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Comparative Study: The Effect of Tuned Mass Damper and Fluid Viscous Damper on The Response of Two Different Models of G+15 Storey Building During Earthquake

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Research Article

Abstract

During an earthquake phase, dampers are used to dissipate energy as well as stop the Deformation of the Structure. Dampers help in reducing buckling and failure of columns and beams by increasing the stability of the frame. During earthquakes, high-rise buildings are prone to destruction or significant deformation. Use of dampers reduce the shaking of reinforcement cement concrete structures during an earthquake. We used and analyzed various types of dampers to determine the suitability of various types dampers during an earthquake. An empirical study has been performed for the comparative review of two dampers: a fluid viscous damper and a tuned mass damper used for multi-story cement concrete building reinforcement. Time History Method is applied to assess the seismic behaviour of a G+15 storey building with and without dampers. The earthquake load is applied in both the x and y directions for research. TheIS1893:2002(part 1) code is used in conjunction with the ETABS 2018 version18.1.1 package for the purpose of analysis. The findings of these experiments are discussed in terms of numerous parameters such as maximal absolute displacement, absolute acceleration, absolute velocity, storey shear, storey drift, storey stiffness, and modal participation mass ratio in order to compare these parameters. Two kinds of dampers are used to dissipate seismic energy. In this article, a comparison of two different buildings of different bay sizes (5mx5m & 6mx6m) is used, as well as a comparative analysis of various parameters using Tuned Mass Damper and Fluid Viscous Damper.

Keywords: - Fluid Viscous Damper, Tuned Mass Damper, Max. Absolute Displacement, Storey Drift, Time History Analysis, Storey Stiffness

1. Introduction

Vibration is defined as the oscillation of an entity at an equilibrium point and vibration control in different types of machinery is important. With the help of emerging technology, new engineering technologies have been created for vibration control. The vibration reduction technique has made its way into civil engineering as well as a number of other fields. Countless multi-story structures are being constructed all over the world. This is in response to concerns about high population density in cities, commercial areas, and space conservation, as well as to create national landmarks and ensure that their countries meet the requirements of other developed countries [1]. As a result, when buildings are exposed to wind and earthquake loads, they become more susceptible to shaking. Large displacements do not always endanger the structure's integrity, but a constant state of vibration can cause considerable discomfort and even illness to building occupants. In all of our efforts, we adhere to the principle of energy conservation. If we can ensure that the energy exerted on the system by wind and earthquake loads is fully reduced or dissipated, the system can vibrate less [2]. Natural damping is found in virtually every structure to the tune of 5%. Vibration can be regulated in a variety of ways, including passive, active, semi-active, and Hybrid control. Passive control framework, Housner et al. [3] have given concise overviews of auxiliary management, as well as acceptable descriptions for the various categories of executives typically found in systems. In their case, a disconnected framework is one that does not require an external power supply. All of the forces required by aloof administration devices manifest as immediate reactions to the structure's movement. As a result, the total energy of each unit, as well as the basic structure, remains constant [4]. Dynamic control framework is a sort of control framework in which an outside power source is used to offer complement or extra powers to the structure in a regulated manner through the use of actuators. Because of the proximity of an external power source, the power linked to the system can either contain or disseminate vitality [5]. A semi dynamic control system needs less external vitality than a dynamic control framework, causing it to differ from a dynamic control framework in the fact that they all follow the same guidelines. Since they don't bring mechanical vitality to the fundamental structure, semi dynamic gadgets have a simple solidity in terms of minimal knowledge and yield. In these lines, it may be considered a remote-controllable device. Hybrid control frameworks are designed to incorporate the advantages of both detached and dynamic control structures. For example, consider a detached base structure with an actuator that essentially monitors the progress of its execution. For also the term "hybrid control" refers to the use of both active and passive control mechanisms in one system.

1.1 Damper

The device “damper” absorbs and dampens shock and vibration energy in several ways. Multistory buildings are now shielded from seismic and wind forces using several methods, one of which is the use of dampers, which is both widespread and effective in reducing the external force caused by seismic and wind loads. Damper devices dissipate seismic energy and track building deformation to preserve structural stability, minimize losses, and keep occupants safe [6].

1.1.1 Fluid Viscous Damper

In structural design, vibration control is accomplished by using liquid viscous dampers, which are similar to the safety features used in automobiles [7]. They were used in military building and the aeronautic trade for a long time. Fluid viscous dampers have been designed to reduce both distraction and anxiety inside a structure; Fig.1 shows a typical example of a liquid viscous damper. A fluid thick damper consists of a cylinder head with holes enclosed inside a barrel filled with a thick liquid, normally silicone or a similar form of oil [8]. The vitality is dispersed by the liquid opening as the cylinder head moves in an odd location through the liquid. The liquid fluid in the barrel has an almost incompressible form. The available space inside the barrel shrinks as the damper is compressed, resulting in the forming of the cylinder bar section. The FVD re-establishes power as a result of the shorter duration. This skill aids the gatherer's ability to remain inside the gadget [9].

1.1.2 Tuned Mass Damper

A tuned mass damper (TMD) is a structure-connected mechanism that consists of a mass, a spring, and a damper to reduce the dynamic response of the structure. When the structural frequency is excited, the damper's frequency is tuned to that of the structure, causing the damper to react out of phase with the structural motion. The damper inertia force dissipates energy in the device. In 1909, Frahm was the first to use the TMD concept to reduce ship rolling motion and hull vibration [10]. Since it is chosen to closely match that of the primary structure, the normal frequency of TMDs is a significant architecture parameter. This parameter is determined by a stiffness factor or, more generally, by suspending the mass in a pendulum tuned mass damper (PTMD) [11]. Now a Day seismic design parameter is most important all over the world so energy dissipation devices mostly used to control the damages of the structure due to seismic activity and wind forces. Example: Statue of unity Gujrat, ATC tower Delhi Airport, Taipei 101 in Taiwan etc.

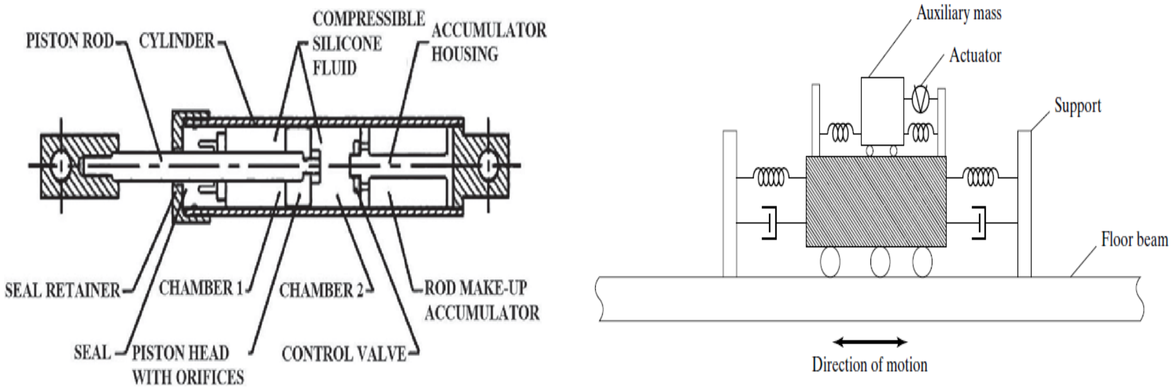
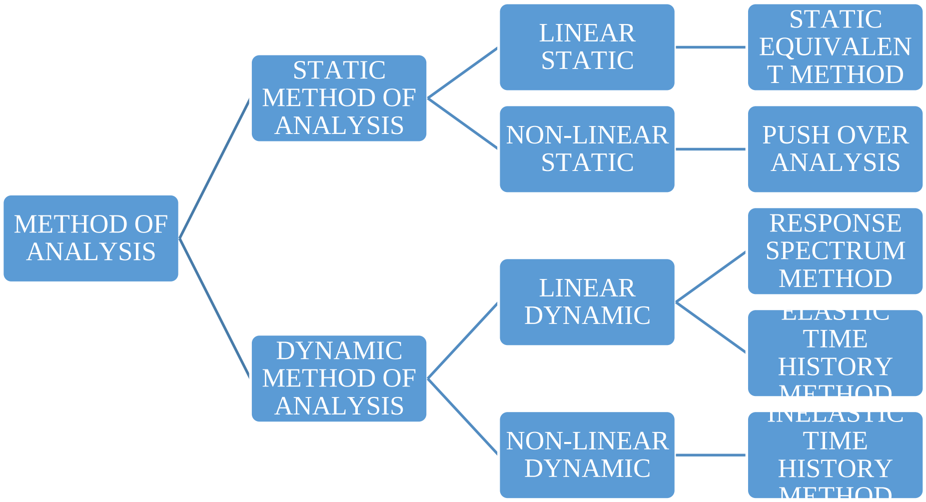


Fig 1: Left side figure show the Typical representation of Fluid Viscous Damper [8] & right-side figure shows an active Tuned Mass Damper Configuration [10]

2. Method of Analysis

Following the selection of the structural model, analysis can be carried out to determine the seismically induced forces in the structures. Different method of analysis has been established with different degree of precision.



The analysis processes are classified on the basis of three factors: the type of the externally applied loads, the behaviour of structure or structural materials, and type of structural model selected [12]. The analysis can be further classified as follows, depending on the type of external action and structure behaviour

2.1 Time History Method

The most advanced method of dimensional analysis for buildings is the time history analysis approach. This approach involves solving the equation of motion step by step over a time interval using the displacements, velocities, and accelerations from the previous step as the initial function. Fast Nonlinear Analysis (FNA) is a modal analysis approach that can be used to evaluate linear or nonlinear structural structures in both static and dynamic modes. FNA is well-suited for time-history analysis due to its computationally efficient formulation, and it is often recommended over direct-integration applications. The separation of the nonlinear-object force vector $R_{NL}(t)$ from the elastic stiffness matrix and the damped equations of motion, as seen in the fundamental equilibrium equation of FNA, is largely responsible for the efficiency of FNA formulation [13].

$$M\ddot{U} + C\dot{U} + KU + R_{nl}(t) = F(t) \qquad (1)$$

The equilibrium relationships within the elastic structural system are described by stiffness- and mass-orthogonal Load-Dependent Ritz Vectors. The uncoupled modal equations are solved exactly at each time increment, while forces within the predefined nonlinear DOF, indexed within $R_{NL}(t)$, are resolved via an iterative mechanism that converges to equilibrium. FNA is an effective and reliable dynamic-nonlinear application that satisfies equilibrium, force-deformation, and compatibility relationships while using this technique [13].

2.2 Methodology

The research focuses on a G+15 Multi-storey Building frame's seismic activity. Studies on damper-enhanced structures, including linear and nonlinear static as well as linear and nonlinear dynamic analyses of damper-enhanced building frames have been released. In this study, we have used two different dampers: a fluid viscous damper and a tuned mass damper. The Fluid Viscous damper in this study is located in the periphery of the structure and The Tuned Mass Damper in this study is located on the top floor of the building at the centre of mass action to improve

Seismic behaviour of the building. The important parameters such as Story Displacements, Joint Acceleration, Base Shear, Modal Frequency, Storey Drift and Storey Stiffness are compared in a time history study with and without damper.

2.3 Modelling and assumption

The G+15 Frame structure is the structural framework studied in this article. The building has 3 bays in the X direction and 3 bays in the Y direction [Figs. 3, 4 and 5], and it is 48 meters tall. The FVD damper is located on the structure's perimeter, while the TMD is located on the top storey. The current research uses an SMRF to investigate the structure's seismic activity, assuming that seismic responses in two perpendicular directions are independent of one another. The building materials, loads, and properties of the frame, as well as area of section, are shown in Table 1.

Table 1: The member properties and specification of model

S. NO.	Specification	Size
1	Plan size (X x Y)	18m x 18m, 15m x 15m
2	Two bay sizes	6m x 6m, 5m x 5m
3	Floor to floor height (m)	3.0m
4	Total height of the building (G+15)	48.0m
5	Types of structure	SMRF
6	Size of beam	0.4m x 0.3m
7	Size of column	0.5m x 0.5m
8	Wall thickness	0.2m
9	Thickness of slab	0.150m
10	Grade of concrete and steel	M30, M20, Fe415, Fe250

11	Types of soil (as per IS1893(part 1): 2002		Type II Medium rocky soil
12	Response Reduction Factor (R)		5
13	Importance Factor		1
14	Seismic Zone Factor		0.36 (Zone V)
15	Load Combination		According to IS:1893 (part 1): 2002
16	Load Applied	Dead Load	Calculated as per Self Weight
		Live Load	3 KN/m^2
		Seismic Load	As per IS 1893 (part 1): 2002
		Floor Finish	1 KN/m^2

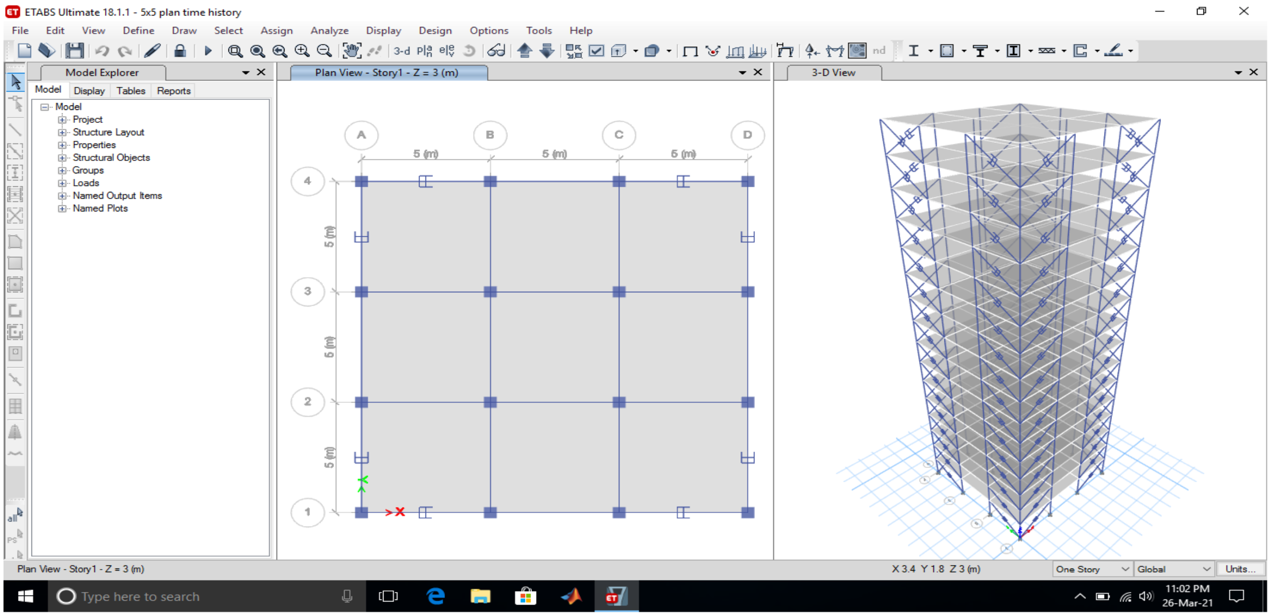


Fig. 1 2D and 3D View of G+15 Building with FVD along the Periphery of Building

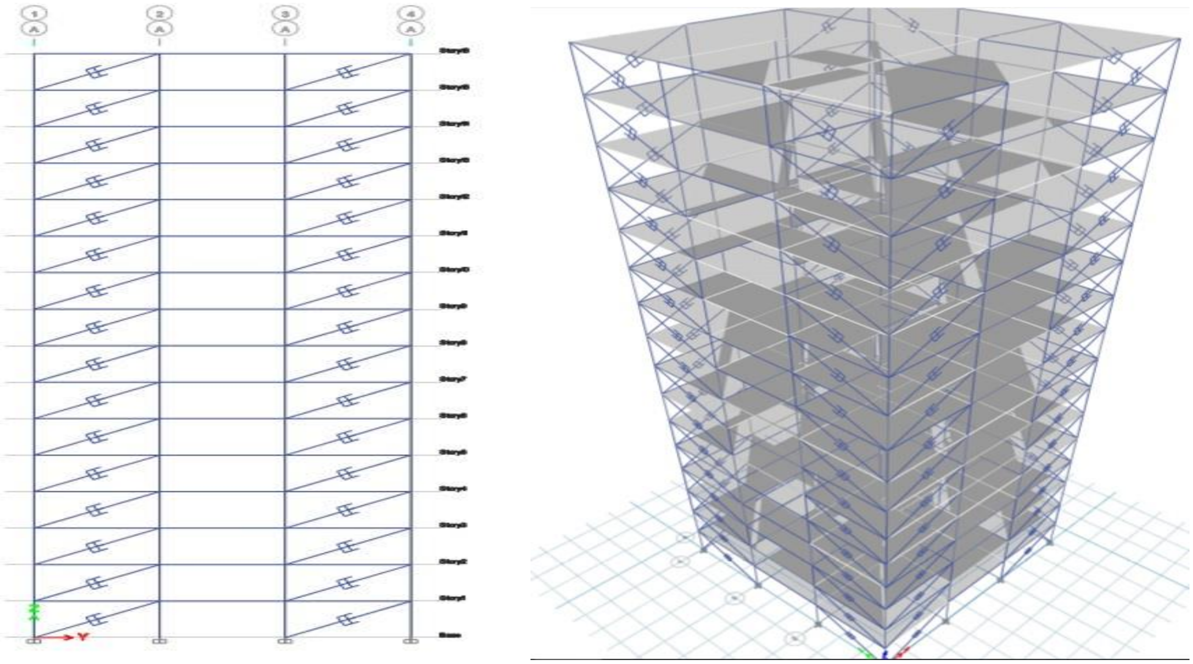


Figure 2: Elevation & Isometric view of G+15 Building with FVD

Table 2: Properties of FVD

Building Size/Properties	C_D	C_L	V_{max}	F_{dmax}	K_L
18m x 18m (bay 6x6)	0.615	70297.79	0.076	5369.497	723129.93
15m x 15m (bay 5x5)	0.615	50478.49	0.083	4223.042	474077.15

2.4 Damper modeling

The effect of Fluid Viscous Dampers and Tuned Mass Dampers on the seismic efficiency of the structure is simulated and compared in this analysis. This paper uses ETABS 2018.1.1, a nonlinear finite element based structural analysis program, to perform nonlinear time history analyses of the structure. Table 2 presents the properties of the fluid viscous damper and Table 3 shows the properties of the tuned mass damper. In Table 3, f_{opt} means optimal frequency of Tuned Mass Damper, ξ_{dopt} means dumping ratio of dampers,M_d means the mass of tuned mass dampers in tone, K_d means stiffness of dampers in KN/m, and C_d means dumping coefficient of dampers in Kn-S/m. Similarly, in Table 2 C_D means modification factor, C_L means damping coefficient in Kn-S/m, K_L means stiffness in KN/m, F_{dmax} & V_{max} represent the peak damping force and peak damping velocity of the FVD. Analysis of the result shows that as the frequency increases, the mass of the tuned mass damper is decreasing. Also, the value of stiffness and dumping capacities is increasing. The table only mentions the value of the initial four modes because according to the IS-1893 2002(Part 1) Because the amplitudes of 95 percent mode shapes can be scaled to any desired value.(IS:1893, 2002) [17] All values of the fluid viscous damper are obtained by using the formula of five steps to design fluid viscous damper [14, 15].

Table 3 Properties of Tuned Mass Damper

Properties of TMD for 18m x 18m building (bay 6x6)				
Mode	1	2	3	4
f_{opt}	0.9316	0.8823	0.812	0.801
ξ_{dopt}	0.127	0.140	0.154	0.168
m_d	158.024	151.962	149.662	147.755
k_d	3045.454	23495.634	53788.96	99337.61
c_d	176.206	529.058	873.939	1287.262
Properties of TMD for 15m x 15m building (bay 5x5)				
Mode	1	2	3	4
f_{opt}	0.930	0.870	0.801	0.7218
ξ_{dopt}	0.128	0.1433	0.156	0.169
m_d	121.387	120.152	116.137	114.729
k_d	2968.274	22993.047	51661.503	79671.768
c_d	153.635	476.364	764.226	1021.88

3. Results and Discussion

3.1 Storey Displacement

Building without a damper, a building with tuned mass damper, and a building with Fluid Viscous damper, Storey Displacement of different stories were calculated using Time History Analysis in the x and y directions. Analyses the damper's efficiency and response reduction are presented Tables and graphs. Table 4 show the displacement value of the different storey. Now we consider the G+15 building if maximum displacement occurs at top of the building without a damper. TMD & FVD two dissipating devices are used individually to control the displacement of the building. We consider the two models with different bay sizes (5x5 & 6x6) if the bay size is changed if the displacement of the building also changed. Table 4 show that the bay size changed so the displacement value of building 6x6 is higher than the 5x5 building without damper and with damper. Figures 4 & 5 show the comparative graph of displacement value of x-direction and y-direction due to earthquake forces in the x-direction at storey 16, storey 12, storey 8, storey 4, and storey 1. To study the graph properly we have found that displacement at maximum in 6x6 building and efficiency of Tuned Mass Damper to dissipate storey displacement is more than the Fluid Viscous Damper.

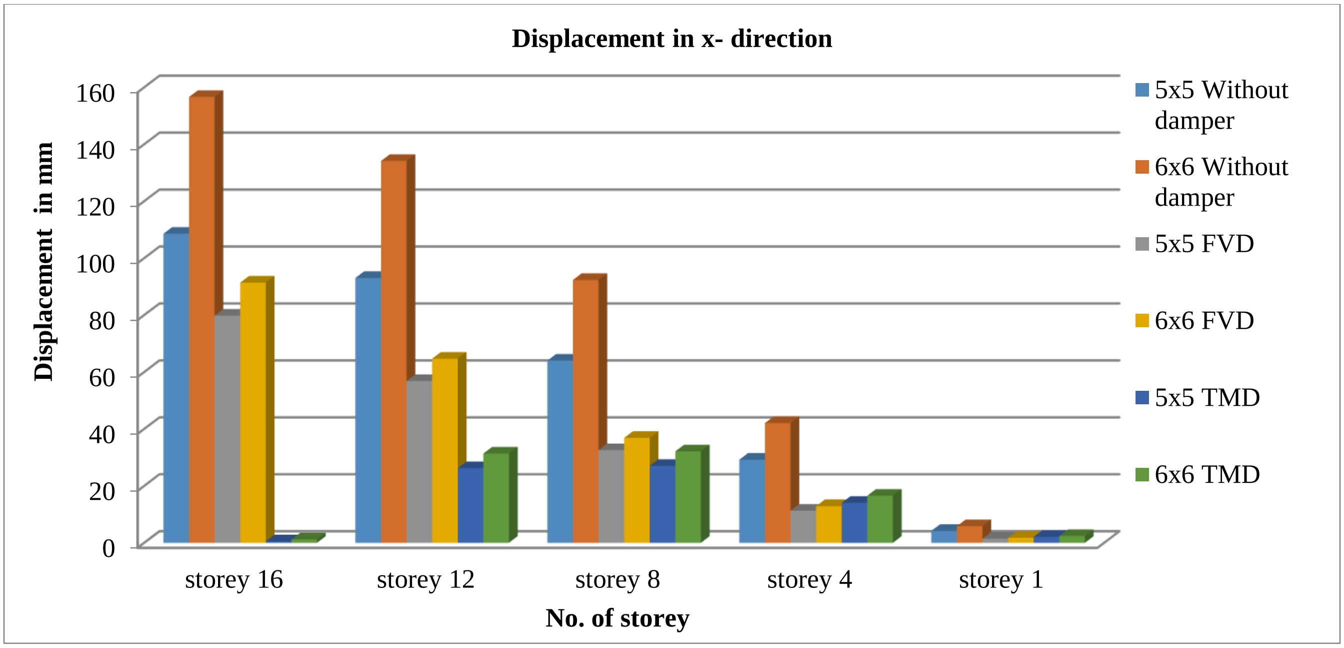


Figure 3: Combined graph of Story displacement of both building bay sizes (5x5 & 6x6) in x-direction due to EX

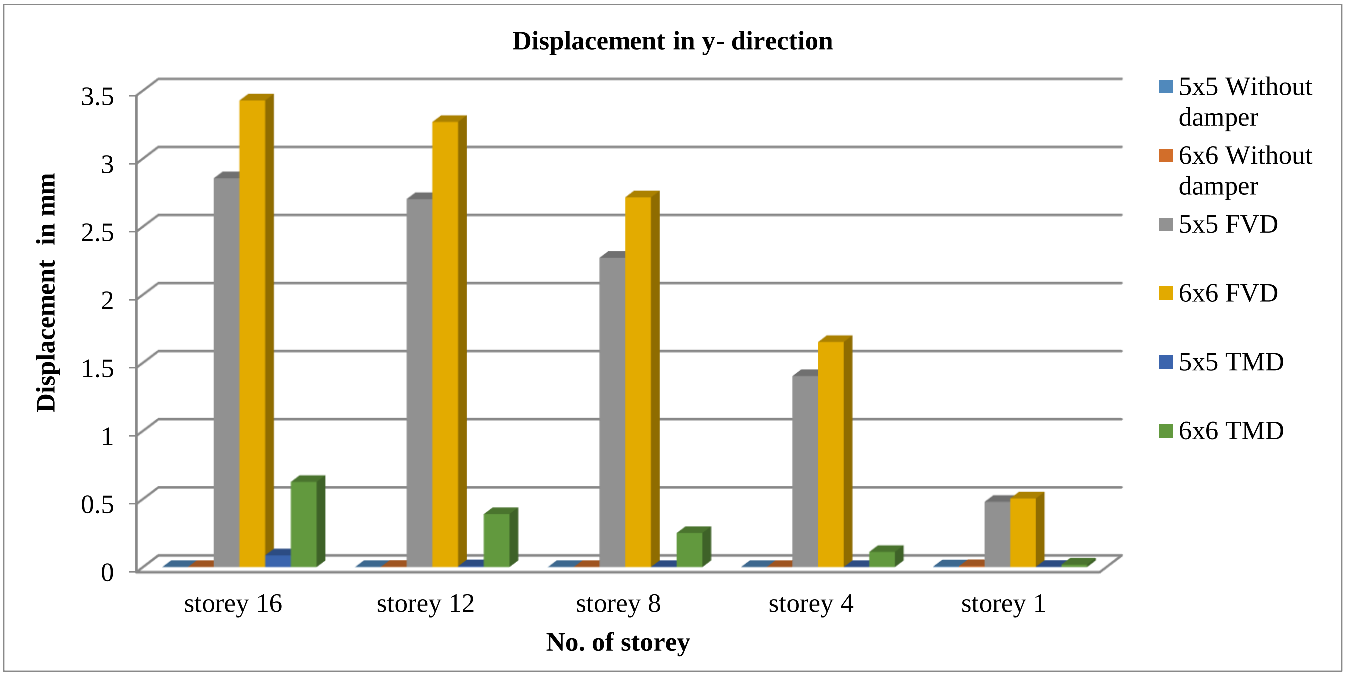


Figure 4: Combined graph of Story displacement of both building bay sizes (5x5 & 6x6) in y-direction due to EX

Table 4: Displacement from time history analysis in x and y direction due to EX

Storey	Elevation	Displacement 15m x 15m Building (bay 5m x 5m)						Displacement 18m x 18m Building (bay 6m x 6m)					
		Without Damper		With FVD		With TMD		Without Damper		With FVD		With TMD	
	m	mm		mm		mm		Mm		mm		mm	
		X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir
Storey16	48	108.54	0.0003	79.78	2.855	0.505	0.086	156.60	0.001	91.38	3.427	1.176	0.625
Storey15	45	106.27	0.003	74.20	2.813	8.524	0.001	153.29	0.005	84.88	3.389	10.54	0.488
Storey14	42	102.94	0.002	68.56	2.773	16.28	0.006	148.42	0.003	78.31	3.355	19.63	0.462
Storey13	39	98.49	0.001	62.77	2.744	22.23	0.003	141.98	0.002	71.57	3.326	26.65	0.424
Storey12	36	93.03	0.001	56.82	2.702	26.22	0.002	134.11	0.002	64.68	3.269	31.36	0.389
Storey11	33	86.72	0.001	50.77	2.635	28.46	0.002	125.01	0.002	57.69	3.18	33.97	0.354
Storey10	30	79.68	0.001	44.66	2.541	29.17	0.002	114.89	0.001	50.67	3.058	34.77	0.319
Storey9	27	72.06	0.001	38.55	2.42	28.60	0.001	103.94	0.001	43.70	2.903	34.06	0.284
Storey8	24	63.99	0.001	32.54	2.271	27.00	0.001	92.31	0.001	36.86	2.715	32.11	0.25
Storey7	21	55.56	0.0004	26.70	2.095	24.57	0.001	80.17	0.001	30.25	2.496	29.17	0.215
Storey6	18	46.90	0.0003	21.13	1.892	21.49	0.001	67.66	0.001	23.97	2.245	25.47	0.18
Storey5	15	38.08	0.0002	15.95	1.661	17.93	0.0003	54.911	0.0004	18.15	1.964	21.19	0.146
Storey4	12	29.20	0.0002	11.27	1.402	14.04	0.0003	42.03	0.0004	12.88	1.652	16.53	0.111
Storey3	9	20.37	0.0004	7.2	1.113	9.95	0.001	29.21	0.001	8.31	1.307	11.64	0.077
Storey2	6	11.77	0.001	3.876	0.794	5.831	0.002	16.78	0.002	4.56	0.926	6.759	0.045
Storey1	3	4.164	0.005	1.428	0.479	2.077	0.002	5.834	0.007	1.75	0.504	2.363	0.018

3.2 Storey Stiffness

The term stiffness in structural engineering refers to a structural element's rigidity. In general, this refers to the element's ability to resist deformation or deflection under the influence of an applied force. In this section we have discussed storey stiffness of G+15 building without a damper, a building with tuned mass damper, and a building with Fluid Viscous damper, Storey Stiffness of different stories was calculated using Time History Analysis in the x and y directions. Table5 show the stiffness value of the entire modal that we have considered. For analysis of both the table, we have found out 5x5 bay size building is stiffer than 6x6 bay size building. If we also find that stiffness at bottom of the storey is much higher than the top of the storey. From Figure 6 show the comparative graph of stiffness in a different storey. If observation of graph, stiffness of building by using FVD slightly lower as compared to without damper and at the same modal by using TMD stiffness is higher than as compare to FVD and Without damper. In graph represent the stiffness value at storey 16, 12, 8, 4, & storey 1, study the graph stiffness of TMD of the 5x5 bay size building is much higher than 6x6 bay size building.

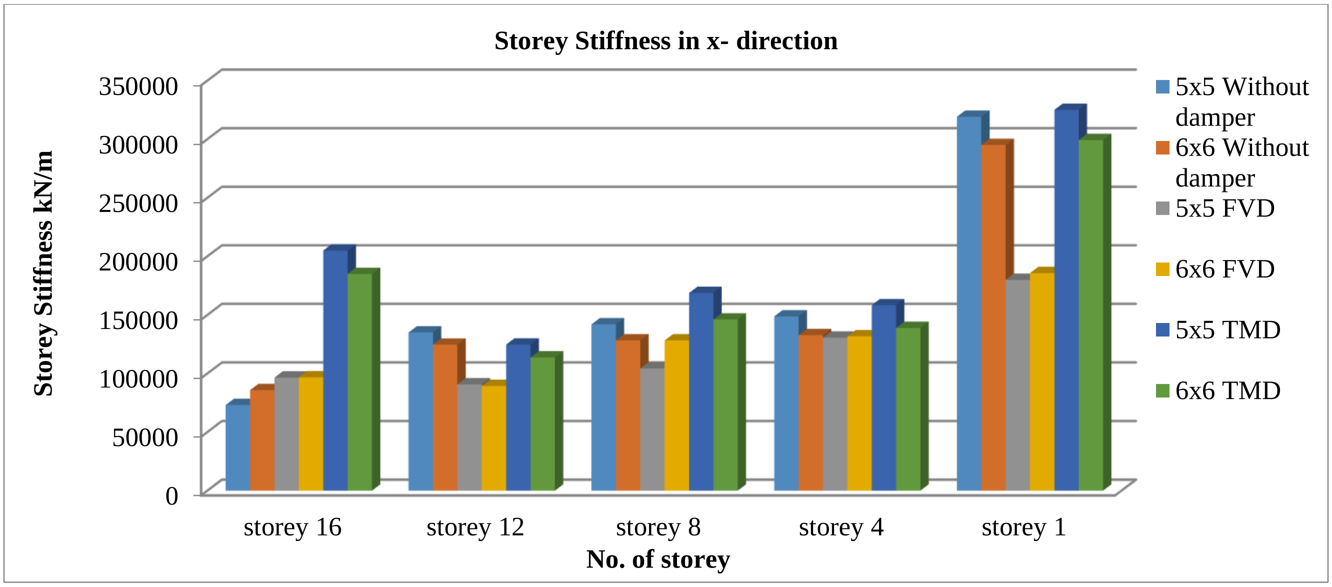


Fig. 5 Story Stiffness in x direction for both the building (bay size 6x6 & 5x5) due to Ex

3.3 Storey Drift

The relative translational displacement difference between two consecutive floors is known as the inter-story drift of building structures [16]. In this section, we have discussed the storey drift of the building. Table 6 show the storey drift of the entire storey. Figure 7 shown the story drift of the entire building which after analyzing it shows that when the damper is not used then the value of the story drift increases from the top story to the bottom story. The value of the story drift when using damper, the top is higher and decreases towards the bottom of the building. Comparing the story drifts of the two buildings in this section, it is found that the story drift of 5x5 bay size buildings is less than that of 6x6 bay size buildings. By doing the comparison of the graph, we found that the control of the story drift by the Tuned Mass Damper in the middle story of the building is higher than as compared to the fluid viscous damper. In the effect of the bottom story, both of them have almost the same effect.

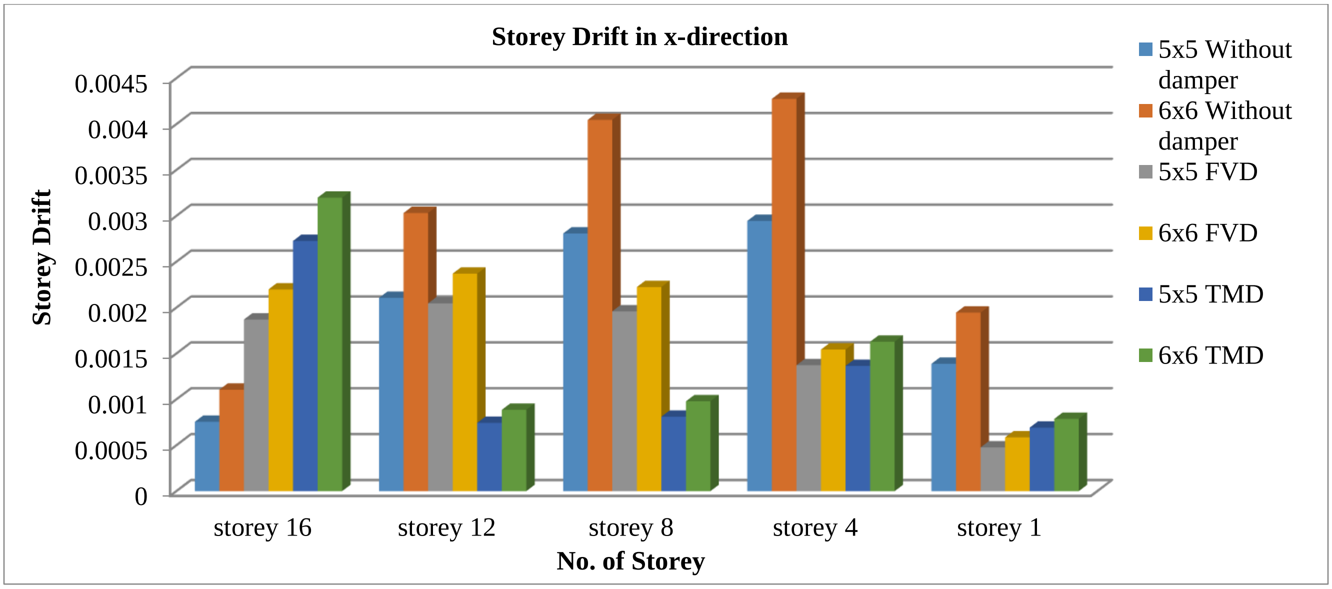


Fig. 6 Story Drift in x direction (bay size 5x5 and 6x6)

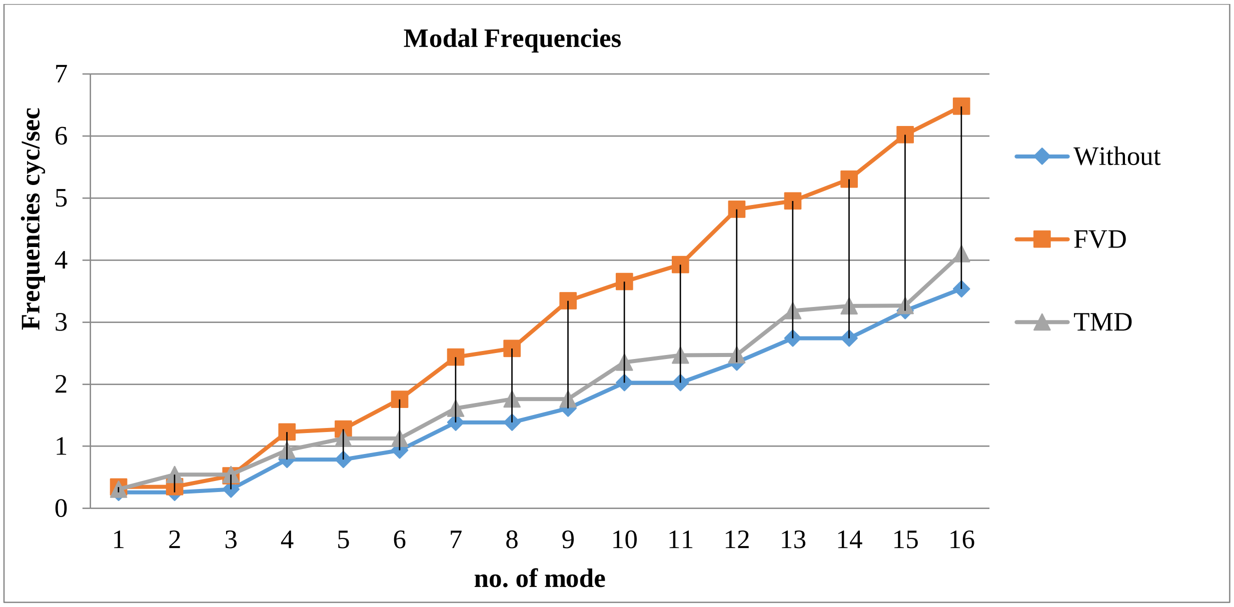


Fig. 7 Modal Frequency without Damper, With TMD and FVD (bay size 5X5)

Table 5. Storey Stiffness from time history analysis in x and y direction due to EX

Storey	Elevation	Storey Stiffness 15m x 15m Building (bay 5m x 5m)						Storey Stiffness 18m x 18m Building (bay 6m x 6m)					
		Without Damper		With FVD		With TMD		Without Damper		With FVD		With TMD	
	m	kN/m		kN/m		kN/m		kN/m		kN/m		kN/m	
		EQ$_X$	EQ$_Y$	EQ$_X$	EQ$_Y$	EQ$_X$	EQ$_Y$	EQ$_X$	EQ$_Y$	EQ$_X$	EQ$_Y$	EQ$_X$	EQ$_Y$
		X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir
Storey16	48	73111	73111	96538	96538	204922	204922	85821	85821	96737	96737	184969	184969
Storey15	45	112894	112894	77031	77031	159417	159417	111912	111912	75325	75325	143551	143551
Storey14	42	125796	125796	84225	84225	145752	145752	119590	119590	82927	82927	130741	130741
Storey13	39	131650	131650	87232	87232	137329	137329	122816	122816	85899	85899	123510	123510
Storey12	36	135053	135053	90677	90677	124679	124679	124607	124607	89352	89352	113685	113685
Storey11	33	137378	137378	93925	93925	70950	70950	125813	125813	92592	92592	73096	73096
Storey10	30	139156	139156	97193	97193	245567	245567	126735	126735	95888	95888	201908	201908
Storey9	27	140643	140643	100593	100593	181151	181151	127515	127515	99368	99368	155190	155190
Storey8	24	141988	141988	104307	104307	168753	168753	128230	128230	103239	103239	146086	146086
Storey7	21	143297	143297	108589	108589	163374	163374	128943	128943	107782	107782	142129	142129
Storey6	18	144669	144669	113824	113824	160371	160371	129734	129734	113416	113416	139938	139938
Storey5	15	146292	146292	120686	120686	158637	158637	130789	130789	120894	120894	138763	138763
Storey4	12	148731	148731	130627	130627	158270	158270	132721	132721	131760	131760	138877	138877
Storey3	9	154232	154232	148268	148268	161379	161379	137833	137833	150639	150639	142477	142477
Storey2	6	173644	173644	181556	181556	178985	178985	156655	156655	182689	182689	160180	160180
Storey1	3	319149	319149	179869	179869	325020	325020	295030	295030	185695	185695	299246	299246

Table 6. Storey Drift from time history analysis in x and y direction due to EX

Storey	Elevation	Storey Stiffness 15m x 15m Building (bay 5m x 5m)						Storey Stiffness 18m x 18m Building (bay 6m x 6m)					
		Without Damper		With FVD		With TMD		Without Damper		With FVD		With TMD	
	m	Unit less		Unit less		Unit less		Unit less		Unit less		Unit less	
		EQ_X	EQ_Y	EQ_X	EQ_Y	EQ_X	EQ_Y	EQ_X	EQ_Y	EQ_X	EQ_Y	EQ_X	EQ_Y
		X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir	X-dir	Y-dir
Storey16	48	0.00075	0.00075	0.00187	0.00187	0.00272	0.00272	0.00110	0.00110	0.00219	0.00219	0.00320	0.00320
Storey15	45	0.00111	0.00111	0.00191	0.00191	0.00258	0.00258	0.00162	0.00162	0.00225	0.00225	0.00305	0.00305
Storey14	42	0.00148	0.00148	0.00196	0.00196	0.00198	0.00198	0.00214	0.00214	0.00230	0.00230	0.00236	0.00236
Storey13	39	0.00181	0.00181	0.00201	0.00201	0.00133	0.00133	0.00262	0.00262	0.00234	0.00234	0.00159	0.00159
Storey12	36	0.00210	0.00210	0.00204	0.00204	0.00074	0.00074	0.00303	0.00303	0.00237	0.00237	0.00089	0.00089
Storey11	33	0.00234	0.00234	0.00206	0.00206	0.00023	0.00023	0.00337	0.00337	0.00237	0.00237	0.00029	0.00029
Storey10	30	0.00253	0.00253	0.00205	0.00205	0.00018	0.00018	0.00365	0.00365	0.00235	0.00235	0.00023	0.00023
Storey9	27	0.00269	0.00269	0.00202	0.00202	0.00053	0.00053	0.00387	0.00387	0.00230	0.00230	0.00065	0.00065
Storey8	24	0.00280	0.00280	0.00195	0.00195	0.00081	0.00081	0.00404	0.00404	0.00222	0.00222	0.00098	0.00098
Storey7	21	0.00288	0.00288	0.00186	0.00186	0.00102	0.00102	0.00417	0.00417	0.00211	0.00211	0.00123	0.00123
Storey6	18	0.00293	0.00293	0.00173	0.00173	0.00118	0.00118	0.00425	0.00425	0.00195	0.00195	0.00142	0.00142
Storey5	15	0.0029	0.0029	0.00157	0.00157	0.00129	0.00129	0.00429	0.00429	0.00177	0.00177	0.00155	0.00155
Storey4	12	0.00294	0.00294	0.00137	0.00137	0.00136	0.00136	0.00427	0.00427	0.00154	0.00154	0.00162	0.00162
Storey3	9	0.00285	0.00285	0.00112	0.00112	0.00137	0.00137	0.00414	0.00414	0.00126	0.00126	0.00163	0.00163
Storey2	6	0.00254	0.00254	0.00086	0.00086	0.00125	0.00125	0.00365	0.00365	0.00098	0.00098	0.00146	0.00146
Storey1	3	0.00138	0.00138	0.00047	0.00047	0.00069	0.00069	0.00194	0.00194	0.00058	0.00058	0.00078	0.00078

3.4 Modal Frequency

Building without a damper, a building with tuned mass damper, and a building with Fluid Viscous damper, Modal Frequencies was calculated using Time History Analysis in the x and y directions. Tables and graphs are used to calculate the damper's efficiency and response reduction.

Mode shapes are naturally occurring movement patterns in structures that have been set in motion by ground shaking. Each seismic-resistant structure has its own natural or fundamental period of vibration, which is the amount of time it takes to complete one cycle of free vibration. In Table 7 and Figure 8, Fig.9, and Fig.10 the modal frequency and modal time period is presented. On comparing all the data, we found that the tuned mass damper is reducing the frequency better than the fluid viscous damper.

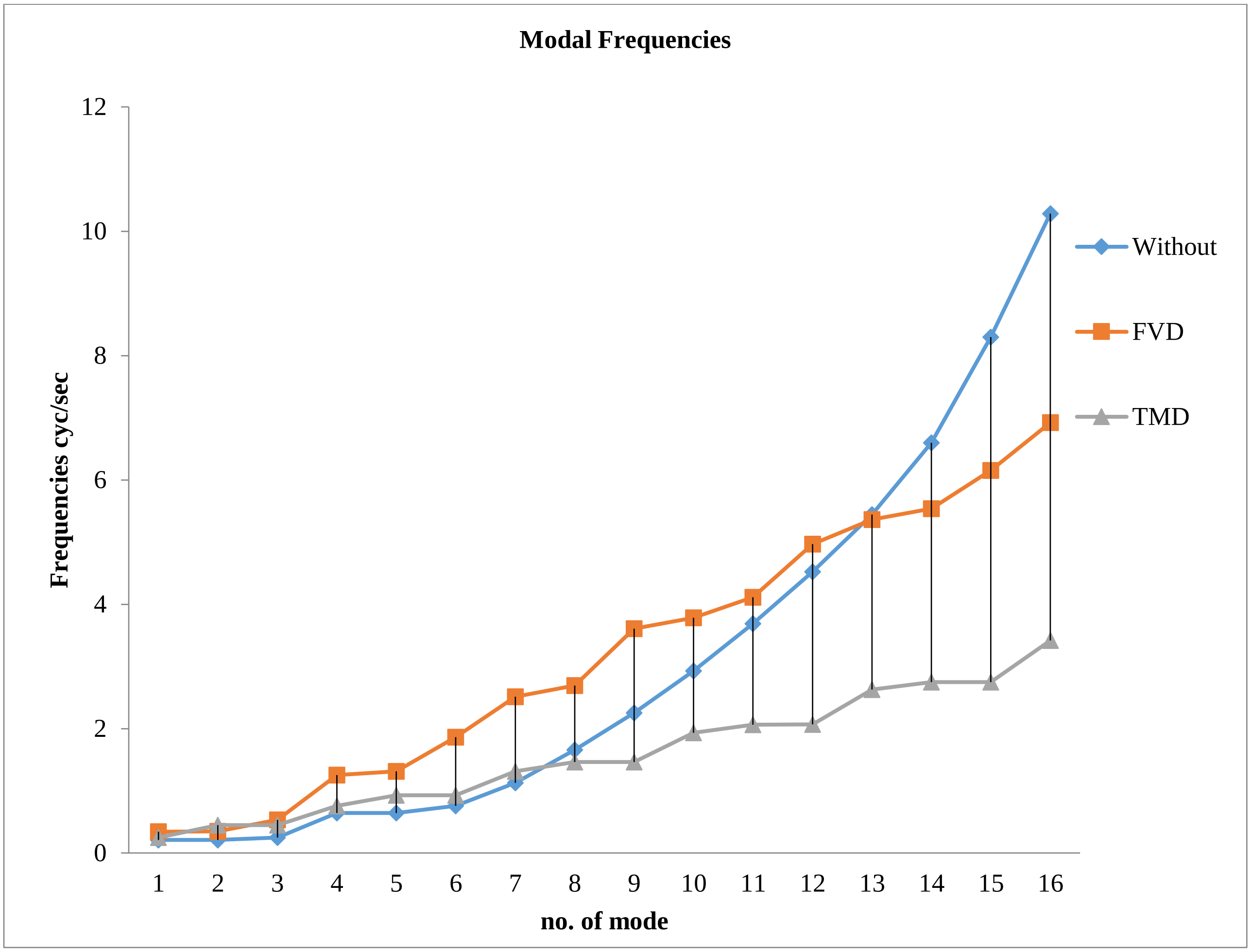


Fig. 8 Modal Frequency without Damper, With TMD and FVD (bay size 6X6)

Table 7. Modal Frequency from time history analysis in x and y direction due to EX

Mode	Modal Frequency 15m x 15m Building (bay 5m x 5m)						Modal Frequency 18m x 18m Building (bay 6m x 6m)					
	Without Damper		With FVD		With TMD		Without Damper		With FVD		With TMD	
	Period	Frequency	Period	Frequency	Period	Frequency	Period	Frequency	Period	Frequency	Period	Frequency
	sec	cyc/sec	sec	cyc/sec	sec	cyc/sec	sec	cyc/sec	sec	cyc/sec	sec	cyc/sec
1	3.898	0.257	2.903	0.344	3.262	0.307	4.772	0.21	2.932	0.341	4.025	0.248
2	3.898	0.257	2.866	0.349	1.85	0.541	4.772	0.21	2.88	0.347	2.235	0.447
3	3.262	0.307	1.916	0.522	1.849	0.541	4.03	0.248	1.872	0.534	2.234	0.448
4	1.268	0.788	0.814	1.229	1.069	0.936	1.554	0.644	0.799	1.252	1.316	0.76
5	1.268	0.788	0.785	1.274	0.89	1.124	1.554	0.644	0.762	1.313	1.076	0.93
6	1.069	0.936	0.57	1.753	0.889	1.124	1.318	0.759	0.537	1.861	1.075	0.93
7	0.723	1.383	0.411	2.435	0.62	1.612	0.888	1.126	0.398	2.512	0.761	1.314
8	0.723	1.383	0.388	2.574	0.569	1.759	0.604	1.656	0.371	2.693	0.684	1.462
9	0.62	1.612	0.299	3.345	0.568	1.76	0.443	2.255	0.277	3.608	0.683	1.464
10	0.494	2.025	0.274	3.652	0.425	2.355	0.341	2.93	0.264	3.785	0.518	1.931
11	0.494	2.025	0.255	3.929	0.405	2.468	0.271	3.687	0.243	4.115	0.484	2.064
12	0.425	2.355	0.207	4.82	0.405	2.47	0.221	4.521	0.201	4.968	0.484	2.066
13	0.365	2.742	0.202	4.953	0.314	3.183	0.184	5.442	0.186	5.364	0.38	2.629
14	0.365	2.742	0.189	5.305	0.307	3.262	0.152	6.597	0.18	5.54	0.364	2.746
15	0.314	3.183	0.166	6.02	0.306	3.265	0.121	8.297	0.162	6.155	0.364	2.749
16	0.283	3.537	0.154	6.477	0.244	4.103	0.097	10.283	0.144	6.921	0.293	3.417

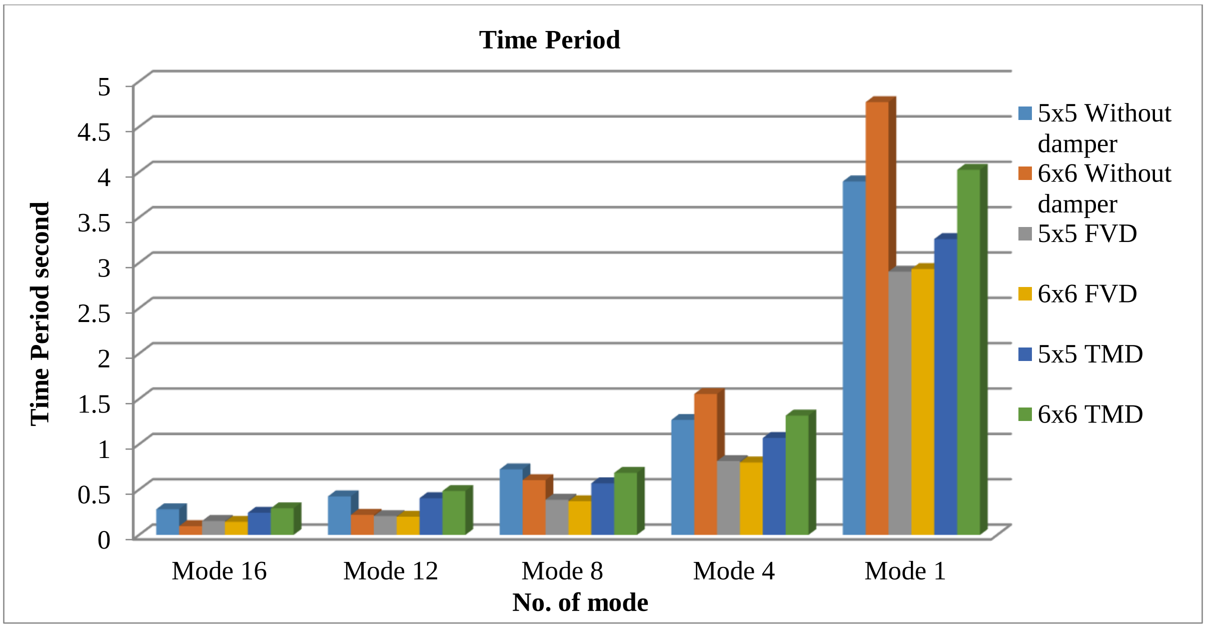


Fig. 9 Modal Time Period without Damper, With TMD and FVD (bay size 5x5 & 6x6)

3.5 Base Shear

Building without a damper, a building with tuned mass damper, and a building with Fluid Viscous damper, Base Shear was calculated using Time History Analysis in the x and y direction. The highest predicted lateral force on the base of the structure due to seismic activity is called base shear. It is measured using the seismic zone, soil content and lateral force equations from the building code. In this section, we are discussing base shear. Base shear without a damper is less compared with a damper. Base shear is less of a 5x5 bay building compared to a 6x6 bay size building. Table8 and figure11 represent the base shear of both modal in X-direction and y-direction. The base shear depends on what kind of structure is there and what kind of load is applied to it.

Table 8. Base Shear from time history analysis in x and y direction

Modal	Direction	Without Damper	With FVD	With TMD
		kN	kN	kN
First Modal (bay size 5x5)	X-Dir	1327.1095	2774.6494	2875.2258
	Y-Dir	1327.1095	2774.6494	2873.6327
Second Modal (bay size 6x6)	X-Dir	1718.4083	3234.6256	3158.1628
	Y-Dir	1718.4083	3234.6256	3156.1327

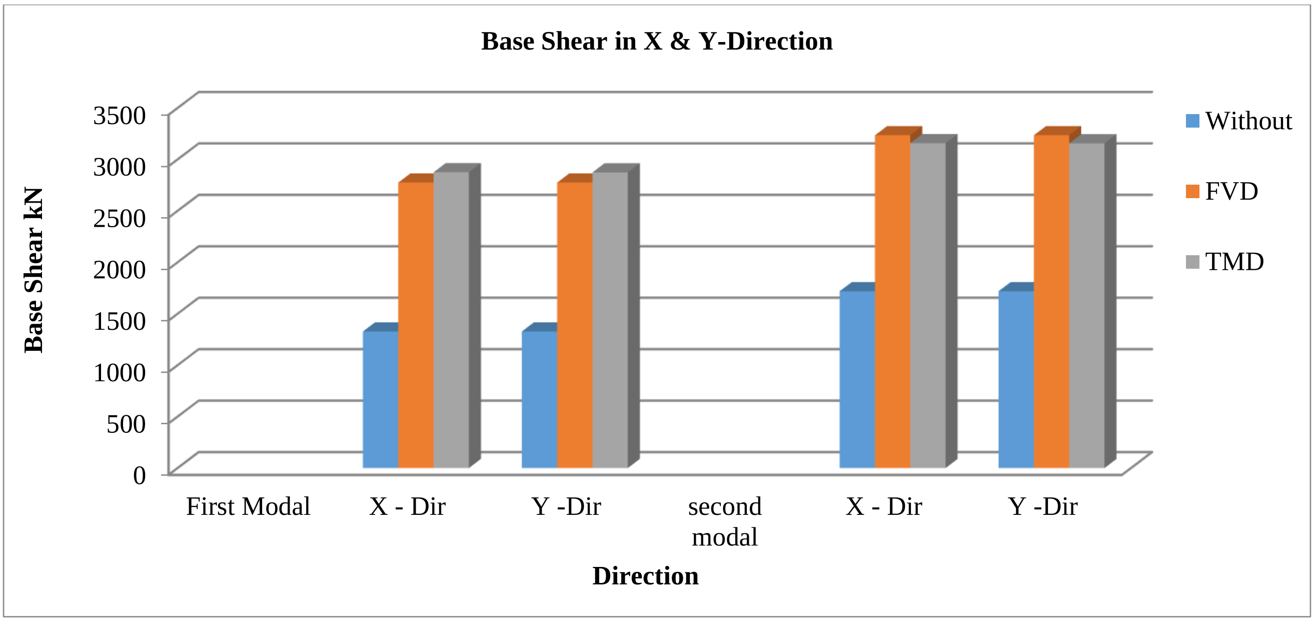


Fig. 10 Base Shear of both the modal in X and Y direction

Now in this section, we have taken Symmetrical Building for Comparative Analysis, due to which the effect of earthquake has come in the same in x-direction and y-direction.

4. Conclusion

The difference in SMRF structure behaviour with and without damper for a seismic load was investigated in this research. The analysis of a G+15-story building was done using ETABS2018 Version 18.1.1 software and numerical calculations. The results show that using the control of the seismic energy with FVD and TMD in buildings reduces structural response significantly as compared to buildings without Damper. However, in the case of a G+15 story building, the following are the key conclusions:

- Analytical study is done for multi-storey building by using Fluid Viscous Damper and Tuned Mass Damper separately, it is found that Tuned Mass Damper more effectively control the displacement as compare to Fluid Viscous Damper.
- In the first building bay size 5m x 5m, the capacity to prevent maximum displacement is 26.5 % using a fluid viscous damper, while the use of tuned mass damper is 73 percent. Thus, the efficiency in other buildings is 41% and 77% when using the fluid viscous damper and tuned mass damper respectively.
- India is situated in different earthquake zones (II, III, IV.V), the high-risk region is in Zones IV and V. If the relation during the construction of the building in Zone IV & V is central to these research works.
- We also looked at buildings with different dampers and bays, and found that tuned mass dampers are more effective at absorbing shocks than fluid viscous dampers.
- Stiffness of near the damper is slightly more than as compare to other stories and max at the bottom stories of building. In this study found that Tuned mass Damper more effectively act during the earthquake because the stiffness is higher than as

compare to Fluid Viscous Damper or without damper at the top storey and bottom storey of building.

References

[1] Vargas, R., & Bruneau, M. (2007). Effect of Supplemental Viscous Damping on the Seismic Response of Structural Systems with Metallic Dampers. *Journal of Structural Engineering*, *133*(10), 1434–1444. https://doi.org/10.1061/(asce)0733-9445(2007)133:10(1434)

[2] Sotnikov, V. I., Berzina, A. N., & Berzina, A. P. (2002). Fluorine in light micas of Siberian and Mongolian porphyry copper-molybdenum deposits and its probable origin. *Geochemistry International*, *40*(10), 1004–1012.

[3] Housner, G. W., Soong, T. T., & Masri, S. F. (1996). Second generation of active structural control in civil engineering. Computer-Aided Civil and Infrastructure Engineering, 11(5), 289-296.

[4] Aliakbari, F., Garivani, S., & Aghakouchak, A. A. (2020). An energy based method for seismic design of frame structures equipped with metallic yielding dampers considering uniform inter-story drift concept. *Engineering Structures*, *205*(December 2019), 110114.

https://doi.org/10.1016/j.engstruct.2019.110114

[5] Yogesh, R., Suryawanshi, Shitole, A., & Rahane, T. (2012). Study of Tuned Mass Dampers System as Vibration Controller in Multistoried buildings. *International Journal of Advanced And Innovative Research (IJAIR)*, *1*(November 2012), 280–284.

[6] Naziya Ghanchi, & Shilpa Kewate. (2015). Dynamic Analysis of 25 Storey Rcc Building With and Without Viscous Dampers. *International Journal of Scientific & Engineerign Research*, *6*(12), 63–68.

[7] Cristian, P. (2014). *SEISMIC RESPONSE OF BUILDING*. *April 2015*.

[8] Ras, A., & Boumechra, N. (2016). Seismic energy dissipation study of linear fluid viscous dampers in steel structure design. *Alexandria Engineering Journal*, *55*(3), 2821–2832. https://doi.org/10.1016/j.aej.2016.07.012

[9] Guidelines, G., Including, E., & History, B. (n.d.). *Fluid Viscous Dampers.Pdf*.

[10] Connor, J. J. (n.d.). *Introduction To Structural Motion Control*.

[11] Roffel, A. J., & Narasimhan, S. (2016). Results from a Full-Scale Study on the Condition Assessment of Pendulum Tuned Mass Dampers. *Journal of Structural Engineering*, *142*(1), 04015096. https://doi.org/10.1061/(asce)st.1943-541x.0001339

[12] Tamura K. (1972). Earthquake- resistant design of railway structures. In *Perma Way* (Vol. 13, Issue 3).

[13] Computers & Structures, I. (2016). *Welcome to ETABS Welcome to*. 31.

[14] Palermo, M., Silvestri, S., Landi, L., Gasparini, G., & Trombetti, T. (2016). Peak velocities estimation for a direct five-step design procedure of inter-storey viscous dampers. *Bulletin of Earthquake Engineering*, *14*(2), 599–619. https://doi.org/10.1007/s10518-015-9829-8

[15] Silvestri, S., Gasparini, G., & Trombetti, T. (2010). A five-step procedure for the dimensioning of viscous dampers to be inserted in building structures. *Journal of*

Conflict of Interest

Authors declare no conflict of interest.

Earthquake Engineering, *14*(3), 417–447. https://doi.org/10.1080/13632460903093891.

[16] Patil Jaya, P., & Alandkar, D. P. M. (2016). International journal of engineering sciences & research technology drift analysis in multistoried building. *International Journal of Engineering Sciences & Research Technology*, *5*(12), 490–505.

[17] IS:1893. (2002). Criteria for Earthquake Resistant Design of Structures - General Provisions and Buildings Part-1. *Bureau of Indian Standards, New Delhi*, *Part 1*, 1–39.