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Analysis of multistoried braced steel space frame subjected to gravity and seismic loading.

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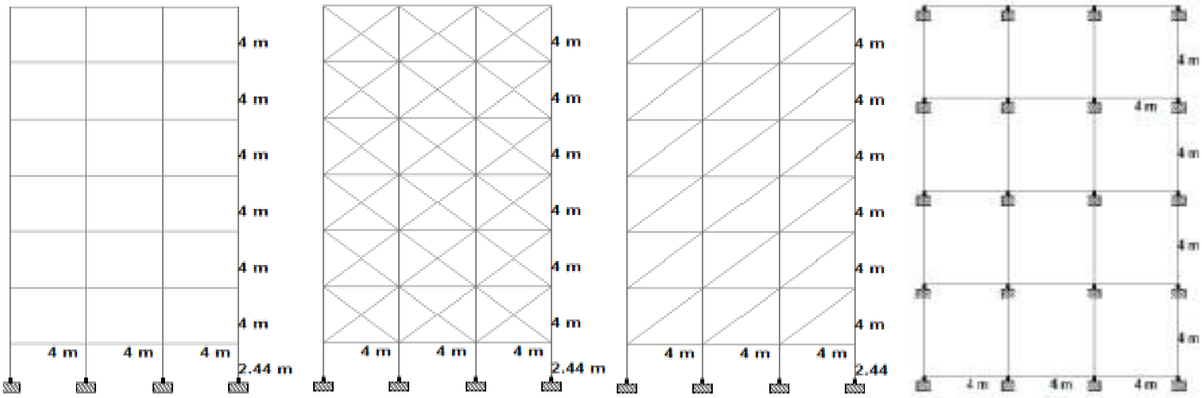
ABSTRACT
Steel structures are generally more flexible than other types of structure and lower in weight. Earthquake loads are random in nature. It is difficult to predict them exactly. The action applied to a structure by an earthquake is a ground movement with horizontal and vertical components. The horizontal movement is the most specific feature of earthquake action because of its strength and because structures are generally better designed to resist gravity than horizontal forces. These forces produce large stresses, strains, deformation and displacement particularly in tall structures. To keep displacement within limit generally bracing is provided in steel structure. . Bracings are generally used to increase lateral-stiffness, lateral- strength as well as lateral stability of the frame. Variations in the column stiffness can influence the mode of failure and lateral stiffness of the bracing. In this study steel frame is modeled and analyzed three Parts viz., (i) Model without Steel bracing (bare frame), (ii) Model completely with fully braced steel frame ('Cross' bracing), (iii) Model completely with fully braced steel frame ('Single diagonal' bracing).
Keywords – Steel structures, Bracings, Base shear, Displacement, Soft storey.

I. INTRODUCTION

In recent years, in the Indian subcontinent analysis of multistory buildings for earthquake forces has become important due to high seismic activity or potential seismic activity. Due to the exorbitant price of land, multistoried buildings are the only economically feasible construction. Hence, designers are warranted to design important structures against earthquakes for safety and to prevent loss of property. Steel structures are generally more flexible than other types of structure and lower in weight. As earthquake forces are associated with inertia, they are related to the mass of the structure and so reducing the mass inevitably leads to lower seismic design forces. This reduction of design forces significantly reduces the cost of both the superstructure and foundations of a building. As compared to reinforced concrete structures, steel has got some important properties like high strength and ductility. We know that steel is ductile so it gives warning before failures. All these properties of steel will play very important role in case of seismic design. In this study a number of structures with different heights and widths with and without braces have been analyzed. However, partially braced frames also have been studied and optimum locations of braces have been found. Fully braced frames with soft storey as well as that of partially braced frames also were studied, to predict the behavior of real life structures. In this research study of different types of bracing systems have been investigated for the use in tall building in order to provide lateral stiffness and finally we conclude the best suited option from them.

II. PROBLEM DEFINITION

The structural modeling and analysis is done using STAAD-PRO software package to resist seismic load. Investigation is carried out for G+5 to G+11 storied steel structure. Three types of frames were analyzed namely bare frame, 'Cross' bracing frame and 'Single diagonal' bracing frame. typical rigid steel frame structure with and without bracing system containing three different model of similar plan are subjected to seismic load according to zone-III. a typical plan is shown in figure 1.1. Located on a medium soil strata are chosen for the study. Equivalent static analysis is performed on the models of the building considered in this study. Bracings are provided at the peripheral edges of the building. Column sizes and bracing sizes are changed according to loading condition and storey height. In this study the load combinations shall be accounted as per I.S 1893 (Part I)-2002.



(a) Bare *frame* ***(b) 'Cross' frame*** ***(c) 'Single diagonal' frame*** ***Plan***

Fig 1.1 Models used for analysis

Table 1-Models used for analysis.

Sr. No.	**Model**	**Frame Type**	**Structure variation**	**Bay variation**	**Beam depth variation in (mm)**
1	I	Bare Frame	G+5 to G+11	3, 5 and 7	ISMB500-P=32 to ISMB600-P=32
2	II	"Cross" type Braced Frame	G+5 to G+11	3, 5 and 7	ISMB500-P=32 to ISMB600-P=32
3	III	"Single diagonal" type Braced Frame	G+5 to G+11	3, 5 and 7	ISMB500-P=32 to ISMB600-P=32

III. RESULT

Different types of structures were analyzed in order to study response of multistoried building space frame with different geometric parameters. soft storey analysis is carried out in this research in that Ra, Rs, Rm stands for axial, shear, and bending moment ratio respectively. It was checked whether the structures satisfy maximum permissible relative drift criterion as per IS: 1893 (Part 1): 2002.For G+11base shear comparison is carried out for different types of bay. In addition to this optimization is also studied in this research from economical point of view for partially bracing frame.

For 3 Bays Bare Frame

Table 2-Variations observed in axial forces for 3 bays bare frame

H/w Ratios	***Beam Depth* →**	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	***Levels (i)* ↓**			
2.333	6	1.000	1.012	1.059
3.333	9	6.707	6.869	7.067
4	11	11.122	11.378	11.720

Table 3-Variations observed in shear forces for 3 bays bare frame

H/w Ratios	***Beam Depth* →**	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	***Levels (i)* ↓**			
2.333	6	1.000	1.020	1.065
3.333	9	1.841	1.905	1.982
4	11	2.120	2.189	2.272

Table 4-Variations observed in bending moment for 3 bays bare frame

H/w Ratios	***Beam Depth* →**	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	***Levels (i)* ↓**			
2.333	6	1.000	0.987	1.002
3.333	9	1.609	1.630	1.667
4	11	1.768	1.801	1.849

For 3 Bays Fully 'Cross' Braced Frame

Table 5-Variations observed in axial force for 3 bays 'Cross' frame

H/w Ratios	***Beam Depth →***	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	Levels (i) ↓			
2.333	6	1.000	1.019	1.043
3.333	9	7.470	7.586	7.720
4	11	12.379	12.541	12.771

Table 6-Variations observed in shear force for 3 bays 'Cross' frame

H/w Ratios	***Beam Depth →***	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	Levels (i) ↓			
2.333	6	1.000	1.013	1.035
3.333	9	1.384	1.440	1.529
4	11	1.567	1.663	1.786

Table 7-Variations observed in bending moment for 3 bays 'Cross' frame

H/w Ratios	***Beam Depth →***	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	Levels (i) ↓			
2.333	6	1.000	0.983	1.020
3.333	9	1.285	1.340	1.416
4	11	1.409	1.490	1.605

For 3 Bays Fully 'Single diagonal' Braced Frame

Table 8-Variations observed in axial force for 3 bays 'Single diagonal' frame

H/w Ratios	***Beam Depth →***	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	Levels (i) ↓			
2.333	6	1.000	1.024	1.047
3.333	9	6.769	6.889	7.020
4	11	11.153	11.383	11.537

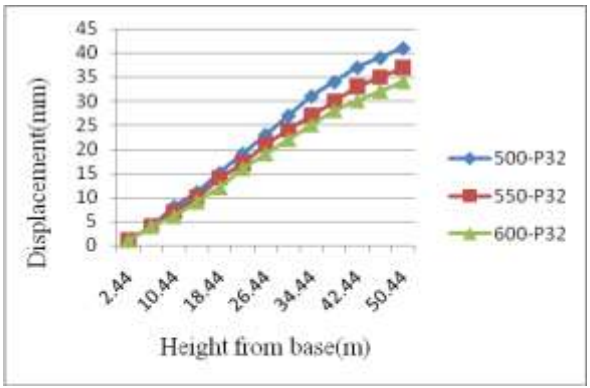
Table 9-Variations observed in shear force for 3 bays 'Single diagonal' frame

H/w Ratios	***Beam Depth →***	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	Levels (i) ↓			
2.333	6	1.000	1.033	1.060
3.333	9	1.427	1.480	1.559
4	11	1.613	1.682	1.780

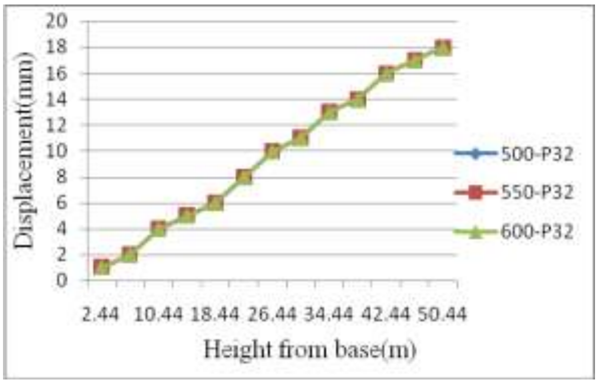
Table 10-Variations observed in bending moment for 3 bays 'Single diagonal' frame

H/w Ratios	***Beam Depth →***	**ISMB500-P=32**	**ISMB550-P=32**	**ISMB600-P=32**
	Levels (i) ↓			
2.333	6	1.000	1.359	1.422
3.333	9	1.322	1.360	1.423
4	11	1.443	1.493	1.571

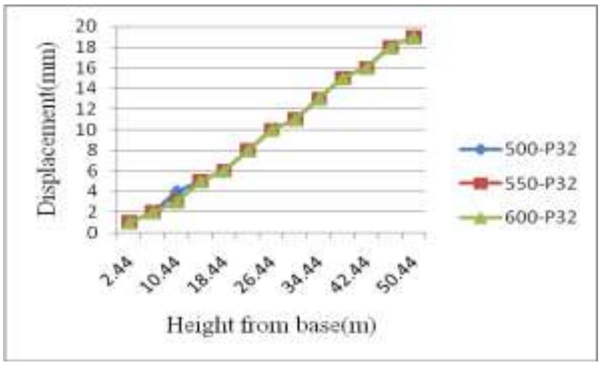
Graph 1, 2, 3 shows variation of displacement in frame and Graph 4 shows base shear



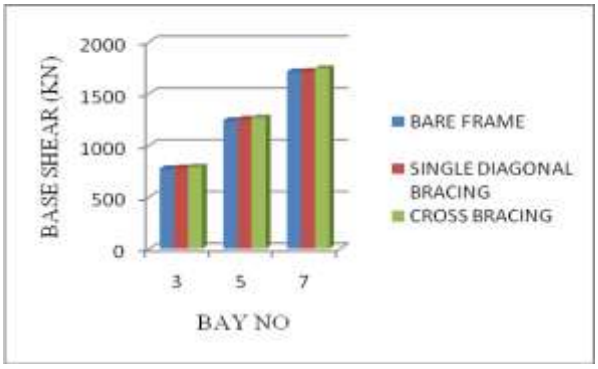
Graph-1 Variation of Lateral Displacement in bare frame



Graph-2 Variation of Lateral Displacement in 'Cross' frame



Graph-3 Variation of Lateral Displacement in 'Single diagonal' frame



Graph-4 Variation of base shear for frame

Table-11 Forces induced in various members of a 5 bay G+5 fully braced structure with soft storey at intermediate floor

Beam	Node	Fx	Fs	Mz	Ra	Rs	Rm
390	145	623.077	-58.726	-119.491	1.063	3.656	4.231
	175	-601.545	58.726	-115.415	-1.026	-3.656	4.086
391	146	632.834	-61.966	-124.681	1.080	3.858	4.414
	176	-611.301	61.966	-123.183	-1.043	-3.858	4.361

Table-12 Forces induced in various members of a 5 bay G+11 fully braced structure with soft storey at intermediate floor

Beam	Node	Fx	Fs	Mz	Ra	Rs	Rm
390	145	2528.068	-108.561	-261.384	4.315	6.759	9.255
	175	-2499.807	108.561	-172.859	-4.267	-6.759	6.120
391	146	2378.709	-127.087	-289.164	4.060	7.913	10.239
	176	-2350.448	127.087	-219.184	-4.012	-7.913	7.761

Table-13 Forces induced in various members of a 5 bay G+5 fully braced structure with soft storey at ground floor

Beam	Node	Fx	Fs	Ra	Rs
74	25	1516.568	-59.839	o.967	0.730
	55	-1503.434	59.839	-0.958	-0.730
75	26	1429.760	-72.600	0.911	0.886
	56	-1416.625	72.600	-0.903	-0.886
153	55	1449.778	-65.927	0.924	0.805
	85	-1428.246	65.927	-0.910	-0.805
154	56	1400.208	-76.134	0.923	0.929
	86	-1378.676	76.134	-0.909	-0.929

Table-14 Forces induced in various members of a 5 bay G+11 fully braced structure with soft storey at ground floor

Beam	Node	Fx	Fs	Ra	Rs
74	25	3565.885	-108.504	2.274	1.325
	55	-3565.646	108.504	-2.263	-1.325
75	26	3558.348	-122.269	2.269	1.493
	56	-3241.109	122.269	-2.066	-1.493
153	55	3497.088	-119.168	2.230	1.469
	85	-3468.827	119.168	-2.212	-1.469
154	56	3222.034	-131.459	2.054	1.605
	86	-3193.774	131.459	-2.036	-1.605

IV. CONCLUSIONS

Following conclusions are drawn on the basis of the analyses carried out for various types of structures.

1. As height of the storey is increases in bare frame it attracts larger axial forces in the column also as the beam depth increases.
2. In Cross and Single diagonal braced frame axial force in columns increases as compared with that in bare frames.
3. As compared to bare frames, braced frames have drastically less value of maximum lateral displacements also the values are within the permissible limit.
4. For 'Cross' and 'Single diagonal' type frame axial force in penultimate column is reduces as compare to end column. The same result is observed for different height of the structure.
5. Axial forces carried by the braces in 'Cross' type-braced frames are smaller than those in 'Single diagonal' type braced frames.
6. 'Cross' type braced frame are more rigid than 'Single diagonal' type braced frame.
7. Soft storey at intermediate levels proves to be best than fully braced frames with soft storey at ground level
8. Fully braced structures with soft storey are attracts very large moments compared with that in structure without soft storey.
9. Fully braced frames as well as optimally braced frames with soft storey are found to be more flexible at intermediate level than that at ground level.
10. When provision of soft storey is a must at that time optimally braced frames are found to be best suited compared with the fully braced structure with soft storey.
11. Partially braced frames satisfying the adopted acceptance criteria revealed that as single bay braced and 2 bay braced yield optimum positions from viewpoint of minimizing the cost. It also increases flexibility of the structure so as to have displacement within permissible limit.
12. 1 bay of 'Cross' braced frame proves to be economical as compare to 'Single diagonal' type braced frame for 1 bay braced.

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