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Dynamic Analysis of A Steel Structure for Horizontal and Vertical Loading With and Without Dampers

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Abstract:
Earthquakes are the most capricious and destroying of every single catastrophic event, which are extremely hard to spare over building properties and life, against it. Thus so as to beat these issues we have to recognize the seismic execution of the fabricated condition through the improvement of different explanatory strategies, which guarantee the structures to withstand amid visit minor tremors and create enough alert at whatever point subjected to real quake occasions. So that can spare however many lives as could be expected under the circumstances. There are a few rules everywhere throughout the world which has been over and again refreshing on this subject. In the present study, Extensive literature review is carried out and few conclusions were drawn and also predicted few out comings. SAP2000 Software is used for the modelling and analysis of different building and damper configurations. The static and dynamic analysis is carried out. Finally, Conclusions are made based on the performance of each system under study. The conclusions drawn from analysis, from the modal analysis results it can be concluded that presence of damper increase the overall frequency of structure due to stiffness increase. From the displacement results of equivalent static analysis, it can be concluded that, dampers play a very important role in reducing the overall displacement of the structure. From time history analysis it can be concluded that, dampers are effective in reducing the displacements along Y direction compared to X direction. Hence it is suggested that provision of dampers at re-entrant corner will be advantageous with respect to overall stability of structure.

Keywords: dampers, dynamic analysis, static analysis, SAP2000.

1. INTRODUCTION

Earthquakes are the most capricious and destroying of every single catastrophic event, which are extremely hard to spare over building properties and life, against it. Thus so as to beat these issues we have to recognize the seismic execution of the fabricated condition through the improvement of different explanatory strategies, which guarantee the structures to withstand amid visit minor tremors and create enough alert at whatever point subjected to real quake occasions. So that can spare however many lives as could be expected under the circumstances. There are a few rules everywhere throughout the world which has been over and again refreshing on this subject. The examination methodology evaluating the earth quake powers and its request contingent upon the significance and cost, the technique for breaking down the structure differs from straight to nonlinear. The conduct of a working amid an earth quake relies upon a few elements, solidness, and sufficient parallel quality, and pliability, basic and normal setups. The structures with normal geometry and consistently conveyed mass and solidness in design and in rise endure significantly less harm contrasted with sporadic arrangements. Be that as it may, these days need and request of the most recent age and developing popular has made the modelers or designers unavoidable towards arranging of sporadic setups. Subsequently quake designing has turned into a critical branch of structural building. Vibration control is having its foundations basically in aviation related issues, for example, in adaptable space structures, the innovation immediately moved into structural designing and framework related issues, for example, the assurance of structures and scaffolds from extraordinary heaps of seismic tremors and winds. The quantity of tall structures being assembled is expanding step by step. Today we can't have a tall number of low-ascent or medium ascend and elevated structures existing on the planet. For the most part these structures are having low common damping. So expanding damping limit of an auxiliary framework, or considering the requirement for other mechanical intends to build the damping limit of a building, has turned out to be progressively normal in the new age of tall and super tall structures. Be that as it may, it ought to be influenced a standard outline to practice to plan the damping limit into a basic framework while planning the basic framework.

2. LITERATURE REVIEW

[1] Haitham Mohamed Khalaf: In this study models created as regular and symmetrical models with 15 storey (45m) ,25 storey (75m) and 35 storey (105m).Analytical models created by SAP 2000 program with and without Tuned mass damper. The accompanying parameters to be utilized as a part of the accompanying exchange. Common Frequency of TMD, Damping Ratio of TMD, Natural Frequency of Main Structure, Damping Ratio of Main Structure. Conclusion: Base shear reduction after used TMD as following: In 15 storeys building the reduction 24%. , In 25 storey building the reduction 28%. , In 35 storey building the reduction 31%. Lateral deflection (displacement) reduction after used TMD as following: In 15 storey building lateral deflection decrease between (23.8-24.9) %. , In 25 storey building lateral deflection decrease between (28.5-28.9) %. , In 35 storey building lateral deflection decrease between (29.4-30.9) %.

[2] Mr.Khemraj S. Deore: Time History Analysis and Response Spectrum Analysis is a vital technique for structural seismic analysis particularly once the structural is high rise. This thesis study of the damper effect in the frame is an important factor for the analysis. For Analysis purpose practical (G+16) storey building modeled with and without tuned mass damper by using software ETABS. Constant loading parameters are used for both cases. Load combinations are taken from IS code 875 Part 5. A tuned mass damper (TMD) is placed on top floor of building and Response spectrum analysis has performed Parameters/Model/Software: Mass of damper, mass ratio, Frequency of damper, Optimum damping ratio Conclusion: Based on exhibit consider and explored writing The accompanying conclusions can be drawn: Seismic execution of working after utilization of damper is greatly improved when we give to best of story. It has been discovered that the TMD can be effectively used to control vibration of the structure. For story drift which is important behavior for finishes such as sliding windows, performance is better for building with TMD. Use of TMD damper lessens expansive measure of uprooting of the structure. Because of supreme dislodging lessening the structure have not required greater flexibility to opposing earth-shudder powers. With the utilizing of TMD in the structure, the base shears marginally increments. With the using of TMD in the structure, the Fundamental Period of structure reduces.

[3] Muhammad Murad.K: This paper is to study the comparison of shear wall and TMD for reducing vibration of tall buildings due to wind and earthquake loading by using SAP2000 software. Shear walls and Tuned Mass Dampers are assigned in the structure alternatively. Various arrangements of Tuned Mass Dampers in this 30 storey building are studied and the best arrangement among these is applied in a 50 storey building to study the effectiveness in controlling vibration. And also the characteristic of this 50 storey building is studied by applying Time History Analysis of El-Centro earthquake. Parameters/Model/Software: Mass of damper, mass ratio, Frequency of damper , Optimum damping ratio, Frequency of building Conclusion: The storey displacement of 30 storey buildings with TMDs are also very less when compared with building with shear wall. The maximum storey displacement obtained for building with shear wall is 0.088m and the maximum displacement of buildings with TMDs is 0.046m. It is almost just the half of that with shear wall. The minimum displacement obtained is 0.037m. The joint acceleration obtained for 30 storey buildings with TMDs are also having a large difference between that of building with shear wall. Proved to be safe. The Base shear, Storey displacements, joint accelerations and frequency of the structure are very less. These storey displacements, joint accelerations and frequency of the 50 storey structure are less than that of 30 storey building with TMDs for the designed optimum parameters of TMDs, The cost of TMDs is almost similar to that of shear wall in 30 storey's structure. But less base shear, storey displacement, joint acceleration, and frequency makes TMDs more applicable than shear wall. For 50 storey building the TMDs could be cost effective. Our Conclusion In this paper the comparison of TMD & base shear wall is done. The result is obtained that the TMD gives less value than shear wall in all direction. We concluded that from this mostly for tall buildings TMD is used instead of shear wall.

3. MODELLING

3.1 GENERAL: The SAP name has been synonymous with best in class expository techniques since its presentation more than 30 years prior. SAP2000 follows in a similar custom including an exceptionally advanced, instinctive and flexible UI controlled by an unmatched investigation motor and configuration devices for engineers dealing with transportation, modern, open works, sports, and different offices. From its 3D protest based graphical demonstrating condition to the wide assortment of examination and plan alternatives totally incorporated crosswise over one intense UI, SAP2000 has turned out to be the most coordinated, beneficial and useful broadly useful auxiliary program available today. This instinctive interface enables you to make basic models quickly and naturally without long expectation to learn and adapt delays. Presently you can outfit the energy of SAP2000 for the greater part of your investigation and configuration undertakings, including little everyday issues.

3.2 Modeling Using SAP2000

This chapter includes the modelling of the G+30 storey building. This building is modelled with steel structural elements. The models are further studied for footing present in different soil condition, with soil structure interaction. Here are the types of model shown for the easy assessment.

1. MODEL 1 – Irregular building – L shape
2. MODEL 2 – Irregular building – L shape with damper location 1
3. MODEL 3 – Irregular building – L shape with damper location 2
4. MODEL 5 – Irregular building – L shape with damper location 3
5. MODEL 5 – Irregular building – L shape with damper location 4

3.2.1 Defining Material Properties:

The material property is an important aspect to be defined while modeling a structure. The steel structure which has to be specified as listed below such as modulus of elasticity of steel, concrete, compressive strength of concrete and also the yield strength of the reinforcing and structural steel.

Young's Modulus (steel), Es = 2,10,000MPa

Yield stress for structural steel, fy = 360 MPa

The grade of steel is readily available by default. We can choose the required grade. The other properties are readily available with concrete grade.

3.2.2 Defining Frame Sections

The beam and column form the frame. The frame members have to be defined, as listed below. Here readily available various geometries that are chosen and the material property has been assigned.

3.2.3 Defining Loads

The different types of loads are defined under this option, here we can define the

1. Dead load
2. Live Load
3. FF Load
4. Glazing Load

All are categorised based on the different types.

Further the load combinations are automatically generated in the SAP2000. Before generating, we should choose IS code IS1893:2016. Later we can generate it by using options – Define – Default design combo's –steel frame design.

And is generated.

1.7x (DL + LL)

1.7 x (DL ± EL)

1.7 x (DL + IL ± EL)

3.2.4Mass Source

In the seismic analysis, the mass of the structure is considered, as some ratio of the load is acted as lateral force. All the dead load will be considered with a scale factor 1. Whereas the live load will be considered with a 0.5% as applied. This is due to live load is more than 3kN/m^2. This value is considered as the seismic weight. This shall be further multiplied with the horizontal seismic co-efficient, to get the base shear values.

3.2.5 Building Information:

Table.4.1. Detailed data for the example building

Structure		Steel Structure.
No. of storey		G+30 Storey.
Storey height	First storey	3.0 m
	Upper storey	3.0 m
TYPE of building use		Commercial
Foundation Type		Isolated footing / Raft
Seismic zone		Z-5
Assumed Dead Load Intensities		
Roof finishes		1.50 KN/m^2
Floor finishes		1.50 KN/m^2
Live Load Intensities		
Roof		3.0 KN/m^2
Floor		3.0 KN/m^2

3.2.6 Standard Model:

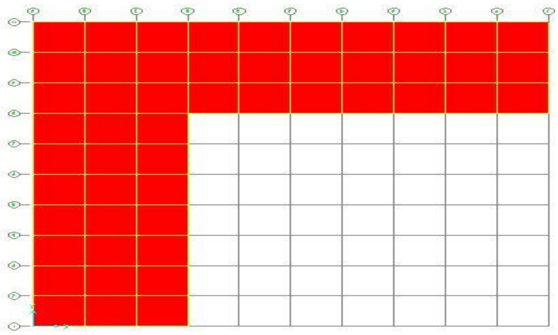

Figure.4.1. Plan View.

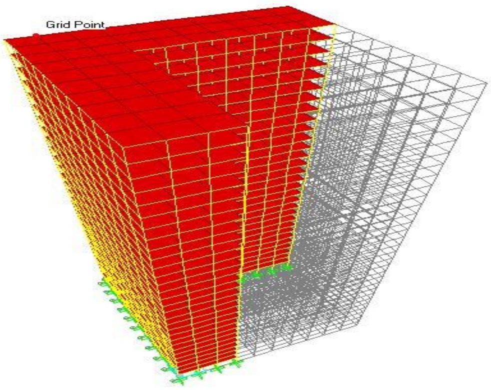

Figure.4.2: 3D View.

The standard models are prepared. The similar models are created based on the dampers at different locations. And all the models are indicated below.

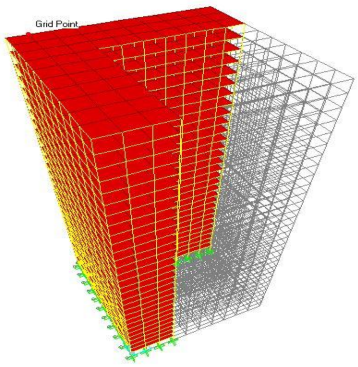

Figure.4.3: 3D View of Model 1

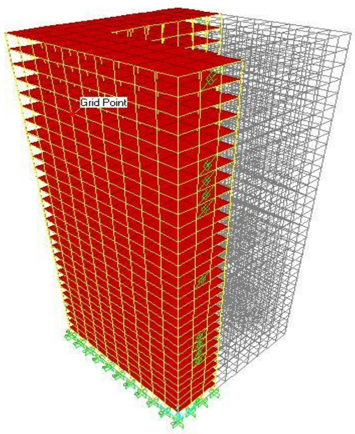

Figure.4.4: 3D View of Model 2

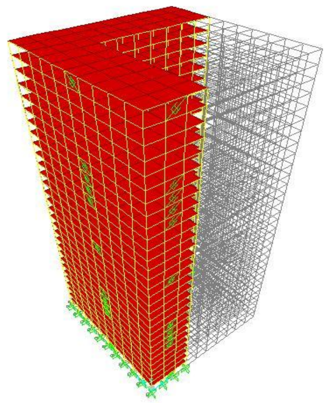

Figure.4.5: 3D View of Model 3

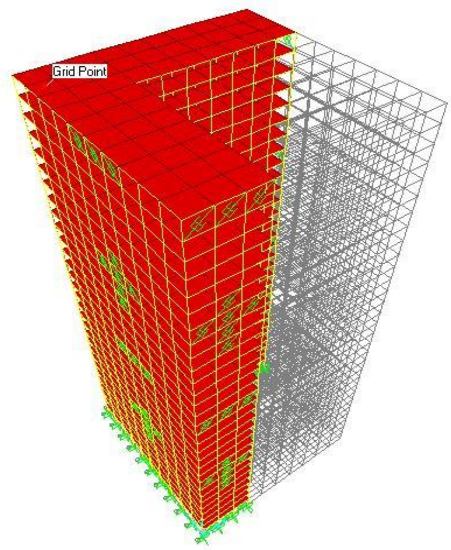

Figure.4.6: 3D View of Model 4

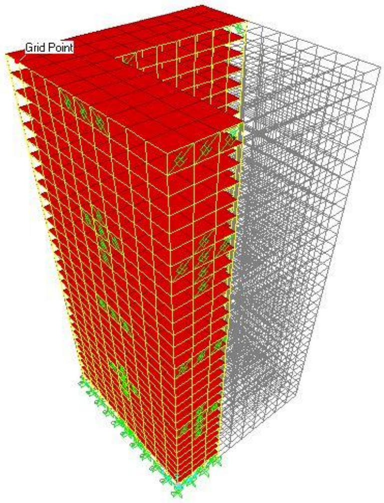

Figure.4.7: 3D View of Model 5.

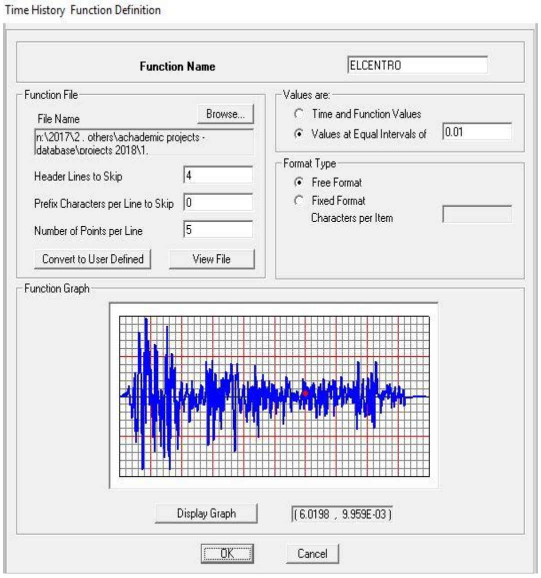

Figure.4.8: Time history function definition.

4 RESULTS

Equivalent static analysis is carried out for all the different types of floating column configuration including regular RC moment resisting frame for ZONE 3 and ZONE 5. Results are presented in the form of tables and graphs in this section.

4.1 Equivalent Static Analysis

4.1.1 Modal Analysis

Table 4.1: Mode vs. Time Period

Mode No.	Time Period (Seconds)				
	Steel Structure (SS)	SS Damper-1	SS Damper-2	SS Damper-3	SS Damper-4
1	5.08	4.94	4.69	4.47	3.83
2	3.59	3.33	3.26	3.10	2.83
3	2.79	2.77	2.68	2.54	2.24
4	1.68	1.63	1.54	1.48	1.19
5	1.14	1.04	1.02	0.97	0.87
6	0.98	0.94	0.90	0.86	0.70
7	0.91	0.90	0.87	0.83	0.68
8	0.70	0.67	0.63	0.61	0.50
9	0.64	0.58	0.57	0.55	0.47
10	0.54	0.52	0.49	0.47	0.40
11	0.51	0.50	0.48	0.45	0.36
12	0.46	0.43	0.41	0.40	0.33

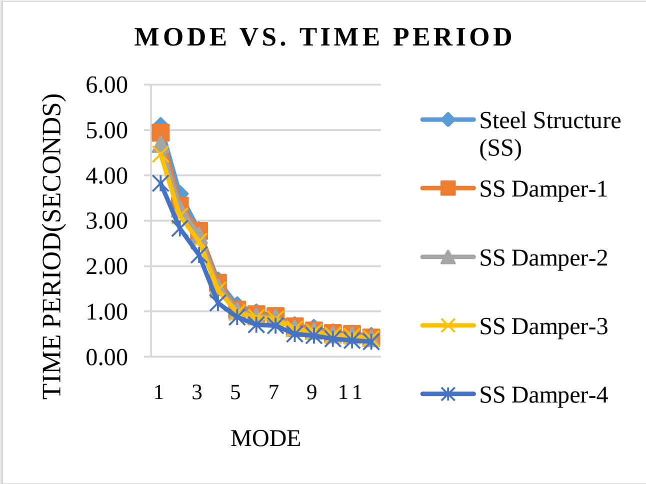

Figure.4.1. Mode vs. Time Period

Table 4.2: Mode vs. Frequency

Mode No.	Frequency (Hz)				
	Steel Structure (SS)	SS Damper-1	SS Damper-2	SS Damper-3	SS Damper-4
1	0.20	0.20	0.21	0.22	0.26
2	0.28	0.30	0.31	0.32	0.35
3	0.36	0.36	0.37	0.39	0.45
4	0.59	0.61	0.65	0.68	0.84
5	0.88	0.96	0.98	1.03	1.14
6	1.02	1.06	1.12	1.16	1.42
7	1.10	1.11	1.15	1.20	1.46
8	1.44	1.48	1.58	1.63	1.99
9	1.57	1.71	1.75	1.83	2.14
10	1.86	1.91	2.04	2.12	2.53
11	1.96	1.99	2.10	2.23	2.80
12	2.17	2.34	2.43	2.49	3.03

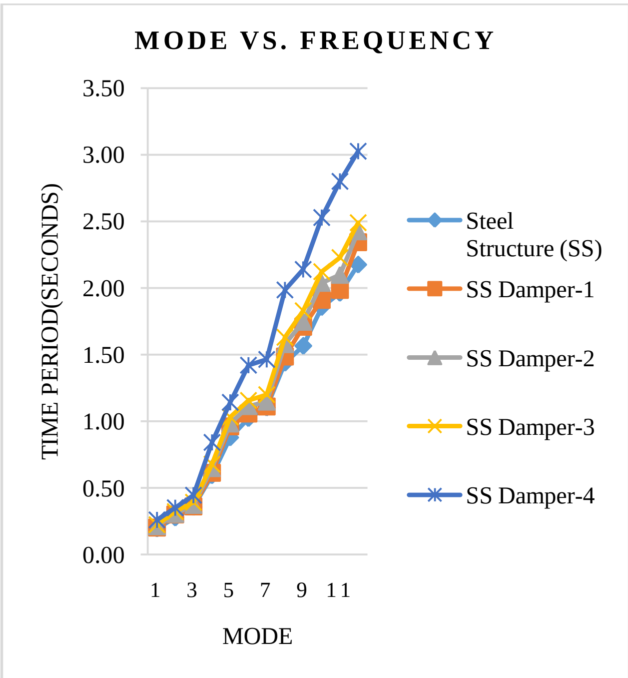

Figure.0.1. Mode vs. Frequency

From modal analysis results it can be observed that, maximum time period is found to be in steel structures (SS) without dampers i.e., 5.08 seconds compared to steel structures without dampers. And Steel structure with dampers at location type 4 exhibits least time period which is 24% less than that of SS. Since SS damper – 4 is having least time period, maximum frequency is found in the same compared to all other structures.

4.1.2 Story displacements

Table 0.1: Story vs. displacements – X Dir.

	Story Displacements - X Direction				
Story	Steel Structure (SS)	SS Damper-1	SS Damper-2	SS Damper-3	SS Damper-4
Story30	120.2	110.79	110.87	104.9	92.54
Story29	117.1	107.58	107.69	101.8	90.09
Story28	113.8	104.29	104.43	98.6	87.35
Story27	110.4	100.86	101.02	95.3	84.39
Story26	106.7	97.27	97.45	91.7	81.32
Story25	102.9	93.56	93.76	88.0	78.11
Story24	99.0	89.94	90.16	84.7	75.27
Story23	94.9	86.26	86.52	81.6	72.78
Story22	90.6	82.54	82.84	78.3	69.96
Story21	86.3	78.81	79.14	74.9	67.04
Story20	81.8	74.57	74.94	70.9	63.35
Story19	77.2	70.08	70.47	66.4	59.21
Story18	72.6	65.48	65.89	61.8	55.02
Story17	67.9	60.84	61.24	57.1	51.00
Story16	63.2	56.34	56.74	52.7	47.25
Story15	58.5	52.58	52.99	49.8	44.83
Story14	53.8	48.20	48.60	45.6	41.16
Story13	49.1	43.53	43.93	40.9	36.79
Story12	44.4	38.86	39.24	36.1	32.25
Story11	39.8	34.24	34.60	31.4	27.70
Story10	35.3	29.84	30.17	26.9	23.47
Story9	30.9	26.35	26.65	24.0	20.92
Story8	26.6	23.04	23.31	22.0	19.26
Story7	22.4	19.92	20.15	19.5	17.07
Story6	18.3	17.07	17.28	17.1	14.87
Story5	14.4	13.46	13.63	13.5	11.55
Story4	10.7	9.68	9.82	9.7	7.99
Story3	7.2	6.06	6.18	6.0	4.86
Story2	4.0	2.72	2.78	2.6	2.11
Story1	1.4	0.16	0.16	0.00	0.00

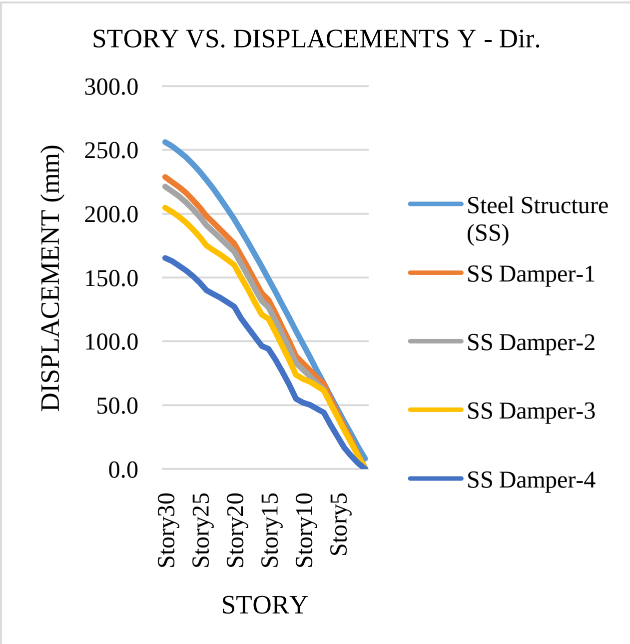

Figure.0.3. Story vs Displacements – Y Dir.

Table 0.4. Story vs. drifts – X Dir.

	Story Drifts X - Direction				
Story	Steel Structure (SS)	SS Damper-1	SS Damper-2	SS Damper-3	SS Damper-4
Story 30	3.09	3.21	3.18	3.05	2.45
Story 29	3.27	3.29	3.26	3.18	2.73
Story 28	3.45	3.43	3.40	3.37	2.97
Story 27	3.62	3.59	3.57	3.57	3.07
Story 26	3.79	3.71	3.69	3.66	3.21
Story 25	3.96	3.62	3.59	3.35	2.84
Story 24	4.11	3.68	3.64	3.05	2.49
Story 23	4.25	3.72	3.68	3.31	2.82
Story 22	4.37	3.73	3.70	3.39	2.92
Story 21	4.47	4.24	4.20	4.07	3.69
Story 20	4.56	4.50	4.47	4.44	4.14
Story 19	4.63	4.59	4.58	4.59	4.19
Story 18	4.68	4.65	4.64	4.68	4.01
Story 17	4.71	4.50	4.50	4.45	3.75
Story 16	4.72	3.76	3.75	2.94	2.41
Story 15	4.72	4.38	4.39	4.11	3.67
Story 14	4.69	4.67	4.68	4.72	4.37
Story 13	4.65	4.67	4.68	4.78	4.54
Story 12	4.59	4.62	4.64	4.77	4.55
Story 11	4.52	4.39	4.43	4.47	4.22
Story 10	4.43	3.50	3.52	2.93	2.56
Story 9	4.32	3.31	3.34	1.97	1.65
Story 8	4.20	3.12	3.16	2.48	2.19
Story 7	4.06	2.85	2.88	2.45	2.20
Story 6	3.90	3.61	3.64	3.56	3.32
Story 5	3.72	3.79	3.81	3.85	3.56
Story 4	3.50	3.61	3.64	3.67	3.13
Story 3	3.19	3.34	3.39	3.40	2.75
Story 2	2.64	2.56	2.62	2.60	2.11
Story 1	1.37	0.16	0.16	0.00	0.00

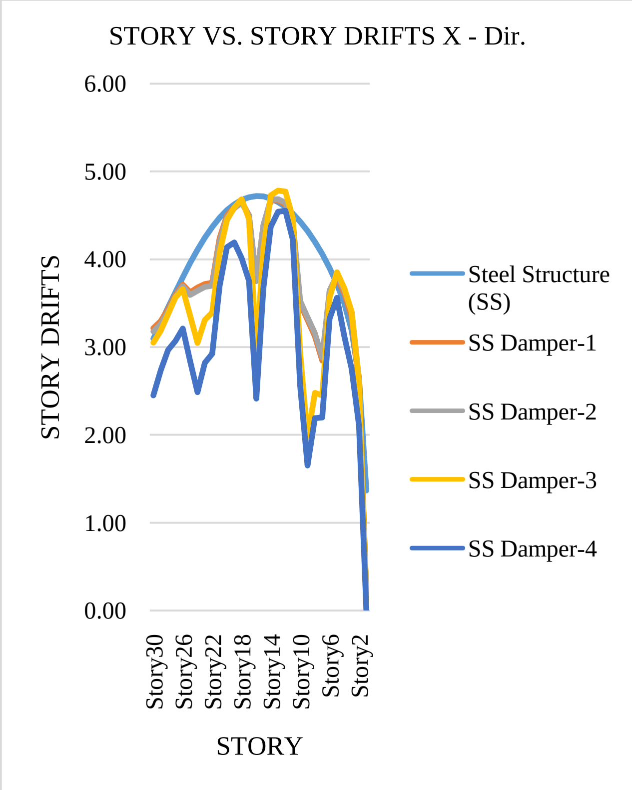

Figure.0.4. Story vs drifts – X Dir.

From the above table and figure response of SS with dampers at different locations is identified. And it is evident that, there is significant reduction in the story drifts at damper location compared to SS without dampers. And SS damper – 4 type structure shows maximum reduction of 61.8% at story 9 compared to all other damper location along X direction.

Table.0.5: Story vs. drifts – Y Dir.

Story	Story Drifts Y - Direction				
	Steel Structure (SS)	SS Damper-1	SS Damper-2	SS Damper-3	SS Damper-4
Story 30	3.24	3.99	3.84	3.27	2.57
Story 29	3.92	3.82	3.80	3.69	3.34
Story 28	4.62	4.57	4.58	4.56	3.88
Story 27	5.29	5.33	5.34	5.34	4.29
Story 26	5.92	6.12	6.08	6.10	5.21
Story 25	6.51	6.86	6.74	6.69	6.05
Story 24	7.05	5.07	4.88	3.72	3.10
Story 23	7.56	5.32	5.12	3.28	2.59
Story 22	8.01	5.43	5.23	3.99	3.49
Story 21	8.42	5.49	5.29	4.17	3.65
Story 20	8.79	9.47	9.39	9.52	8.89
Story 19	9.11	9.59	9.55	9.68	7.68
Story 18	9.39	9.82	9.79	9.89	7.02
Story 17	9.63	9.99	9.89	9.95	7.09
Story 16	9.83	5.32	5.11	3.12	2.36
Story 15	10.00	10.66	10.53	10.54	8.56
Story 14	10.13	10.81	10.71	10.85	9.23
Story 13	10.22	11.15	10.98	11.14	10.31
Story 12	10.28	11.47	11.20	11.36	10.90
Story 11	10.31	5.54	5.28	3.34	2.94
Story 10	10.31	5.68	5.40	2.19	1.79
Story 9	10.28	5.45	5.16	3.47	3.10
Story 8	10.23	5.07	4.77	3.33	2.99
Story 7	10.15	11.74	10.80	10.46	9.45
Story 6	10.05	11.14	10.56	10.43	9.39
Story 5	9.93	10.81	10.36	10.29	8.64
Story 4	9.79	10.69	10.19	10.12	6.60
Story 3	9.62	10.79	10.15	10.07	5.42
Story 2	9.40	10.90	9.93	9.95	4.62
Story 1	7.92	0.61	0.52	0.15	0.07

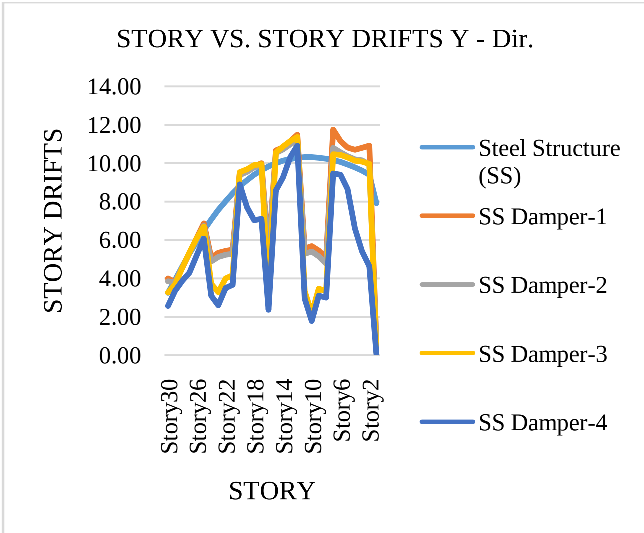

Figure.0.5. Story vs drifts – Y Dir.

From the above graph it is clear that, SS damper – 4 types shows good performance to reduce the story drifts significantly throughout the height of the structure i.e., 10.39 mm in SS structure where 1.79 mm in SS damper – 4 are. Similarly all other type of SS with damper shows well performance in reducing the story drifts of minimum of 50% reduction.

5. CONCLUSION

Following conclusions are drawn with from the results and discussions

1. From the modal analysis results it can be concluded that presence of damper increase the overall frequency of structure due to stiffness increase.
2. From the displacement results of equivalent static analysis it can be concluded that, dampers plays a very

important role in reducing the overall displacement of the structure.

3. Also it is concluded that, damper are very effective in reducing the story drifts particularly at their respective location.

4. Hence it is suggested that provision of dampers at re-entrant corner will be advantageous with respect to overall stability of structure.

6. ACKNOWLEDGEMENT

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