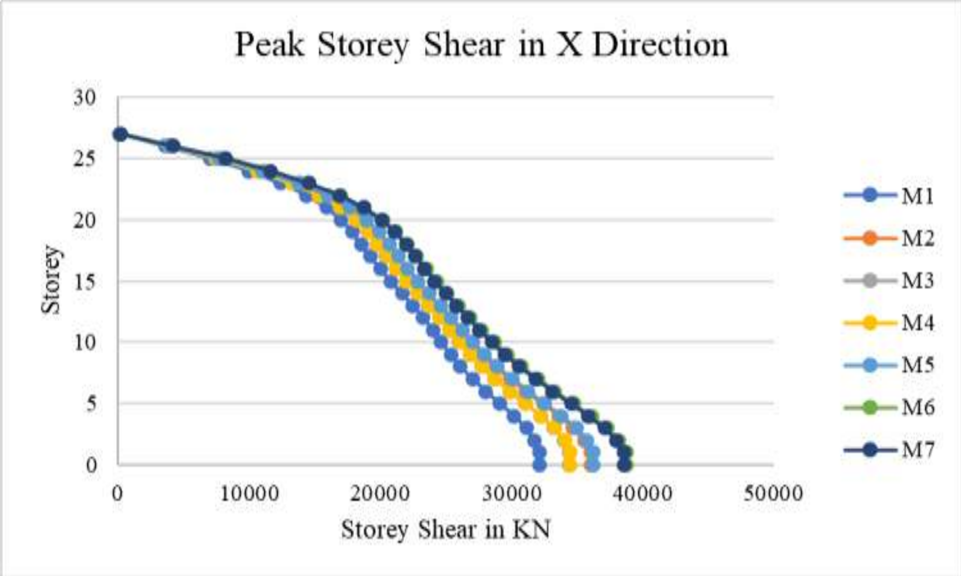

Figure 2. Storey Vs Peak Storey Shear in X direction

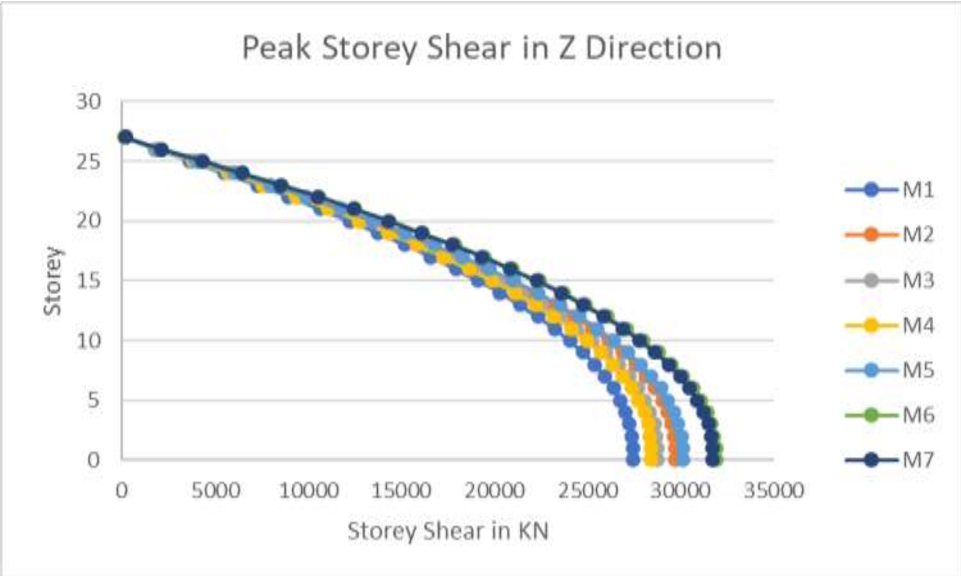

Figure 3. Storey Vs Peak Storey Shear in Z Direction

V. Conclusions

A. Node Displacement

Comparison of Braced Models (M2 to M7):

- Models M2 to M7 generally demonstrate lower node displacement compared to M1, indicating enhanced structural stiffness and reduced deformation.
- Specific bracing configurations, such as M3 and M4, tend to show slightly lower displacement values, suggesting their effectiveness in minimizing building movement and reducing node displacement compared to other bracing configurations.

In summary, the inclusion of bracing elements contributes to reduced node displacement in structural models. While specific bracing configurations may offer varying degrees of effectiveness in minimizing node displacement, overall, models incorporating bracing elements demonstrate improved structural stiffness and reduced deformation compared to models without bracing. Further analysis and optimization strategies can help refine the performance of these models in minimizing node displacement and enhancing overall structural stability.

B. Peak Storey Shear

- Model M1 exhibits moderate to high shear forces across storeys but slightly higher than Model M1, suggesting adequate lateral load resistance with room for improvement in optimizing shear force distribution.
- Models M3, M4, M5, M6, and M7 generally show comparable shear forces to M2, indicating moderate to high lateral load resistance but similar performance in this comparison.
- Each model may benefit from further analysis and optimization strategies to enhance overall stability and reduce shear forces.

In conclusion, while the inclusion of bracing elements generally enhances structural stiffness and reduces deformation, specific configurations may offer varying degrees of effectiveness in minimizing building movement. Model M1 stands out for its relatively lower peak storey shear values, indicating higher stability compared to the other models. Further analysis and optimization strategies are recommended for all models to improve their structural performance under lateral loads.

References

[1]. Raagavi, M. T., & Sidhardhan, S. (2021). A Study on Seismic Performance of Various Irregular Structures. International Journal of Research in Engineering and Science (IJRES), 9(5), 12-19.

[2]. Khazaei, M., Vahdani, R., & Kheyroddin, A. (2020). Optimal Location of Multiple Tuned Mass Dampers in Regular and Irregular Tall Steel Buildings Plan. Shock and Vibration, Volume 2020, Article ID 9072637, 20 pages. DOI: 10.1155/2020/9072637.

[3]. Prasad, G. V. S. S., Devi, P. J., & Patnaik, M. (2020). Seismic Response Analysis of Symmetrical and Asymmetrical High-Rise Structures in Seismic Zone II. International Journal of Engineering Research and Applications, 10(10) (Series-III), 36-49. DOI: 10.9790/9622-1010033649.

[4]. İlerisoy, Z. Y. (2019). Discussion of the Structural Irregularities in the Plan for Architectural Design within the Scope of Earthquake Codes. Periodica Polytechnica Architecture, 50(1), 50–62.

[5]. Krishna, K. S., & Sankar, P. S. (2019). Seismic Analysis of Multi Storied Buildings with Floating Columns. International Journal of Innovative Research in Science, Engineering and Technology, 8(5), 6063. DOI: 10.15680/IJIRSET.2019.0805145.

[6]. Ahirwal, A., Gupta, K., & Singh, V. (2019). Effect of Irregular Plan on Seismic Vulnerability of Reinforced Concrete Buildings. In Proceedings of the International Conference on Sustainable Materials and Structures for Civil Infrastructures (SMSCI2019) (AIP Conf. Proc. 2158, pp. 020012-1–020012-5). AIP Publishing. DOI: 10.1063/1.5127136.

[7]. Sağlıyan, S., & Yön, B. (2018). Assessment of Earthquake Behavior of Reinforced Concrete Buildings with Slab Discontinuity. Turkish Journal of Science & Technology, 13(1), 87-92.

[8]. Sanjay, K., & Rao, P. Mallikharjuna. (2018). Effect of Diaphragm Discontinuity in the Seismic Response of Multi-Storeyed Building. International Journal of Research Sciences and Advanced Engineering (IJRSAE), 2(20), 182-187

[9]. Sarojini, B. B., & Kumar, K. K. (2018). Diaphragm Discontinuity Consequence with The Seismic Performance of RC Building. International Journal of Innovative Technology and Research, 6(3), 8159-8161.

[10]. Sahu, R., & Dwivedi, R. (2017). Seismic Analysis of RC Frame with Diaphragm Discontinuity. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 14(4) Ver. VI, 36-41. DOI: 10.9790/1684-1404063641.

[11]. Chacko, D. M., & Eliyas, A. (2017). Seismic Analysis of Fixed Base and Base Isolated RC Buildings Having Diaphragm Discontinuity. International Research Journal of Engineering and Technology (IRJET), 04(06), 1966.

[12]. Soni, A., Rawat, A., & Kushwah, S. S. (2017). Wind Analysis of Tall Building with Floor Diaphragm. International Research Journal of Engineering and Technology (IRJET), 04(03), 1095.

[13]. Bagawan, R. K., & Patel, M. Q. (2017). Seismic Performance Study of RC Framed Building with Diaphragm Discontinuity. International Research Journal of Engineering and Technology (IRJET), 04(09), 103.

[14]. Kusuma, B. (2017). Seismic Analysis of a High-rise RC Framed Structure with Irregularities. International Research Journal of Engineering and Technology (IRJET), 04(07), 1338.

[15]. Kadiyala, R., & Kota, T. (2016). Effect of Diaphragm Discontinuity of the Building. International Journal of Research in Engineering, IT and Social Sciences, 06(09), 33-40.

[16]. Habib, M. Z., Alam, M. A., Barua, S., & Islam, M. M. (2016). Effect of Plan Irregularity on RC Buildings due to BNBC-2006 Earthquake Load. International Journal of Scientific & Engineering Research, 7(1), 761.

[17]. Sawarkar, B. R., & Nandurkar, B. P. (2016). Critical Analysis of Column Displacement and Forces in Selected Column for a Structure with Diaphragm at Different Levels. International Journal of Science Technology & Engineering (IJSTE), 2(10), 806.

[18]. Abdlebasset, Y. M., Sayed-Ahmed, E. Y., & Mourad, S. A. (2016). Seismic Analysis of High-Rise Buildings with Transfer Slabs: State-of-the-Art Review. Electronic Journal of Structural Engineering, 16(1).

[19]. Scarry, J. M. (2015). Floor Diaphragms and a Truss Method for Their Analysis. Bulletin of the New Zealand Society for Earthquake Engineering, Vol. 48, No. 1, March 2015. Structural Engineer, Auckland. (Submitted May 2014; Reviewed August 2014; Accepted December 2014).

[20]. Monish, S., & Karuna, S. (2015). A Study on Seismic Performance of High-Rise Irregular RC Framed Buildings. International Journal of Research in Engineering and Technology (IJRET), 04(05), 340.

[21]. Öztürk, T. (2011). A study of the effects of slab gaps in buildings on seismic response according to three different codes. Scientific Research and Essays, 6(19), 3930-3941. DOI: 10.5897/SRE10.076.

[22]. González Herrera, R., & Gómez Soberón, C. (2008). Influence of Plan Irregularity of Buildings. In Proceedings of the 14th World Conference on Earthquake Engineering, October 12-17, 2008, Beijing, China..