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Comparison in Results and Analysis of Lateral Displacements Storey Drift of the RC Frames With Dampers to The RC Frames Without Damper Element and With Walls to Without Walls at all Seismic Zones in India

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Abstract :

In recent days high rise buildings mostly composed of concrete slabs and walls. Commercial software such as ETABS is used for design and analysis of these structures. Earthquakes had become one of the major reasons for failure of these structures. Earthquake resistant equipment was placed at different locations of building. This may have a significant influence on the lateral response of the structures. If the effect of earthquake resistant equipment on the structures were ignored then the major lateral displacement effect will be underestimated. In order to reduce the lateral displacement in various earthquake zones for different building cross-sections earthquake resistant equipment should be modeled.

The present study is concerned with the effects of stiffness attained by considering damper elements on the seismic response of a structure. The objective of the study is to carry out the linear static (seismic coefficient) analyses on different RC building frames cross sections modeled with and without dampers eighteen story and with and without walls at all seismic zones in India considering IS 1893 (Part 1): 2002 code guidelines. Finally compared the results of analysis lateral displacements, story drift of the RC frames with dampers to the RC frames without damper element and with walls to without walls at all seismic zones in India. From the study, it was observed that there is decrease in the stiffness of RC frame with wall and damper than that of the RC frame without wall and damper.

INTRODUCTION:

1.1 General:

Earthquake is a most devastating event which usually occurs due to the movement of earth crust and causes severe damage to human life as well as of buildings. Usually buildings with irregular plans and excessive heights are subjected to damages caused by earthquakes. Placing earthquake resisting elements in the buildings helps to reduce the damage caused by earthquake to the structures. One of the different types of methods to increase seismic resistance of structures was base isolation. Earthquake majorly causes the damage to the structures in the form of lateral displacements in story or members. The seismic performance of the structure can be increased by introducing the energy absorbing devices in the buildings. Dampers were provided around the walls of the structure in soft stories of the building. These dampers were usually viscoelastic dampers which have stiffness and damping coefficients. Dampers was one of the cost effective solution for earthquake resistance of buildings. These dampers absorb the energy released by the structure during earthquake and causes structure to resist the movement.

1.2 Research problem:

Irregularities in the buildings are the major reason for the damage caused in the buildings during earthquakes. Dampers are one of the cost effective solution for the buildings against earthquakes. Buildings should be built as cost effective and earthquake resistant. To solve this problem of building damage due to earthquake dampers were placed at different places of building and calculated their displacements in various earthquake zone for various plans and models. Linear static analysis was carried out to calculate the lateral displacements of buildings. ETABS v9.5 is used to solve seismic effect on the buildings with irregularities.

1.3 Aim:

This thesis aims to investigate the performance of various building models i.e., Regular, L, T Sec in different earthquake zones. The main objective is to show variations in the displacement at various heights

1.4 Objectives:

Out of various methods available for the analysis of the buildings subjected to earthquakes linear static analysis is used for analysis of RC framed structure with and without dampers, walls. RC frame buildings were modelled and analysed using ETABS software which is commonly used for tall buildings. Dampers were placed at various locations of soft story this may alter response of building under earthquake loads. In order to include the dampers at various locations of the building they need to be modelled. The objective of this study is to study is the effect of stiffness achieved by including damping elements in soft story walls of Regular, L, T Sec RC frames for 18 story height.

LITERATURE REVIEW:

Julius Marko studied the response of high rise buildings during the seismic events by inserting energy absorbing passive damping devices which were mostly used for energy absorption. Dampers were placed between two load bearing systems in new buildings and old buildings which require retrofitting. Seismic mitigation of the high rise buildings with three types of dampers viscoelastic, friction and combined friction viscoelastic dampers were used. ABAQUS 6.2 was used to embed finite element methods for analysis. Dampers were placed in various locations of buildings and seismic response of these structures with dampers was studied. YuvrajBisht, SaraswatiSetiaBuildings with dampers and without dampers in soft stories was studied and analyzed. Five story building with dampers as braces and without dampers as braces was analyzed and the study was performed using SAP2000. Nonlinear time history analysis was performed in this thesis.

Yukihiro Tokuda and KenzoTagaconducted case study in which viscous dampers are used to enhance earthquake resistance of building. The viscous type devices have been employed by focusing on the fact that viscous type device is superior to hysteresis type device in that viscous type devices display damping effect even under small or medium earthquakes and in that the viscous type devices display stable performance for accumulated deformation. With regards to use of viscous type damper as energy absorption device, this paper will introduce an instance of high-rise building actually designed and constructed.

In this high-rise building, the 1st basement was designed as soft first story in which dampers are collectively placed for intensive-type vibration damping. In the soft story, columns are made of 350-mm-diameter thick, high-strength steel pipes (590N/mm2 class steel) to ensure large elastic limit deformation of main frame, thus enhancing damping performance.Hitoshi Ozaki, Hiroaki Harada, Katsuhide Murakami describes two cases where seismic retrofitting work was carried out by using seismic damping members for greater seismic resistance in conjunction with the large-scale renovation work of the tall buildings. Renovation work requires design consideration and invention specific to it, differently from that required for new construction, such as approaches to use the existing building frames so as to reduce the amount of additional members to use, or work methods and execution consideration to minimize noises and vibration.

One of the cases described is a renovation work of a tall building which achieved an enhancement in seismic resistance by avoiding removal of existing members and frames or addition of new members wherever possible but instead, installing viscoelastic dampers into the connections between existing brace members, thereby improving the damping performance of the building. The other case is about a tall building which increased its seismic energy absorption capacity by replacing existing braces with buckling restrained braces. This work adopted a bonding work system using epoxy resin so that a minimum of noise and vibration would be caused at the connections between the damping braces and the existing building structure. Each of the cases described in this paper is a successful project in effectively improving the seismic resistance of an existing tall building. It can be expected that these approaches will be applied to renovation cases faced with similar problems in the future.

Kiyoshi Muto, Toshihiko Hisada, Tsunehisa Hisada, SantoshiBesshostudied earthquake resistance of structure for an unconventional type of building. The height of structure exceeds 31m, a special construction permit was issued by minister of construction, is required by article 38 of building standard law unprecedented case. Due to defects revealed in 1968 much research and investigation for shear reinforcements has been carried out.

The authors found that, with adequate arrangement of sufficient reinforcing bars, brittle failure of the members is completely prevented and deformability, ductility was ensured.Michael Constantinoustudied the application of fluid viscous dampers in the earthquake resistance design. Damping devices based on the operating principle of high velocity fluid flow through orifices have found numerous applications in the shock and vibration isolation of aerospace and defense systems. Isolation bearing systems were studied and analysed in the buildings by placing them in the locations of the buildings.

K. KRISHNE GOWDA and K. K. KIRAN conducted a review on earthquake resistance design of structures using dampers. Now a days severe earthquakes occur in the various zones. It is required to resist these damages caused by earthquakes. The seismic resistance was done using control devices. Those control devices are dampers which are used in structures to control seismic damage. The dampers were divided into various categories based on their functions or control systems. They are active, passive, hybrid and seismic active control system.

Shilpa G. Nikam, S.K. Wagholikar, G.R. Patil conventional methods of seismic rehabilitation with concrete shear walls or steel bracing are not considered suitable for some buildings as upgrades with these methods would have required expensive and time consuming foundation work. Supplemental damping in conjunction with appropriate stiffness offered an innovative and attractive solution for the seismic rehabilitation of such structures extensive use of friction joints in new and retrofitted buildings has demonstrated the economic advantages of this form of device to control the amplitude of building motion due to seismic action.

The paper highlights in particular the use of friction devices in conjunction with rigid structural frames, either steel or concrete. The introduction of supplemental damping provided by friction devices dramatically reduces forces on structure, amplitude of vibration and floor acceleration.

METHODOLGY:

3.1 Geometrical configuration:

Three different geometries were considered one plan is regular geometry and others are geometries with irregularities.

(a) Regular Building (Fig 3.1)

(b) L Sec Building (Fig 3.2)

(c) T Sec Building (Fig 3.3)

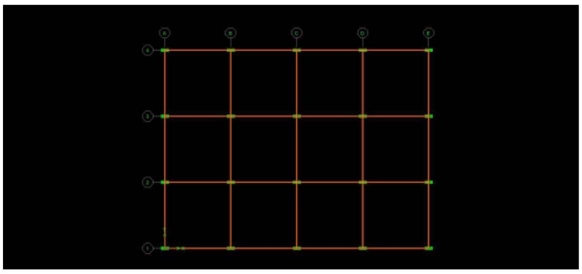

Fig3. 1Regular Building

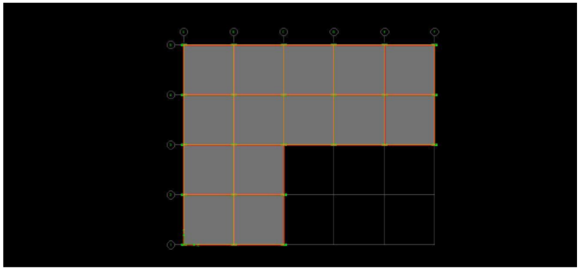

Fig3. 2 L Sec Building

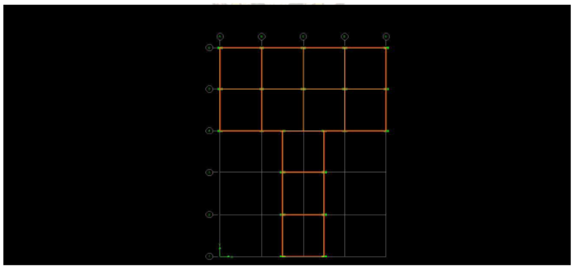

Fig3. 3 T Sec Building

3.2 Material and Section properties

18 story reinforced buildings with different crosssections were modelled and analysed with walls without walls, with dampers in soft stories and without dampers in soft stories.fig 4.1, 4.2, 4.3 shows the plans of different models. Story height was taken as 3m. the width and depth of each bay was taken as 8m. For simplicity, the beam cross sections are assumed 600 mm x 300 mm and column cross sections as 900 mm x 300 mm for three plan cross sections (at seismic zones II, III, IV & V). Slab thickness was 150mm.

Concrete and Steel grades was M25, M30& Fe415. Modulus of elasticity and poisons ratio of brick were 16 × 10^6 and 0.22. External and Internal wall thicknesses were 150mm & 115mm. Effective Stiffness and Effective damping values of dampers were 10 × 10^6 N/m & 50 × 10^6 Ns/m. Wall has rigid Diaphragm type.

RESULTS AND DISCUSSION:

4.1 Case 1: Regular Building:

4.1.1 Case 1(a): Regular building without Dampers and Infill wall

Table 4.1 Story displacements of regular building without Dampers and Infill wall at different Heights for various seismic zones

Height (m)	Lateral Displacements(mm)			
	II zone	III zone	IV zone	V zone
0	0	0	0	0
3	0.12	0.19	0.28	0.42
6	0.63	1.01	1.52	2.27
9	1.32	2.11	3.17	4.76
12	2.08	3.32	4.98	7.47
15	2.85	4.56	6.85	10.27
18	3.63	5.81	8.71	13.07
21	4.4	7.04	10.56	15.85
24	5.16	8.25	12.37	18.56
27	5.89	9.42	14.13	21.19
30	6.58	10.53	15.8	23.7
33	7.24	11.59	17.38	26.07
36	7.85	12.56	18.84	28.26
39	8.4	13.43	20.15	30.22
42	8.87	14.2	21.29	31.94
45	9.27	14.83	22.24	33.36
48	9.57	15.31	22.97	34.46
51	9.78	15.65	23.48	35.22
54	9.94	15.89	23.83	35.73

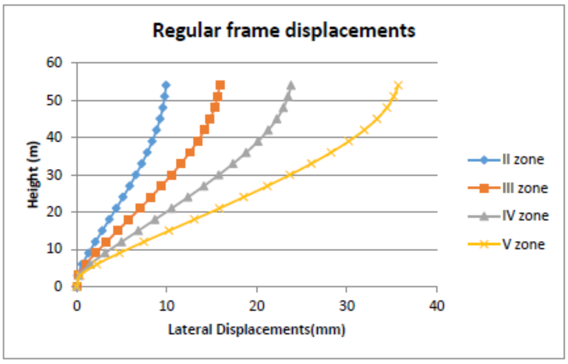

Fig 4.1 Lateral displacements of Regular building without Dampers and Infill wall at different heights of building

From the Fig 4.1, it was observed that variations in maximum lateral displacements for regular building frame without infill and dampers are 60%, 140%, and 260% for seismiczones III, IV and V with respect to zone II.

4.1.2 Case 1(b): Regular building with Dampers and without Infill wall

Table 4.2Story displacements of regular building with Dampers and without Infill wall at different Heights for various seismic zones

Height (m)	Lateral Displacements(mm)			
	II zone	III zone	IV zone	V zone
0	0	0	0	0
3	0.07	0.11	0.16	0.24
6	0.16	0.22	0.29	0.4
9	0.26	0.33	0.42	0.56
12	0.39	0.48	0.61	0.8
15	0.85	1.2	1.67	2.37
18	1.51	2.25	3.24	4.73
21	2.24	3.41	4.98	7.33
24	2.98	4.59	6.75	9.98
27	3.7	5.75	8.48	12.58
30	4.39	6.86	10.15	15.08
33	5.05	7.91	11.72	17.44
36	5.66	8.88	13.18	19.62
39	6.2	9.75	14.49	21.59
42	6.68	10.51	15.63	23.3
45	7.07	11.14	16.57	24.71
48	7.38	11.63	17.3	25.81
51	7.59	11.97	17.81	26.57
54	7.75	12.21	18.16	27.08

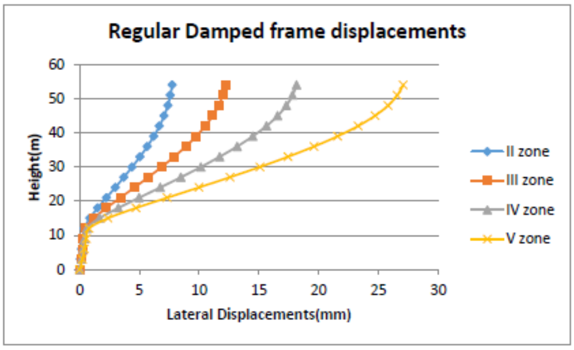

Fig 4.2Lateral displacements of Regular building with Dampers and without Infill wallat different heights of building

From the Fig 4.2, it was observed that variations in maximum lateral displacements for regular building frame with dampers and without infill are 57%, 134%,

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and 249% for seismiczones III, IV and V with respect to II zone.

4.2 Case 2: L Sec Building:

4.2.1 Case 2(a): L Sec Building without Dampers and Infill wall

Table 4.4Story displacements of L Sec Building without Dampers and Infill wall at different Heights for various seismic zones

Height (m)	Lateral Displacements(mm)			
	II zone	III zone	IV zone	V zone
0	0	0	0	0
3	0.15	0.24	0.37	0.55
6	0.83	1.34	2.01	3.01
9	1.76	2.82	4.24	6.36
12	2.78	4.45	6.69	10.05
15	3.82	6.14	9.22	13.85
18	4.87	7.83	11.77	17.67
21	5.91	9.5	14.29	21.46
24	6.93	11.14	16.75	25.17
27	7.91	12.73	19.15	28.77
30	8.85	14.24	21.43	32.21
33	9.74	15.67	23.59	35.46
36	10.55	16.99	25.58	38.46
39	11.28	18.18	27.37	41.16
42	11.91	19.21	28.93	43.52
45	12.44	20.06	30.22	45.47
48	12.84	20.72	31.23	47
51	13.13	21.2	31.96	48.1
54	13.35	21.56	32.5	48.91

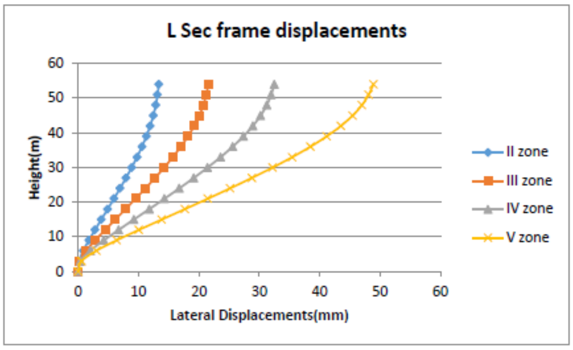

Fig 4.3 Lateral displacements of L Sec Building without Dampers and Infill wallat different heights of building

From the Fig 4.3, it was observed that variations in maximum lateral displacements for regular building frame without infill and dampers are 61%, 144%, and 266% for seismiczones of III, IV and V with respect to II.

4.2.2 Case 2(b): L Sec Building with Dampers and without Infill wall

Table 4.5Story displacements of L Sec Building with Dampers and without Infill wall at different Heights for various seismic zones

Height(m)	Lateral Displacements(mm)			
	II zone	III zone	IV zone	V zone
0	0	0	0	0
3	0.07	0.12	0.18	0.27
6	0.22	0.29	0.39	0.54
9	0.35	0.46	0.6	0.82
12	0.54	0.69	0.89	1.19
15	1.15	1.65	2.32	3.33
18	2.03	3.06	4.44	6.51
21	3.01	4.63	6.8	10.05
24	4.01	6.24	9.21	13.67
27	4.98	7.81	11.57	17.23
30	5.92	9.32	13.85	20.65
33	6.8	10.75	16	23.88
36	7.62	12.06	17.99	26.88
39	8.35	13.25	19.78	29.57
42	8.99	14.28	21.34	31.92
45	9.51	15.13	22.63	33.88
48	9.91	15.79	23.63	35.39
51	10.21	16.27	24.36	36.49
54	10.43	16.64	24.91	37.31

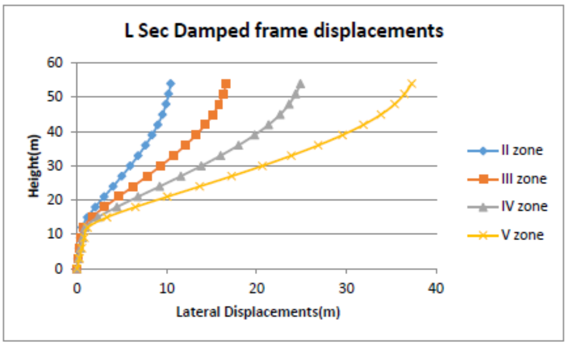

Fig 4.4Lateral displacements of L Sec Building with Dampers and without Infill wallat different heights of building

From the Fig 4.4, it was observed that variations in maximum lateral displacements for regular building frame without infill and dampers are 60%, 139%, and 258% for seismiczones of III, IV and V with respect to II.

4.3 Case 3: T Sec Building:

4.3.1 Case 3(a): T Sec Building without Dampers and Infill wall

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Table 4.8Story displacements of T Sec Building without Dampers and Infill wallat different Heights for various seismic zones

Height (m)	Lateral Displacements(mm)			
	II zone	III zone	IV zone	V zone
0	0	0	0	0
3	0.13	0.22	0.32	0.49
6	0.77	1.22	1.84	2.75
9	1.66	2.65	3.98	5.97
12	2.67	4.27	6.4	9.6
15	3.73	5.97	8.95	13.43
18	4.81	7.7	11.54	17.32
21	5.89	9.43	14.14	21.21
24	6.96	11.14	16.71	25.07
27	8.01	12.82	19.23	28.84
30	9.03	14.44	21.66	32.49
33	9.99	15.99	23.98	35.98
36	10.9	17.44	26.16	39.24
39	11.73	18.77	28.15	42.23
42	12.47	19.96	29.94	44.91
45	13.12	20.99	31.48	47.22
48	13.66	21.85	32.77	49.16
51	14.09	22.55	33.82	50.74
54	14.45	23.12	34.68	52.02

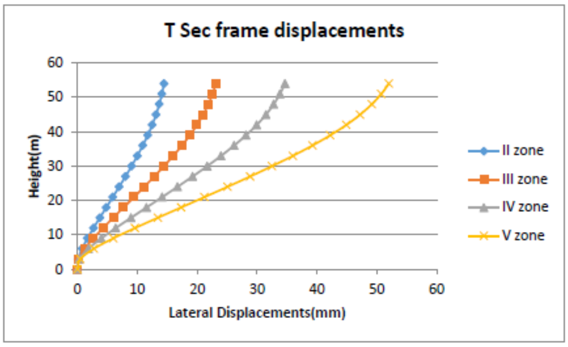

Fig 4.5Lateral displacements of T Sec Building without Dampers and Infill wallat different heights of building

From the Fig 4.5, it was observed that variations in maximum lateral displacements for regular building frame without infill and dampers are 60%, 140%, and 260% for seismiczones of III, IV and V with respect to zone II.

4.3.2 Case 3(b): T Sec Building with Dampers and without Infill wall

Table 4.9Story displacements of T Sec Building with Dampers and without Infill wall at different Heights for various seismic zones

Height	II zone	III zone	IV zone	V zone
0	0	0	0	0
3	0.14	0.23	0.34	0.51
6	0.74	1.19	1.79	2.68
9	1.43	2.29	3.45	5.18
12	1.82	2.94	4.43	6.66
15	1.86	3	4.52	6.8
18	1.88	3.04	4.58	6.9
21	1.91	3.08	4.65	7
24	1.93	3.12	4.72	7.1
27	1.95	3.16	4.78	7.21
30	1.97	3.21	4.85	7.31
33	2	3.24	4.91	7.41
36	2.02	3.28	4.97	7.51
39	2.04	3.32	5.03	7.6
42	2.06	3.36	5.09	7.7
45	2.08	3.39	5.15	7.79
48	2.1	3.43	5.21	7.88
51	2.12	3.47	5.27	7.97
54	2.14	3.51	5.33	8.06

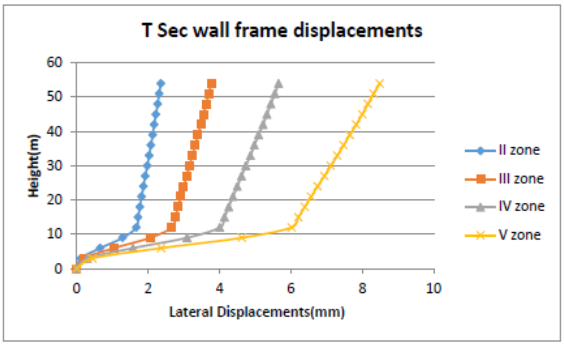

Fig 4.6 Lateral displacements of T Sec Building with Dampers and without Infill wallat different heights of building

From the Fig 4.6, it was observed that variations in maximum lateral displacements for regular building frame without infill and dampers are 64%, 149%, and 277% for seismic zones of III, IV and V with respect to zone II.

CONCLUSIONS:

In this thesis work analysis of RC frames of different models i.e. with dampers, without dampers, with infill, without infill, in different plans for 18 story building was carried out under various seismic zones. Linear Static analysis (seismic coefficient method) method was used to analyse the building models.IS 456- 2000 & IS 1893- 2002 were used in the analysis and design of the structures.Based on the analysis of results and discussions thereon the following conclusions are drawn

1. When compared 18stories RC Regular building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 22%, 82%, 92%found in earthquake zone II.
2. When compared 18 stories RC Regular building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 23%, 82%, 93% found in earthquake zone III.
3. When compared 18 stories RC Regular building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 24%, 82%, 95% found in earthquake zone IV.
4. When compared 18 stories RC Regular building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 24%, 82%, 95% found in earthquake zone V.
5. When compared 18 stories RC L Sec building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 22%, 84%, 94% found in earthquake zone II.
6. When compared 18 stories RC L Sec building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 23%, 84%, 95%found in earthquake zone III.
7. When compared 18 stories RC L Sec building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 23%, 84%, 95%found in earthquake zone IV.
8. When compared 18 stories RC L Sec building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 23%, 84%, 95%found in earthquake zone V.
9. When compared 18 stories RC T Sec building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 20%, 85%, 91%found in earthquake zone II.
10. When compared 18 stories RC T Sec building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 23%, 84%, 95%found in earthquake zone III.
11. When compared 18 stories RC T Sec building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 28%, 85%, 92%found in earthquake zone IV.
12. When compared 18 stories RC T Sec building frame without damper and infill results to RC frame with Damper and without infill, RC frame with infill and without damper, RC frame with Damper and infill the variations are 22%, 85%, 93% found in earthquake zone V.

In the view of above results it was observed that decrease in the lateral displacements of the story was observed in various zones when compared to structure without dampers and infill to structures with damper and without infill, structure with infill and without damper, structure with infill and damper for different plans in various earthquake zones.