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Comparative Seismic Analysis of Multistorey Core in Core Structure Using Beams, Fluid Viscous Dampers and Bracing

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Abstract

The main objective of this paper is to analyze and study the comparative analysis of multistorey core in core structure with beam, Fluid viscous dampers and bracings using Etabs. Core in core structures, also known as dual core structures, are a structural design concept employed in high-rise buildings to enhance their structural performance and increase resistance to lateral loads such as wind and earthquakes. The concept of core in core structures stems from the need to optimize structural efficiency and occupant comfort while maintaining architectural flexibility in tall buildings. The report provides an in-depth analysis of a multistorey G+10 commercial building utilizing ETABS software. The structures underwent different loads, including dead load, live load, and earthquake load. The primary focus of this study revolves around Equivalent Static Analysis, a linear static analysis method employed to assess the seismic performance of the structures. The obtained results offer valuable insights into the displacements across different stories, the shear forces experienced by each story, and the automatic application of lateral loads. These findings demonstrate the structure's performance under diverse parameters, providing a comprehensive understanding of its behavior.

Keywords: Core structure, beam, fluid viscous dampers, bracing, equistatic analysis, storey displacement, storey shear, auto lateral loads seismic zone III

INTRODUCTION

This project provides information on a study of seismic analysis of multistorey (G+10) Core in core structure using beams, Fluid viscous dampers (FVD) and bracings by Equivalent static analysis method using different parameters for the structures. Core in core structures is designed to address the challenges posed by tall buildings, particularly in areas prone to high wind or seismic activity. The primary purpose of the cores in core in core structures is to resist lateral loads. Lateral forces such as wind or earthquakes can cause significant stresses and deformations in tall buildings. By incorporating multiple cores, the structure gains enhanced resistance and stability, reducing potential for excessive drift and improving overall performance. In addition, for this basic configuration of the cores, various strategies can be incorporated within the cores to enhance their performance. For example, beams, FVD and bracings can be introduced within the core. In which beam increases their lateral stiffness and provide additional load transfer paths, FVDs are devices that absorb and dissipate energy during lateral movements, thus reducing the magnitude of vibrations and improving the structural response, X

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bracings effectively resist lateral forces by transferring them from one core to another, thus improving the overall stability of structure. This helps in reducing the overall deformations and redistributing the loads more efficiently. This project involves examining the behavior of a structure in Zone III by comparing various models. The objective is to understand how the structure performs during checks, identify any deviations, and analyze behaviors. The study includes investigating storey displacements, storey shears, and autolateral loads when the building is exposed to seismic forces using the Equistatic method. The focus is on evaluating the performance of a core in a core structure utilizing beams, Fluid Viscous Dampers (FVD), and bracings [1] [2]. Thakur et. al., investigates the seismic response of hybrid structures incorporating fluid viscous dampers (FVDs) and base isolation, essential for enhancing resilience against severe seismic events. The study evaluates 16-story hybrid structures with Circular Hollow Section (CFST) and concrete-encased steel (CES) columns, comparing them to conventional RCC structures. Utilizing finite element analysis and response spectrum approach, the research examines parameters like inter-story drifts, time period, stiffness, displacements, base shear, and overturning moments. Results highlight a significant reduction in structural response through the synergistic use of FVDs and base isolation, providing valuable insights for safer and more resilient building designs in seismic-prone regions [3]. Hu et. al., focuses on assessing the structural and nonstructural damage of steel buildings equipped with Self-centering energy-absorbing rocking core (SCENARIO) systems during earthquakes. Two types of SCENARIO systems, SCENARIO-F with friction spring dampers and SCENARIO-H with hybrid dampers, were examined for their seismic responses. Three prototype steel buildings were designed with SCENARIO systems to achieve the same target displacement under design basis earthquakes. Seismic fragility analysis reveals that the SCENARIO-H systems outperform SCENARIO-F systems in controlling both structural and nonstructural damage under far-field and near-fault earthquakes with high intensities, showcasing excellent post-earthquake repairability attributed to their superior self-centering capacity [4]. Our analysis incorporates insights from existing research papers, particularly those emphasizing the comparison of shear core structures employing beams, bracing systems, and fluid viscous dampers. This paper delves into the seismic effects on a multistorey core in core structure, exploring the impact of beams, fluid viscous dampers, and bracings. The conclusion drawn from utilizing ETABs software, along with the Equistatic analysis method on symmetrical structures, provides valuable insights into the structural performance [5].

METHODOLOGY

To examine the seismic behavior of multistorey core in core structure, comparative study has been carried out between the models using equistatic method. The modelling and analysis are done by using ETABs 17.0.1 version software. The outcomes are tabulated in order to focus the parameters such as storey displacement, storey shear and autolateral loads. Step by step procedure to achieve the objectives are as follows

1. An extensive literature review was carried out and find the problem of work for which parameter should be used for analysis.
2. To establish the objectives for the project work. G+10 storey structure is chosen for the present project work.
3. ETABS software is used for the modelling and analysis for the selected structure.
4. In the modelling shear wall is placed in core using beam, bracings and dampers are considered.
5. To understand behavior of the structure total three models are considered.
6. The linear static analysis (Equivalent static analysis) is carried out for all the models.
7. The results obtained from models are checked and tabulated and are represented in graphical form

Table 1 displays the initial data for the building, while Table 2 provides details about the model. Figure 1 illustrates Model 1, representing a Core in Core Structure with Beam. Model 2, depicting a Core in Core Structure with Fluid Viscous Dampers (FVD), is presented in Figure 2, and Figure 3 exhibits Model 3 - Core in Core Structure with Bracings.

Table 1. Preliminary data for building

Sl. No	Parameter	Remarks
1	Structure type	Commercial
2	Total number of the floors	G+10
3	Area of Plan	19 x 24 m
4	Total height of building	30 m
5	Floor to floor height	3 m
6	Column size	600 x 600 mm
7	Beam size	450 x 600 mm
8	Slab thickness	200 mm
9	Thickness of wall	230 mm
10	Thickness of shear wall	200 mm
11	Concrete grade	M45
12	Steel grade	Fe550
13	Live load	1.5 kN/m^2
14	Dead load	1 kN/m^2
15	Seismic zone	III
16	Soil type	II (Medium)
17	Seismic zone factor	Z = 0.36
18	Importance factor	I = 1.5
19	Response reduction factor	R = 3.0

Table 2. Model Details

Sl No.	Model No.	Description
1	1	Core in core structure with beam
2	2	Core in core structure with Fluid viscous dampers (FVD)
3	3	Core in core structure with bracings

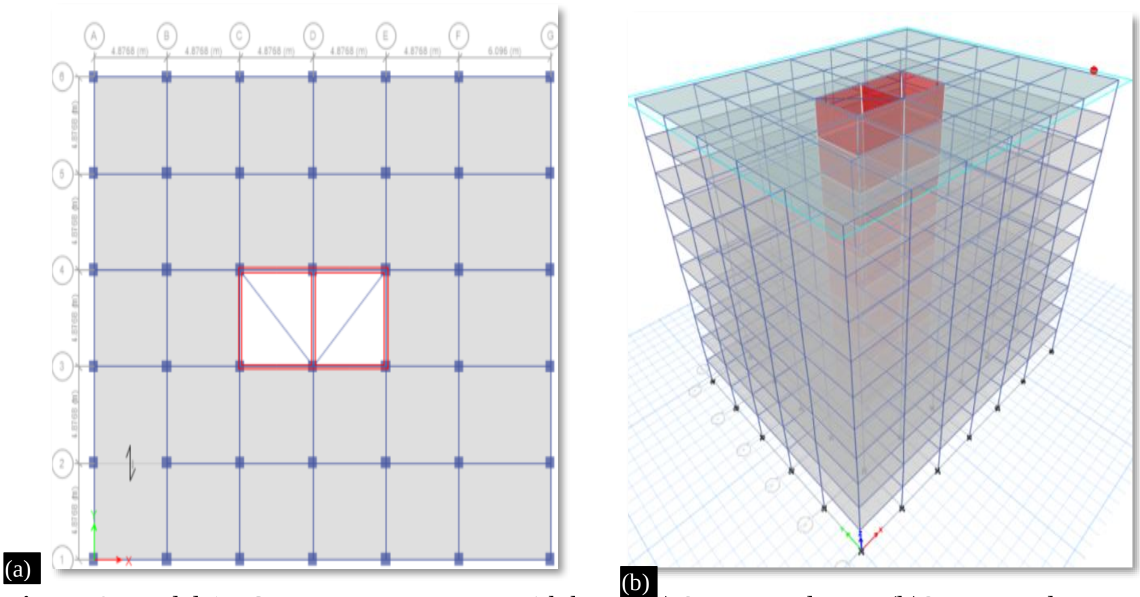

Figure 1. Model 1 - Core In core structure with beam (a) 2D Frame layout (b)3D Frame layout

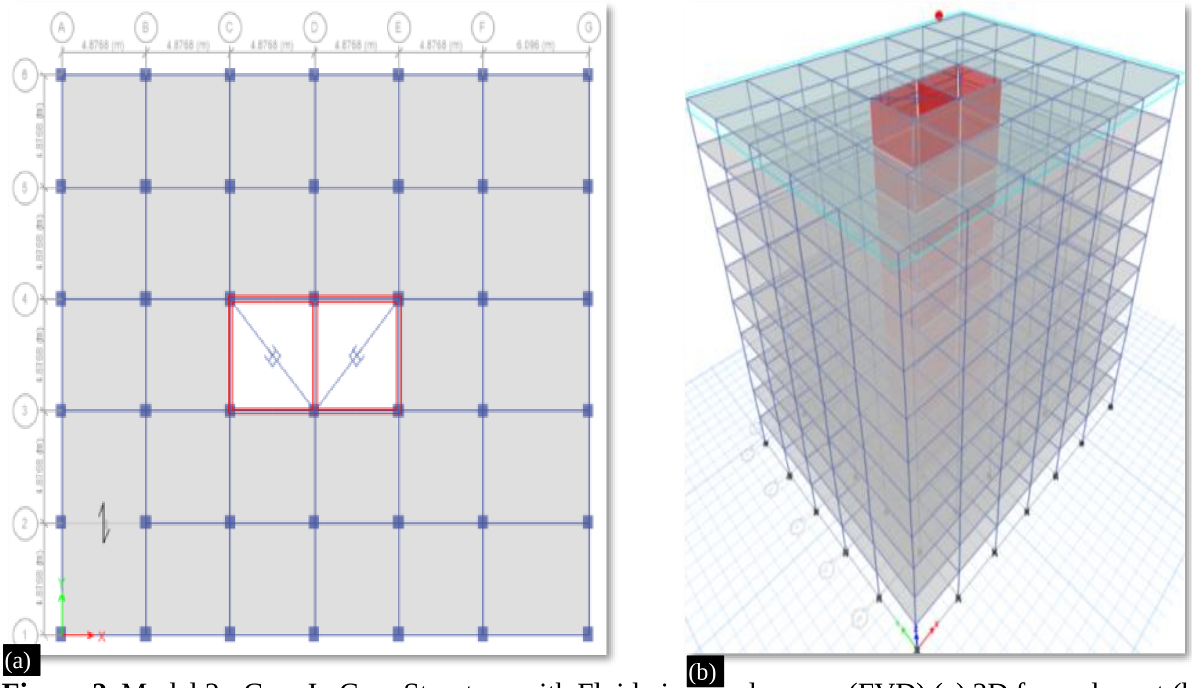

Figure 2. Model 2 - Core In Core Structure with Fluid viscous dampers (FVD) (a) 2D frame layout (b) 3D frame layout

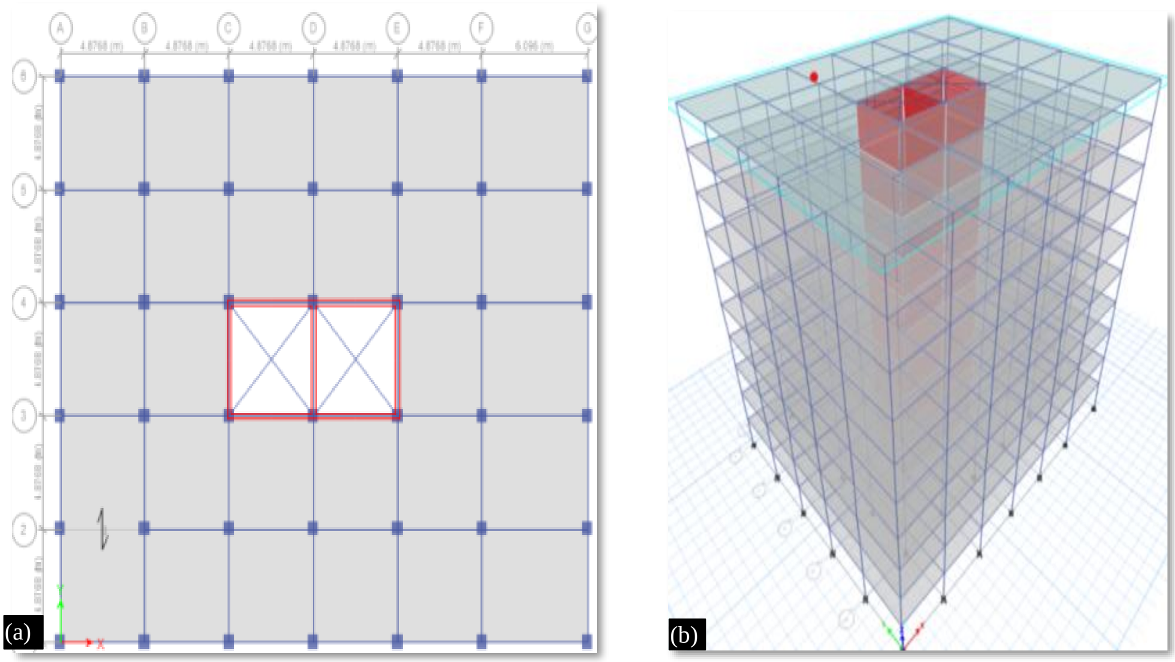

Figure 3. Model 3 - core in core structure with bracings (a) 2D frame layout (b) 3D frame layout

RESULTS AND DISCUSSIONS

Using ETABs 2017 software, the models are subjected to Equivalent satic analysis as per IS 1893–Part 1 (2002). Seismic parameters viz. storey displacement, storey shear & and auto lateral loads are obtained from the analysis for all the developed models in seismic zone III. Figures 3 to 5 show the variation of storey displacement, storey shear and auto lateral loads over the number of stories in both X and Y directions obtained for all the models by Equivalent static analysis. Results and discussion are compared on minimum values [6][7].

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Storey Displacement Results and Graphs

Figures 4 to 6 depict the storey displacements in both the X and Y directions. It is evident that the maximum displacements occur in the Y direction, while the minimum displacements are observed in the X direction. This pattern will be similarly assessed in subsequent models to examine whether the comparison values increase or decrease.

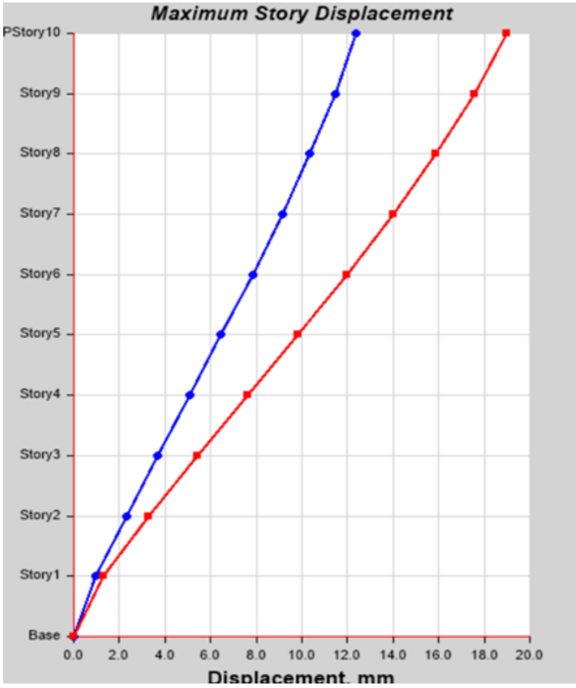

Figure 4. Storey displacement in model 1

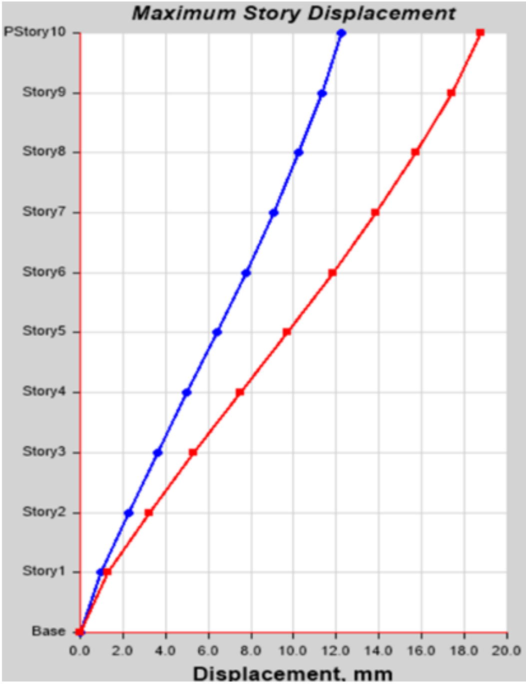

Figure 5. Storey displacement in model 1

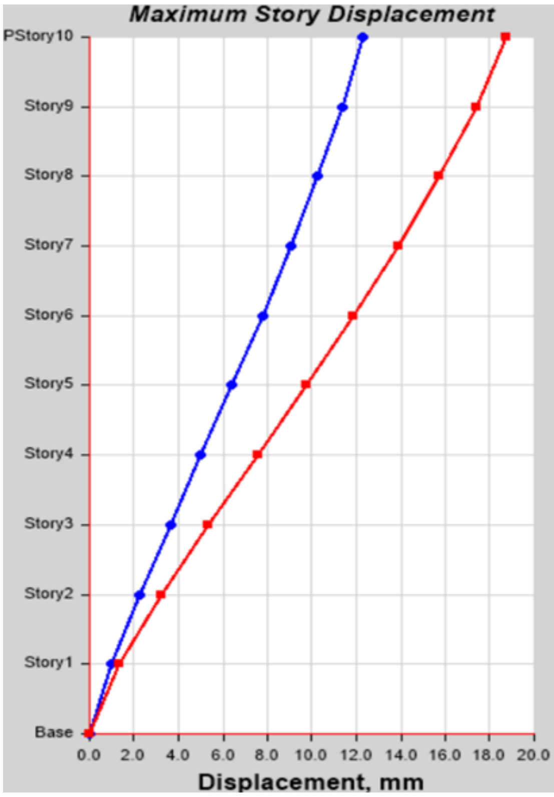

Figure 6. Storey displacement in model 1

Storey shear results and graphs

Figures 7 to 9 illustrate the value plots for both the X-axis and Y-axis in the X direction. It is notable that the plots are identical for both X and Y directions. A more detailed comparison will assist in determining the optimal results for various models in both the X and Y directions

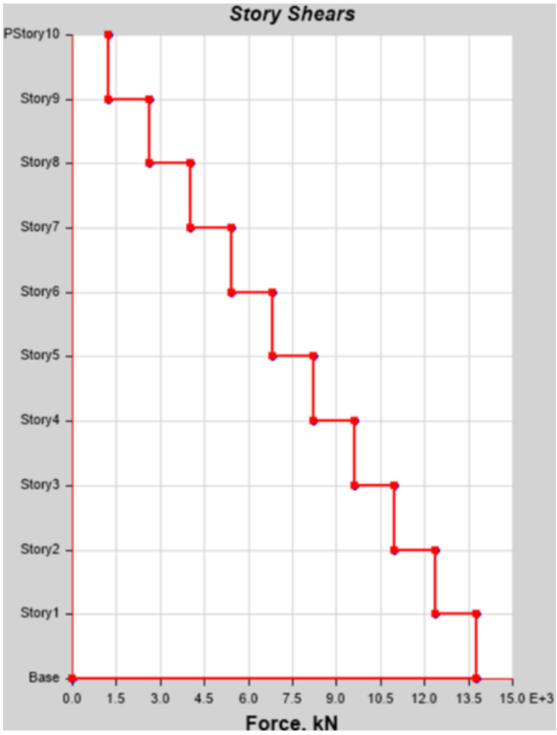

Figure 7. Storey displacement in model 1

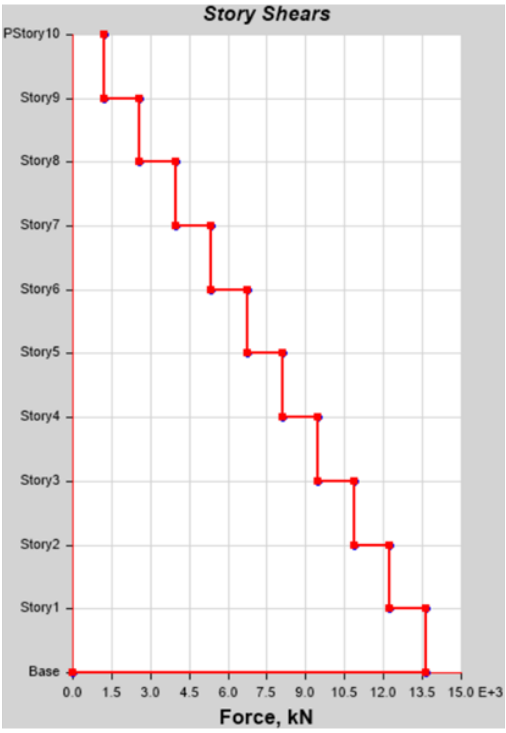

Figure 8. Storey displacement in model 2

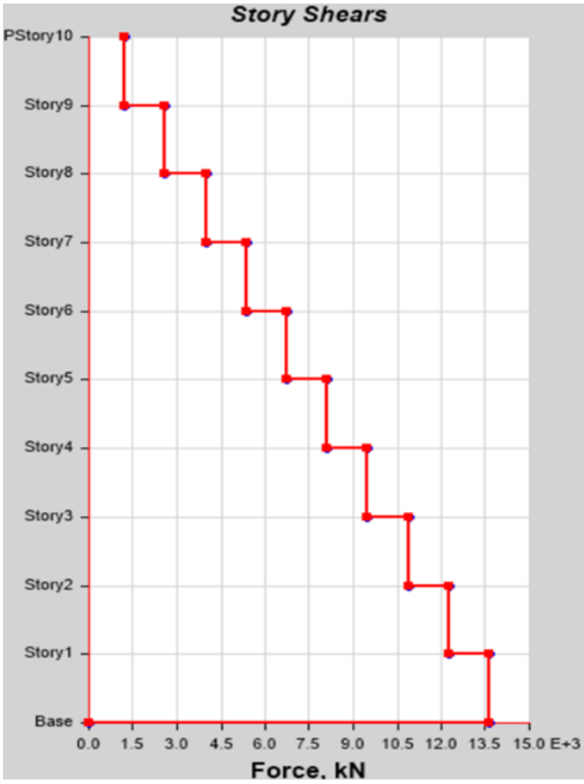

Figure 9. Storey displacement in model 3

Auto lateral load Results and Graphs

Figures 10 to 12 depict the value plots for the X-axis in the X direction and the Y-axis in the Y direction. The observation reveals that the plots are consistent for both X and Y directions. A more thorough comparison will aid in determining the optimal results for various models in both the X and Y directions.

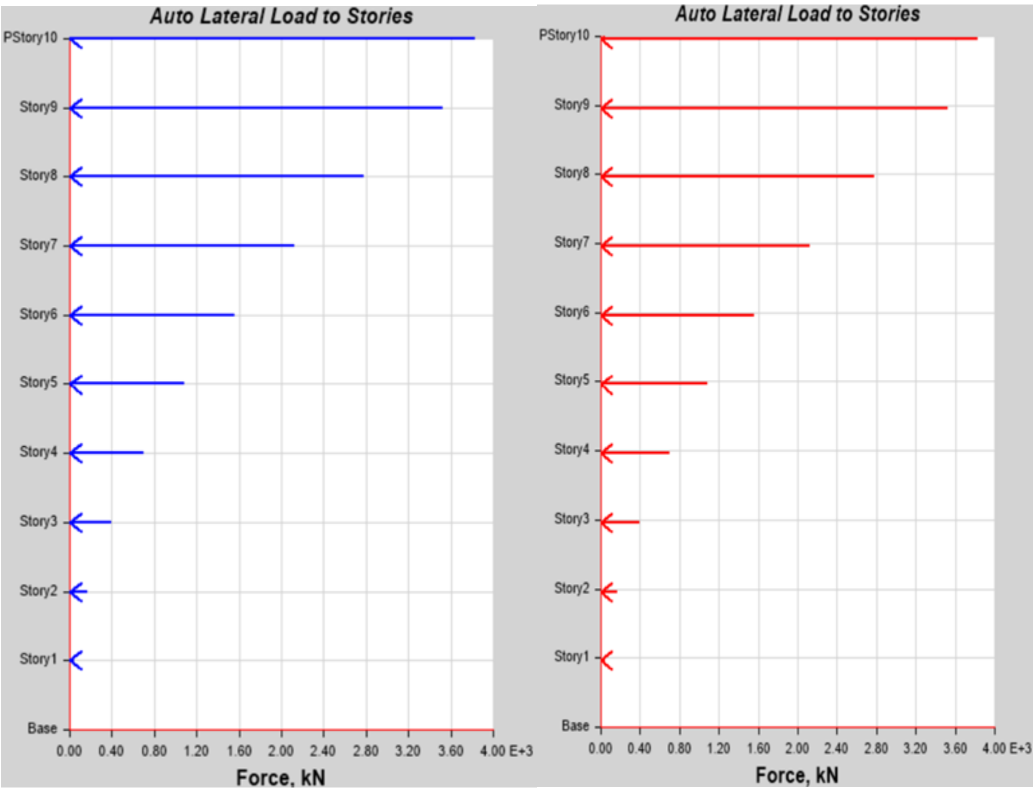

Figure 10. Auto lateral load in model 1

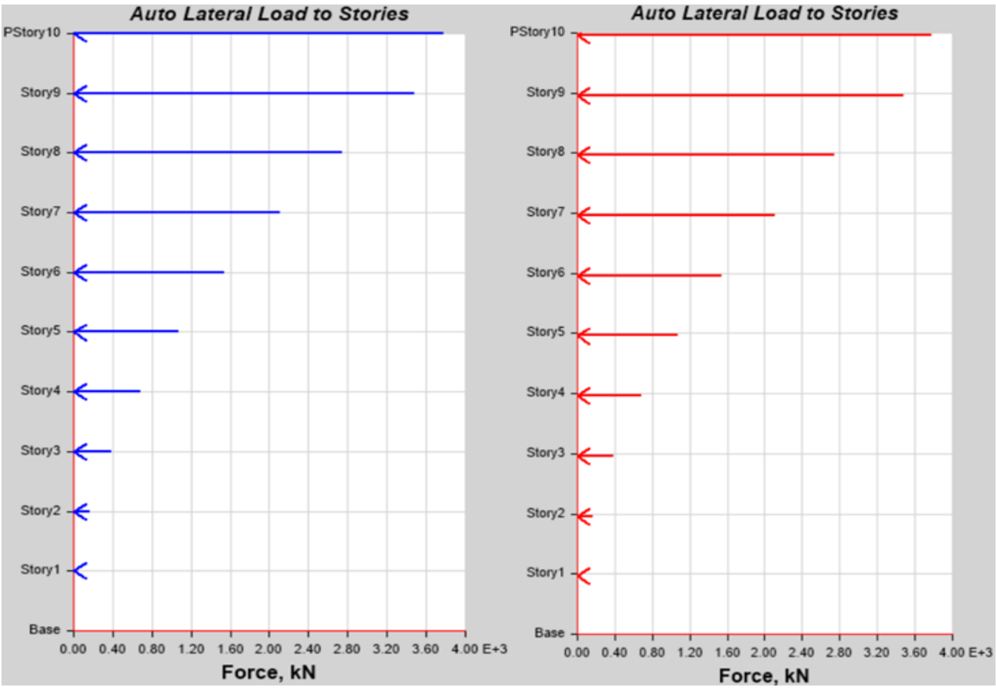

Figure 11. Auto lateral load in model 2

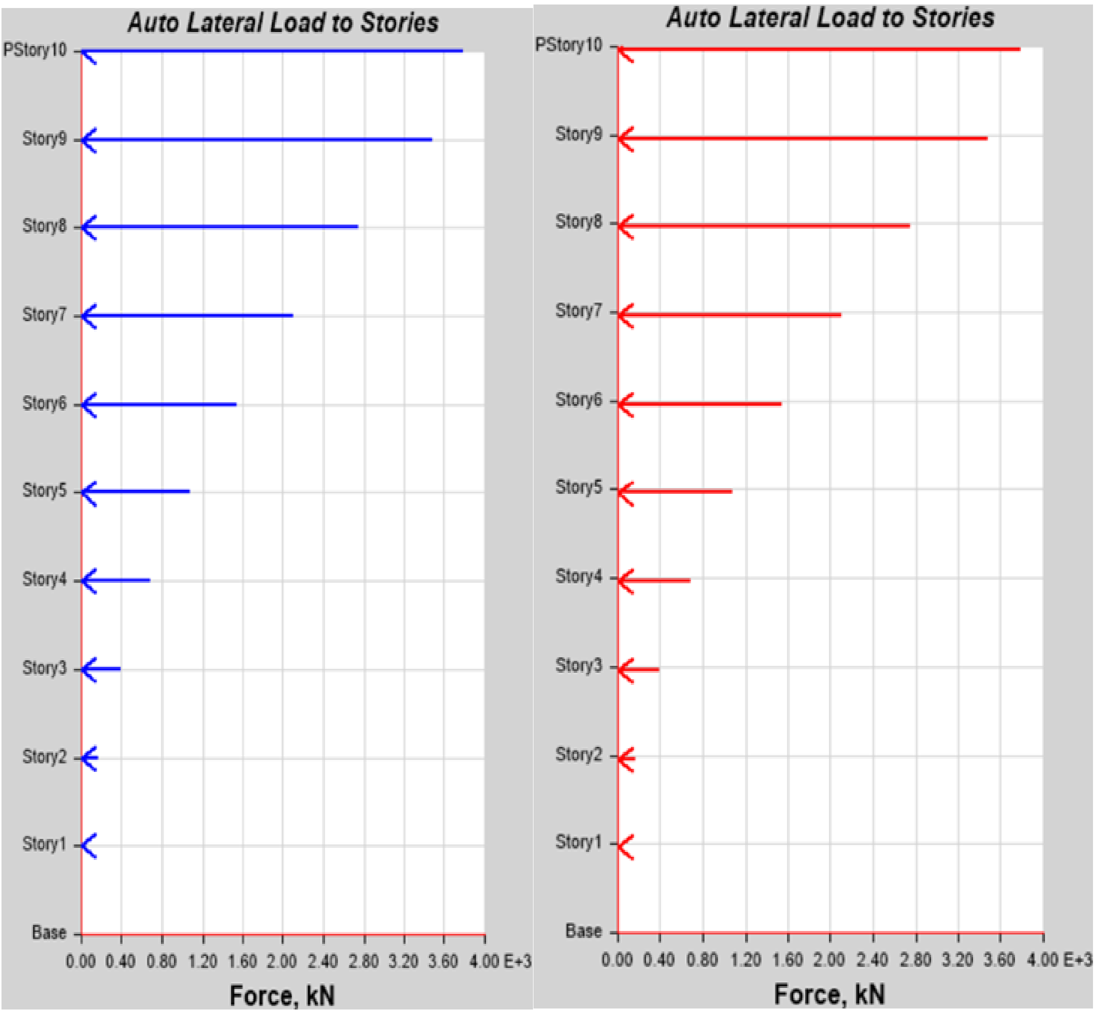

Figure 12. Auto lateral load in model 3

Results And Discussion on Comparison of Minimum Values

Minimum Storey displacement

Figures 13 and 14 suggest that Model 2, involving the analysis of a core in a core structure with fluid viscous dampers, demonstrates effective performance when assessing displacements in both the X and Y directions. This observation indicates that the fluid viscous dampers effectively mitigate lateral movements and reduce inter-story drifts. The primary purpose of these dampers is to dissipate energy and control the dynamic response during seismic events or wind loads. By integrating fluid viscous dampers within the core structure, they absorb and dissipate energy generated by lateral forces, resulting in reduced overall displacements and vibrations for the building [8] [9].

If the displacement results in both the X and Y directions are within acceptable limits, it suggests that the fluid viscous dampers are effectively absorbing and dissipating the energy, thus limiting the lateral deformations and ensuring better structural performance. However, it is essential to consider other factors as well when assessing the overall performance of the structure. These factors include inter-story drifts, base shear, and other relevant structural response parameters. Evaluating these parameters in conjunction with displacement results will provide a comprehensive understanding of the structural behavior and the effectiveness of the fluid viscous dampers. Additionally, it is important to compare the analysis results with the required design criteria and performance objectives specified for the project. This ensures that the displacement results, along with other performance indicators, meet the necessary standards and provide a safe and reliable structure [10].

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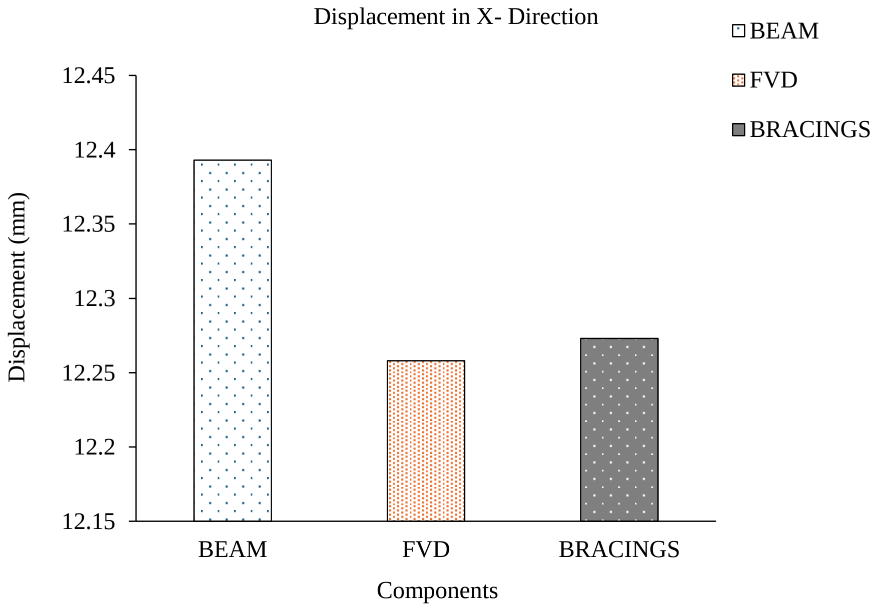

Figure 13. Minimum Storey displacement in X–direction of all the models

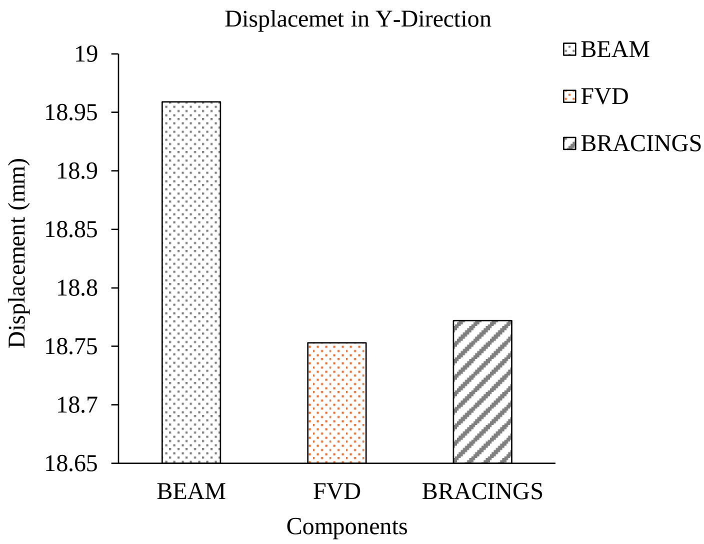

Figure 14. Minimum storey displacement in y–direction of all the models

Minimum Storey Shear

Figures 15 and 16 lead to the conclusion that in Model 2, effective performance of fluid viscous dampers in a core in core structure is indicated by favorable story shear results in both the X and Y directions. This suggests that the dampers efficiently reduce lateral forces, distributing them uniformly throughout the structure. Story shear pertains to the shear forces experienced at each floor level, and the integration of fluid viscous dampers within the core structure aids in absorbing and dissipating a substantial amount of energy. This, in turn, contributes to controlling and diminishing story shear forces. If the story shear results meet acceptable limits in both the X and Y directions, it signifies that the fluid viscous dampers are adept at mitigating lateral forces and ensuring a balanced load transfer across the structure. [11].

Nevertheless, it is crucial to account for additional structural response parameters, including inter-storey drifts, member forces, and overall structural stability, alongside the story shear results.

Examining these factors collectively offers a comprehensive insight into the structural behavior and the efficacy of fluid viscous dampers in upholding the integrity and performance of the core in core structure. Moreover, a critical step involves comparing the analysis results with project-specific design criteria and performance objectives. This verification ensures that the story shear results, along with other performance indicators, align with required standards, guaranteeing the establishment of a safe and resilient structure [12].

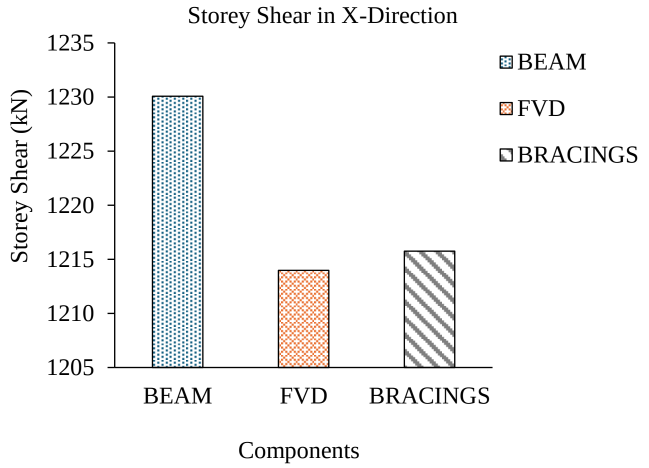

Figure 15. Minimum Storey Shear in X–direction of all the models

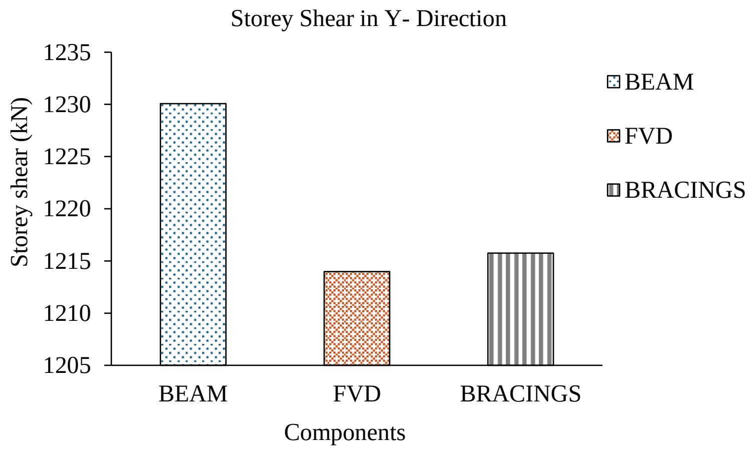

Figure 16. Minimum Storey Shear in Y–direction of all the models

Minimum autolateral loads

Inferences drawn from Figures 17 and 18 affirm that in Model 2, proficient performance of fluid viscous dampers within a core in core structure is indicated by favorable auto lateral load results in both the X and Y directions. This implies that the dampers adeptly mitigate the effects of lateral loads, contributing to an overall reduction in structural response. Auto lateral loads denote the automatically generated lateral forces during the analysis process, simulating the impact of wind or seismic loads on the structure. The dampers' effectiveness in these load scenarios suggests efficient absorption and dissipation of energy induced by lateral loads, leading to a diminished structural response [13].

Effective performance of fluid viscous dampers in mitigating auto lateral loads in both the X and Y directions signifies their adept control over the building's lateral displacements, leading to reduced inter-storey drifts and enhanced structural stability. This plays a crucial role in ensuring the overall performance and safety of the core in core structure. However, a comprehensive assessment of the structure's overall performance requires consideration of other factors, including inter-storey drifts, base shear, member forces, and relevant structural response parameters. Evaluating these parameters alongside the results of auto lateral loads provides a holistic understanding of the structural behavior and the efficacy of fluid viscous dampers.

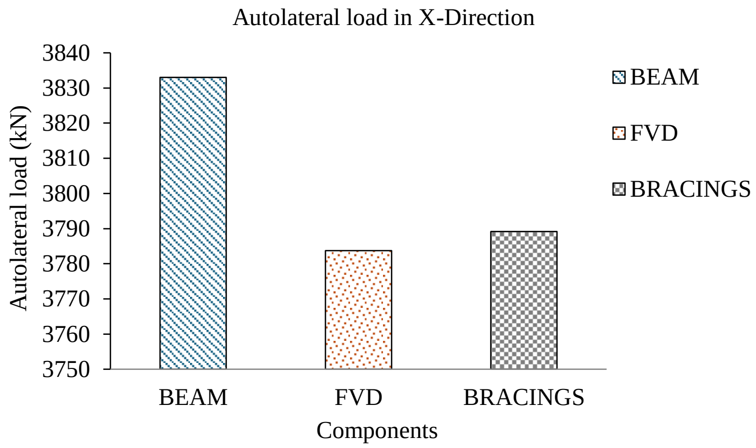

Figure 17. Minimum Autolateral load in X–direction of all the models

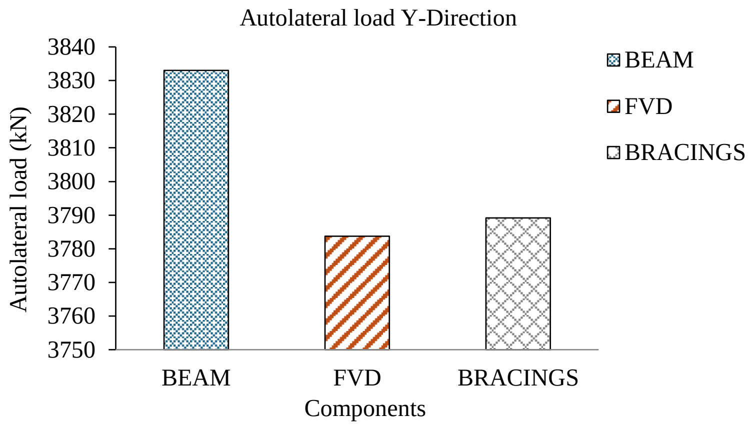

Figure 18. Minimum Autolateral load in Y–direction of all the models.

CONCLUSIONS

This research delves into the seismic analysis of a multistorey (G+10) core-in-core structure, incorporating beams, FVD, and bracings through the utilization of ETABS software. The conclusions drawn are based on Equivalent Static Analysis.

1. The fluid viscous dampers in the core in core structure are performing well in various aspects, including displacement results, story shear results, and auto lateral loads results in both the X and Y directions. This indicates that the fluid viscous dampers are effectively reducing the lateral forces, controlling displacements, distributing loads evenly, and improving the overall structural response.
2. The satisfactory performance of the fluid viscous dampers signifies their effectiveness in mitigating impact of the lateral loads, such as like wind or seismic forces, on the structure. They absorb and dissipate energy, reducing inter-story drifts, maintaining structural stability, and ensuring a balanced load transfer throughout the building.
3. *Energy Dissipation*: Fluid viscous dampers are specifically designed to dissipate energy during dynamic events, such as earthquakes or high wind loads. The effective performance of the dampers in dissipating energy helps reduce the overall structural response and minimize the potential damage to building.

4. *Structural Resilience*: In the presence of fluid viscous dampers enhances the structural resilience of the core in core structure. By absorbing and dissipating energy, the dampers help to limit deformations, control vibrations, and maintain the structural integrity under extreme loading conditions.
5. Fluid viscous dampers typically demand minimal maintenance and boast an extended service life. Their performance can be easily monitored, and any necessary adjustments or inspections can be conducted without significant disruption to the building occupants or operations.
6. *Cost Considerations*: While the initial cost of installing fluid viscous dampers may be higher than traditional structural systems, they can provide cost savings in the long run. The enhanced performance and reduced structural demands can result in a more efficient use of materials, potentially reducing construction and maintenance costs over the building's lifespan.

REFERENCES

1. Soni DP, Mistry BB. Qualitative review of seismic response of vertically irregular building frames. ISET J Earthq Technol Tech Note 2006; 43: 121–132.
2. Dargush GF, Green ML, Wang Y. Evolutionary Aseismic Design and Retrofit of Passively Damped Irregular Structures. In: 13th World Conference on Earthquake Engineering Vancouver, BC, Canada August. 2004, pp. 1–6.
3. Thakur R, Tiwary AK. Comparative study on the effectiveness of fluid viscous dampers and base isolation: an approach toward enhancing seismic performance of composite structures. Innov Infrastruct Solut 2023; 8: 267.
4. Hu S, Zhu S, Wang W, et al. Structural and nonstructural damage assessment of steel buildings equipped with self-centering energy-absorbing rocking core systems: A comparative study. J Constr Steel Res 2022; 198: 107559.
5. Seo J, Hu JW, Davaajamts B. Seismic performance evaluation of multistory reinforced concrete moment resisting frame structure with shear walls. Sustainability 2015; 7: 14287–14308.
6. Standard I. Criteria for earthquake resistant design of structures. Bur Indian Stand Part; 1.
7. Institution IS. Code of Practice for Plain and Reinforced Concrete: IS. Indian Standards Institution, 1965.
8. Zhao DH, Tong LL, Chen YQ, et al. Intensity-reduced Design for Structure with Fluid Viscous Dampers. Appl Mech Mater 2014; 638: 1818–1821.
9. Costa AG, Oliveira CS, Duarte RT. Influence of vertical irregularities on seismic response of buildings. In: Proceedings of the Ninth World Conference on Earthquake Engineering WCEE. 1988.
10. Poonam AK, Gupta AK. Study of response of structurally irregular building frames to seismic excitations. Int J Civil, Struct Environ Infrastruct Eng Res Dev 2012; 2: 25–31.
11. Ali MM, Moon KS. Advances in structural systems for tall buildings: emerging developments for contemporary urban giants. Buildings 2018; 8: 104.
12. Salawdeh S. Displacement based design of vertically irregular frame-wall structures. Eur Sch Adv Stud Reduct Seism risk (ROSE Sch.
13. Maula BH, Zhang L. Assessment of embankment factor safety using two commercially available programs in slope stability analysis. Procedia Eng 2011; 14: 559–566.

