Comparative Study on Seismic Behavior of Multistoreyed Frames With Different Passive Dampers for Different Zones

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Abstract: **Severe ground shaking induces lateral inertial forces(seismic forces) on buildings, causing them to sway back and forth with amplitude proportional to the energy fed in. If a major portion of this energy can be consumed during building motion, the seismic response can be considerably improved. The manner in which this energy is consumed in the structure determines the level of damage.**

In general, all current methods of seismic design place reliance on the ductility of the structural elements, i.e., ability to dissipate energy while undergoing inelastic deformations causing bending, twisting, and cracking. This assumes some permanent damage, in some cases just short of collapse, but the primary and secondary damage may be as economically significant as the collapse of the structure. If a major portion of the seismic energy can be dissipated mechanically, the response of the structure can be controlled without structural damage.

Seismic energy dissipation devices have been employed in many tall buildings. Such devices are often used to supplement the inherent earthquake-resistant structural response properties of buildings including both high and low rise structures. This study compares the performance and effects on structural systems with added metallic, friction, viscous and viscoelastic passive energy dissipating dampers for different earthquake zones.

.Keywords—Passive energy dampers, Metallic damper, Friction damper, Viscous damper

I. INTRODUCTION

The application of modern control techniques to diminish the effects of seismic loads on building structures offers an appealing alternative to traditional earthquake resistant design approaches. Over the past decade there has been significant research conducted on the use of damper devices for dissipating seismic energy.

Recently many investigations have been conducted to evaluate and analyze the seismic response of structures equipped with different types of damper. In the other hands, the role of dampers in preventing buildings from collapse during intense earthquake ground motion was extensively investigated by using numerical modeling. Due to the widespread technique for computer simulation and analyzing of structures with supplemental dampers subjected to steady-state excitation is direct integration technique which is generally implemented in finite element method.

Seismic energy dissipation devices have been employed in many tall buildings. Such devices are often used to supplement the inherent earthquake-resistant structural response properties of buildings including both high and low rise structures. This study compares the performance and effects on structural systems with added passive energy dissipation systems

Passive energy dissipation system means a system that require no externally supplied power to operate, this system develops motion forces at the point of attachment of the system to the structure. The motion the points of attachment provides the power needed to generate resisting forces during dynamic excitation. The relative motion of these points of attachment determines the amplitude and direction of control forces. In these systems, mechanical devices are incorporated into the frame of the structure and dissipate energy throughout the height of the structure. The addition of an energy dissipation system will result in a reduction in drift and therefore reduction of damage (due to energy dissipation) and an increase in the total lateral force exerted on the structure (due to increase in strength and stiffness).

Passive energy dissipation devices such as viscous dampers, metallic dampers and friction dampers have widely been used to reduce the dynamic response of civil engineering structures subjected to seismic loads. Their effectiveness for seismic design of building structures is attributed to minimizing structural damages by absorbing the structural vibratory energy and by dissipating it through their inherent hysteresis behavior.

This paper presents the comparison of seismic parameters like base shear, displacement, axial force for columns for different dampers for different zones by equivalent static analysis..

II. METHODOLOGY

The steps involved in this study are as follows

Step 1:Modeling/ defining loads.

It includes modeling of 2D framed building of nine storeys with 3 bays along X axis for four different models using SAP 2000 software.

Material properties used in model are M25(f_{ck}=25N/mm^2) grade concrete and HYSD415(f_y=415N/mm^2) grade of steel. Beams of section 230mm x 450mm and column of section 230mm x 600mm are used for modeling the Frame sections

The different structural systems used for the study are Bare frame with no damper (BF) and RC frame with three different damper (metallic damper, Friction damper, and viscous damper).

For Metallic damper, K bracings are used for the location of dampers (MD).

Continuous X bracing system is used to locate the friction dampers in structure (FD).

Continuous single bracing system is used for viscous dampers (VD).

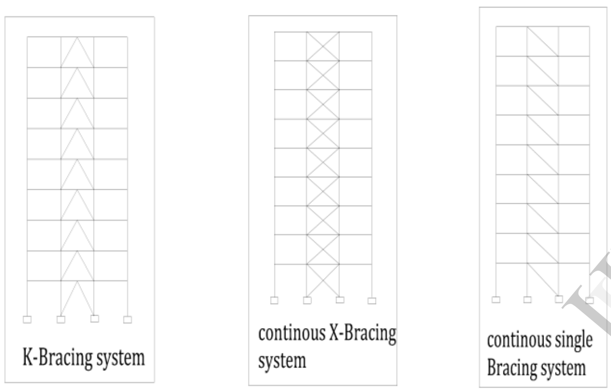

Fig. Different Structural system

Defining loads

The different loads that are considered are

- Dead load (DL)
- Live load (LL)
- Super Imposed Dead load (SDL)
- Earthquake load along X (EQX)

Step 2. Analyzing the frame.

The models generated are then analyzed for the load combination of DL+LL+EQX by using SAP2000.

Step 3. Tabulation of analyzing results.

Base shear

After analyzing the frame for base shear for Equivalent static case. The results obtained are tabulated in table.

Table 1: base shear for EQX Direction [Equivalent static]

Base shear (kN)				
Models	Load case	Zone II	Zone III	Zone IV
BF	DL+LL+EQX	39.25	62.8	94.2
MD	DL+LL+EQX	45.761	73.217	109.826
FD	DL+LL+EQX	46.701	74.722	112.083
VD	DL+LL+EQX	55.994	89.591	134.386

Displacements.

The displacements obtained after analyzing the frame for equivalent static analysis for bare frame is tabulated in table 2 and that for different dampers are tabulated in table 3, table 4 and table 5.

Table 2: Displacements for bare frame for different zones

Storey height	Load case	Zone II	Zone III	Zone IV
		U1(m)	U1(m)	U1(m)
0	DL+LL+EQX	0	0	0
1	DL+LL+EQX	0.001447	0.002301	0.003438
2	DL+LL+EQX	0.003469	0.005551	0.008327
3	DL+LL+EQX	0.005657	0.009049	0.013573
4	DL+LL+EQX	0.007811	0.012496	0.018743
5	DL+LL+EQX	0.009843	0.015747	0.02362
6	DL+LL+EQX	0.011671	0.018672	0.028008
7	DL+LL+EQX	0.013205	0.021129	0.031694
8	DL+LL+EQX	0.014393	0.023013	0.034507
9	DL+LL+EQX	0.015034	0.024103	0.036194

Table 3: Displacements for RC frame with metallic damper.

Storey height	Load case	Zone II	Zone III	Zone IV
		U1(m)	U1(m)	U1(m)
0	DL+LL+EQX	0	0	0
1	DL+LL+EQX	0.001336	0.002125	0.003178
2	DL+LL+EQX	0.003091	0.004948	0.007423
3	DL+LL+EQX	0.004938	0.007902	0.011853
4	DL+LL+EQX	0.006746	0.010794	0.016192
5	DL+LL+EQX	0.008453	0.013527	0.020292
6	DL+LL+EQX	0.009996	0.015996	0.023995
7	DL+LL+EQX	0.011297	0.018079	0.027122
8	DL+LL+EQX	0.012306	0.01968	0.029514
9	DL+LL+EQX	0.012876	0.02063	0.030969

Table 4: Displacements for frame with FD

Storey height	Load case	Zone II	Zone III	Zone IV
		U1(m)	U1(m)	U1(m)
0	DL+LL+EQX	0	0	0
1	DL+LL+EQX	0.001308	0.002077	0.003103
2	DL+LL+EQX	0.003022	0.004836	0.007254
3	DL+LL+EQX	0.004833	0.00773	0.011594
4	DL+LL+EQX	0.006605	0.010567	0.01585
5	DL+LL+EQX	0.008282	0.013251	0.019875
6	DL+LL+EQX	0.0098	0.01568	0.023519
7	DL+LL+EQX	0.011084	0.017735	0.026604
8	DL+LL+EQX	0.01209	0.019329	0.02898
9	DL+LL+EQX	0.012637	0.020254	0.030409

Table 5: Displacements for frame with viscous damper

Storey height	Load case	Zone II	Zone III	Zone IV
		U1(m)	U1(m)	U1(m)
0	DL+LL+EQX	0	0	0
1	DL+LL+EQX	0.000874	0.001542	0.002432
2	DL+LL+EQX	0.001997	0.003517	0.005544
3	DL+LL+EQX	0.003238	0.005637	0.008835
4	DL+LL+EQX	0.004507	0.007781	0.012146
5	DL+LL+EQX	0.005759	0.009877	0.015366
6	DL+LL+EQX	0.006941	0.011838	0.018367
7	DL+LL+EQX	0.007988	0.013565	0.021
8	DL+LL+EQX	0.008868	0.014985	0.02314
9	DL+LL+EQX	0.009346	0.01583	0.024476

Axial Force

Axial force in columns for frame for equivalent static load case with no damper case is tabulated in 6 and that for different dampers are tabulated in table 7, table 8, and table9.

Table 6: Axial force for bare frame.

Storey height	Load case	Zone II	Zone III	Zone IV
		Axial force (kN)	Axial force (kN)	Axial force (kN)
0	DL+LL+EQX	0	0	0
1	DL+LL+EQX	60	61	62
2	DL+LL+EQX	124	126	130
3	DL+LL+EQX	188	193	200
4	DL+LL+EQX	254	262	273
5	DL+LL+EQX	319	332	348
6	DL+LL+EQX	386	402	424
7	DL+LL+EQX	451	472	500
8	DL+LL+EQX	517	542	575
9	DL+LL+EQX	582	610	649

Table 7: Axial force for frame with metallic damper.

Storey height	Load case	Zone II	Zone III	Zone IV
		Axial force (kN)	Axial force (kN)	Axial force (kN)
0	DL+LL+EQX	0	0	0
1	DL+LL+EQX	59.57	60.52	61.78
2	DL+LL+EQX	120.76	123.33	126.76
3	DL+LL+EQX	183.03	187.94	194.5
4	DL+LL+EQX	246.17	254.01	264.47
5	DL+LL+EQX	309.91	321.1	336.01
6	DL+LL+EQX	373.97	388.77	408.51
7	DL+LL+EQX	438.08	456.66	481.42
8	DL+LL+EQX	501.95	524.29	554.09
9	DL+LL+EQX	566.47	592.22	626.55

Table 8: Axial force for frame with friction damper

Storey height	Load case	Zone II	Zone III	Zone IV
		Axial force (kN)	Axial force (kN)	Axial force (kN)
0	DL+LL+EQX	0	0	0
1	DL+LL+EQX	59.43	60.42	61.75
2	DL+LL+EQX	121.76	124.42	127.97
3	DL+LL+EQX	184.89	189.92	196.63
4	DL+LL+EQX	248.77	256.73	267.34
5	DL+LL+EQX	313.09	324.17	339.42
6	DL+LL+EQX	377.54	392.42	412.25
7	DL+LL+EQX	441.85	460.45	485.26
8	DL+LL+EQX	505.72	528.03	557.79
9	DL+LL+EQX	569.9	595.55	629.76

Table 9: Axial force for frame with viscous damper

Storey height	Load case	Zone II	Zone III	Zone IV
		Axial force (kN)	Axial force (kN)	Axial force (kN)
0	DL+LL+EQX	0	0	0
1	DL+LL+EQX	61	62	63
2	DL+LL+EQX	124	127	131
3	DL+LL+EQX	188	193	200
4	DL+LL+EQX	253	261	271
5	DL+LL+EQX	317	328	342
6	DL+LL+EQX	381	395	413
7	DL+LL+EQX	444	462	485
8	DL+LL+EQX	507	527	555
9	DL+LL+EQX	569	593	624

III. RESULTS AND DISCUSSIONS

This research work is carried out to compare the dynamic response of RC 2D bare frame and frames with three different dampers. Four models are considered for the equivalent static analysis. The results of base shear, displacement and axial force in columns are obtained for three seismic zones as per IS 1893(part 1).

Base shear

The results obtained after analyzing is represented as shown in fig1

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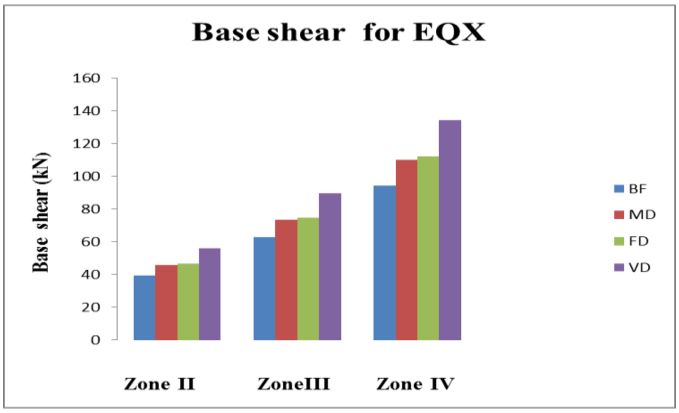

Fig 1: Comparison of Base shear for different dampers at different zones

From the above fig. 1, it is clearly observed that base shear is maximum in zone IV and minimum in zone II and also it is clear that base shear is maximum in RC frame with viscous damper(VD) and minimum in Bare frame(BF).

Displacements

The comparisons of displacements for RC bare frame (BF) with RC frame with dampers are as shown below and for different zones.

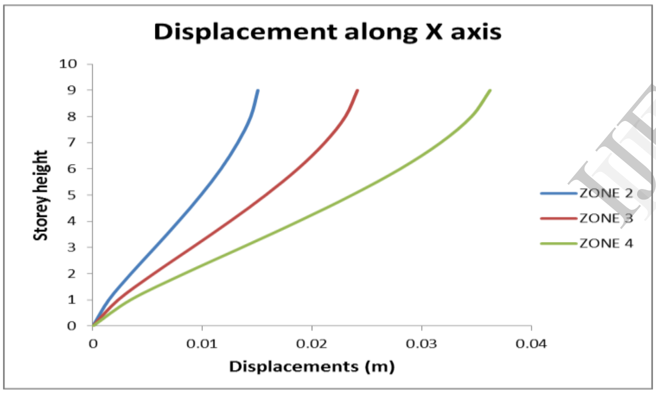

Fig 2: Comparison of RC bare frame for different zones.

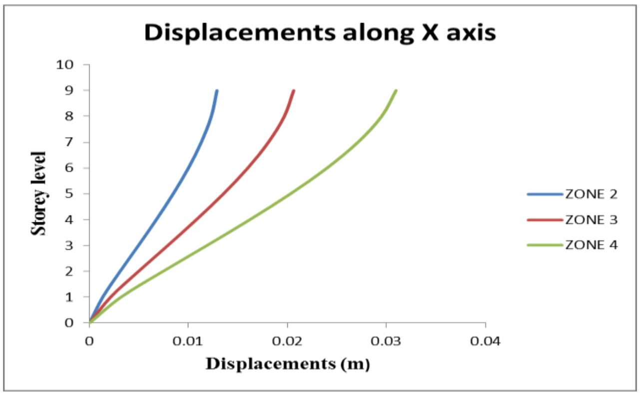

Fig 3: Comparison of RC frame with metallic damper for different zones.

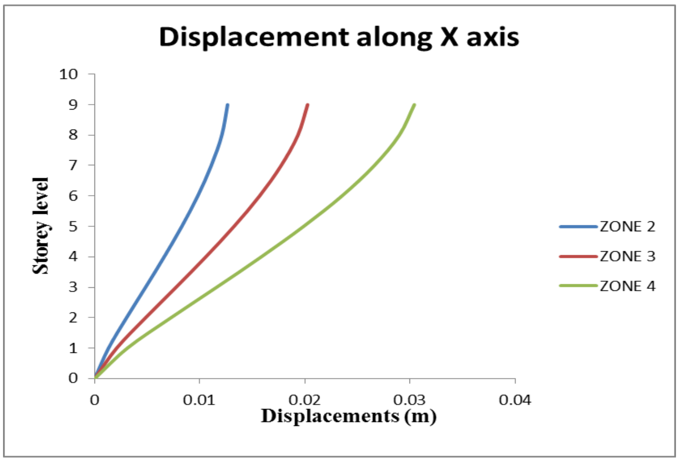

Fig 4: Comparison of RC frame with friction damper at different zones.

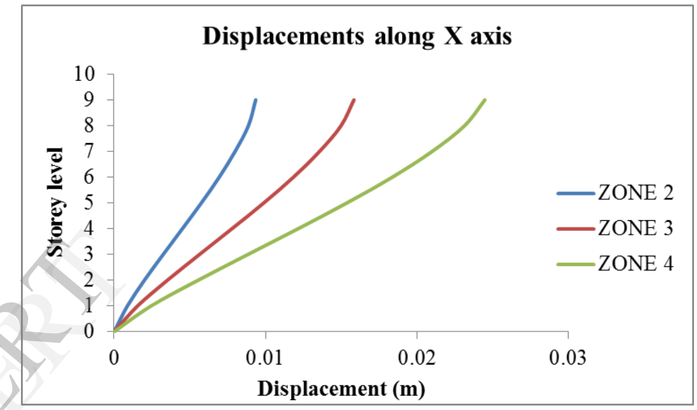

Fig 5: Comparison of RC frame with viscous damper for different zones

From the above figures it is clear that displacement is maximum in case of zone IV.

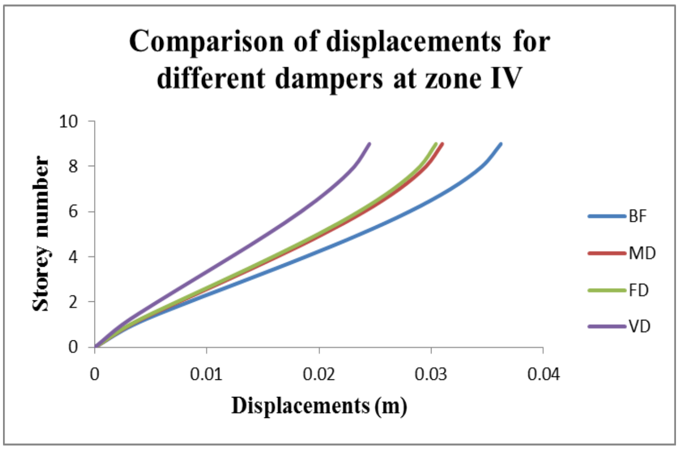

Fig 6: Comparison of RC frames with different dampers for Zone IV.

Since the displacement is maximum in zone IV, it is a critical hence all the structural systems are compared for zone IV and it is observed that displacement is maximum in case bare frame (BF) and minimum in frames with dampers.

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AXIAL FORCE

The comparison of axial force obtained for RC bare frame and RC frame with dampers are represented as shown below fig 7.

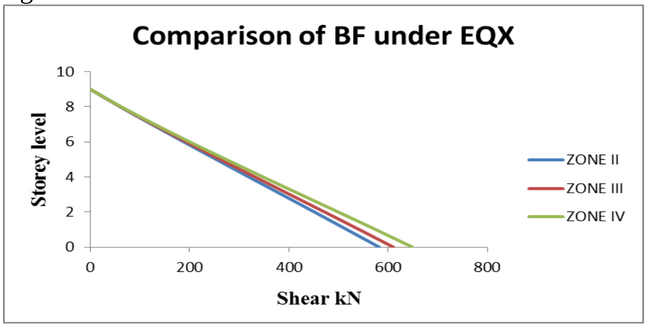

Fig 7: Comparison of RC bare frame for different zones

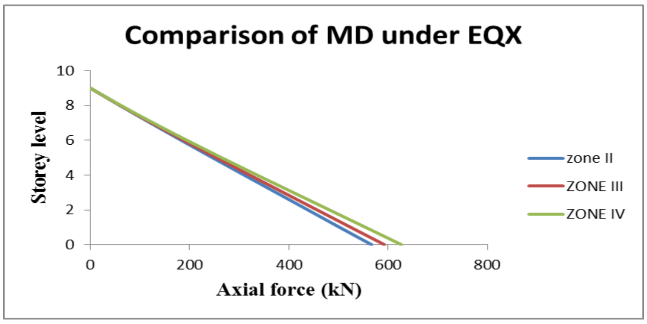

Fig 8: Comparison of RC frame with Metallic damper for different zones

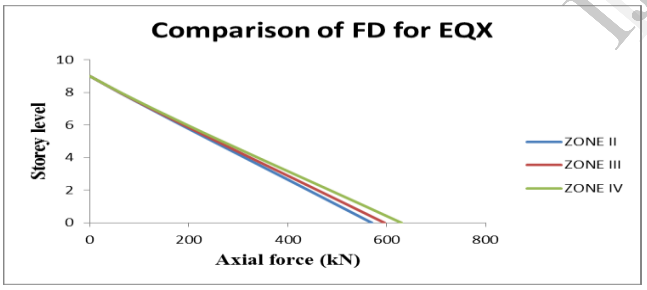

Fig 9 Comparison of Rc frame with friction damper for different zones

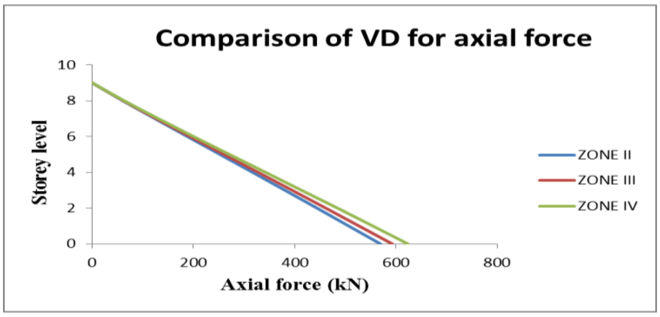

Fig 10: Comparison of RC frme with Viscous damper for different zones.

From the above graphs it is clearly observed that the axial force is maximum in zone IV

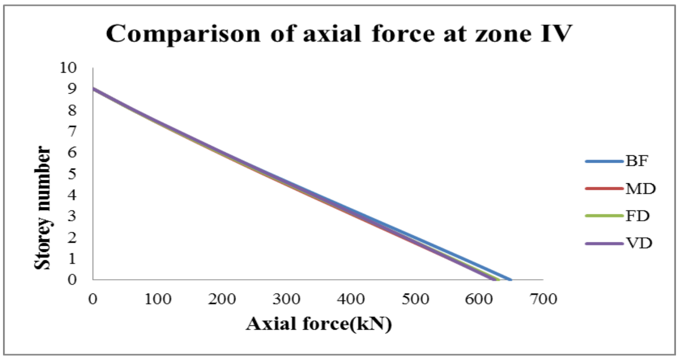

Fig 11: Comparison of Bare frame with RC frame with different dampers at zone IV

Since the axial force is maximum in zone IV it is acritical zone, hence all structural systems are compared for zone IV and it is clearly observed that axial force in columns are maximumin bare frame (BF) compared to frames with dampers.

IV. INFERENCES

1. The analytical results are higher in zone IV compared to zone II and zone III, because they increases with increase in zone factor and zone IV have higher zone factor value.
2. When RC bare frame (BF) is compared with RC frame with the dampers, it shows higher values because of energy dissipation by the dampers.
3. There are three major differences between Viscous Dampers and other devices like metallic damper, friction damper, etc. The primary difference is that the constant force output of a other dampers increases maximum column or pier stress under any deflection of the structure. Viscous Dampers do not increase column stresses due to their inherent out of phase response output. The second difference is that the other dampers put out an essentially constant force when deflected, independent of velocity. This response causes continual stress in the structure during all thermal expansion and contraction of the structure. Viscous Dampers put out virtually zero force at the low velocities associated with thermal motion. The third difference is that other dampers restrict a structure from restoring itself to its original position after seismic events. Viscous Dampers allow the structure to re-center itself perfectly at all times.
4. Of all the dampers used, viscous dampers show significant results because viscous damping reduces stress and deflection because the force from the damping is completely out of phase with stresses due to flexing of the columns. This is only true with viscous damping, where damping force varies with stroking velocity. Other types of damping such as friction devices, metallic etc., do not vary their output with velocity.

V. CONCLUSIONS

In this study, an attempt has been made to compare the dynamic response of 2D RC bare frame and RC frame with dampers. Totally four models of nine storeys each considered for equivalent static analysis. The results obtained from analysis are investigated and compared. From comparison of results following are the major conclusions drawn.

1. Equivalent static analysis is carried out for all models and for all zones to obtain static base shear.
2. Of all seismic zone considered (Zone II, Zone III and Zone IV), zone IV is critical zone with highest base shear, displacements, and axial force.
3. Addition of dampers to the system increases the stiffness to the frame thereby increasing the strength.
4. Base shear is directly proportional to self -weight of the structure. It decreases with increase in natural time period. It is maximum for zone IV and minimum for zone II.
5. Displacements for RC frame with dampers are 10%-35% less compared to RC bare frame.
6. Displacement of RC frame with viscous damper is 30%-35%, metallic damper is 10%-15% and that with friction damper is 8%-15% lesser than that RC bare frame.
7. Displacements at each storey level increases as the height of structure increases and maximum displacements occurs at top storey level
8. Displacements increases as the base shear increases. When the dampers are added to the structures base shear increases due to the addition of self-weight but displacements reduces due to increase in stiffness.
9. Axial force in columns decreases as the height of the frame increases due to the load coming from higher is less.
10. Axial force in bare frame is higher than the frame with dampers.
11. Of all the dampers used (metallic damper, friction damper and viscous damper) viscous damper is found to be effective i.e., they have lower displacement, lesser drift, lesser axial force and lesser storey shear and it can be used.
12. Metallic damper and friction damper shows same seismic behavior.

REFERENCES

1. Constantinou. M. C., Soong, T. T., and Dargush, G. F. (1998). “Passive energy dissipation systems for structural design and retrofit”, Monograph No. 1, Multidisciplinary Center for Earthquake Engineering Research, Buffalo, New York.
2. Chang, K. C., Soong, T. T., Lai, M. L., and Nielsen, E. J. _1993_. “Development of a design procedure for structures with added viscoelastic
3. Trevor e Kelly and t k dutta “optional use of VE dampers in frames for seismic forece” ,ASCE J.Strutural engineering
4. Dougles way “ friction damperd moment resisting frames”, earthquake spectra,
5. A. filiatrault and s cherry “ performance evaluation of friction damping devices for a use in aseismic design.
6. Gregg Haskell david lee, “fluid viscous damping as ab alternate to base isolation”
7. G.F dargush and T T SOONG “ behaviour of metallic plate dampers in seismic systems”