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Engineering

PERFORMANCE EVALUATION OF DIFFERENT DAMPERS FOR STEEL FRAMED STRUCTURE

Mohammed Yunus A H	M.Tech (CADS), DoS in Civil Engineering, University BDT College of Engineering, Davangere, Karnataka, India
Dr. N Venkata Ramana*	Associate Professor, DoS in Civil Engineering, University BDT College of Engineering, Davangere, Karnataka, India*Corresponding Author

ABSTRACT The objective of this project is to assess the seismic performance of steel-framed structures with a focus on their ability to resist lateral loads, minimize story displacement, and reduce drift. By incorporating or omitting various dampers within the structural systems, the study aims to evaluate their effectiveness in enhancing seismic resilience. Conducted in accordance with Indian standards and using ETABS for the analysis, the project seeks to identify the most efficient structural configurations that ensure safety and stability in high-rise buildings. The outcomes of this research will provide critical insights for structural engineers and designers in optimizing material use and implementing seismic mitigation strategies.

KEYWORDS : Steel Framed Structure, Friction Dampers, Fluid Viscous Dampers, Tuned Mass Dampers, Story displacement, Story drift, Zone V, ETABS

INTRODUCTION

Steel-framed structures are increasingly favoured in contemporary construction due to their remarkable strength, durability, and adaptability. These structures rely on steel components arranged in a grid pattern to support floors, roofs, and walls. Key elements include columns, which resist compressive forces, and beams, which manage bending and shear stresses. Together, these components create a robust framework capable of carrying substantial loads and enduring diverse environmental challenges.

The advantages of steel-framed structures, such as their superior strength, durability, and flexibility, make them an ideal choice for a wide range of construction projects. However, it is crucial to address challenges like corrosion, fire resistance, and thermal conductivity to ensure the longevity and safety of these structures. With careful design, regular maintenance, and appropriate protective measures, steel structures can offer sustainable and resilient solutions tailored to modern construction demands.

TYPES OF DAMPERS USED

A. FRICTION DAMPERS: Friction dampers are crucial components designed to mitigate the impact of dynamic forces, such as those encountered during seismic events, by dissipating energy. These devices operate by converting kinetic energy into heat through the frictional resistance generated between sliding surfaces made of high-friction materials. This energy dissipation reduces vibrations and enhances the structural integrity of buildings.

B. FLUID VISCOUS DAMPERS: Fluid viscous dampers play a significant role in attenuating seismic forces and other dynamic loads, such as wind-induced vibrations. These devices function by utilizing the resistance offered by fluid movement to dissipate energy, thereby reducing the vibrational response of structures and improving their overall stability.

C. TUNED MASS DAMPERS (TMDS): Tuned Mass Dampers are engineered to counteract mechanical vibrations in structures, effectively reducing their amplitude. By doing so, TMDs improve the comfort and stability of buildings, particularly in the face of seismic activities and wind loads. These devices are especially beneficial in tall buildings and large-scale structures, where they help to mitigate vibration-related issues.

OBJECTIVES

The goals of the learning can be listed following:

1) Analyse the influence of seismic events on a G+8 steel-framed structure by examining key metrics such as maximum story displacement and maximum story drifts.

2) Conduct a comparative study of the performance of structural elements under both seismic and wind loads. This includes scenarios without dampers, as well as with the integration of friction dampers, fluid viscous dampers, and tuned mass dampers.

3) Evaluate the seismic performance of Steel-framed structures by comparing cases with and without the use of various types of dampers.

METHODOLOGY

In this study, a static seismic analysis, often referred to as the equivalent static or simplified seismic method, is utilized to assess the seismic performance of structures subjected to earthquake-induced forces. This method simplifies the complex dynamic behaviour of earthquakes by translating them into static forces that can be more readily applied to the structure, thereby easing the process of evaluating and designing for earthquake resistance.

The project specifically examines a G+8 steel-framed building, constructed using high-strength steel to ensure robust performance under significant loads and adverse conditions. The analysis is conducted using ETABS 2021, following the provisions of IS 1893:2016, with key parameters sourced from relevant tables within the standard. The focus is on assessing the effectiveness of various dampers in enhancing the seismic resilience of the structure, aligning with the objectives of the project titled "Performance Evaluation of Steel Framed Structure with Various Dampers."

Table 1: Structural Details

Sl. No	Item	Specifications
01	Material	Fe 500 grade Steel
02	No. of Stories	G + 08
03	No. of Bay in X – Direction	06
04	No. of Bay in Y – Direction	04
05	Bay spacing in X – Direction	5000 mm
06	Bay spacing in Y – Direction	6000 mm
07	Floor Height	3500 mm
08	Depth of Slab	150 mm
09	Size of Column	400 mm X 400 mm
10	Size of Beam	450mm X 450mm
11	Seismic Zone Considered	Zone 5
12	Support Condition	Fixed Supports

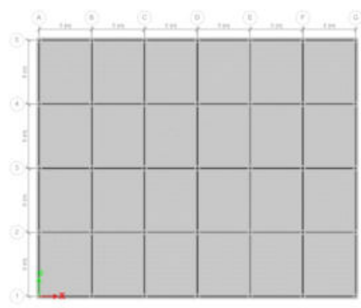

Figure 1: Floor Plan

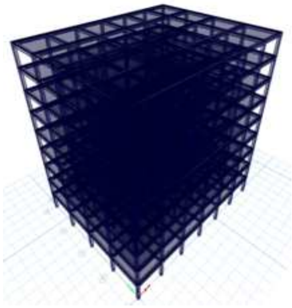

Figure 2: 3D Elevation of the Structure

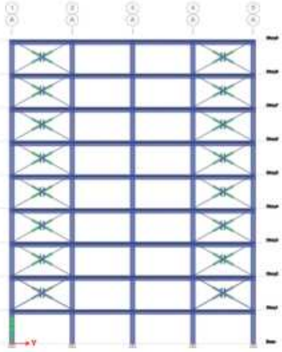

Figure 3: Front Elevation with Friction Dampers

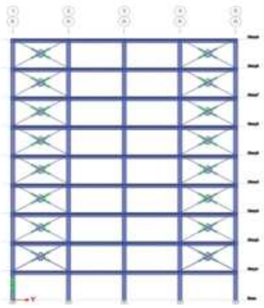

Figure 4: Front Elevation with Fluid Viscous Dampers

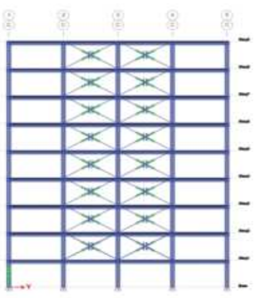

Figure 5: Front Elevation with Tuned Mass Dampers

RESULTS AND DISCUSSION

In the study a steel-framed structure, as detailed in Table 1, was subjected to analysis under different conditions: without dampers, and with the inclusion of Friction Dampers, Fluid Viscous Dampers, and Tuned Mass Dampers. This analysis adhered to the relevant Indian Standards. The structural performance was assessed under each scenario, and a detailed comparison was made to draw a comprehensive conclusion regarding the effectiveness of these dampers.

MAXIMUM STORY DISPLACEMENT:

In the evaluation of a steel-framed structure, both Fluid Viscous Dampers and Tuned Mass Dampers demonstrate significant efficacy in minimizing maximum story displacements, ensuring these remain comfortably within the permissible limit of 126 mm. These dampers enhance the structural system's capacity to absorb and dissipate seismic energy effectively. Overall, while all types of dampers contribute to improved seismic performance relative to a structure without dampers, Fluid Viscous Dampers and Tuned Mass Dampers provide superior control over story displacements, thereby enhancing the structure's safety and compliance with IS 1893:2016 seismic performance criteria.

Table 2: Maximum Story Displacement

Story No.	Without Dampers (mm)	FD (mm)	FVD (mm)	TMD (mm)
Base	0.0000	0.0000	0.0000	0.0000
1	6.1410	6.2160	6.1710	6.6510
2	13.999	8.0408	9.8710	8.1900
3	21.905	11.544	13.329	10.569
4	28.114	14.780	17.344	13.655
5	35.858	18.245	21.577	16.667
6	39.139	21.669	25.842	19.119
7	44.223	25.695	29.340	23.814
8	47.693	28.115	32.212	26.230
9	49.717	31.384	34.895	29.400

Figure 6: Maximum Story Displacement

MAXIMUM STORY DRIFTS

The integration of dampers—specifically friction and tuned mass dampers—substantially enhances the seismic performance of a G+8 steel-framed structure. The observed reduction in maximum story drift values demonstrates improved stability and safety. Among the different dampers analyzed, structures equipped with friction dampers show the most significant reduction in story drift, closely followed by those utilizing tuned mass dampers and fluid viscous dampers. These findings underscore the importance of incorporating damping systems into seismic design to preserve structural integrity and ensure compliance with IS 1893:2016 standards.

Table 3: Maximum Story Drift

Story No.	Without Dampers (mm)	FD (mm)	FVD (mm)	TMD (mm)
Base	0.00000	0.00000	0.00000	0.00000
1	0.00169	0.00187	0.00171	0.00186
2	0.00230	0.00059	0.00078	0.00050
3	0.00241	0.00086	0.00120	0.00070
4	0.00179	0.00099	0.00119	0.00079
5	0.00167	0.00103	0.00120	0.00090
6	0.00149	0.00103	0.00109	0.00089
7	0.00132	0.00095	0.00105	0.00093
8	0.00090	0.00089	0.00089	0.00091
9	0.00050	0.00079	0.00069	0.00077

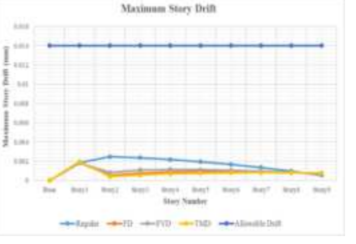

Figure 7: Maximum Story Drifts

CONCLUSIONS.

The installation of dampers leads to a significant reduction in maximum story displacement, with Friction Dampers achieving a reduction of 54.26%, Fluid Viscous Dampers reducing it by 45.16%, and Tuned Mass Dampers achieving the highest reduction at 58.93%. All reductions fall comfortably within the permissible limit of 126 mm. Additionally, the use of dampers substantially decreases maximum story drift. Friction Dampers reduce drift by 72.88%, Fluid Viscous Dampers by 61.33%, and Tuned Mass Dampers by 78.22%, all within the permissible limit of 0.014.

Steel-framed structures demonstrate effective performance both with and without the use of dampers, as their maximum story displacements and drifts remain comfortably within the allowable limit of 126 mm in both cases. The inherent properties of steel, including enhanced ductility, reduced weight, and superior energy dissipation, make it a reliable and preferred choice for ensuring building safety during seismic events.

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