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Analysis & Design of a High Rise Unsymmetrical Building with Dampers

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Abstract : Earthquake load is changing into an excellent concern in our country as a result of not one zone may be selected as earthquake resistant zone. One of the most important aspects is to construct a building structure, which can resist the seismic force efficiently. In the present analysis, a residential building with 20 floors is analyzed with columns having viscous dampers at different locations were for all the 2 cases. The building is analyzed in Zone 2 & Zone 5 with three soils in both static & Dynamic Analysis. Moments, Shear, Displacement was compared for all the cases. It is observed that the deflection was reduced by providing the viscous dampers.
Keywords : Earth quake, column, dampers, static and dynamic.

1. Introduction

Many parts of the country have suffered earthquake in the last three decades. Many R.C.C buildings have also collapsed and are found unsafe due to faulty workmanship. Many other causes are responsible for major collapse and damage to the R.C.C structures [2]. It may be noted that seismic zone map of earlier of Indian codes of practice for earthquake resistant design of structures (Is 1893:1984) had five seismic zones which has been modified to four zones in the latest version (IS 1893:2002 (part 1). Similar revisions are possible in near future, Hence it is required to review the existing buildings for any possible enhancement of base shear demand due to revision of seismic zone[4]. The same has been addressed in this thesis. A methodology has been proposed to enhance base shear capacity of buildings with and without infill by addition of visco-elastic dampers.

1.1 Concept of retrofitting

Retrofitting is technical interventions in structural system of a building that improve the resistance to earthquake by optimizing the strength, ductility and earthquake loads. Strength of the building is generated from the structural dimensions, materials, shape, and number of structural elements, etc[1]. Ductility of the building is generated from good detailing, materials used, degree of seismic resistant, etc. Earthquake load is generated from the site seismicity, mass of the structures, importance of buildings, degree of seismic resistant, etc. Seismic retrofit of an existing building most often would be more challenging than designing a new one[5]. The first step of seismic evaluation aims at detecting the deficiencies of the building. Seismic retrofitting of existing structures is one of the most effective methods of reducing the risk of human life and damage of the buildings. Retrofitting procedures could be selected and applied so that the performance objective of the retrofit depends upon the importance of the structure and the desired structural performance during a seismic event with a particular recurrence interval.

1.2 Fluid Viscous Devices

Fluid viscous devices are piston/cylinder devices that utilize fluid flow through orifices to provide a reaction that is a function of the velocity applied to the aforesaid piston. The orifices are located in the piston head and this allows the fluid to move back and forth between two chambers. The cylinder is filled with a silicon fluid selected for its rheological stability and its being non-corrosive. The force generated by these devices is the result of a pressure differential across the piston head. These devices are equipped with spherical hinges at both ends to keep the transmitted load aligned along the main axis[3]. This detail is of major importance to yield reliable performance: it prevents the piston rod from bending and thus the sealing system from failing. High-strength steel components are used for the vessel and the plated piston rod so as to withstand the actions imposed by dynamic loads. The anchoring details depend only on the structure to which they are anchored.

For example, the tang plate/clevis system illustrated in below figure.

Typical anchoring configuration of a fluid viscous device (photo taken during the installation).

Fig 1: Damper

A very important issue related to the utilization of the technology entails the correct numerical modelling of the devices as integrated into the structural model The most appropriate mathematical model to represent the behaviour of viscous devices is to use a Maxwell constitutive law characterized by a linear spring in series to a non-linear dashpot element The first element represents the elasticity of the device and the second, its damping properties. Device elasticity, represented by the stiffness K, is mainly due to the compressibility of the fluid, whilst the damping parameters C and α depend upon the hydraulic circuit used with the particular unit.

2. Experimental

The present project deals with the earthquake resistant multi-storeyed building. For analysis we have to use software which is known as E-TABS 2013. Though E-TABS, is used to analyze the columns and beam of multi-storeyed building , I designed a multi-storeyed building of (G+20) floors.

The plan of multi-storeyed building is 24 x 24 m, here 24m is the length of the plan and 24m is the width of the plan and have a lift section design in the building. There are 6 flats in the ground floor and it is similar in the upper most part of the building and in the entry of the building there is a hall is have and in that hall we have given a lift section from bottom to upper part of the building.

Statement of project
Salient features of building

Utility of building: Commercial complex
No of stories: G+20

Type of construction: R.C.C framed structure
Types of walls: Brick wall

Geometry details
Width of the building: 24m
Height of building: 60m
Height of the floor: 3m

Materials
Concrete grade: M_{30}
All steel grades: Fe_{500}

Size of Structural Members

Column Size:

From ground floor to tenth floor: 750 mm X 900 mm

From eleventh floor to twentieth floor: 450 mm X 750 mm

Beam Size: 400 mm X 600 mm

Slab Thickness: 120 mm

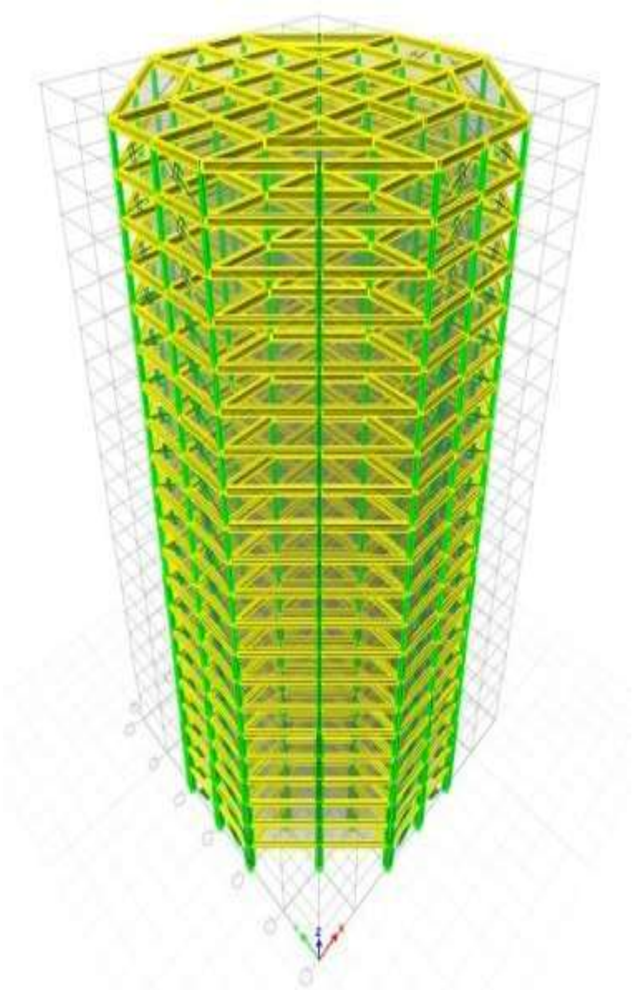

Fig2: Showing 3d view of high rise building with dampers

3. Results and Discussion

Displacement Comparison Values &Graphs for High Rise Building.

Table 1: Showing comparison values of displacement in zone-2 for all 3 models

Displacements in z-2, S-1			**Displacements in z-2, S-2**			**Displacements in z-2, S-3**		
stor	**withou t**	**with dampe**	**storey**	**without dampers**	**with dampers**	**Storey**	**without dampers**	**with dampers**
21	36.4	26	21	60.8	43.4	21	60.8	43.4
20	35.8	24.4	20	59.7	40.7	20	59.7	40.7
19	34.7	22.7	19	57.9	37.9	19	57.9	37.9
18	33.2	21	18	55.5	35.1	18	55.5	35.1
17	31.4	19.3	17	52.5	32.1	17	52.5	32.1
16	29.3	17.4	16	49.1	29.1	16	49.1	29.1
15	27	15.6	15	45.2	26	15	45.2	26
14	24.4	13.7	14	40.9	22.9	14	40.9	22.9
13	21.7	11.9	13	36.3	19.8	13	36.3	19.8
12	18.8	10.1	12	31.4	16.9	12	31.4	16.9
11	15.7	8.5	11	26.4	14.1	11	26.4	14.1
10	12.6	7	10	21.1	11.7	10	21.1	11.7
09	9.5	5.9	09	15.9	9.6	9	15.9	9.6
08	8.3	4.6	08	14	7.6	8	14	7.6
07	7.2	3.5	07	12.1	5.9	7	12.1	5.9
06	6.1	2.7	06	10.1	4.5	6	10.1	4.5
05	5.2	2	05	8.7	3.2	5	8.7	3.2
04	4.3	1.4	04	7.2	2.3	4	7.2	2.3
03	3.4	1	03	5.6	1.6	3	5.6	1.6
02	2.5	0.6	02	4.2	0.9	2	4.2	0.9
01	1.5	0.3	01	2.5	0.4	1	2.5	0.4
BA	0	0	BASE	0	0	BASE	0	0

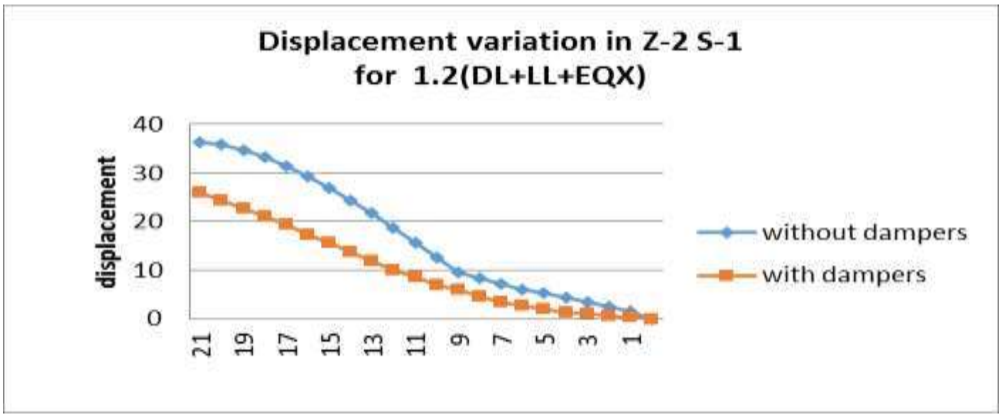

Fig 3: Showing displacement variation in z-2S-1

From the above fig 3, we can conclude that for zone-2 soil type-1, displacement variation throughout storey (i.e. from base to 21 stories) is increased linearly. Building without dampers has more displacement from Base to 21 stories it is observed that 0 at base and 36.4mm at top. Building with dampers has less displacement when compared with without dampers building i.e., from Base to 21 stories it is observed that 0 at base and 26 mm at top.

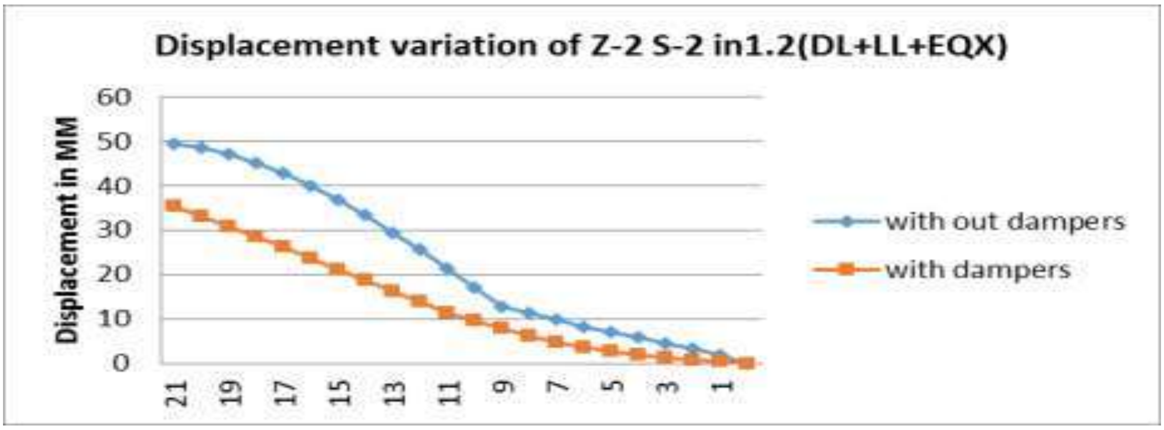

Fig 4 : Showing displacement variation in z-2S-2

From the above fig4 , we can conclude that for zone-2 soil type-2, displacement variation throughout storey (i.e., from base to 21 stories) is increased linearly. Building without dampers has more displacement from Base to 21 stories it is observed that 0 at base and 49.50mm at top. Building with dampers has less displacement when compared with without dampers building i.e., from Base to 21 stories it is observed that 0 at base and 35.30mm at top.

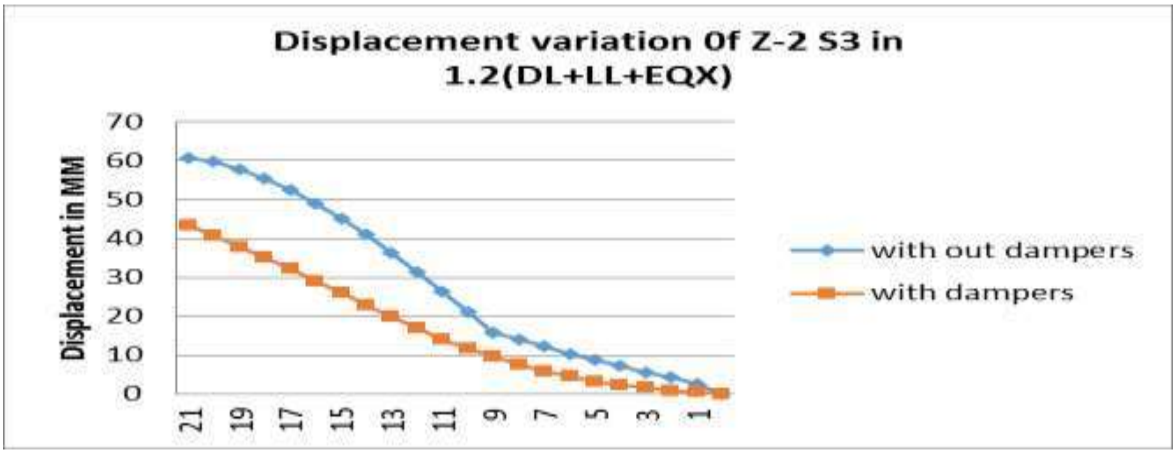

Fig5: Showing displacement variation in z-2S-3

From the above fig 5, we can conclude that for zone-2 soil type-3, displacement variation throughout storey (i.e., from base to 21 stories) is increased linearly. Building without dampers has more displacement from Base to 21 stories it is observed that 0 at base and 60.80mm at top. Building with dampers has less displacement when compared with without dampers building i.e., from Base to 21 stories it is observed that 0 at base and 43.40mm at top.

Table 2: Showing comparison values of displacement in zone-5 for 3 models

Displacements in z-5, S-1			Displacements in z-5, S-2			Displacements in z-5, S-3		
stor	without	with dampe	storey	without dampers	with dampers	Storey	without dampers	with dampers
21	78.6	56	21	106.9	76.2	21	131.3	93.5
20	77.2	52.6	20	105	71.4	20	128.9	87.7
19	74.9	49	19	101.9	66.6	19	125.1	81.7
18	71.8	45.3	18	97.7	61.6	18	119.9	75.6
17	68	41.5	17	92.5	56.4	17	113.5	69.2
16	63.5	37.6	16	86.4	51.1	16	106.1	62.7
15	58.4	33.6	15	79.5	45.7	15	97.7	56
14	52.9	29.6	14	72	40.2	14	88.5	49.4
13	47	25.7	13	64	34.9	13	78.6	42.8
12	40.7	21.8	12	55.4	29.7	12	68.1	36.5
11	34.1	18.3	11	46.5	24.8	11	57.1	30.5
10	27.3	15.1	10	37.2	20.4	10	45.7	25.1
09	20.5	12.4	09	28	16.8	9	34.4	20.5
08	18.1	9.8	08	24.6	13.3	8	30.3	16.3
07	15.6	7.6	07	21.3	10.3	7	26.1	12.7
06	13.1	5.8	06	17.9	7.8	6	22	9.6
05	11.2	4.2	05	15.3	5.7	5	18.8	7
04	9.3	2.9	04	12.6	3.9	4	15.5	4.8
03	7.3	2	03	9.9	2.7	3	12.2	3.3
02	5.4	1.2	02	7.3	1.6	2	9	1.9
01	3.2	0.5	01	4.4	0.7	1	5.4	0.8
BA	0	0	BASE	0	0	BASE	0	0

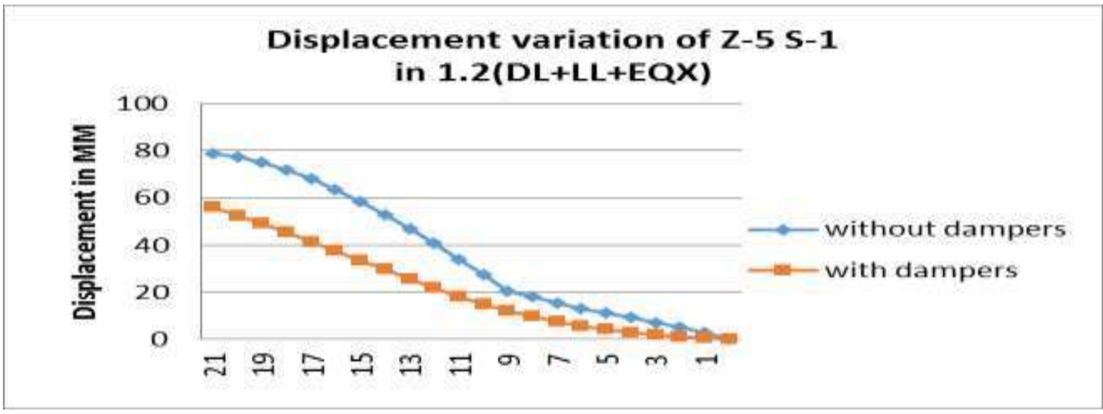

Fig 6: Showing displacement variation in z-5, S-1

From the above fig 6, we can conclude that for zone-5 soil type-1, displacement variation throughout storey(i.e. from base to 21 stories) is increased linearly. Building without dampers has more displacement from Base to 21 stories it is observed that 0 at base and 78.60mm at top. Building with dampers has less displacement when compared with without dampers building i.e., from Base to 21 stories it is observed that 0 at base and 56.00mmattop.

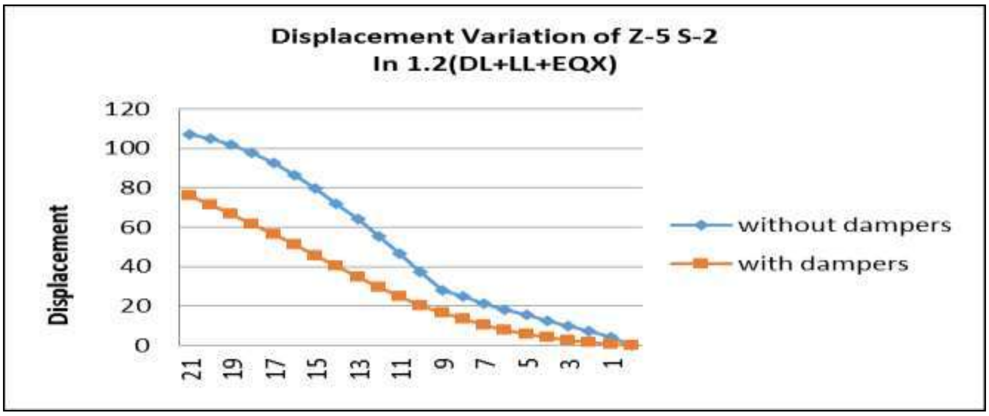

Fig7: Showingdisplacement variation in z-5,S-2

From the above fig 7, we can conclude that for zone-5 soil type-2, displacement variation throughout storey(i.e., from base to 21 stories) is increased linearly. Building without dampers has more displacement from Base to 21 stories it is observed that 0 at base and 106.90mm at top. Building with dampers has less displacement when compared with without dampers building i.e., from Base to 21 stories it is observed that 0 at base and 76.20 mm at top.

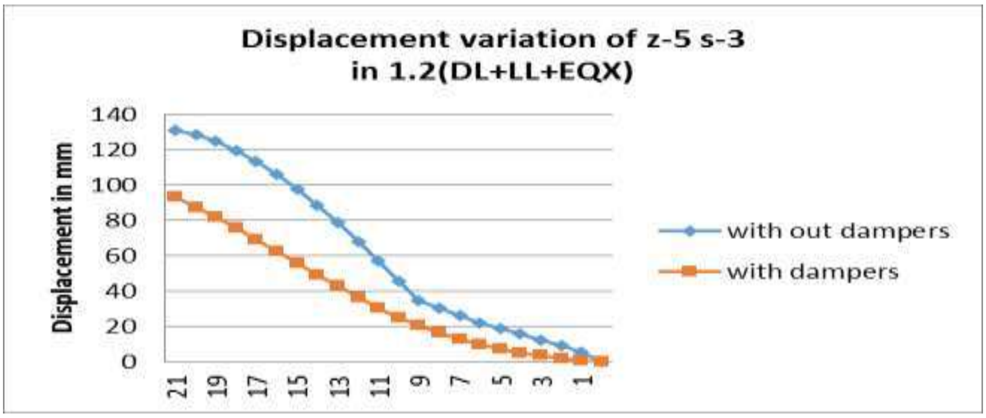

Fig 8: Showing displacement variation in z-5 S-3

From the above fig 8, we can conclude that for zone-5 soil type-3, displacement variation throughout storey(i.e., from base to 21 stories) is increased linearly. Building without dampers has more displacement from Base to 21 stories it is observed that 0 at base and 131.30mm at top. Building with dampers has less displacement when compared with without dampers building i.e., from Base to 21 stories it is observed that 0 at base and 93.50 mm at top.

Zone wise comparison of displacements:

Table 3 : Showing zone wise displacement comparison values &Graphs of soil-1

ZONES	without dampers	with dampers
zone-2	36.4	26
zone-5	78.6	56

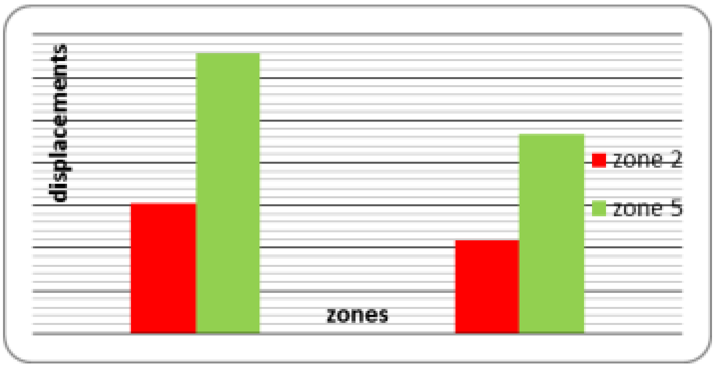

Fig 9: Showing zone wise displacement variation in soil-1

From the above fig 9, we can conclude that zone wise comparison is made for soil-1 in zone-2 & zone-5, the displacement values for the building without dampers is more when compared to the building with dampers we can observe that from the above graph. For soil-1 in zone-2 & zone -5 the values of displacement are 36.4 mm &78.6mm when dampers are not provided, and the values of displacement when dampers are provided to elevations are 26mm & 56mm.

Table-4 : Showing zone wise displacement comparison values &Graphs of soil-2

ZONES	without dampers	with dampers
zone-2	49.5	35.3
zone-5	106.9	76.20

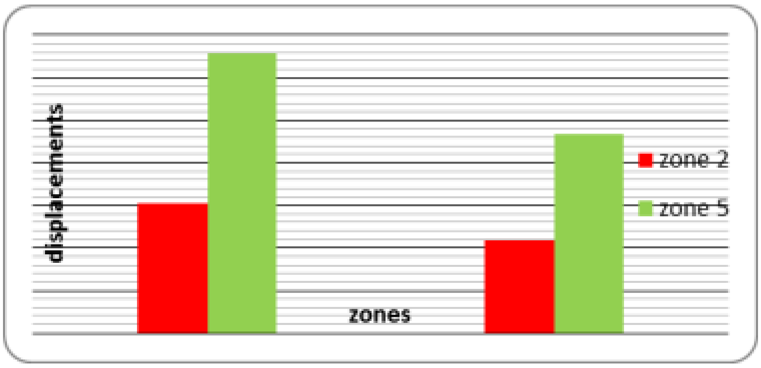

Fig 10: Showing zone wise displacement variation in soil-2

From the above fig 10, we can conclude that zone wise comparison is made for soil-2 in zone-2 & zone-5, the displacement values for the building without dampers is more when compared to the building with dampers we can observe that from the above graph. For soil-1 in zone-2 & zone -5 the values of displacement are 49.5 mm&106.90mm when dampers are not provided, and the values of displacement when dampers are provided to elevations are 35.30mm & 76.20mm.

Table 5: Showing zone wise displacement comparison values &Graphs of soil-3

ZONES	without dampers	with dampers
zone-2	60.80	43.40
zone-5	131.3	93.50

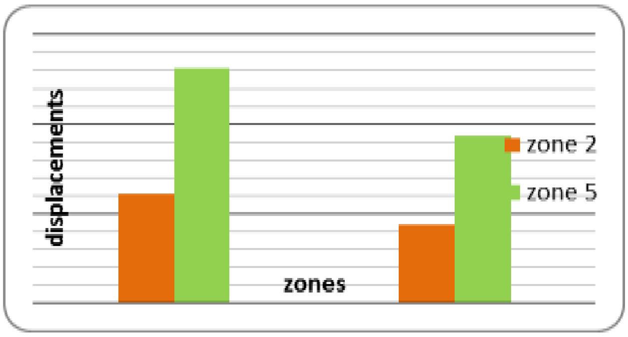

Fig11: Showing zone wise displacement variation in soil-3

From the above fig 11, we can conclude that zone wise comparison is made for soil-3 in zone-2 & zone-5, the displacement values for the building without dampers is more when compared to the building with dampers we can observe that from the above graph. For soil-1 in zone-2 & zone -5 the values of displacement are 60.80 mm& 131.3mm when dampers are not provided, and the values of displacement when dampers are provided to elevations are 43.40mm & 93.50mm.

4. Conclusions:

Displacement is compared for two models i.e., without dampers & with dampers at top storey of a high rise building in zone-2& zone -5 in each soil and it is observed that 50% displacement is reduced when the dampers are provided at each elevation.

Shear is compared for two models i.e., without dampers & with dampers at top storey of a high rise building in zone-2& zone -5 in each soil and it is observed that 40% shear is reduced when the dampers are provided at each elevation.

5. References:

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