Seismic Response Study of Multistoried Reinforced Concrete Building With Fluid Viscous Dampers

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Abstract –*Damping Plays important role in design of Earthquake Resistant Structures, which reduces the response of the structure when they are subjected to lateral loads. There are many different types of dampers in use. In the present study Fluid Viscous dampers (FVD) are used to evaluate the response of RC buildings. The main task of a structure is to bear the lateral loads and transfer them to the foundation. Since the lateral loads imposed on a structure are dynamic in nature, they cause vibrations in the structure. In order to have earthquake resistant structures, fluid viscous dampers have been used. Buildings having square and rectangular plans, with square and rectangular column cross- sections are analyzed, with and without FVD. In the present study the software SAP2000 have been used. It has been observed that buildings with square columns are performing well in terms of response of the structure when compared to the rectangular columns irrespective of the floor plan. FVD250 reduced the Base Shear of the structures . Hence FVD's can be used in RC multistory buildings to reduce the response effectively.*

Key Words: **Fluid Viscous Dampers, SAP2000, Damping, Square and Rectangular plans, Square and Rectangular columns, Seismic Response, Base Shear.**

1. INTRODUCTION

The viscous fluid dampers (VFD) are the more applied tools for controlling responses of the structures. These tools are applied based on different construction technologies in order to decrease the structural responses to the seismic excitation. Over the last fifty years, the earthquakes are categorized into two groups of near-field earthquakes and far-field earthquakes based on the distance of the place of recording the earthquake from the fault. Later, this definition was modified and other factors also influenced this categorization.

Over the recent years, the research studies concentrated on the study of impacts of ground motion in the near-field earthquake on the structural performance. The devastative effects of the recent earthquakes such as Northridge earthquake (1994), Kobe earthquake (1995), and Taiwan earthquake (1999) on the buildings of the cities adjacent to fault, and with regard to the close location of many of the cities of India to the active faults indicate the significance of the research.

In last few years, many essential developments in seismic codes are turned up. Due to the renewed knowledge of the existing buildings behavior, retrofit of buildings is a paramount task in reducing seismic risk. New techniques for protecting buildings against earthquake have been developed with the aim of improving their capacity. Seismic isolation and energy dissipation are widely recognized as effective protection techniques for reaching the performance objectives of modern codes.

1.1 OBJECTIVE OF THE STUDY

- To compare the seismic response of buildings with square and rectangular plans, with square and rectangular column cross sections, with and without FVD.
- To determine displacements variations in the structure due to introduction of FVD. To find the reduction in base shear by using FVD in RC buildings.
- To study the variations in time period for different structures with and without FVD.

1.2 OVERVIEW OF SOFTWARE AND FVD

1.2.1 SAP2000

The SAP name has been synonymous with state-of-the-art analytical methods since its introduction over 30 years ago.SAP2000 follows in the same tradition featuring a very sophisticated, intuitive and versatile user interface powered by an unmatched analysis engine tools for engineers working on transportation, industrial, public works and other facilities.SAP2000 has proven to be the most integrated, productive and practical general purpose structural program on the market today. This intuitive interface allows you to create structural models rapidly and intuitively without long learning curve delays.

SAP2000 also have much of the features.

- Complex models can be generated and meshed with powerful built in templates.
- Integrated design code features can automatically generate wind, wave, bridge, and seismic loads with comprehensive automatic steel and concrete design code.

1.2.2 FVD

In the FVD, by using viscous fluid inside a cylinder, energy is dissipated. Due to ease of installation, adaptability and coordination with other members also diversity in their sizes, viscous dampers have many applications in designing and retrofitting.

These types of dampers are connected to the structure in three ways:

- Damper installation in the floor or foundation (by the method of seismic isolation).
- Connecting dampers in stern pericardial braces.
- Damper installation in diagonal braces

2. LITERATURE REVIEW

Structural analysis is the judgment of the effects of loads on physical structures and their segments. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, machinery, furniture, attire, soil lamina, prostheses and biological tissue. Structural analysis engages the range of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. The results of the analysis are exercised to check a structure's vigor for use, often preventing physical tests. Structural analysis is hence a key component of the engineering design of structures as described by **K. H. Chang** in 2009.

Y. G. Zhao and T. Ono in 2001 mentioned about "Moment methods for structural reliability" in which they said, to perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behavior.

V. Umachagi, K. Venkataramana, G. R. Reddy, and R. Verma in "Applications of Dampers for Vibration Control of Structures: An overview" has briefly explained that Viscous dampers works based on fluid flow through orifices. Viscous damper is as shown in Fig.18 (Feng Qian et al., 2012) consisted viscous wall, piston with a number of small orifices, cover filled with a silicon or some liquid material like oil, through which the fluid pass from one side of the piston to the other. Stefano et al., 2010 have manufactured the viscous damper and it was implemented in 3 storey building structure for seismic control of structure with additional viscous damper. Attar et al., 2007 have proposed optimal viscous damper to reduce the interstory displacement of steel building.

Özgur Atlayan in 2008 "Effect of Viscous Fluid Dampers on Steel Moment Frame Designed for Strength and Hybrid Steel Moment Frame Design," Said, it was found that as the damping of the structure increases with the help of added dampers, the structural response gets better. Maximum and residual roof displacements, interstory drifts, and IDA (Incremental Dynamic Analysis) dispersion decreases with increasing damping. In addition, by using supplemental damping, most of the collapses that occur for the inherently damped frames are prevented.

3. METHODOLOGY

A modal analysis calculates the frequency modes or natural frequencies of a given system, but not necessarily its full-time history response to a given input. The natural frequency of a system is dependent only on the stiffness of the structure and the mass which participates with the structure (including self-weight). It is not dependent on the load function.

It is useful to know the modal frequencies of a structure as it allows you to ensure that the frequency of any applied periodic loading will not coincide with a modal frequency and hence cause resonance, which leads to large oscillations.

The method is:

1. Find the natural modes (the shape adopted by a structure) and natural frequencies

2. Calculate the response of each mode

3. Optionally superpose the response of each mode to find the full modal response to a given loading.

The analysis of SAP2000

1. Modeling
2. Static analysis
3. Design
4. Response spectrum analysis

4. STRUCTURAL ELEMENTS

The different structural elements considered are columns, beams and slabs with variable sections are mentioned below. Also, the different shapes of building are considered while keeping the total area unchanged.

Description of Members used:-

Column Sizes: 1) Square Columns = 600mm*600mm.

2) Rectangular Columns = 1200mm*300mm.

Beam Sizes: 1) Interior Beams = 230mm*600mm.

2) Exterior Beams = 300mm*650mm.

Slab Sizes: 1) Panel Area = 6m*6m= 36

2) Thickness = 150mm

Loads

While applying the loads to the structure we consider only the external loads which are actually acting on the members neglecting its self-weight because SAP 2000 automatically takes the members self-weight.

The Seismic loads EQ-x and EQ-y are given in Load patterns directly using Code IS1893:2002.

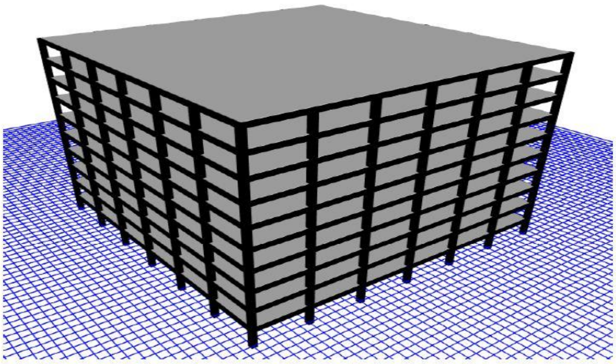


Fig-1. Model of square building with square columns without dampers

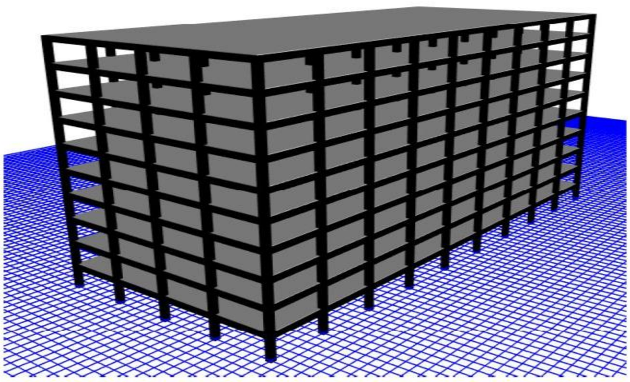


Fig-2. Model of rectangular building with square columns without dampers

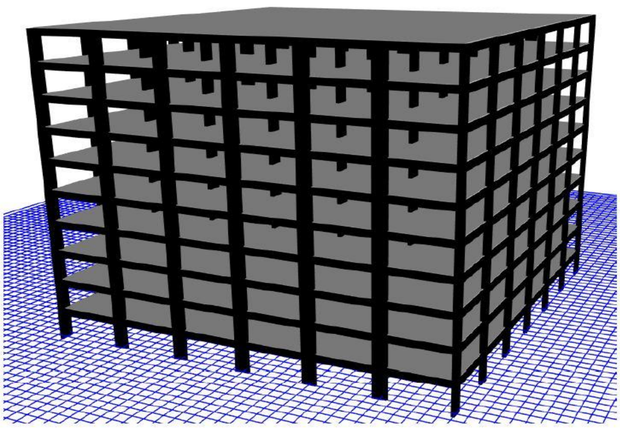


Fig-3. model of square building with rectangular columns without dampers

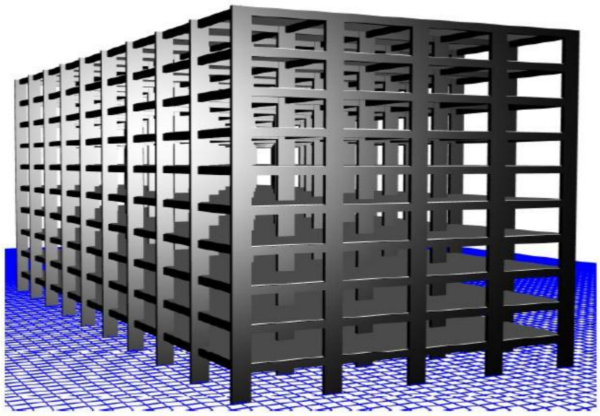


Fig-4. Rectangular building with rectangular columns without dampers

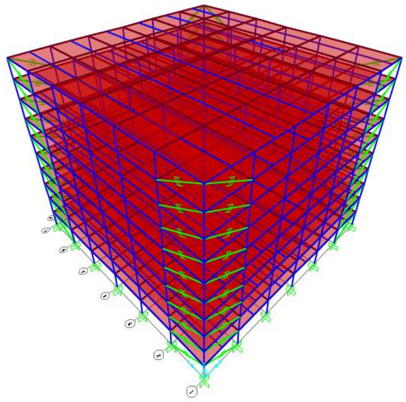


Fig-5. Model of square building with square column with dampers

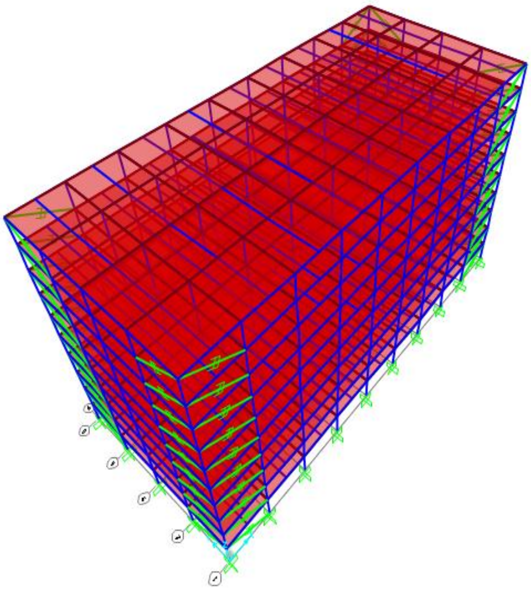


Fig-6. Model of rectangular building with square columns with dampers

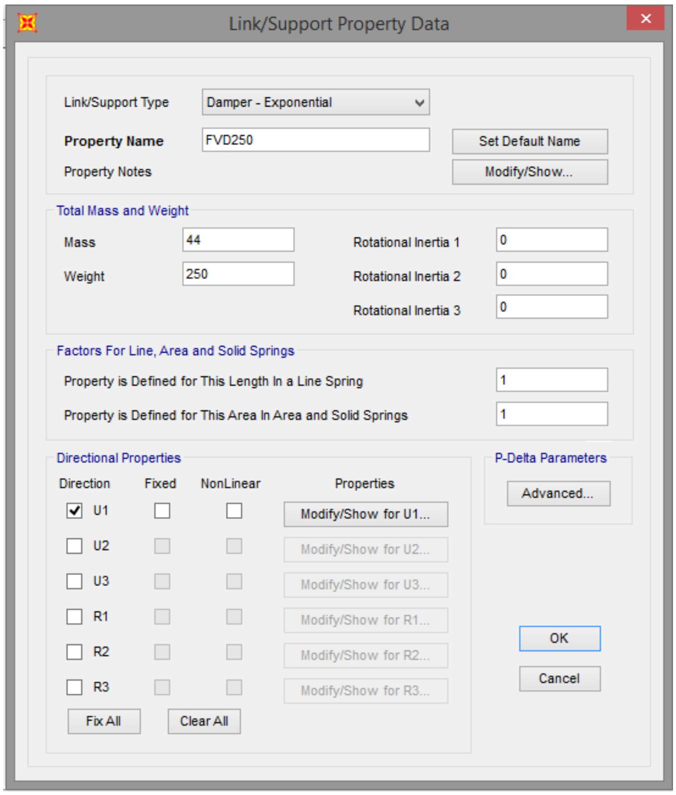
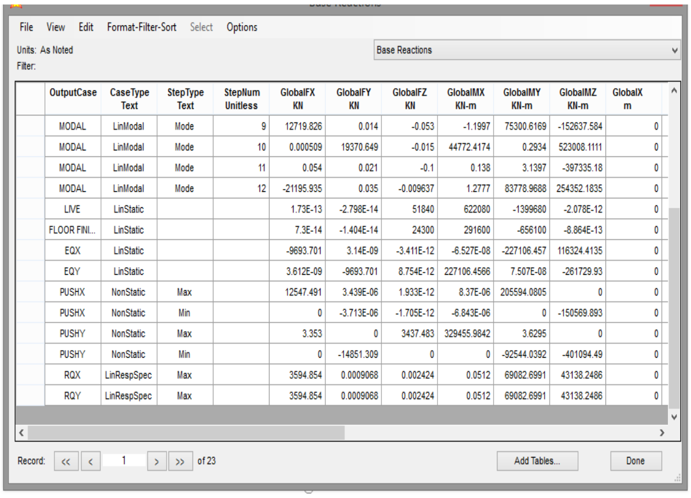


Fig-7. Adding a new damper property

5. RESULT AND DISCUSSION



File View Edit Format-Filter-Sort Select Options

Units: As Noted — Base Reactions

Filter:

OutputCase	CaseType Text	StepType Text	StepNum Unitless	GlobalFX KN	GlobalFY KN	GlobalFZ KN	GlobalMX KN-m	GlobalMY KN-m	GlobalMZ KN-m	GlobalX m
MODAL	LinModal	Mode	9	12719.826	0.014	-0.053	-1.1997	75300.6169	-152637.584	0
MODAL	LinModal	Mode	10	0.000509	19370.649	-0.015	44772.4174	0.2934	523008.1111	0
MODAL	LinModal	Mode	11	0.054	0.021	-0.1	0.138	3.1397	-397335.18	0
MODAL	LinModal	Mode	12	-21195.935	0.035	-0.009637	1.2777	83778.9688	254352.1835	0
LIVE	LinStatic			1.73E-13	-2.798E-14	51840	622080	-1399680	-2.078E-12	0
FLOOR FINI...	LinStatic			7.3E-14	-1.404E-14	24300	291600	-656100	-8.864E-13	0
EQX	LinStatic			-9693.701	3.14E-09	-3.411E-12	-6.527E-08	-227106.457	116324.4135	0
EQY	LinStatic			3.612E-09	-9693.701	8.754E-12	227106.4566	7.507E-08	-261729.93	0
PUSHX	NonStatic	Max		12547.491	3.439E-06	1.933E-12	8.37E-06	205594.0805	0	0
PUSHX	NonStatic	Min		0	-3.713E-06	-1.705E-12	-6.843E-06	0	-150569.893	0
PUSHY	NonStatic	Max		3.353	0	3437.483	329455.9842	3.6295	0	0
PUSHY	NonStatic	Min		0	-14851.309	0	0	-92544.0392	-401094.49	0
RQX	LinRespSpec	Max		3594.854	0.0009068	0.002424	0.0512	69082.6991	43138.2486	0
RQY	LinRespSpec	Max		3594.854	0.0009068	0.002424	0.0512	69082.6991	43138.2486	0

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Fig-8. Base reactions of RBC

Base Reactions

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. Calculations of base shear (**V**) depend on:

- Soil conditions at the site
- Proximity to potential sources of seismic activity (such as geological faults)
- Probability of significant seismic ground motion
- The fundamental (natural) period of vibration of the structure when subjected to dynamic loading.

when FVD is applied to the structure. The displacements have been reduced by 92% for SBSC, 91% for SBRC, 94% for RBSC and 88% for RBRC.

6. CONCLUSIONS

FVD250 reducing the Base Shear of the structures by 70%. The top story Displacements are minimized by 90% with use of FVD. when FVD250 used for exterior corners.

It is observed that buildings with square columns are performing well in terms of response of the structure when compared to the rectangular columns irrespective of the floor plan.

7. RECOMMENDATIONS FOR FURTHER RESEARCH

This thesis is limited to use of FVD250 to the structures in exterior corners. The following are few recommendations for further study:

- Same structures can be modified with FVD500 and can be used in exterior middle position.
- Irregular buildings, unsymmetrical buildings and Tall structures can be an extension to this work.
- Its use in Steel structures can bring much effective solutions.
- The structural systems like K-shape and M-shape can be used along with FVD

REFERENCES

[1] M. R. Arefi, "A study on the damping ratio of the viscous fluid dampers in the braced frames," vol. 3, no. 4, pp. 1223–1235, 2014.

[2] J. Marti, M. Crespo, and F. Martinez, "Seismic Isolation and Protection Systems," Seism. Isol. Prot. Syst., vol. 1, no. 1, pp. 125–140, 2010.

[3] M. K. Muthukumar G, "Analytical modeling of damping," Indian Concr. J., vol. 88, no. 4, 2014.

[4] I. López, J. M. Busturia, and H. Nijmeijer, "Energy dissipation of a friction damper," J. Sound Vib., vol. 278, no. 3, pp. 539–561, 2004.

[5] J. A. Inaudi and J. M. Kelly, "Mass Damper Using Friction-Dissipating Devices," J. od Eng. Mech., vol. 121, no. 1, pp. 142–149, 1995.

[6] w. J. William H. Robinson, "Lead Damper for base isolution.pdf." Proceedings of 9th world conference on Earthquake, 1998.

[7] J. Otten, J. Luntz, D. Brei, K. A. Strom, A. L. Browne, and N. L. Johnson, "Proof-of-Concept of the Shape Memory Alloy ReseTtable Dual Chamber Lift Device for Pedestrian Protection With Tailorable Performance," J. Mech. Des., vol. 135, no. 6, p. 61008, Apr. 2013.

[8] D. Demetriou, N. Nikitas, and K. D. Tsavdaridis, "Semi active tuned mass dampers of buildings: A simple control option," Am. J. Eng. Appl. Sci., vol. 8, no. 4, pp. 620–632, 2015.

[9] E. L. Anderson, "Performance-Based Design of Seismically Isolated Bridges," p. 494, 2003.

[10] S. Infanti, J. Robinson, and R. Smith, "Viscous Dampers For High-Rise Buildings," 14th World Conf. Earthq. Eng., 2008.

[11] V. Umachagi, K. Venkataramana, G. R. Reddy, and R. Verma, "Applications of Dampers for Vibration Control of Structures : an Overview," Int. J. Res. Eng. Technol., pp. 6–11, 2013.