EFFECT OF DAMPER LOCATIONS ON BEHAVIOUR OF PLAN IRREGULAR STEEL STRUCTURE SUBJECTED TO DYNAMIC LOADING

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Abstract: *This research work focuses on the study of behaviour of plan irregular (re-entrant corner) steel structure subjected to dynamic loads using finite element package SAP2000, to study the effect of bracings with damper locations in plan irregular steel structure and to identify the suitable location of dampers in plan irregular steel structure for efficiently resisting the lateral loads. This study includes the modelling of re-entrant corner building of G+15 stories with plan area of 36X40m and storey height of 3m. All the models are analyzed for zone III and zone V by equivalent static method. Also dynamic time history analysis is performed for Bhuj and El Centro earthquake. Various seismic responses like displacements, base shear, storey drifts and time period are obtained. From the results and discussions, it can be concluded that, the combination of bracings and damper has a significant contribution in resisting the lateral loads both in case of equivalent static and dynamic time history loads.*

Key Words: **Re-Entrant Corner, Equivalent Static and Dynamic Time Analysis, Dampers, Bracings.**

1. INTRODUCTION

In the course of recent decades world has encountered various disasters seismic hazards, bringing about expanded loss of human life because of fall of structures and extreme auxiliary harms. Event of such harms amid quakes obviously exhibits the high seismic risks and the structures like private structures, authentic structures and mechanical structures should be outlined precisely to shield from tremors. Earthquake in the least complex terms can be characterized as shaking and vibration at the surface of the earth coming about because of underground development along a blame plane. The vibrations created by the earthquakes are because of seismic waves. Seismic waves are the most unfortunate one. In any case, present day elevated structures and tall structures can't advantageously be adapted with these systems. The security and workableness of any structure is damaged or destroyed with the expanding rise. According to the standard codes, a structure that can oppose the most notable seismic tremor that could happen in that specific territory can be called as an earthquake safe structure. The fundamental goal of Structural building field is to outline and develop the sheltered and stable structures.

The present examination makes attempts to study the impact of re-entrant corners in a building anticipate its seismic execution. A structure is considered as a re – entrant corner, if both the projections of the structure past that corner are more prominent than 15% of its arrangement measurement in the provided guidance. Re-entrant corners for the most part cause two issues, one is torsion and the other is contrast in the stresses initiated in various wings of the building causing stress fixation at the corner. This paper shows the advances with respect to seismic response of irregular plan structures in different seismic zones of India.

1.1 OBJECTIVES

The following are the objectives of the present research work and it is given below

1. To study the behaviour of plan irregular (re-entrant corner) steel structure subjected to dynamic loads using finite element analysis package.
2. To study the effect of incorporating steel bracings on plan irregular steel structure under consideration.
3. To study the effect of bracings location in plan irregular steel structure.
4. To identify the suitable location of bracings in plan irregular steel structure for efficiently resist the lateral loads i.e., equivalent static as well as dynamic loads.
5. Comparison of analysis of results with Bhuj earthquake and El Centro earthquake.

1.2 METHODOLOGY:

The following methods are adopted for modelling and analysis of plan irregular steel structure subjected to static and dynamic loading.

- To carryout extensive literature review, to establish the objectives of the study.
- SAP2000 Software is used for the modelling and analysis of different building and damper configurations.
- Analyze the models using Static and Dynamic analysis using IS 1893-2016.
- Steel of Fe-360 will be considered for the analysis of the structural system.
- Preliminary member sizes are assumed for beams and columns, later member sizes are economized and based on that the system is adopted.
- Conclusions are made based on the performance of each system under study.

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2. MODELLING

This chapter includes the modeling of the G+15 storey building. This building is modeled 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.
Model 1 – Irregular building - Steel structure (SS)
Model 2 – Irregular building with bracings - (SS. Brgs)
Model 3 – Irregular building with dampers - (SS. Damp)
Model 4 – Irregular building with dampers & bracings - (SS Brgs- Damp)

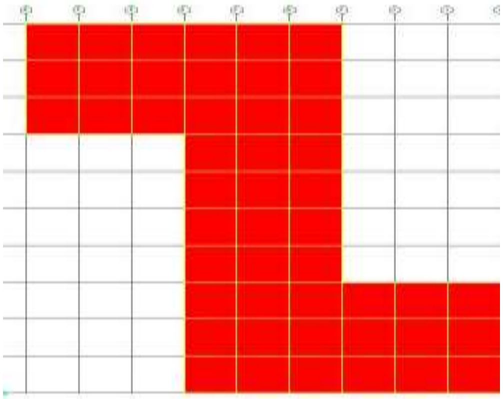

Fig -1: Model 1

The figure-1 represents the re-entrant corner building G+15 with a storey height of 3m. This building has two re-entrant corners.

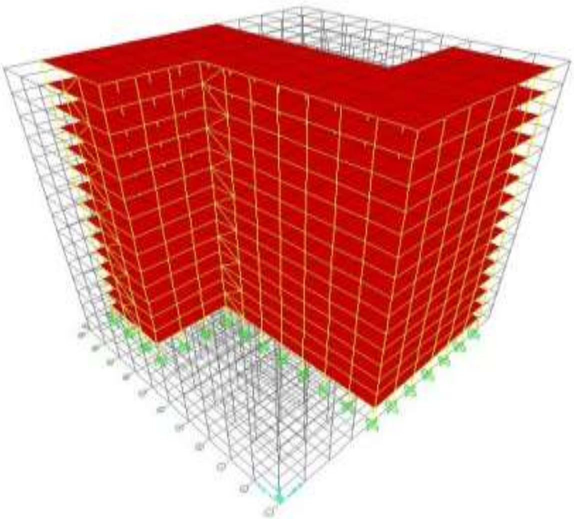

Fig -2: Model 2

The figure-2 represents the steel structure with bracings. Bracings are designed to resist the wind and earthquake forces. The bracings provide stability to the structure. The member in braced frame that is made of structural steel works effectively both in tension and compression.

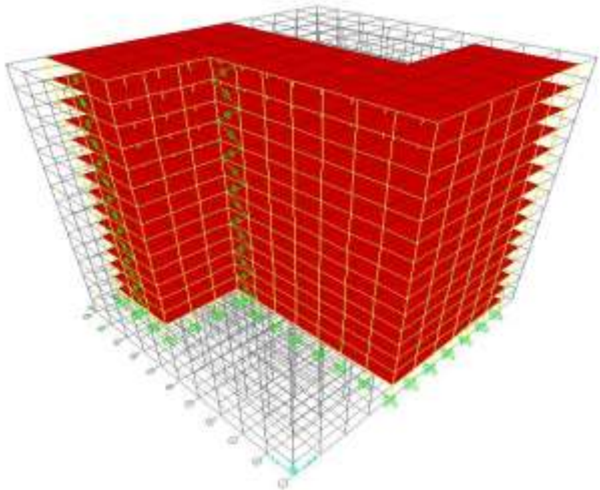

Fig -3: Model 3

The figure-3 represents the irregular steel structure with dampers. The dampers are used in the structure to reduce the amplitude of vibrations.

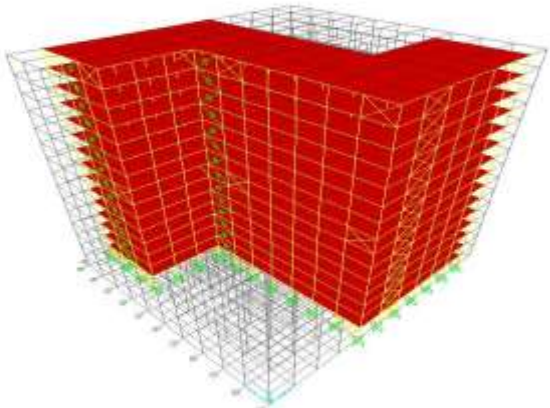

Fig -4: Model 4

The figure 4 represents the irregular steel structure with bracings and dampers. This model is more efficient when compared to all other models. The combination of both bracings and dampers are used to resist the lateral loads.

Table -1: Detailed data for the example

Structure		Steel Structure
No. of storey		G+15 Storey
Storey height	First storey	3.0m
	Upper storey	3.0m
Type of building use		Commercial
Type of support		Fixed Support
Seismic zone		Zone III and ZONE V
Assumed Dead Load Intensities		
Roof finishes		1.50 kN/m²
Floor Finishes		1.50 kN/m²
Live Load Intensities		
Roof		4 kN/m²
Floor		4 kN/m²

3. ANALYSIS

The analysis of irregular steel structure is done by both equivalent static and dynamic analysis. The equivalent static analysis is performed for both zone III and zone V. The dynamic analysis mainly includes the time history analysis for both BHUJ earthquake and EL CENTRO earthquake.

4. RESULTS AND DISCUSSIONS

Equivalent static analysis is carried out for all the four models for zone III and zone V. The dynamic time history analysis is performed for Bhuj and El Centro earthquakes. Hence, the various seismic responses like displacements, base shear, storey drifts and time period were obtained.

Table -2: Comparison of different parameters for Zone III

Slno	Parameters	Steel Structure(SS)		SS. Brgs.		SS. damp.		SS Brgs-Damp	
	Directions	X	Y	X	Y	X	Y	X	Y
1	Displacements(mm)	20	67.6	20	38.8	20	53.6	17.9	45.4
2	Storey Drifts	1.71	5.71	1.71	3.16	1.71	4.49	1.51	4.47
3	Base Shear(kN)	1321		1323		1321		1325	
4	Stiffness(kN/mm)	66.05	19.54	66.15	34.09	66.05	24.64	74.02	29.18

The displacements are maximum in X-direction. The stiffness is inversely proportional to the displacement. From the above table: 2 it can be concluded that stiffness is maximum for Steel structure with bracings and dampers(SS Brgs.-Damp.) when compared to that of Steel structure(SS), Steel structure with bracings (SS.Brgs) and Steel structure with dampers(SS-Damp.) The stiffness is greater by 10.8%.

Table-3: Comparison of different parameters for Zone V

Slno	Parameters	Steel Structure(SS)		SS. Brgs.		SS. damp.		SS Brgs-Damp	
	Directions	X	Y	X	Y	X	Y	X	Y
1	Displacements(mm)	45.1	152.1	44.9	87.3	45	120.6	40.3	102.1
2	Storey Drifts	3.85	12.84	3.85	7.11	3.85	10.11	3.40	10.06
3	Base Shear(kN)	2973		2977		2973		2982	
4	Stiffness(kN/mm)	65.92	19.54	66.3	34.1	66.06	24.65	73.99	29.20

From the above table-3, stiffness is maximum for Steel structure with bracings and dampers (SS Brgs-damp) when compared to that of Steel structure (SS), Steel structure with bracings (SS.Brgs) and Steel structure with dampers (SS-Damp). The stiffness is greater by 10.9%. The stiffness value is more for zone III when compared to that of Zone V.

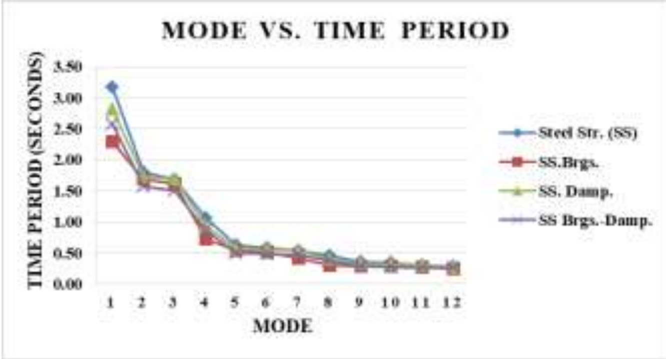

Fig -5: Mode vs. Time period

From the modal analysis it can be observed that, there is considerable reduction in the time period with the implementation of bracings and dampers in steel structures.

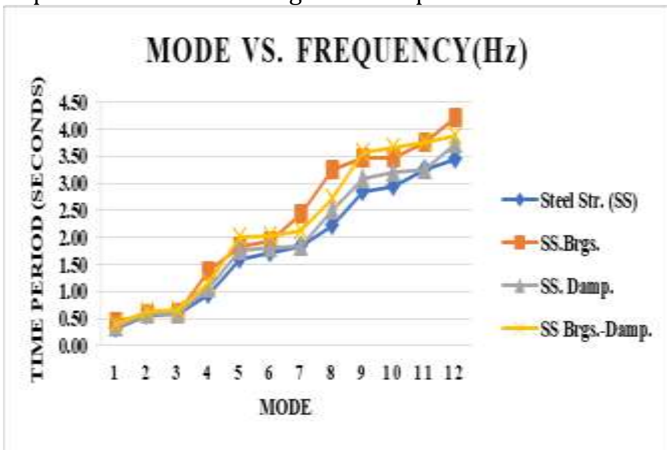

Fig -6: Mode vs. Frequency

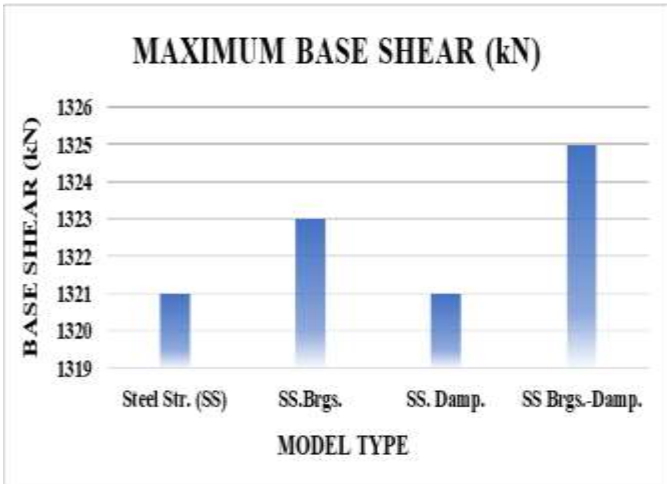

Fig -7: Maximum Base Shear for zone III

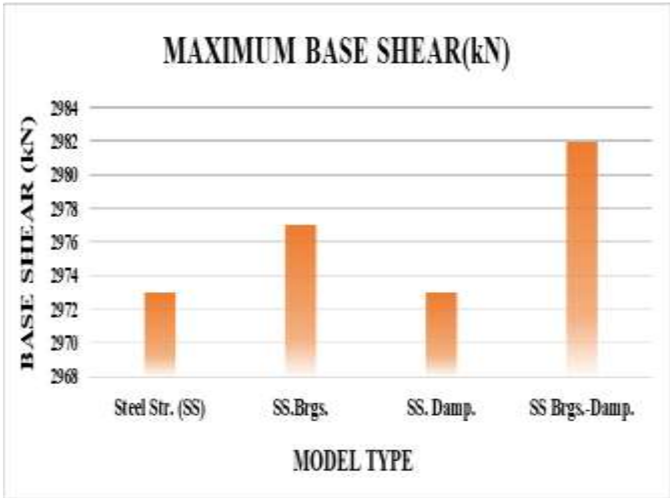

Fig -8: Maximum Base Shear for zone V

From the above figures 7 and 8 it can be observed that, due to change in zone from Zone III to Zone V base force has increased significantly from 1325 kN to 2980 kN.

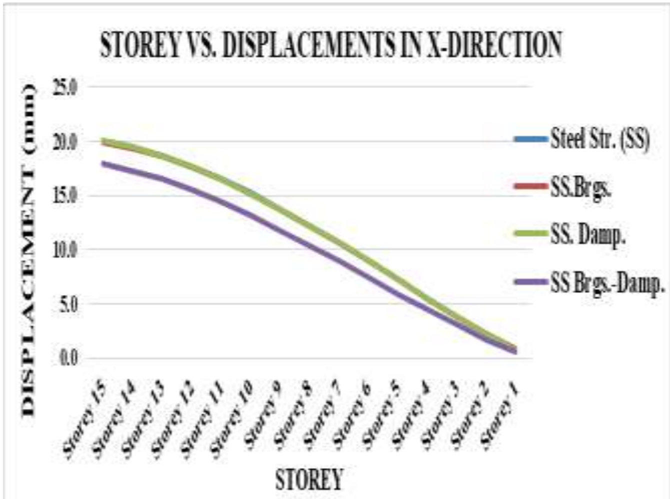

Fig -9: Storey vs. Displacement in X-direction

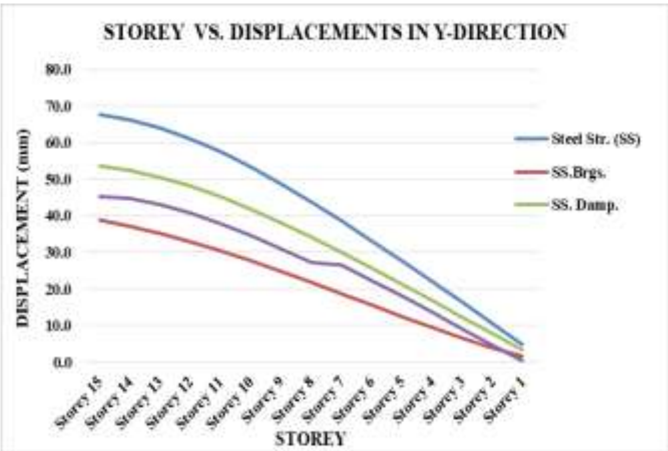

Fig -10: Storey vs. displacement in Y-direction

Storey displacements are found to be more in Y-direction compared to X-direction. Also, the provision of bracings and dampers has a reduced displacement from 67.6 mm to 38.8 mm in Steel structure with bracings and 45.4 mm with both bracings and dampers.

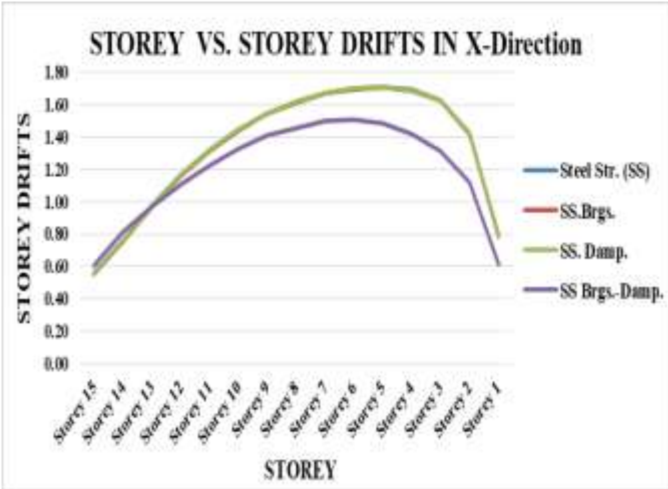

Fig -11: Storey vs. Storey drifts in X-direction

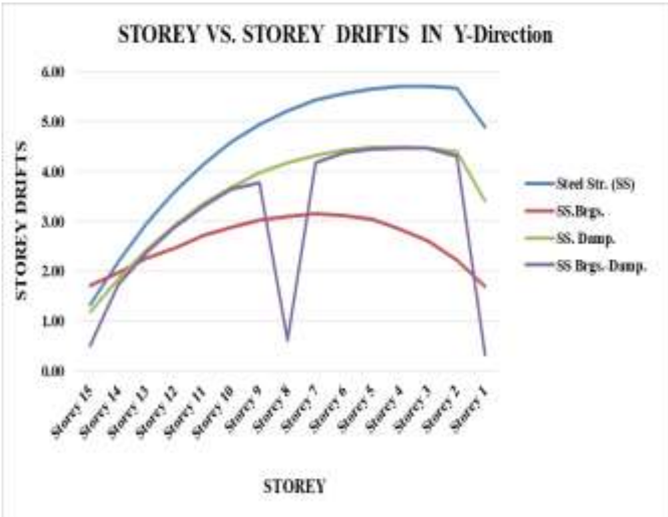

Fig -12: Storey vs. Storey drifts in Y-direction

From the storey drifts responses, a similar kind of variation is observed in like storey displacements, where there is no significant reduction in drifts along X-direction but along Y-direction, a sharp decrease in drifts are found at storey 8 and storey 15 in Steel structure with bracings and dampers to 0.61 mm from 5.23 mm which was found to be in steel structures. The sharp decrease in the curve is mainly due to the presence of both bracings and dampers.

Dynamic Time History Analysis: (EL CENTRO Earthquake)

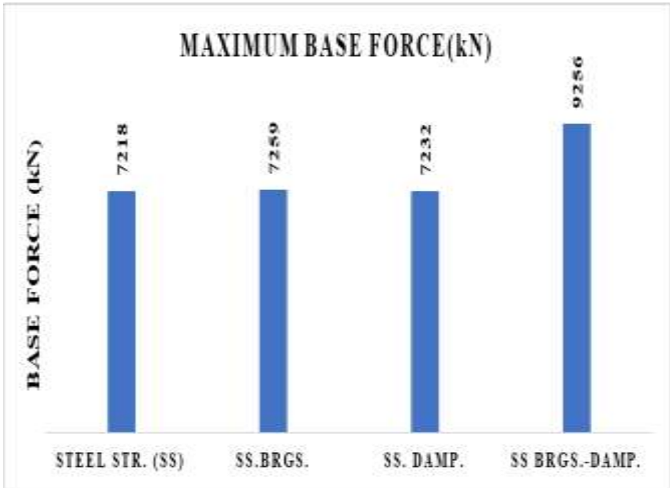

Fig -13: Maximum base shear in X-direction

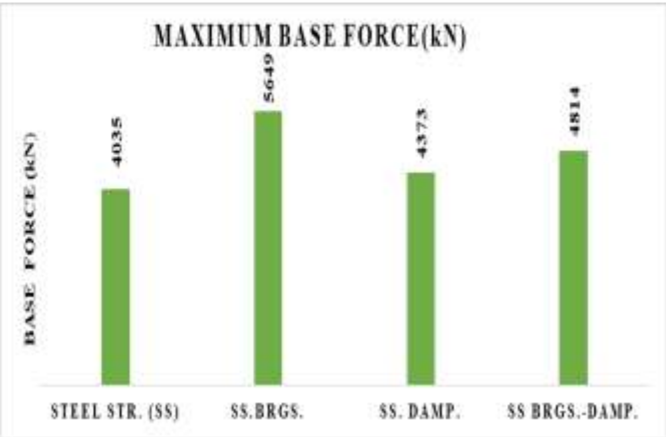

Fig -14: Maximum base shear in Y-direction

The base shear is maximum in the X-direction when compared to Y-direction.

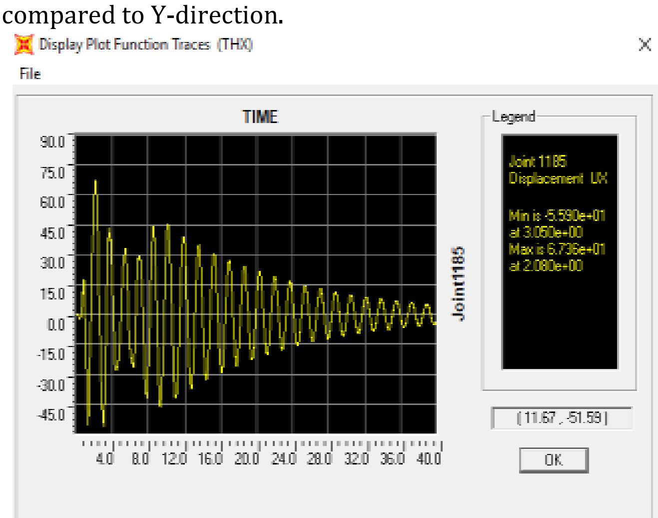

Fig -15: Peak Displacement response

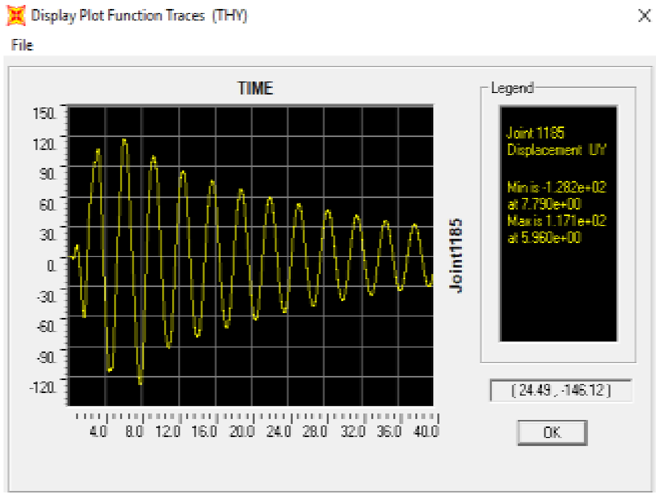

Fig -16: Peak Acceleration response

Table: 4 -. Time History Response Summary Chart – **El Centro**

Models	Base Force (kN)		Peak Acceleration (m/s^2)		Peak Displacements (mm)	
	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.
Steel Structure (SS)	7218	4035	4.28	3.58	67.3	128.2
SS - Bracings	7259	5649	4.32	4.00	67.1	103.0
SS – Dampers	7232	4373	4.30	4.56	67.2	123.8
SS – Brgs. Dampers	9256	4814	4.14	3.58	68.7	111.6

From the time history response summary of El Centro it can be observed that, base force is maximum in Steel structure with bracings and dampers in X-direction, peak acceleration is found to be maximum in steel structure with dampers only and peak displacements are found to less in steel structure with bracings. And also it is observed that, peak displacements are same along X-direction and bracings are dampers are effective along Y-direction.

Dynamic Time History Analysis: (BHUJ Earthquake)

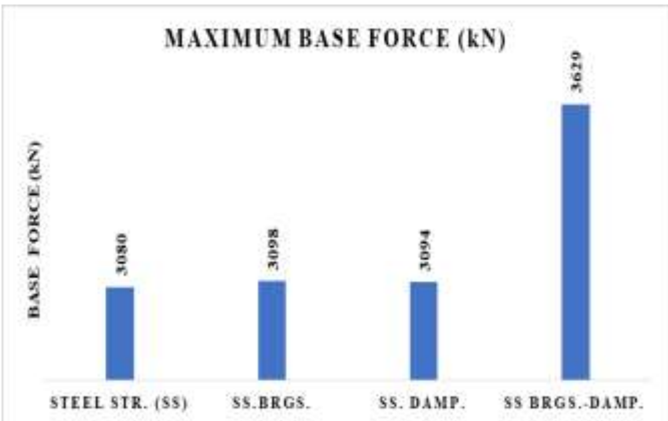

Fig -17: Maximum base shear in X-direction

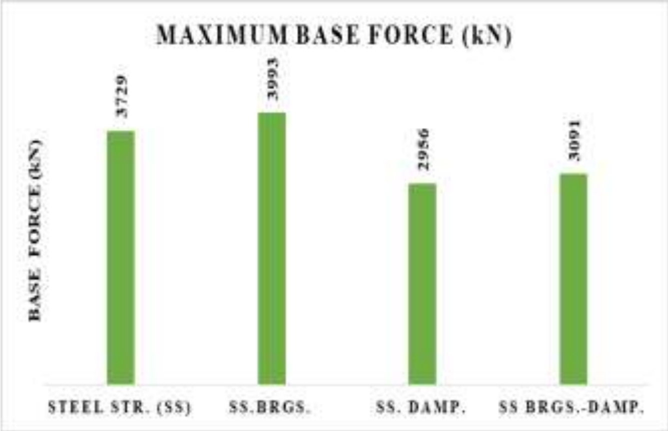

Fig -18: Maximum base shear in Y-direction

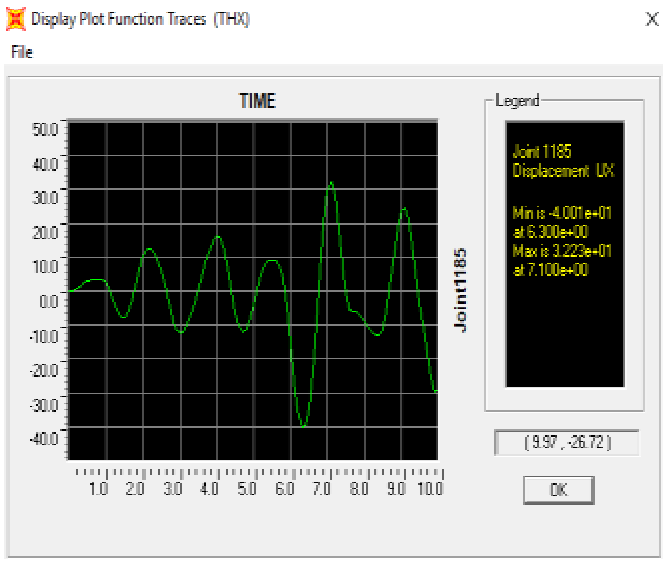

Fig -19: Peak Displacement response

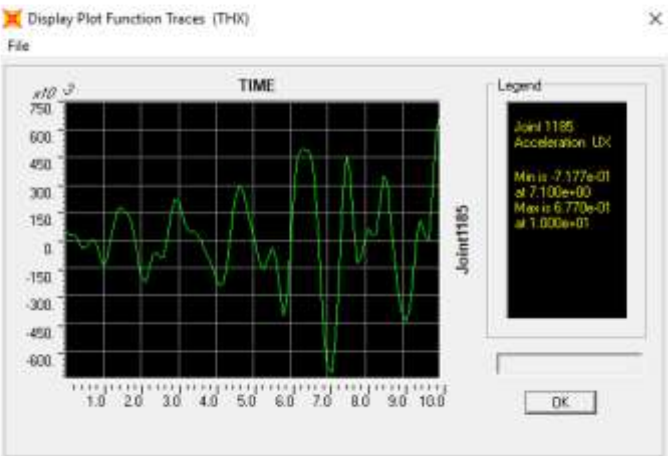

Fig -20: Peak Acceleration response

Table: 5- Time History Response Summary Chart – **Bhuj**

Models	Base Force(kN)		Peak Acceleration(m/s²)		Peak Displacements(mm)	
	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.
Steel Structure (SS)	3080	3729	0.76	1.38	45.1	167.3
SS - Bracings	3098	3993	0.77	1.24	44.9	87.38
SS - Dampers	3094	2956	0.77	1.32	45.2	121.3
SS – Brgs. Dampers	3629	3091	0.71	1.16	40.1	103.3

From the above Table 5, it can be observed that, response values are found to be less in Bhuj time history inputs compared to ELCENTRO. Along X-direction, Steel structure with bracings and dampers peak displacements are less i.e., 40.1 mm which is found to be 11% less than Steel structure with and without bracings and also steel structure with dampers.

5. CONCLUSIONS

By comparing the above results the following conclusions are drawn,

1. From the modal analysis it can be concluded that, introduction of bracings and dampers, increases the overall stiffness of the steel structure thus increase the frequency.
2. The introduction of bracings and dampers in reentrant corner has significant effect in controlling the displacements and drifts of the steel structure.
3. From the results and discussions, it can be concluded that, the combination of bracings and damper has a significant contribution in resisting the lateral loads both in case of equivalent static and dynamic time history loads.
4. Also, the effect of bracings and dampers has more in case of high seismic zone compared to lower zones, hence it is recommended that, they are the necessary structural elements to be incorporated in steel structures.
5. The stiffness and the strength is greater for steel structure with bracings and dampers when compared other models.

SCOPE OF FUTURE WORK

- ➢ The present work can be extended with utilization of bracings at different location.
- ➢ Effect of dampers in high rise structure can be studied.

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