Numerical Investigation on Seismic Analysis of Framed Structures Using Viscous Dampers

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***Abstract*— Earthquakes pose significant risks to structures, especially when seismic design considerations are inadequate. To enhance structural resilience, modern engineering integrates energy dissipation devices such as fluid viscous dampers (FVDs). This study investigates the seismic performance of a G+5 reinforced concrete framed structure equipped with FVDs. The analysis is conducted using ETABS v19 software, adhering to IS 1893:2016 seismic provisions, with the structure located in seismic zone III. A comparative evaluation is carried out using the response spectrum method to assess the structure's behavior with and without dampers. Key performance parameters such as maximum storey displacement, storey drift, storey stiffness, overturning moment, and storey shear are analyzed. Results indicate a substantial improvement in seismic performance with the inclusion of viscous dampers, highlighting their effectiveness in enhancing structural safety and serviceability during seismic events.**

***Index Terms*— Seismic Analysis, Fluid Viscous Dampers, ETABS, Response Spectrum Method, Earthquake Engineering, Storey Displacement, Structural Dynamics.**

I.INTRODUCTION

An earthquake is a natural phenomenon characterized by the shaking or trembling of the Earth's surface. It occurs when two tectonic plates, which are constantly moving, become locked or struck due to friction at their boundaries, stress accumulates over time. When the stress exceeds the strength of the rocks, it is released in the form of earthquake. The seismic waves generated by the sudden release of energy radiate outwards from the earthquake's epicenter, causing the ground to shake.

The impact of an earthquake can range from minor tremors that go unnoticed to catastrophic events that result in significant destruction, loss of life, and economic damage. The severity of an earthquake's effects depends on the various factors, including its magnitude, depth, distance from populated areas, local geology, and the response of the buildings and the infrastructure due to shaking.

Seismic analysis refers to the process of evaluating the response of the structures to seismic waves or vibrations. It involves studying the behavior of the structures, such as buildings, bridges, dams and other infrastructure under seismic forces, which are generated by earthquake. The primary goal of seismic analysis is to ensure that structures can withstand the shaking and ground motion caused by earthquake and remain functional after seismic events.

II. LITERATURE REVIEW

Sairam Baikhan, D. Karunakar et al., (2022) Generally in this paper they studied the G+9 reinforced concrete structure within the proliferation of earthquake analysis using SAP-2000.Seismic Analysis of the structures is done and analyzed. This paper is partially relevant to this project because of incorporating fluid viscous dampers. The G+9 RCC structure has been analysed by means of connection of fluid viscous dampers situated at numerous patterns in two various systems such as diagonal bracing and combined bracing system by a total of 30 types has been espoused by trial based in various stimulating pattern. The finest optimum arrangement of fluid viscous damper had recommended to use for seismic resistant structure for vibration control system. The best optimum bracing patterns, which reduces the maximum lateral displacements, are wing pattern, diagonal sequence, X shape. By comparing all the best optimum arrangements in each system, namely diagonal and combined bracing system. The vital time steadily decreases to the unbraced edifice.

Yash Chhatani, Prashant Y Pawade, et al., (2021) Irregular model and regular model were considered which were analyzed exploitation ETABS2018 to see the unstable reaction of the structure. In this study, they considered Equivalent Static Method and Response Spectrum Method. Because of using Irregular shape and Response Spectrum method, it is more suitable for this project. The models were analyzed exploitation static and dynamic ways, parameters through-about being displacement, storey drift, torsional irregularity. They suggested that the outcome of the response spectrum method is precise, when contrasted and consequences of Equivalent Static Method. The performance of the regular model was only good in base shear and storey shear and in other responses it is vulnerable to earthquake. The irregular model was good in every response except in base shear and storey shear.

M. R. Solaimani Nezhad, M.Mahmoudi, et al., (2021) In this paper a single- storey single-span frame with Y- shaped bracing was considered and subjected to cyclic load experimentally and analytically in two cases of with and without yielding diagonal damper. Analytical analysis was done using ABAQUS software using Push over analysis method. In this research, a yielding diagonal damper was utilized on the long member of the bracing to increase ductility capacity and reduce the risk of buckling. However, the dampers increase the capacity for energy absorption by about 30%. Examination of the results reveals that adding a damper to the frame causes that the hysteresis behavior of frame be almost symmetrical, which sudden drop of strength is not absorbed in them. Using damper in the frame lessens the forces applied to the structural members(column-beam-bracing). Using dampers with lower capacities is more effective in decreasing the shear capacity.

III. DAMPERS

A damper is a device used to control or dampen the motion or oscillation of a structure by dissipating energy. Dampers are commonly used in various applications to reduce the vibrations, oscillations, or the effect of the external forces. They work by absorbing and dissipating energy indifferent forms, such as heat, fluid flow, or mechanical resistance.

In this paper, Fluid Viscous Dampers are used. Fluid viscous dampers (FVD) are devices used to reduce the effects of vibrations caused by earthquakes, wind, or other external forces. They work by dissipating the energy of the vibrations as heat by passing the fluid through a constriction, which generates a resistance force.

IV. METHODOLOGY

Literature Review: A literature review is an essential component of research that involve reviewing and analyzing published literature and research studies relevant to the topic or research question.

Modelling: The first step is to create a detailed three- dimensional geometric model of the structure in ETABS. This include defining structural elements, assigning material properties, assigning loads for the structure.

Analysis & Design: Response Spectrum method of analysis is carried out. Define the type of analysis, load combinations, analysis parameters. After setting up the analysis, the model is analyzed using ETABS.

Results and Discussion: In ETABS research section provides the output and data related to the analysis. The discussion part involves provides the interpretation and analysis of the obtained results.

V. MODELLING

The model is created in ETABS. The Display units is set to Metric SI and the steel and concrete Design as IS 800:2007 & IS 456:2000. A new grid system is created as per the required plan configuration. The System origin is specified for each grid system in terms of the Global Coordinates. The Bottom storey and top storey of each grid system is selected from the drop- down menu. The grid lines can be manually added in both X and Y direction in terms of spacing or ordinates

Grade of concrete	M30
Grade of steel	Fe500

Type of the building	Regular building (Rectangular shaped)
No of bays	5
Spacing of bay	3m x 3m
Height of base storey	4m
Height of remaining	3m

storey	
Number of floors	6

Size of beam	300mm x 400mm
Size of column	450mm x 450mm
Thickness of slab	150mm

For beam sections, the design type is set to M30 design and the corresponding rebar material is selected. The desirable cover to longitudinal reinforcement bars are entered manually. For Column sections, the design type is as set to P-M2-M3 design and the section properties of the column are uploaded. The details of reinforcement configuration type and the confinement bar type are also given. The properties of the longitudinal and the confinement bars are entered separately. The diameter and the number of bars are entered manually. For Slab section the slab material is selected from the list. It is important to select the modelling type of the slab to shell-thin, the type of slab to slab and the details of the slab are entered. The Earthquake load pattern is defined according to IS 1893:2016. The lateral load according to the code is modified as shown below.

VI. ANALYSIS

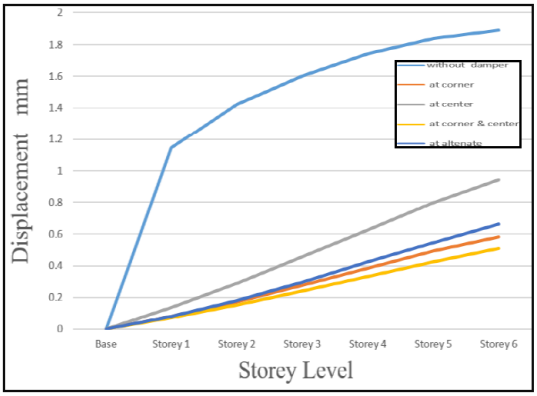
Before carrying out the analysis of the model, the model is to be checked for the errors made during the creation. All the checkboxes are ticked and the model is checked

.Before beginning the process of analysis, the load cases that are about to run during the analysis should be checked for better performance. Change the action of all load cases to Run, especially The Modal Load Case which is the most important to run during a seismic analysis. Then Run Now button is clicked.

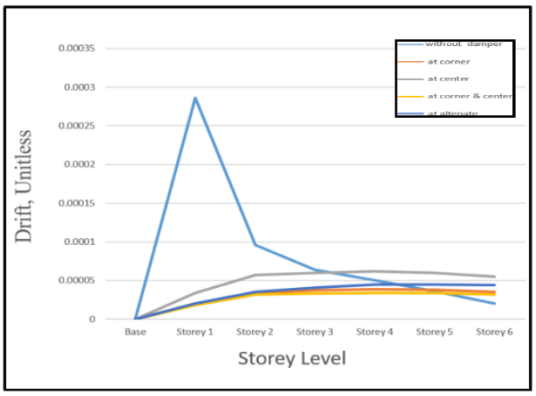
The damper is drawn using the option Link property. Select link and modify the name as FVD 500 and link type as Damper-exponential. Add mass, weight of the damper. Next click Draw links using Link property. Select the link and replicate it to required locations.

Name	Type	Mass kg	Weight kN
FVD 500	Damper-exponential	98	500

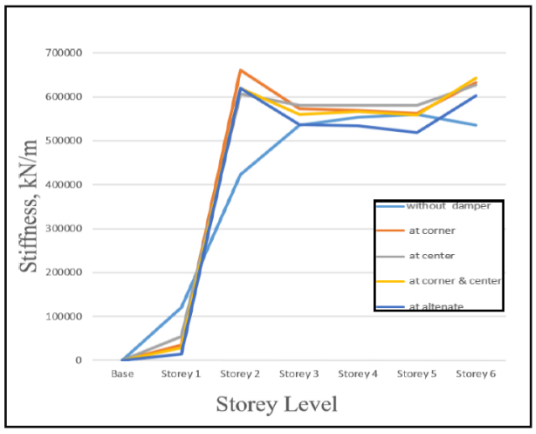
VII. RESULTS & DISCUSSION



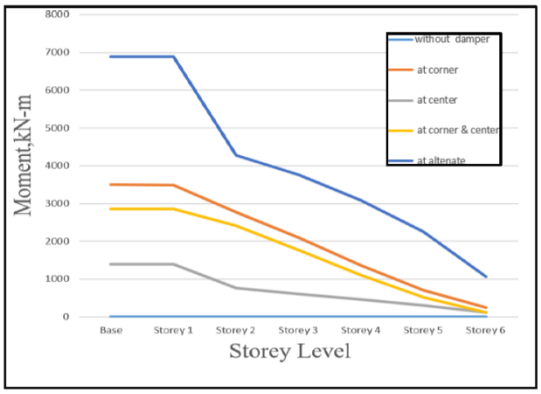
Maximum Storey Displacement



Maximum Storey Drift



Maximum Storey stiffness



Storey overturning moment

VIII.CONCLUSION

The main goal of this study is to analyze the rectangular shaped building equipped with fluid viscous dampers. Parameters such as maximum storey displacement, maximum storey drift, storey stiffness, overturning moment and storey shear are studied and the results are as follows.

1.The performance of the structure with damper is more effective.

2.Dampers in structure has an effect on maximum storey displacement and storey drift.

3.Dampers decreases storey displacement. Maximum storey displacement is an important parameter because excessive storey displacement can cause the structural damage or failure.

4.Controlling of storey drift reduces the probability of collapse under seismic loading.

5.The value of storey stiffness increases which ensures that the building has better seismic resistance compared to the building with no damper. Performance of buildings with damper at corners and center is more effective compared to other position of dampers

7.Dampers helps to reduce the effect on overturning moments of the structure.

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