Study of Seismic Energy Dissipation and Effect in Multistory RCC Building with and Without Fluid Viscous Dampers

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ABSTRACT Earthquakes are major natural hazards and can cause catastrophic damage by increasing the energy within the structural system. Such unwanted energy can be dissipated by introducing the several control systems such as passive, active, hybrid and semi active control system. The present work includes one such dissipating device namely fluid viscous damper. The aim of the work is to reduce seismic response of the structure using fluid viscous damper in ETABS2016. A 10 story structure with and without fluid viscous damper was analyzed using ETABS2016 to get the seismic response with and without fluid viscous damper. Non-linear time history, which is being calculated by fast nonlinear analysis of Bhuj earthquake data is considered for the analysis.In the present paper, dampers position and optimizing their position at the height of the structure are studied. It investigates about viscous damper systems and their effects on seismic behavior of multistory structures and determines effects of damper system position on structure height.

Key words: Energy dissipation, Fluid viscous damper, Non-linear time history analysis,Passive control system, Seismic response control.

I INTRODUCTION

In seismic structures progression, the lateral force due to earthquake can be reduced by the utilization of Seismic control devices called dampers. During the seismic events, large amount of energy is applied to the structure. If structure is free of damping, its stiffness is less and the vibration of the structure is more, but due to the fluid viscous damping, the stiffness of the structure increases as a result vibration is reduced. The fluid viscous dampers (FVD) are the more applied devices for controlling the responses of the structures. These devices are applied based on different construction techniques in order to reduce the structural responses to the seismic excitation.

The devastative effects of the recent earthquakes such as 1991 Uttarkashi earthquake, 1993 Killari (Latur) earthquake, 2001 Bhuj earthquake, 2004 Great Sumatra earthquake, 2005 Kashmir earthquake and with regard to the close location of many of the cities of India to the active faults indicate the significance of the research.

The aim of improving the capacity of building leads to invention of new techniques for earthquake resistant structures. According to the objectives of modern codes Seismic isolation and seismic energy dissipation are most standard and operative protection techniques.

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Fluid viscous dampers comes under passive seismic control system does not require any external energy source to operate and is activated by the earthquake input motion only. A viscous fluid damper consists of a hollow cylinder filled with a fluid. As the damper piston rod and piston head are stroked, the fluid flows at high velocities, resulting in the development of friction. A damper resists the dynamic motion and dissipates energy from a structure during wind or seismic events and allows it to withstand severe input energy and reduce harmful deflections, forces and accelerations to structures. The damping fluid is silicone oil, which is inert, non-flammable, non-toxic, and stable for extremely long periods of time.

II MODELLING OF BUILDINGS FOR ANALYSIS

ETABS 2016 has been used for this study. The building was created with 10 storey RCC frame as per IS 1893:2002 for seismic zone II with soil type II. Four models namely square building with square column (SBSC), square building with rectangular column (SBRC), rectangular building with square column (RBSC) and rectangular building with rectangular column (RBRC) are modelled with square and rectangular columns of dimensions 700mmx700mm and 1400mmx350mm with story height of 3m.The base is restrained with fixed support.

For the modelling of building in ETABS, shell loads on slabs of D.L=1.5KN/m^2 and L.L=4KN/m^2 were assigned to the slabs and frame loads of D.L=5.25KN/m^2 was assigned to all the frames. Seismic loads are considered according to code IS: 1893-2002 and wind loads according to IS:875-1987. For seismic zone II, the seismic zone factor 0.10 with importance factor 1 and response reduction factor 5 is considered. The mass source includes total self-weight and 25% live load.

All the buildings are modelled with and without FVD. FVD used in this study was manufactured by the Taylor Devices Inc. USA. These dampers are installed at the extreme corners of all the sides of all the four types of models. It is modelled as a link element with link type damper exponential.

Damper properties used in the modelling are taken from data available at the Taylor Devices Inc. made in USA. In this modelling 250KN mass with 44kg weight damper is used with non-linearity along the direction U1.

Response function has been defined using IS1893: 2002 for a damping of 5% and Time history function has been defined using BHUJ earthquake data from the program file.

For all the types of models response spectrum analysis and time history analysis was done in ETABS2016.

A Modelling of building without damper in ETABS 2016

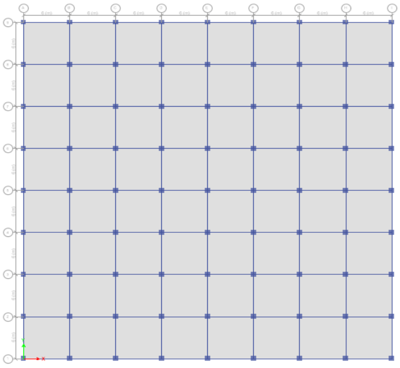

Fig1. Plan view of a square building with square column

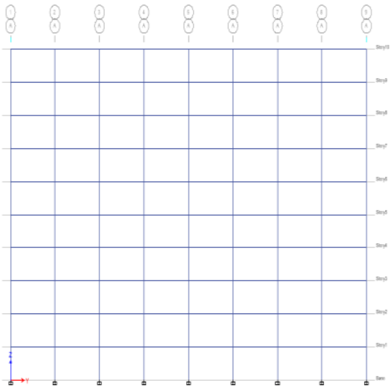

Fig2. Sectional view of a square building with square column

2.1. Modelling of building with damper in ETABS 2016

The dampers used in modelling these buildings are from Taylor Devices Inc. made in USA. They provide two types of FVD with data that can be used in ETABS 2015 for modelling of structure.

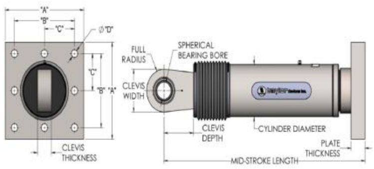

Fig3. Fluid viscous dampers & lock-up devices clevis – base plate configuration

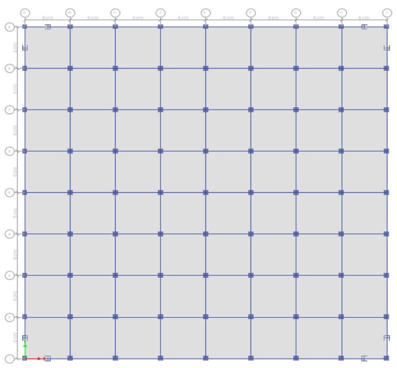

Fig4. Plan view of square building with square column using dampers

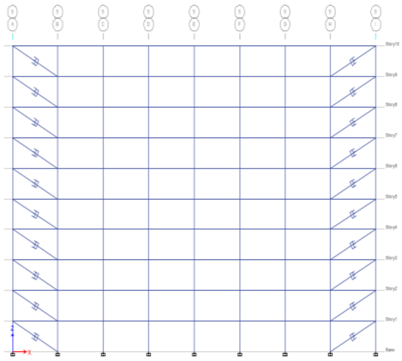

Fig5. Sectional view of square building with square column using dampers

RESULTS

3.1. Time history responses

3.1.1. Maximum pseudo spectral acceleration and spectral acceleration with and without FVD

3.1.2. **Table1.** Max. pseudo spectral acceleration and spectral acceleration at zero damping with and without FVD

Shape of building	Time history case	Max. pseudo spectral acceleration at zero damping And Max. spectral acceleration at zero damping			
		Without damper		With damper	
		Time period (sec)	PSA(mm/sec) &SA(mm/sec^2)	Time period (sec)	PSA (mm/sec) &SA(mm/sec^2)
SBSC	THAX/X	0.346	690.95	0.199	2147.48
	THAX/Y	0.330	427.66	1.021	210.68
	THAY/X	0.330	427.66	1.021	210.68
	THAY/Y	0.346	690.95	0.199	2147.48
SBRC	THAX/X	0.276	1333.06	0.196	1925.83
	THAX/Y	0.276	495.16	1	175.96
	THAY/X	0.585	372.62	1.021	140.77
	THAY/Y	0.276	661.88	0.196	1813.56
RBSC	THAX/X	0.293	859.75	0.917	1703.51
	THAX/Y	0.555	662.42	0.909	211.48
	THAY/X	0.555	430.27	0.909	165.06
	THAY/Y	0.261	298.27	0.940	1406.92
RBRC	THAX/X	0.432	925.68	1.063	2033.41
	THAX/Y	0.452	259.66	0.618	192.85
	THAY/X	0.454	695.64	1.010	164.204
	THAY/Y	0.454	1853.98	0.203	1669.14

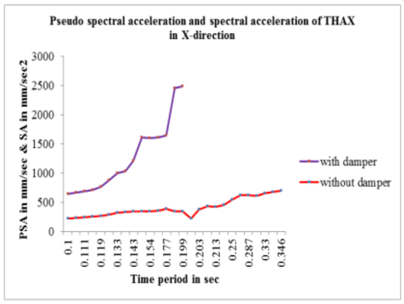

Fig6. Pseudo spectral acceleration and spectral acceleration of THAX in X-direction

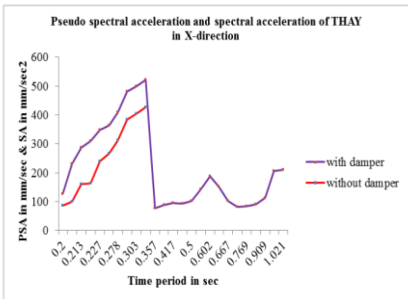

Fig7. Pseudo spectral acceleration and spectral acceleration of THAY in X-direction

3.1.3. Maximum pseudo spectral velocity and spectral velocity with and without FVD

Table2. Max. pseudo spectral velocity and spectral velocity at zero damping with and without FVD

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Shape of building	Time history case	Max. pseudo spectral velocity at zero damping And Max. spectral velocity at zero damping			
		Without damper		With damper	
		Time period (sec)	PSV(mm/sec) &SV(mm/sec)	Time period (sec)	PSV(mm/sec) &SV(mm/sec)
SBSC	THAX/X	2.048	138.15	1.028	257.25
	THAX/Y	2	115.86	1.021	34.24
	THAY/X	2	115.86	1.021	34.24
	THAY/Y	2.048	138.15	1.028	257.25
SBRC	THAX/X	2	240.99	1.021	253.94
	THAX/Y	1.941	85.71	1	28.00
	THAY/X	2	83.93	1.021	22.89
	THAY/Y	2	148.24	1.021	216.38
RBSC	THAX/X	1.859	159.33	0.917	248.70
	THAX/Y	1.666	129.34	0.909	30.59
	THAY/X	1.666	84.38	0.909	23.88
	THAY/Y	1.666	128.21	0.940	210.61
RBRC	THAX/X	2.341	228.31	1.063	344.07
	THAX/Y	1.666	39.53	1.063	24.46
	THAY/X	1.666	85.94	1.010	26.40
	THAY/Y	1.610	188.07	1	178.58

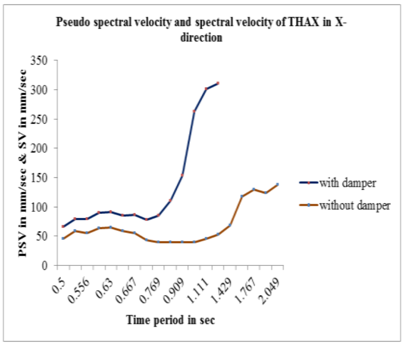

Fig8. Pseudo spectral velocity and spectral velocity of THAX in X-direction

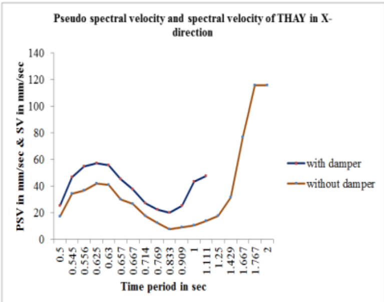

Fig9. Pseudo spectral velocity and spectral velocity of THAX in X-direction

3.1.4. Maximum spectral displacement with and without FVD

Table3. Spectral displacement at zero damping with and without FVD

Shape of building	Time history case	Max. Spectral displacement at zero damping			
		Without damper		With damper	
		Time period (sec)	SD (mm)	Time period (sec)	SD (mm)
SBSC	THAX/X	2.048	45.05	1.028	42.09
	THAX/Y	2	36.88	1.021	5.56
	THAY/X	2	36.88	1.021	5.56
	THAY/Y	2.048	45.05	1.028	42.09
SBSC	THAX/X	2.009	76.77	1.021	41.29
	THAX/Y	1.941	26.47	5	5.04
	THAY/X	2.009	26.80	5	4.04
	THAY/Y	2	47.18	1.021	35.18
RBSC	THAX/X	1.859	47.14	0.940	37.04
	THAX/Y	1.666	34.31	5	10.56
	THAY/X	1.859	22.65	5	9.76
	THAY/Y	1.666	34.01	0.940	31.52
RBRC	THAX/X	2.341	85.07	1.063	58.22
	THAX/Y	2.341	12.33	1.063	4.13
	THAY/X	1.666	22.79	1.010	4.24
	THAY/Y	1.610	48.21	1	28.42

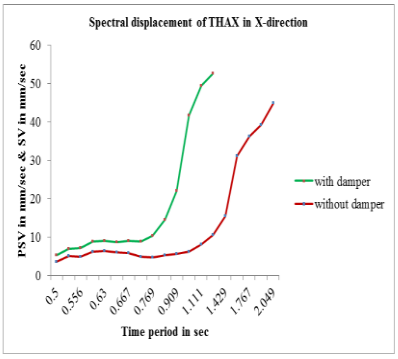

Fig10. Spectral displacement of THAX in X-direction

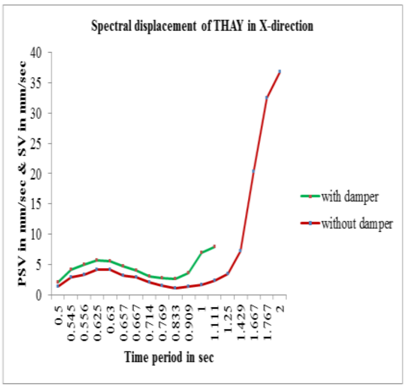

Fig11. Spectral displacement of THAX in X-direction

3.2.Base shear

Maximum base shear due to time history THAX and THAY for different shapes of the building with and without FVD are compared in the below table.

Table4. Comparison of maximum base shears with and without FVD

Shape of the building	Time history case	Without damper	With damper
SBSC	THAX Max	1632.33	398.80
	THAY Max	217.00	11.34
SBRC	THAX Max	1652.50	610.42
	THAY Max	145.18	16.68
RBSC	THAX Max	1252.27	278.05
	THAY Max	118.49	7.52
RBRC	THAX Max	1471.68	121.19
	THAY Max	67.98	2.15

3.3.Maximum story displacements

Maximum story displacements are compared for SBSC with and without FVD

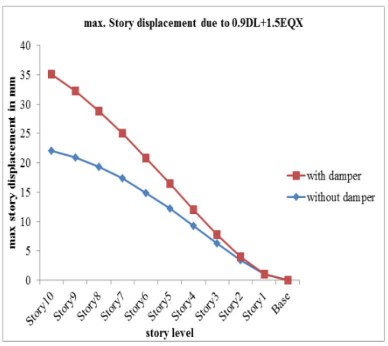

Fig12. Maximum story displacement due to load combination0.9DL+1.5EQX in X-direction for SBSC

3.4. Maximum story drifts

Maximum story drifts are compared for SBSC with and without FVD

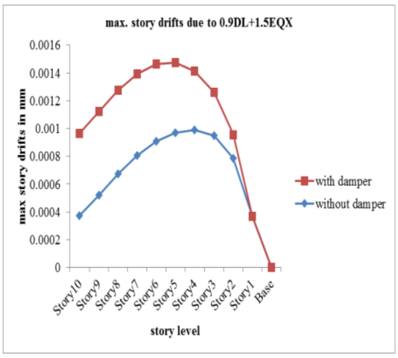

Fig13. Maximum story drifts due to load combination0.9DL+1.5EQX in X-direction for SBSC

3.5. Story shears

Story shears are compared for SBSC with and without FVD

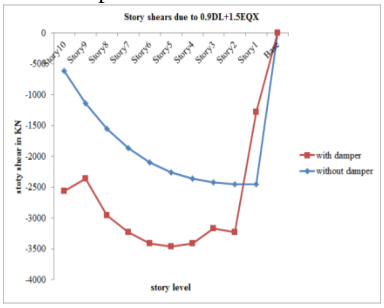

Fig14. Story shears at top and bottom due to load combination0.9DL+1.5EQX in X-direction for SBSC

CONCLUSIONS

The story responses from the time history analysis in terms of PSA, PSV and SD have been reduced with the use of fluid viscous dampers. The response spectrum curves of PSA, PSV and SD shows the reduction over time period with the use of dampers compared to the buildings without dampers. 90% mass participation is achieved in 7th and 8th modes of all types of buildings. It can be observed that 75% reduction in base shear due to time history analysis. There is a considerable reduction in maximum story displacement, maximum story drifts and story shears when the damper is used in buildings. The responses can be further reduced by the selection of damper, position of damper and shape and type of construction of the building involved.

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