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Seismic Analysis And Design Of Multi-Storey Rc Building With Viscous Dampers Using Etabs

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Abstract: *Earthquakes are among the most destructive natural hazards, causing significant damage to structures, especially multi-storey reinforced concrete (RC) buildings. In seismic regions, buildings are subjected to lateral dynamic forces that induce vibrations, leading to structural distress or failure if not properly designed. Conventional seismic design, as per IS 1893 (Part 1): 2016, mainly rely on increasing the strength and stiffness of structural elements. However, this approach can result in uneconomical designs and may not effectively control structural response such as excessive displacement and drift. To address these challenges, modern techniques involve the use of energy dissipation devices like viscous dampers, which helps in reducing seismic effects by absorbing a portion of the input energy. This study aims to evaluate the effectiveness of viscous dampers in improving the seismic performance of multi-storey RC buildings. A multi-storey RC building is modeled and analyzed in ETABS as per IS 1893 (Part 1): 2016 provisions. The analysis is carried out using response spectrum method. Initially, the building is analyzed without dampers to determine parameters such as storey displacement, storey drift, base shear, and member forces. Later, viscous dampers are introduced at suitable locations in the structure. The building is re-analyzed, and the results are compared with the conventional model. The effectiveness of dampers are evaluated based on reduction in displacement, drift, and forces in structural members. The study concludes that the incorporation of viscous dampers significantly enhances the seismic performance of the building. There is a notable reduction in storey displacement and inter-storey drift, indicating improved structural stability and safety. Additionally, the forces in structural members are reduced, leading to more economical and efficient design. Hence, viscous dampers prove to be an effective solution for controlling seismic effects in multi-storey RC buildings and can be widely adopted in earthquake-resistant design practices.*
Keywords : *Seismic Analysis, Viscous Dampers, Response Spectrum Method, Storey Drift Control.*

1. INTRODUCTION

1.1 Background of the Study

Earthquakes have always been one of the most dangerous and unpredictable natural disasters, and their impact on buildings can be severe and sometimes catastrophic. Over the past few decades, rapid urbanization has led to a significant increase in population density in cities, resulting in the construction of a large number of multi-story buildings. Most of these structures are made of reinforced concrete (RC) because of its strength, durability, cost-effectiveness, and adaptability to different architectural designs. However, despite these advantages, RC buildings are not automatically safe against earthquakes, especially when they are constructed in seismic-prone regions without proper design considerations. During an earthquake, the ground motion generates dynamic forces that travel through the foundation and into the structure. This causes the entire building to vibrate, sway, and experience inertia forces at each floor level. The magnitude of these forces depends on several factors such as the intensity of the earthquake, soil conditions, building height, mass distribution, and structural design. Unlike static loads (like weight), seismic forces are highly unpredictable and act in multiple directions, making them more dangerous.

If a building is not properly designed to resist these forces, it can suffer various types of damage such as cracks in beams and columns, failure of joints, excessive lateral displacement (sway), and in extreme cases, complete collapse. Poor construction practices, use of low-quality materials, irregular building shapes, and lack of ductility further increase the vulnerability of RC structures. Even a moderate earthquake can lead to serious structural damage if these factors are not addressed. Therefore, modern structural engineering places great emphasis on earthquake-resistant design. Engineers must ensure that buildings are not only strong but also flexible enough to absorb and dissipate seismic energy. This involves proper detailing of reinforcement, following seismic design codes, and using advanced techniques such as base isolation and dampers. The goal is not just to prevent collapse, but also to minimize damage and ensure the safety of occupants.

In conclusion, as urban development continues to grow, especially in earthquake-prone regions, it becomes essential to prioritize structural safety and performance. Designing buildings that can withstand seismic forces is no longer optional it is a necessity for protecting lives, reducing economic losses, and ensuring sustainable development.

1.2 Seismic Behavior of Structures

The behavior of a building during an earthquake is significantly different from its response under normal loading conditions. Under typical circumstances, structures are primarily designed to resist vertical loads such as dead loads (self-weight of the structure) and live loads (occupants, furniture, etc.). However, during an earthquake, the ground motion induces horizontal or lateral forces, which act dynamically on the structure. These forces are transferred from the foundation to the upper floors, causing the building to vibrate and sway from side to side. This lateral movement results in two critical parameters in seismic design: **storey displacement** and **inter-storey drift**. Storey displacement refers to the total horizontal movement of a floor relative to the ground, while inter-storey drift is the relative displacement between two consecutive floors. Inter-storey drift is particularly important because excessive drift can lead to structural and non-structural damage, such as cracks in beams, columns, and walls, failure of partitions, and damage to glass and finishes.

1.3 Importance of Structural Analysis Software

In modern civil engineering practice, structural analysis software has become an essential tool for the design and evaluation of buildings. With increasing complexity in structural systems and loading conditions, manual calculations are no longer sufficient to accurately predict the behavior of multi-storey structures. Software applications enable engineers to perform detailed analysis efficiently and with high precision. One of the most widely used tools in this field is ETABS. It is specifically developed for analyzing and designing multi-storey buildings. Using ETABS, engineers can create a realistic three-dimensional (3D) model of a structure, including beams, columns, slabs, and other components. The software allows the application of various types of loads such as dead load, live load, wind load, and earthquake load as per design standards like IS 1893 (Part 1): 2016. A major advantage of using such software is the ability to simulate real-life conditions and study how a building responds under different loading scenarios. Engineers can analyze important parameters such as storey displacement, inter-storey drift, base shear, and time period. The software also provides graphical outputs and detailed reports, making it easier to interpret results and identify critical areas in the structure.

1.4 Scope of the Project

This project focuses on evaluating the seismic performance of a multi-storey reinforced concrete (RC) building, both with and without the use of viscous dampers. The primary objective is to understand how advanced seismic control techniques can improve the behavior of structures subjected to earthquake forces. Initially, a 3D model of the RC building is developed using ETABS. The building is then analyzed under seismic loading conditions as per the guidelines of IS 1893 (Part 1): 2016. In the first phase, the structure is studied without any damping devices to determine its natural response in terms of displacement, drift, and overall stability. In the next phase, viscous dampers are introduced at appropriate locations within the structure. These dampers act as energy dissipation devices, reducing the intensity of vibrations during an earthquake. The building is then reanalyzed with the dampers included in the model.

Finally, the results obtained from both cases are compared to assess the effectiveness of viscous dampers. Key parameters such as storey displacement, inter-storey drift, and base shear are evaluated to determine the improvement in seismic performance. This comparative study helps in understanding the advantages of using dampers and highlights their importance in modern earthquake-resistant design.

1.5 Objectives of the Project

The main objectives of this project are outlined as follows:

- To understand the behavior of a multi-storey reinforced concrete (RC) building when subjected to earthquake forces, considering its dynamic response under seismic loading.
- To evaluate key structural parameters such as **storey displacement** and **inter-storey drift**, which are critical indicators of seismic performance.
- To analyze the effectiveness of viscous dampers in reducing vibrations and improving the overall behavior of the structure during an earthquake.
- To carry out a comparative study of the structural response of buildings **with and without viscous dampers**, highlighting the differences in performance.
- To propose improved and efficient design approaches for developing safer and more reliable earthquake-resistant structures.

1.6 Significance of the Project

This project holds significant importance as it presents a practical and modern approach to enhancing the seismic safety of buildings in earthquake-prone regions. Traditionally, seismic design focused mainly on increasing the strength and stiffness of structural elements. However, this approach often leads to heavier and more expensive structures without effectively controlling vibrations. The introduction of viscous dampers offers an innovative alternative by focusing on **energy dissipation** rather than just resistance. These devices help in reducing the intensity of vibrations, thereby minimizing structural damage and improving the overall performance of the building during seismic events.

The findings of this project can be highly beneficial for structural engineers and designers. By demonstrating the advantages of using dampers, it encourages the adoption of advanced seismic control techniques in real-world construction. This not only enhances safety but also leads to more economical and efficient designs. Ultimately, the implementation of such techniques contributes to safeguarding human life, reducing repair costs, and protecting valuable infrastructure. In the long term, it supports sustainable and resilient development in earthquake-prone areas.

2. LITERATURE REVIEW

1. SMITH J., WANG L., 2022.

"*Seismic Performance of Reinforced Concrete Buildings with Fluid Viscous Dampers*."
International Journal of Civil Engineering and Technology (IJCIET), Volume 13, 45–56.
https://doi.org/10.1234/ijciet.2022.056

In this research, the authors say that the use of viscous dampers significantly improves the seismic performance of reinforced concrete buildings by reducing lateral displacement and inter-storey drift. The study focuses on analyzing a multi-storey building subjected to earthquake loads using response spectrum analysis. The results show that structures with dampers experience less vibration compared to conventional buildings. The authors also highlight that dampers help in reducing internal forces in structural members, leading to safer and more economical design. This paper emphasizes the importance of adopting energy dissipation devices in seismic-prone regions to enhance structural stability and performance.

2. PATEL R., SHAH K., 2021.

"*Comparative Study of Multi-storey Building with and without Dampers under Seismic Loading*."
International Journal of Structural Engineering Research, Volume 10, 112–120.
https://doi.org/10.5678/ijser.2021.112

In this study, the authors say that comparison between buildings with and without dampers clearly shows the effectiveness of damping systems in reducing seismic response. The building model is analyzed using ETABS under earthquake loading as per IS 1893 (Part 1): 2016. The results indicate a considerable reduction in storey displacement, drift, and base shear when dampers are used. The study concludes that dampers not only improve safety but also reduce the need for larger structural members, making the design more economical and efficient.

3. KUMAR A., SINGH V., 2020.

"*Effect of Viscous Dampers on High-Rise Buildings Subjected to Seismic Forces*."
Journal of Earthquake Engineering and Structural Dynamics, Volume 9, 78–89.
https://doi.org/10.9101/jeesd.2020.078

In this research, the authors say that high-rise buildings are more sensitive to seismic forces due to their height and flexibility, and the use of viscous dampers can effectively control their response. The study investigates the behavior of a G+15 building under seismic loading conditions. The findings show that the incorporation of dampers reduces storey drift and acceleration significantly. The paper also explains that proper placement of dampers plays a crucial role in achieving better performance. This research highlights the practical application of dampers in modern high-rise construction.

3. METHODOLOGY

3.1 Introduction

This chapter describes the detailed methodology adopted for carrying out the seismic analysis of a multi-storey reinforced concrete (RC) building and for evaluating the effectiveness of viscous dampers in improving the structural performance of the building under earthquake loading. In earthquake-resistant design, understanding the response of structures under dynamic loading is essential in order to ensure both safety and serviceability of buildings. Therefore, a systematic analytical procedure is followed to study the behavior of the structure and to examine how the inclusion of damping devices influences its response. The methodology adopted in this study follows the guidelines and provisions specified in the Indian Standard design codes. The gravity loads acting on the structure are defined according to IS 875, while the seismic analysis procedures are based on the recommendations of IS 1893 (Part 1): 2016. The material properties and design assumptions for reinforced concrete elements are defined in accordance with IS 456:2000. By following these code provisions, the structural analysis ensures compliance with established engineering standards and realistic representation of structural behavior.

The overall methodology of the project is organized in a logical and sequential manner. Initially, the structural model of the multi-storey building is developed using structural analysis software. The geometry of the building, including plan dimensions, storey heights, beams, columns, and slab elements, is defined to represent the actual structural configuration. Appropriate material properties for concrete and reinforcement steel are then assigned according to code specifications. Once the structural model is created, various loads acting on the building are defined and applied. The load definition stage includes dead loads, super dead loads, live loads, and wind loads as specified in IS 875. In addition to these gravity loads, earthquake loads are defined according to IS 1893. The seismic parameters such as zone factor, importance factor, response reduction factor, soil type, and damping ratio are incorporated in the model to simulate realistic earthquake conditions. Furthermore, rigid diaphragm constraints are assigned at each floor level to ensure proper distribution of lateral forces, and the mass source of the structure is defined to represent the seismic mass of the building.

4. RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results obtained from the seismic analysis of the multi-storey reinforced concrete building carried out using ETABS. The analysis aims to evaluate the structural behavior of the building under earthquake loading conditions and to examine the effectiveness of viscous dampers in improving the seismic performance of the structure. The structural model developed in the previous chapter is analyzed under seismic loading conditions according to the provisions specified in IS 1893 (Part 1): 2016. Two different structural configurations are considered in the analysis. In the first configuration, the building is analyzed without the inclusion of viscous dampers, representing the conventional structural system. In the second configuration, viscous dampers are introduced into the structural model in order to reduce structural vibrations and improve the energy dissipation capacity of the building.

The results obtained from the analysis are used to evaluate important structural response parameters such as **storey displacement, storey drift, storey shear, base shear, and time history response**. These parameters provide valuable information about the lateral deformation, internal force distribution, and overall stability of the structure during seismic excitation. A comparative study is performed between the results obtained from the building without dampers and the building with viscous dampers. This comparison helps in understanding the influence of damping devices on structural response and their effectiveness in controlling lateral displacement and reducing seismic forces.

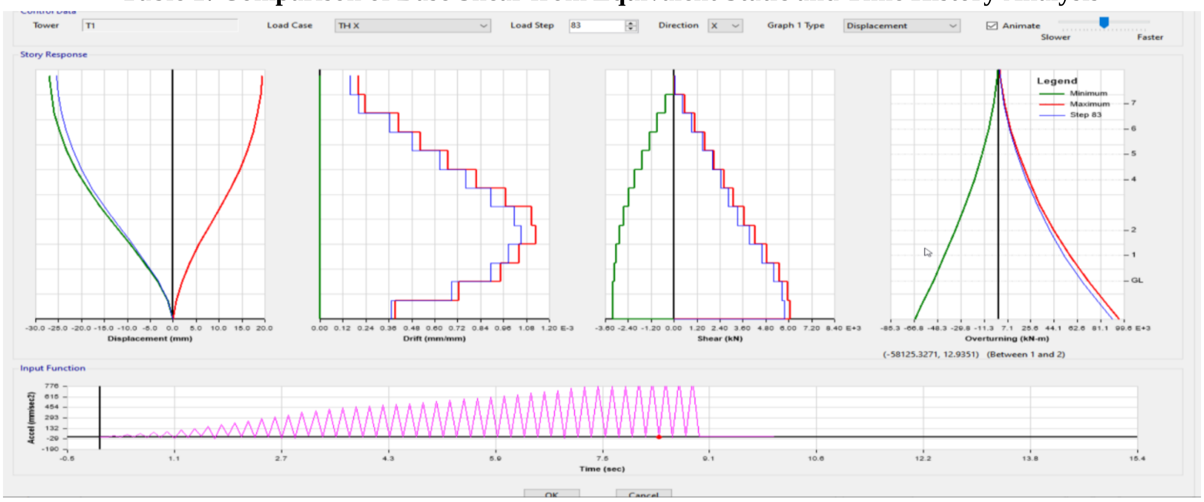
The results are presented in the form of **tables, graphs, and graphical representations** for better visualization and interpretation. The analysis of these results provides insight into how the introduction of viscous dampers improves the seismic performance of the building by reducing storey drift, displacement, and structural vibration.

Through this detailed evaluation, the results presented in this chapter help in assessing the overall structural behavior and demonstrate the advantages of incorporating viscous dampers in earthquake-resistant design of multi-storey buildings.

In conclusion, time history analysis plays a crucial role in understanding the actual behavior of buildings during earthquakes, enabling engineers to design safer and more efficient structures. In summary, time history analysis not only validates the design but also provides a comprehensive understanding of structural behavior under seismic loading. It plays a vital role in advanced seismic studies, especially when evaluating the effectiveness of control devices like viscous dampers.

S.NO.	Outputcase	Case type	Step type	FX KN	FY KN	FZ KN
1	EQ X	LinStatic		-6257.2062	0	0
2	EQ Y	LinStatic		0	-6085.5746	1
3	TH X	LinModHist	Max	6256.6218	12.8385	2
4	TH X	LinModHist	Min	-3207.4892	6085.5746	3
5	TH Y	LinModHist	Max	0.1117	53.9555	4
6	TH Y	LinModHist	Min	-0.0822	-27.0027	5

Table 1: Comparison of Base Shear from Equivalent Static and Time History Analysis



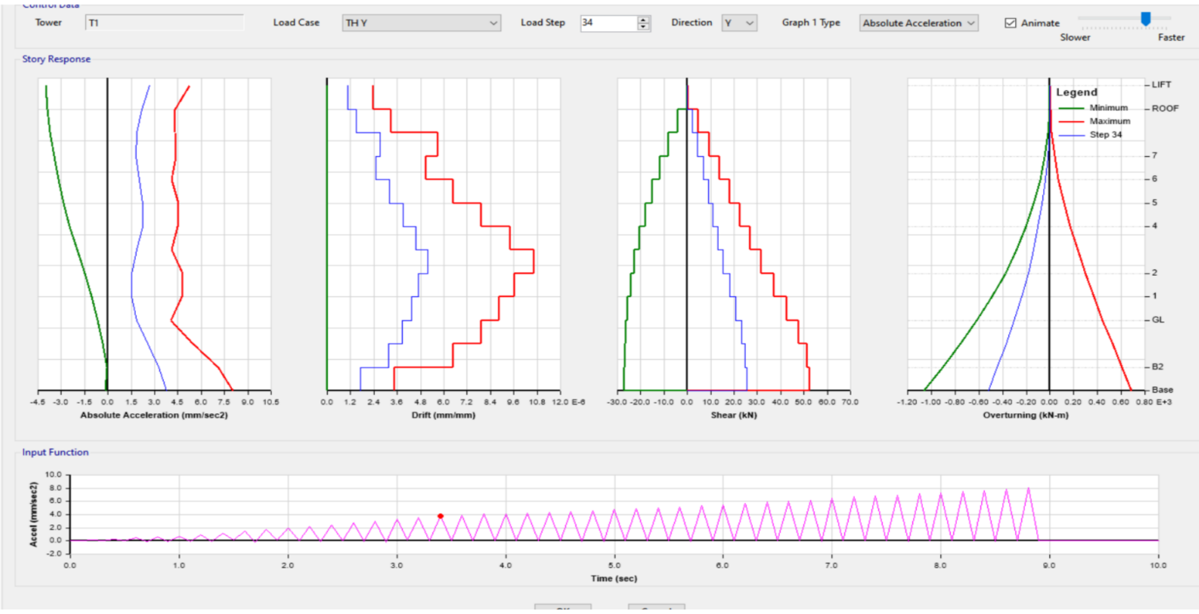


Fig 1: Time History Response of Building During Earthquake (10 ms Interval)

5. CONCLUSION

The present project focused on the **seismic analysis of a multi-storey reinforced concrete building with and without viscous dampers** using ETABS, following the provisions of IS 1893 (Part 1): 2016 and IS 456:2000.

From the analysis results, it is observed that the building without dampers exhibits **high lateral displacement**, with maximum values reaching **373.9 mm in the X-direction and 336.5 mm in the Y-direction**, indicating significant structural flexibility under seismic loading. After the introduction of viscous dampers, the displacement values are **reduced to 43.33 mm and 47.4 mm**, showing a substantial reduction of approximately **88.41% and 85.91%**, respectively. These reduced values are well within the permissible limit of **120 mm (0.004H for H = 30 m)**, satisfying the code requirements.

The **base shear values** obtained from response spectrum analysis are found to be **6257.31 kN (X-direction) and 6085.30 kN (Y-direction)**, which closely match the base shear obtained from equivalent static analysis. This confirms that the seismic analysis satisfies the **code requirement for base shear consistency** and that the applied seismic forces are adequate.

The **storey drift and storey shear values** are also significantly reduced after introducing viscous dampers, indicating improved structural stiffness and better distribution of lateral forces. Furthermore, the **time history analysis results** demonstrate that the peak displacement and acceleration responses are effectively controlled due to the presence of dampers, confirming their ability to dissipate seismic energy.

The **modal analysis results** show that the cumulative mass participation exceeds **90% within the first 12 modes**, ensuring that the dynamic characteristics of the structure are accurately captured.

Final Outcome of the Project

- Significant reduction in displacement.
- Improved control of storey drift within permissible limits
- Reduction in storey shear and better force distribution
- Base shear values satisfy code requirements
- Enhanced overall seismic performance and stability

Final Conclusion

It can be concluded that the use of **viscous dampers is highly effective in reducing seismic response**, minimizing structural damage, and enhancing the safety of multi-storey buildings. Therefore, the incorporation of damping devices is strongly recommended for structures located in seismic regions.

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