Seismic Analysis using Dampers in High Rise Building

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Abstract: This study investigates the results occurring due to the application of dampers, which can help in reducing the influence of seismic radiations on the structure. High rise building affected by ground motion in daily life needs to be supervised its behaviour, as this is a common problem for development. The foundation of the building is shaking due to earthquake. The vibration caused by the seismic activities causes the building to vibrates which can cause structural damage. The resistance capacity of building components including columns, beams and other structural elements gets lower ultimately due to the development of lateral stresses due to the transmission of vibrations created at the bottom to the topof the building. The article presents the results of studies on theseismic behaviour of the structures two different dampers i.e Fluid viscous dampers (FVD) and Friction dampers equipped on the structure. According to the current edition of IS 1893 almost all multilayer systems should be studied as three dimensional system. Building floor plan may be seen as symmetrical. In the present work, response spectrum analysis method is used to compare the FVD and frictional dampers. Results for both G+ 15 structure are been compared in terms ofstorey displacement, storey drift, storey shear, time period, torsional irregularity.

Keywords: Dampers, Fluid Viscous Damper, Friction Damper, Response spectrum method, Etabs

1. INTRODUCTION

The growing infrastructure leads to great investment and economic development of the society, it is necessary to make them safer against earthquake and let people feel confident in their structures. The striking of earthquake results in moving ofground beneath the building and it displaces the foundation andthe lower levels of the structure, sending shock waves to the structure and causing it to move back and forth. The strength ofthe oscillation depends on two factors, the first being the buildings mass and its stiffness which is the force required to cause a certain amount of displacement. Along with the buildings material type and the shape of the column, the stiffness is largely a matter of height. Shorter buildings are stiffer and shift less while taller buildings are more flexible. In the design of building structures with integration of seismic dampers, the section sizes of structural components and the amount of reinforcement may be reduced so that the seismic performance of the structure remains comparable to a conventional design without dampers under design seismicactions. Dampers is a hydraulic shock absorber to break the shaking of a building during an earthquake. The purpose of thisproject is to compare between viscous and friction damper under high seismic radiation and also the performance of placement techniques is evaluated on Etabs software. In this paper comparison and result of fluid viscous damper, friction damper with conventional building is analyzed respectively.

Dampers

Dampers is a hydraulic shock absorber to break the shaking of a building during an earthquake. Dampers is a mechanical system which dissipate earthquake energy into specialized devices which deforms or yield during earthquake. They enhance energy dissipation in a structure to which they are installed so that the structure has to absorb lesser amount of earthquake forces. When seismic energy is transmitted throughthem, dampers absorb part of it, and thus damp the motion of the building. The advancement of computational methods on computers and the use of robust testing facilities have significantly advanced the subject of earthquake engineering. As a result, several damping devices have emerged in thestructures, which have the instant impact of raising the critical damping ratio all the way up to 20–30% while also lowering thestresses and strains brought on by earthquakes. This strategy, also referred to as "energy dissipation," can absorb sizable efforts without dampening the structure and guarantee the security of people's lives and property.

The following time-dependent conservation of energy connection helps to clarify this method of seismic energy dissipation:

$$E(t) = E_k(t) + E_s(t) + E_h(t) + E_d(t)$$

where,
E is the absolute energy input from the earthquake motion;
E_k is the absolute kinetic energy;
E_s is the elastic (recoverable) strain energy, and E_h is the irrecoverable energy dissipated by the structural system throughinelastic or other forms of actions (viscous and hysteretic);
E_d is the energy dissipated by the supplement damping system and t represents time.

Types of Dampers

Fluid Viscous Damper:

It resists motion caused by a viscous fluid moving from one areato another. Silicon base fluid moving between piston cylinder configurations absorbs seismic energy. Dissipation of energy isthe viscous damper's main principle. In the damper system, fluid moves from a bigger to a smaller area. Viscous dampers can work in environments with temps between 40 and 70 degrees Celsius. In the past 30 years, important civil structures have used viscous dampers (VD) to lessen the effects of earthquakes.Their use in high-rise buildings built in seismic areas is a challenge for the designers, since they should reduce the vibrations induced by both strong winds and earthquakes, and the optimal behaviour in these two situations is not usually the same. Consequently, the design requirement for VD to be usedin high-rise buildings is often that they should have two different behaviours in the different range of velocities corresponding to wind and earthquake.

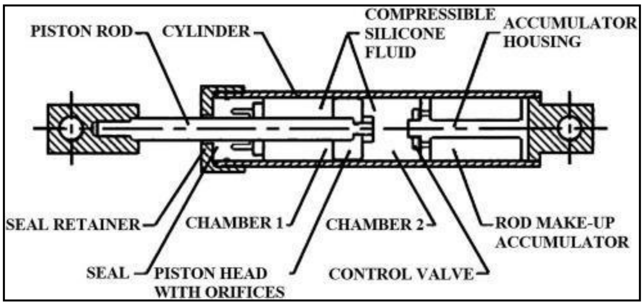


Figure 1:Cross Section of Fluid Viscous Damper

LITERATURE REVIEW:

Puneet Sajjan, Praveen Birdar "Study on the effects of viscous damper for RCC frame structure" (2022)

After analyzing the structure and considering static and dynamic values, the magnification is determined. After structural analysis, the results are obtained and compared. Analysis of the bare frame model without dampers yielded a displacement of 29.63 mm and a floor drift of 0.00181 mm. Observations show that the displacement value increases with the height of the structure. By comparison, applying a viscous damper to a structure reduces the displacement values of the structure by approximately 60% to 85%. Placing a viscous damper in the structure reduces the maximum drift in the structure during seismic loading. By applying a viscous damperto the structure, the drift value is reduced by approximately 60%to 80% on the upper and lower floors.

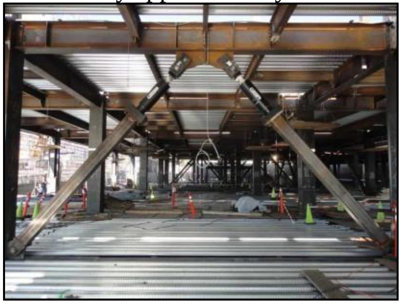


Figure 2: Fluid Viscous Damper

Friction Dampers:

Friction dampers are steel struts that absorb the enormous Charbel Mrad, Magdalini Titirla, Walid Larbi "OptimalDesign of Viscous and Friction Dampers in Symmetric Reinforced Concrete Buildings" (2022) In this paper a evaluation of the seismic overall performance of 3 symmetric in plan strengthened concrete (RC) homes strengthening with viscous or friction dampers are provided. Anreview of the most efficient layout of Viscous and Friction dampers is described. The 3 homes (a four-storey building, a nine-storey building, and a sixteen-storey building) had been subjected to seven (actual and artificial) seismic recorded accelerograms. Nonlinear dynamic time records analyses had been carried out. The results of every strengthening answer areprovided in phrases of the most horizontal displacement on the energy generated during an earthquake. These are a type of seismic dampers that consist of an array of inclined steel platesthat slide against each other in an inclined position. Friction blocks are used between such steel plates. Maintenance of thesedampers is done by regular painting. The friction surface is fixed with a preload block. Exhibits perfect rectangular hysterical behaviour. It is called a path dependent system because the amount of energy dissipated is proportional to the path. Dampers make buildings vibrate elastically and dissipate seismic energy. This in turn produce substantial savings as structural elements can be optimized for cost savings. The plates are specially treated to increase the friction between them.

Figure 3: Friction Damper

OBJECTIVE OF THE STUDY:

1. To compare the seismic behaviour of G+15 storey high risebuilding using dampers by **Response Spectrum Method** in high seismic zone.
2. To design the earthquake resistant structure by using **Friction damper** and **Fluid Viscous Damper.**

3. To find the responses of the buildings in terms of the maximum storey displacement, storey drift and torsional irregularity check under the seismic response. pinnacle of every building, the most inter-tale waft and the mostacceleration on the pinnacle of the building. The consequencesof this evaluation display that viscous dampers (VDs) appear tocarry out nicely beneath earthquake statistics for the mid- upward thrust building, at the same time as friction dampers (FDs) boom the overall performance of all systems beneath seismic action.

METHODOLOGY:

Dynamic Analysis Method

The primary goal of structural analysis is to ascertain how a physical structure will respond to force. For all buildings, excluding regular buildings lower than 15 m in Seismic Zone II,linear dynamic analysis must be done to determine the design lateral force (design seismic base shear, and its distribution to different levels along the height of the building, as well as to various lateral load resisting elements.

In turn, dynamic analysis can be performed in three ways, namely:

1) Response Spectrum Method
2) Modal time History Method
3) Time History Method

Response Spectrum Method

The modal method or mode superposition approach are other names for this technique. It is predicated on the notion that a structure reacts by superimposing the reactions of various vibrational modes, each of which exhibits a unique distorted shape, frequency, and modal damping. Response spectrum method may be performed for any building using the design acceleration spectrum, or by a site-specific design acceleration spectrum. All mentioned data for RCC buildings is analysed asper Indian code which are IS: 456-2000 and IS: 875-1987. Theseismic load and response spectrum analysis of different models are carried out using STAAD-Pro Connect edition. The load combinations considered in seismic analysis are done as per IScode 1893-2016. Response spectrum method may be performedfor any building using the design acceleration spectrum.

DESIGN CONSIDERATION AND MODELS OFTHE BUILDING

In the present study, analysis of G+15 stories building in ZoneV is carried out in ETABS.

Basic parameters considered for the analysis are

1. Utility of building: Residential Building
2. No. of Storey : 16 Stories
3. Grade of Steel : Fe415
4. Grade of Concrete : M35
5. Type of Soil : Loose Soil (Type III)
6. Plot Area : 614.43 m^2
7. Total Built Up Area : 7301.47 m^2
8. For Stories 1-6:

i) Column Size: C1- 400mm X 700 mm
C2- 650mm X 850mm
ii) Main Beam Size : 600 mm X 400 mm
iii) Secondary Beam : 450 mm X 300 mm
iv) Slab Thickness : 125 mm

9. For Stories 7-15:

i) Column Size: C3 – 300 mm X 500 mm
C4 – 450mm X 650mm
ii) Main Beam Size : 600 mm X 400 mm
iii) Secondary Beam : 450mm X 300mm
iv) Slab Thickness : 125mm

10. Shear Wall thickness: 400mm
11. Dead Load : Self Weight
12. Live Load : 4 kN/m^2
13. Floor Finish : 1 kN/m^2
14. Earthquake Load : As per IS 1893:2016
15. Seismic Zone Factor : 0.36
16. Response reduction factor : 5
17. Importance Factor : 1.5
18. Method of Analysis: Response spectrum analysis
19. RCC design code: IS 456:2000
20. Earthquake design code : IS 1893:2016

BUILDING PLAN

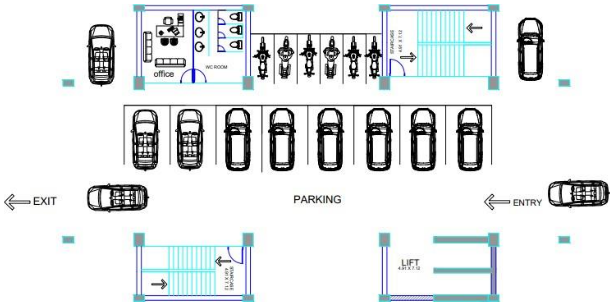


Figure 4: Ground Floor Plan

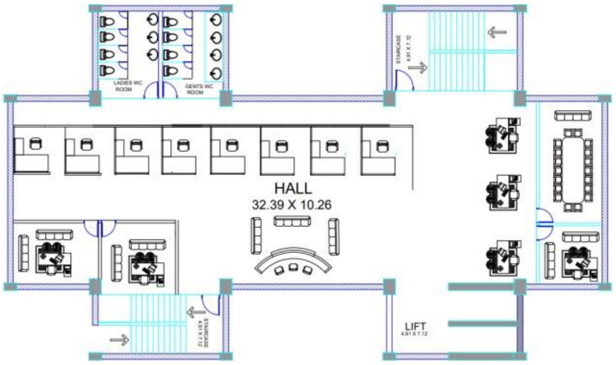


Figure 5: 1-15 Floor Plan

Models in ETABS

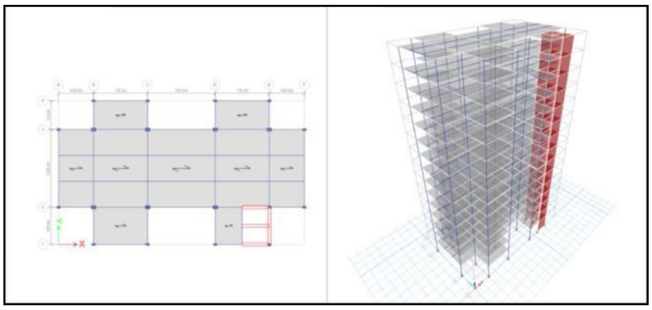


Figure 6: Building Model without dampers

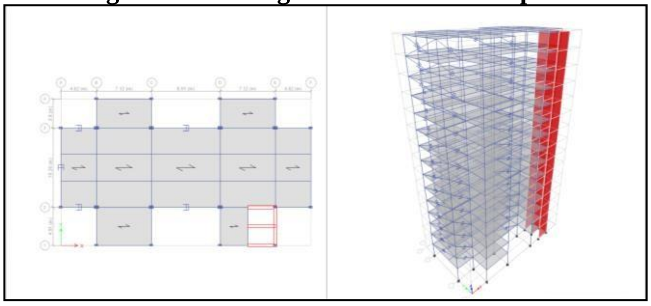


Figure 6: Building with friction damper

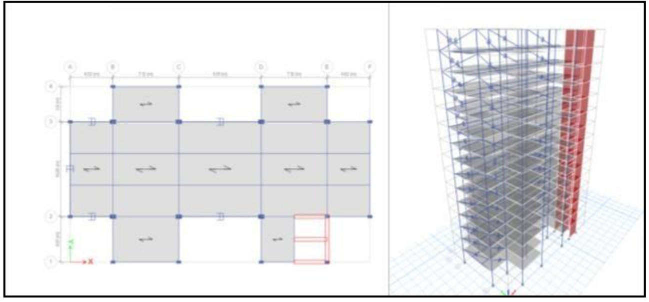
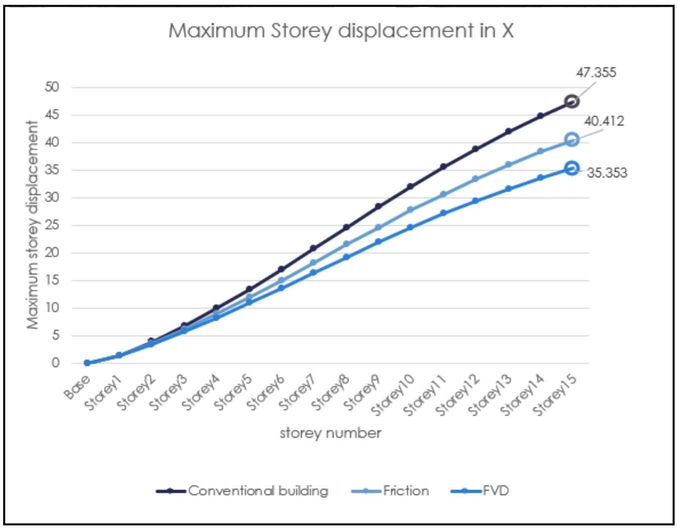


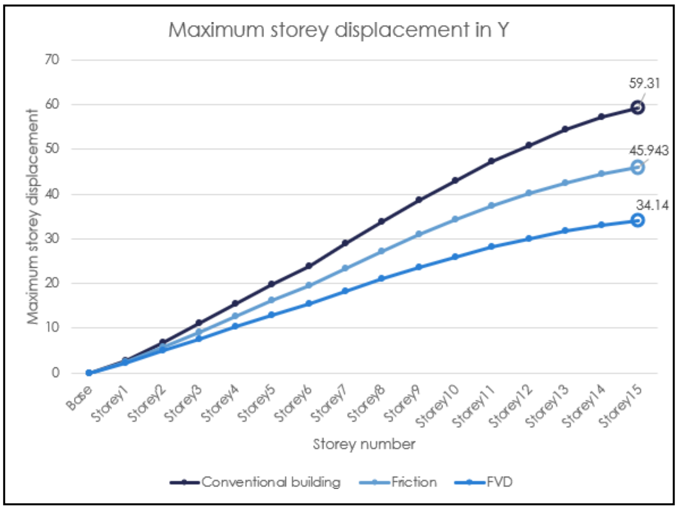
Figure 7: Building model with fluid viscous damper

ESULT AND ANALYSIS:

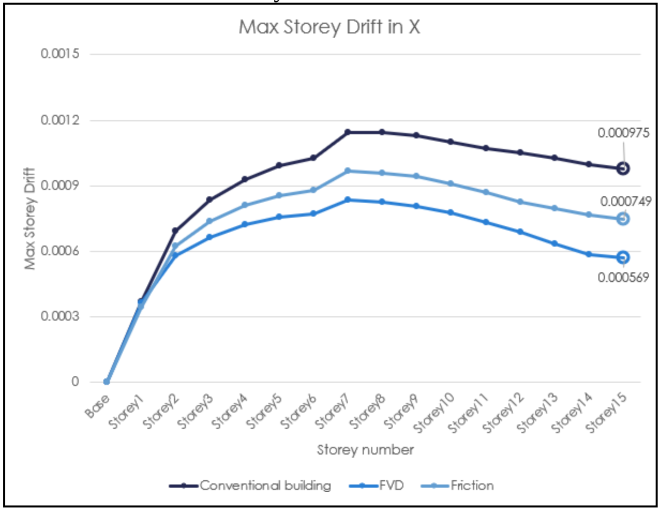
Maximum Storey Displacement in RSA X direction



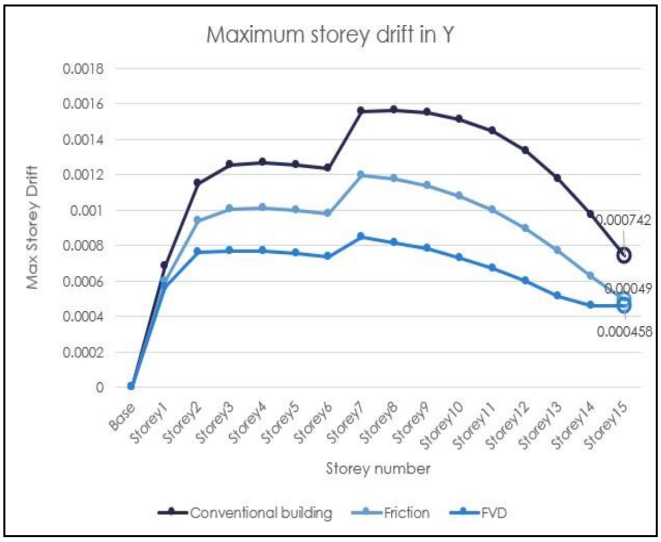
Maximum Storey Displacement in RSA Y direction



Maximum Storey Drift in RSA Y direction



Maximum Storey Drift in RSA X direction



Modal Participating Mass Ratios(Conventional Building)

Mode	Period	UX	UY	RZ	Sum UX	Sum UY	Sum RZ
	sec						
1	2.498	0.0645	**0.4202**	0.2549	0.0645	0.4202	0.2549
2	1.682	**0.5885**	0.0879	0.0013	0.653	0.5081	0.2562
3	1.238	0.0358	0.1567	**0.461**	0.6887	0.6647	0.7172
4	0.827	0.0145	0.0977	0.0326	0.7033	0.7624	0.7498
5	0.475	0.0133	0.0109	0.0212	0.7165	0.7733	0.771
6	0.427	0.1338	0.0334	0.0022	0.8504	0.8067	0.7732
7	0.317	0.0039	0.0104	0.0078	0.8542	0.8171	0.781
8	0.267	0.0053	0.0781	0.1176	0.8595	0.8952	0.8986
9	0.236	0.0022	0.0107	0.0038	0.8617	0.9059	0.9024
10	0.187	0.0444	0.0024	0.0002	0.9061	0.9082	0.9026
11	0.185	0.0098	0.0115	0.0048	0.9159	0.9198	0.9074
12	0.149	0.001	0.0028	0.0026	0.9169	0.9226	0.91
Summation of 12 Modes					91.69%	92.26%	91.00%

Mode no.1 has maximum mass participation in translational Ydirection with 42.02% and Time Period of 2.498 sec.
Mode No.2 has maximum mass participation in translational Xdirection with 58.85% and Time Period of 1.682 sec.
Mode No.3 has maximum mass participation in rotational Zdirection with 46.10% and Time Period of 1.238 sec.
Maximum mass participation for summation of 12 modes is92.26% in Translational Y direction.

Modal Participating Mass Ratios (Friction Dampers)

Mode	Period	UX	UY	RZ	Sum UX	Sum UY	Sum RZ
	sec						
1	2.271	0.066	**0.447**	0.2399	0.066	0.447	0.2399
2	1.604	**0.5829**	0.096	0.0045	0.6489	0.543	0.2444
3	1.226	0.046	0.132	**0.4789**	0.6949	0.675	0.7233
4	0.754	0.0149	0.0925	0.0297	0.7098	0.7675	0.753
5	0.436	0.0246	0.0054	0.0196	0.7343	0.7729	0.7726
6	0.415	0.1178	0.0376	0.0035	0.8521	0.8105	0.7761
7	0.293	0.0037	0.0111	0.0066	0.8558	0.8215	0.7827
8	0.267	0.0058	0.077	0.1173	0.8616	0.8985	0.9
9	0.221	0.0019	0.0091	0.0041	0.8635	0.9076	0.9041
10	0.184	0.053	0.0092	0.0004	0.9166	0.9168	0.9045
11	0.174	0.0002	0.0044	0.0042	0.9168	0.9212	0.9086
12	0.141	0.0009	0.0026	0.0024	0.9177	0.9238	0.911
Summation of 12 Modes					91.77%	92.38%	91.1%

Mode no.1 has maximum mass participation in translational Ydirection with 44.70% and Time Period of 2.271 sec.
Mode No.2 has maximum mass participation in translational Xdirection with 58.29% and Time Period of 1.604 sec.
Mode No.3 has maximum mass participation in rotational Zdirection with 47.89% and Time Period of 1.226 sec.
Maximum mass participation for summation of 12 modes is92.38% in Translational Y direction.

Modal Participating Mass Ratios(Fluid Viscous Damper)

Mode	Period	UX	UY	RZ	Sum UX	Sum UY	Sum RZ
	sec						
1	1.898	0.0631	**0.5222**	0.1802	0.0631	0.5222	0.1802
2	1.461	**0.5614**	0.1029	0.0293	0.6245	0.6251	0.2095
3	1.188	0.0806	0.065	**0.5241**	0.7051	0.6901	0.7336
4	0.625	0.0165	0.0887	0.0252	0.7216	0.7788	0.7588
5	0.391	0.1338	0.0257	0.0002	0.8553	0.8045	0.759
6	0.359	0.0002	0.0152	0.0257	0.8555	0.8198	0.7847
7	0.264	0.0085	0.0785	0.1093	0.864	0.8982	0.894
8	0.246	0.0027	0.0065	0.0103	0.8667	0.9048	0.9043
9	0.187	0.0014	0.0069	0.0037	0.8681	0.9117	0.908
10	0.177	0.0505	0.0104	0.0003	0.9186	0.9221	0.9082
11	0.149	0.0005	0.0027	0.0035	0.9191	0.9248	0.9117
12	0.123	0.0008	0.0021	0.002	0.9199	0.9269	0.9137
Summation of 12 Modes					91.99%	92.69%	91.37%

Mode No.1 has maximum mass participation in translational Ydirection with 52.22% and Time Period of 1.898 sec.
Mode No.2 has maximum mass participation in translational Xdirection with 56.14% and Time Period of 1.461 sec.
Mode No.3 has maximum mass participation in rotational Zdirection with 52.41% and Time Period of 1.188 sec.
Maximum mass participation for summation of 12 modes is92.69% in Translational Y direction.

Torsional Irregularity Check

Function	Conventional building	Friction Damper	Fluid viscous damper
RESP X	1.10	1.059	1.051
RESP Y	1.51	1.39	1.31

CONCLUSION:

From the above study the comparison is made between the convention building, and building with fluid viscous dampers and building with Friction damper

1. It is seen that the response spectrum analysis in X direction,the storey displacement in building with fluid viscous damper as compared to the building without damper is reduced by 25% and when compared with the Friction damper it is reduced by 15%
2. The response spectrum analysis in Y direction, shows that the storey displacement by application of fluid viscous damper is reduced by 42% and by friction damper it is reduced by 23%
3. Through the analysis carried out using the Response Spectrum Method, the storey drift in X direction in building provided with Fluid viscous dampers as compared to building without dampers (conventional building) isreduced by 42% and when compared with Friction dampers, the storey drift in similar direction is reduced by 23%.
4. Through the analysis carried out using the Response Spectrum Method, the storey drift in Y direction of the building provided with Fluid viscous dampers as comparedto building without dampers (conventional building) isreduced by 38% and when compared with Friction dampers, the storey drift in similar direction is reduced by 34%.
5. Maximum storey displacement is observed in conventionalbuilding followed by the building equipped with friction damper and the lowest displacement is observed in building equipped with Fluid viscous damper (FVD).
6. Maximum storey drift is observed in conventional buildingfollowed by the building equipped with friction damper andthe lowest storey drift can be observed in building equippedwith Fluid viscous damper (FVD).
7. Therefore, we can conclude our analysis by saying that building equipped with FVD proves to be sustainable in seismic condition as compared to building equipped with friction damper and any other conventional building.
8. The torsional irregularity check in building with FVD is observed to be safe in comparison to the building equippedwith friction damper and the conventional building.

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