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Seismic Response of Asymmetric Structure with Viscous Damper

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Abstract: The experimental Study on Viscous Damper to determine the response of asymmetric structure by adopting the various positions of the damper in the experimental model. This experimental model is of one way asymmetry in stiffness hence the viscous damper having harder spring is placed diagonally by connecting less stiff columns parallel in the direction of motion, and viscous damper having softer spring is placed diagonally by connecting stiff columns parallel to the direction horizontal excitation. These viscous dampers are placed at different levels (Storey) at which the response of the structure is determined by keeping the amplitude constant and varying the frequency of the harmonic excitation, torsional effect due to one way asymmetry as well as response of the structure is determined.
Keywords: Viscous Damper, Shear frame, Frequency, Displacement.

I. INTRODUCTION

From past decades it has been observed that the structure which is asymmetric in nature gets affected severely during earthquakes. This asymmetry can be due to the uneven distribution of mass and/or stiffness of the structure. Asymmetric structure is subjected to torsional coupling; this can be reduced by avoiding eccentricity. Many researches has been carried out to control the torsional coupling and the horizontal motion by placing multiple tuned mass dampers by keeping it eccentrically to neutralize the torsional moments. Since the use of tuned mass damper requires much space due to its components, they are found to be uneconomical. Whereas viscous damper is compact and placed diagonally to the frames, thus providing torsional resistance with less space consumption. It can be used as an alternative for the multiple tuned mass dampers. Viscous Damper contains viscous liquid in the cylinder, in that piston rod with piston will make reciprocating motion in the cylinder, thus causing energy dissipation. Vibration induced due to seismic events and asymmetry of the structure cannot be completely dissipated. To reduce small to medium vibration due to asymmetry viscous damper (VD) is introduced in the structure. It is also one of passive damper which gives stable performance under accumulated deformation of the structure and also adopting these dampers are economical

II. EXPERIMENTALMETHOD

A. *Experimental Methods*

To reduce torsional coupling of the structure more than one tuned mass damper should be used but it is not economical and it requires larger space, to overcome from these difficulties viscous damper can be used with varied stiffness to balance the asymmetrical structure

B. *Experimental Setup*

The experimental setup required for the present work includes mainly of Horizontal shake table, 3-storey asymmetric shear frame model and viscous damper. To capture the responses of shear model at each storey, sensors are used which are connected to a system having a software called ‘Kampana’ to store the data’s required.

C. *Viscous Damper*

To simulate viscous damper in the present experiment study instead of compressible fluid springs are used. In the frame, where the stiffer columns are placed, viscous damper with softer springs are used and the whole assembly is placed diagonally to the frame in the direction parallel to the excitation. Similarly, for less stiffer columns, viscous damper with harder spring are used. Figure 1 shows model & experimental model of Viscous Damper. Table1 shows the properties of viscous damper used in experimental studies.

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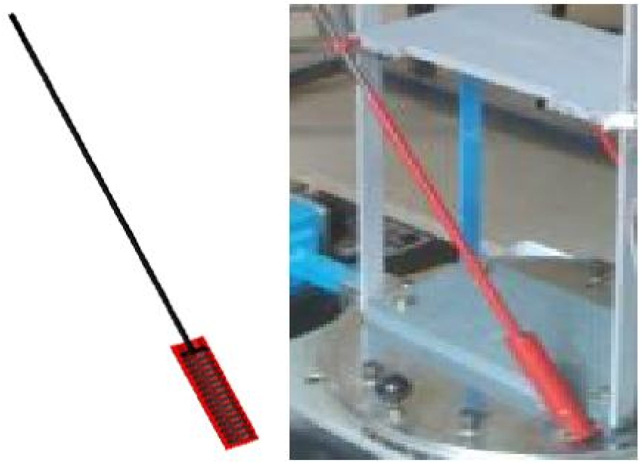

Figure1**:** Model & experimental model of Viscous Damper.

Sl. No.	Properties	Details
1	Type	Linear Spring
2	Mass	0.453kg
3	Material	Mild Steel
4	Compressible material	Springs (Harder & Softer)

Table 1: Properties of Viscous Damper

D. Experimental Procedure

1) Shear frame model is attached to shake table with necessary fasteners.

2) Sensors are attached at each slab levels to determine the response of the each storey, and transfers the dynamic response to the software through the adapters.

3) Amplitude of motion is adjusted to 3mm and for every frequency interval of 0.5 Hz for a range of 0 Hz to 10 Hz different experiments are performed, they are:

a) Responses of asymmetric shear frame model without damper are determined and noted.

*b)*Responses of one way asymmetric model with viscous damper are determined by positioning the dampers in different storey level.

Experiments are carried out on the shear frame model in the order as mentioned in Table 2 and optimum value of damper is determined.

Sl. No	Experiments	Amplitude	Frequency
1	Experiment-1&2 (VD in 1st storey) (Horizontal & torsional Response)	3mm	0Hz to 10Hz
2	Experiment-3&4 (VD in 2nd storey) (Horizontal & Torsional Response)	3mm	0Hz to 10Hz
3	Experiment-5&6 (VD in 3rd storey) (Horizontal & Torsional Response)	3mm	0Hz to 10Hz
4	Experiment-7&8 (VD in all the storey) (Horizontal & Torsional Response)	3mm	0Hz to 10Hz

Table 2: Experiment conducted on one way asymmetric shear frame.

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III. RESULTS AND DISCUSSION

A. *Results obtained for 3mm amplitude of model with and without Viscous Damper*

The results are tabulated for the frames with varying the position of VD in different storey level by considering lateral displacement of the experimental model as listed in table 3. And the results are tabulated in table 4.

Sl. No.	Parameters	Position
1	Case-1	VD in 1st storey
2	Case-2	VD in 2nd Storey
3	Case-3	VD in 3rd Storey
4	Case-4	VD in all Storey

Table 3: Cases adopted for experimental Study of Viscous Damper

Results obtained for 3mm amplitude of model with and without Viscous Damper															
Frequency in Hz	VD-0%			VD in 1st storey			VD in 2nd storey			VD in 1st storey			VD in 1st storey		
	Displacement in mm			Displacement in mm			Displacement in mm			Displacement in mm			Displacement in mm		
	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3
0.5	0.00	0	0	0	0	0	0	1.62	1.52	0	0	0	0	0	0
1.0	0.19	1.72	1.82	0	0	0	1.48	1.7	1.62	0.16	2.66	2.42	0	0	0
1.5	0.23	0.23	0.27	24.4	27.4	26.11	25.28	27.4	27.6	0.18	27.4	25.9	23.7	27.13	27.1
	0.31	0.31	0.36	16.4	17.6	18.24	16.74	17.2	17.2	15.57	16.7	15.7	14.73	16.07	16.6
2.5	11.4	12.7	12.8	12.8	13.5	14.11	12.59	12.8	14.4	11.12	12.2	12.1	11.38	12.47	12.4
3	7.89	9.82	10.12	12	11.1	12.42	11.46	11.9	13.1	8.85	10	9.82	9.82	10.86	10.9
3.5	9.58	11.9	10.01	9.42	10.1	10.66	10.45	13.9	14.2	7.91	10.1	10.8	9.69	11.09	11.6
4.0	8.62	10.7	11.59	14.2	18.6	18.12	14.35	20.1	23	9.17	13.5	14.3	11.01	15.37	17.4
4.5	7.88	12.2	13.46	16.2	26.1	30.06	31.06	48.3	49.1	22.9	35.5	35.3	36.24	46.38	56.6
5	36.9	35.2	41.67	1.66	19.4	28.27	0.39	5.42	6.37	13.15	15.9	24.3	3.91	6.98	8.79
5.5	7.77	15.1	19.53	3.57	6.28	8.17	0.19	4.81	5.02	4.01	7.64	9.77	0.17	5.25	5.98
6	4.44	8.94	10.56	0.88	4.94	5.44	0.15	3.41	3.76	2.08	4.96	6.69	0.92	3.95	4.91
6.5	1.96	5.07	7.22	0.54	3.59	4.58	0.62	2.77	3.35	0.17	3.9	5.2	0.65	3.13	4
7.0	0.05	3.84	5.79	0.93	3.42	4.82	1.23	3.16	1.17	0.21	3.57	4.46	0.71	3.43	3.55
7.5	0.86	3.9	5.67	0.35	0.46	4.14	2.75	0.32	2.8	0.38	3.88	3.68	2.68	2.76	2.99
8	0.39	0.55	4.33	0.31	0.33	3.2	2.25	1.87	2.41	0.29	2.62	3.03	2.33	1.9	2.74
8.5	2.11	2.42	3.45	2.4	1.91	2.82	2.2	1.63	2.32	2.32	1.96	2.82	2.37	1.53	2.6
9	2.35	1.86	3.22	2.35	1.57	2.65	2.22	1.33	2.19	2.21	1.46	2.66	2.43	1.33	2.54
9.5	2.17	1.54	3.09	2.48	1.3	2.56	2.37	1.18	2.2	2.17	1.21	2.54	2.61	1.2	2.52
10.0	2.18	1.2	3.03	2.59	1.13	2.57	2.5	1.08	2.33	2.23	1	2.45	2.79	1.2	2.59
	S-1 Storey-1			S-2 Storey-2			S-3 Storey-3								

Table 4: Variation of lateral displacement in mm at different storey level with & without VD

B. Graphical comparison of asymmetric model with & without VD.

The tabulated results are represented in graphical method and results are discussed below. Figure 2 shows the graphical comparison of lateral displacement at first storey for every frequency interval obtained by experimental investigation of frames with and without VD.

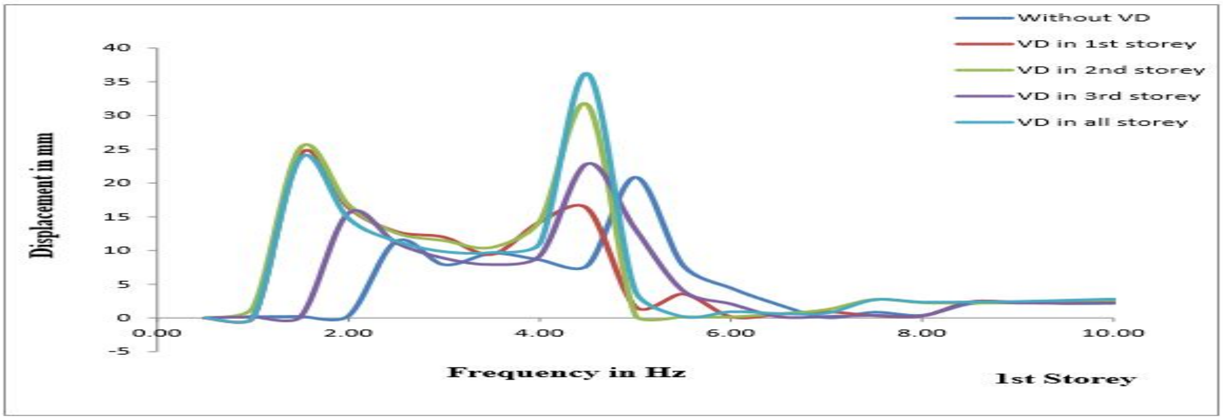

Figure 2 Structural response of 1st storey level with VD (in 1st, 2nd, 3rd & all the storey) & without VD

The maximum displacement for the frame without VD was found to be 36.90mm at first storey at a frequency of 5Hz i.e. the resonant frequency. By considering the displacement found for frame without VD as reference, the variation in displacement values for other frames with VD are computed.

For VD in 1st storey a reduction in 1st storey displacement by 22% was found respectively. Whereas, for VD in 2nd, 3rd and in all storey an increase of 51%, 10% and 73% in 1st storey displacement was found respectively displacement was found respectively displacement was found respectively.

Figure 3 shows the graphical comparison of lateral displacement at second storey for every frequency interval obtained by experimental investigation of frames with & without VD.

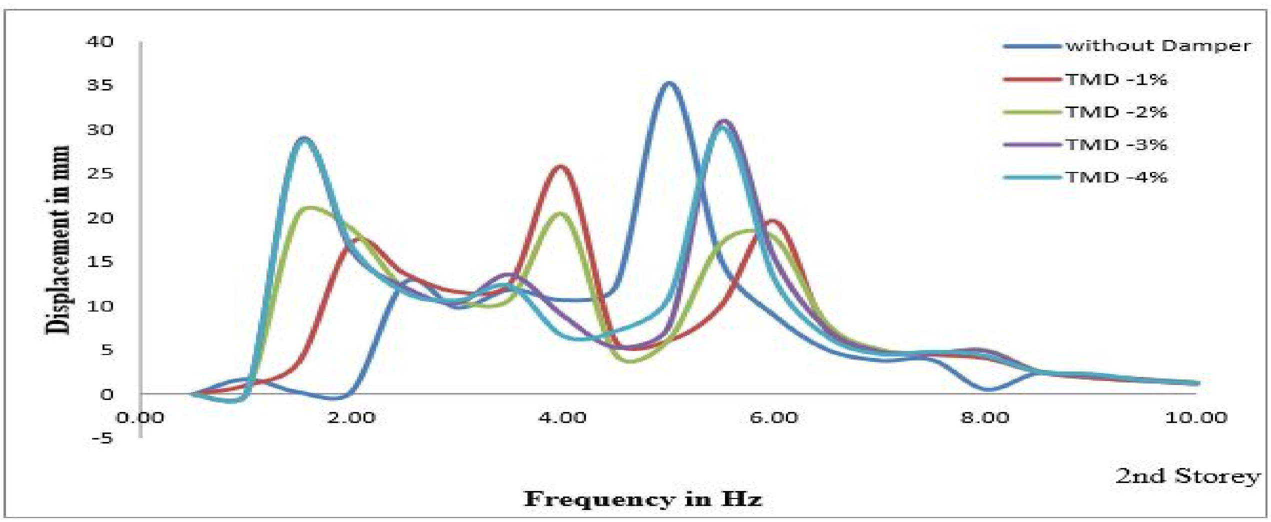

Figure 3: Structural response of 2nd storey level with VD (in 1st, 2nd, 3rd & all the storey) & without VD.

The maximum displacement for the frame without VD was found to be 35.30mm at second storey at a frequency of 5Hz i.e. the resonant frequency. By considering the displacement found for frame without VD as reference, the variation in displacement values for other frames with VD are computed.

For VD in 1st storey a reduction in 2nd storey displacement by 26% was found respectively. Whereas, for VD in 2nd, 3rd and in all storey an increase of 37%, 0.5% and 31% in in 2nd storey displacement was found respectively.

Figure 4 shows the graphical comparison of lateral displacement at third storey for every frequency interval obtained by experimental investigation of frames with & without VD.

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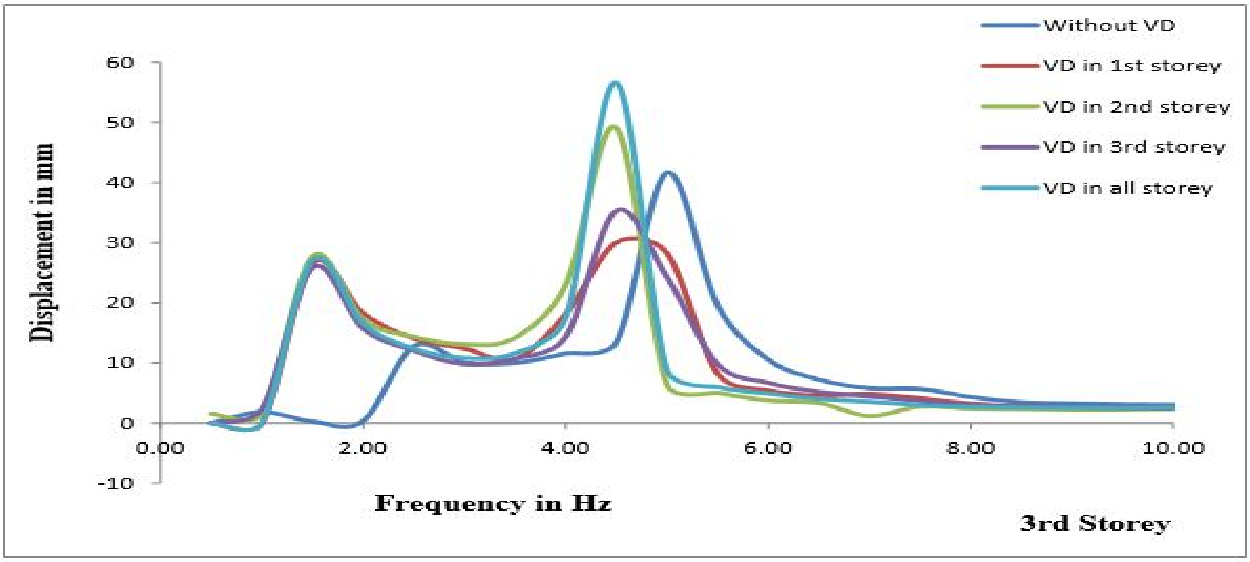

Figure 4Structural response of 3rd storey level with VD (in 1st, 2nd, 3rd & all the storey) & without VD.

The maximum displacement for the frame without VD was found to be 41.70mm at third storey at a frequency of 5Hz i.e. the resonant frequency. By considering the displacement found for frame without VD as reference, the variation in displacement values for other frames with VD are computed.

For VD in 1st & 3rd storey a reduction in 3rd storey displacement by 28% & 15% was found respectively. Whereas, for VD in 2nd and in all storey an increase of 18% and 36% respectively in 3rd storey displacement.

IV. CONCLUSION

It it is observed that there is a good reduction in the displacement of the structure at resonant period, but there is shift in the resonant frequency due to increase in the weight of the structure.

For the different positioning (1st, 2nd, 3rd & all storeys) of VD studied on the experimental model, the optimum positioning of VD was found to be in 1st storey, as it showed a reduction in displacement by an amount of 28% in comparison to bare frame structure.

For the different positioning (1st, 2nd, 3rd & all storeys) of VD studied on the experimental model, lateral deviation due to torsional coupling in X and Y directions of stiffer and flexible columns was found to be least by positioning VD in 1st storey.

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