A Research on the Behaviour of Columns of Steel Framed Structure with Various Steel Sections

Sourabh Dhiman, Nirbhay Thakur, Nitish Kumar Sharma

Abstract: ***The present article represents the comparison between conventional steel sectional columns and tubular steel section column. Therefore, total 6 number of models of 12-Storey Building were analyzed in staad.pro (designing tool) having different conventional and tubular steel section as a column. Different bracing systems (such as cross and v bracing) have also been adopted for lateral stability. The performance of all the models has been studied by performing dynamic seismic analysis in zone IV and has been evaluated in terms of structural parameters of columns i.e. axial force, bending moment, displacement. The effectiveness and economy of conventional and tubular steel section with and without bracing system has also been recorded in order to get the final outcome of the study.***

From the final results of the present study, it has been concluded that the ratio of maximum displacement and total steel quantity comes out to be 1.16 and 0.74 for the buildings without bracing (i.e. Type B to Type A) respectively. Ratio of maximum displacement and total steel quantity is 0.98 and 0.78 for the buildings having cross-bracing (i.e. Type D to Type C) respectively. Ratio of maximum displacement and total steel quantity is 1.05 and 0.80 for the buildings having cross-bracing (i.e. Type F to Type E) respectively. Therefore, tubular sections prove to be more economical than conventional sections as it saves 20% to 30% material cost.

Keywords: Static and Dynamic Seismic Analysis, Steel sections, columns, Staad Pro.

I. INTRODUCTION

There are different types structures which are being constructed everyday such as residential buildings, commercial buildings, hospitals, institutional buildings etc. Every building has its own purpose and it is designed as per the requirements of the structure. However, the structures are categorized in various ways as mentioned below:

- Material Wise Categorization
  - RCC Structures
  - Steel Structures
  - Composite Structures
  - Brick Masonry Structures
- Purpose Wise Categorization
  - Residential Structures
  - Commercial Structures
  - Station Structures
  - Storage Structures

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RCC framed structures are very common and are often constructed in urban and rural areas where as steel framed structures are less common as they required skill engineers and labors. Composite structures are rare and used only in complex situation. Residential structures are the structures used for living purposes and loads are always present in these structures. Commercial buildings are the office and institutional buildings and are used only for commercial purposes. Storage structures are the warehouses which are used for storing the goods and machines and they are usually constructed of steel and composite structures.

Figure 1: Steel Framed Structure

Figure 2: Different Steel Sections in Buildings

Conventionally, the concrete structures were adopted mostly but now with the improved technologies and design methods, steel structures are steeling the market as they as light in weight and requires less time for construction phase. Different steel sections (such as T-Shape, I-shape, channels, angles etc) are welded or bolted together with the help of plates in order to erect the structures. As there is no requirement of curing period unlike concrete structures, steel structures can be erected within days. Sometimes, bracing systems (such as battens, lacings, struts etc) are used in order to give additional strength to the structures as they resist sway and gives stability.

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Column, being the vertical member, is a compression member through which the loads from slabs and beams are transmitted to the foundation safely without any failure. In steel structure, any section can be used as column but the only thing matters is the placement of that section. I-sections, single channel sections, double Channel sections, hollow sections are the sections which can be used as a vertical member in different situations as they impart strength and durability in their own way.

II. MATERIALS AND METHODS

The present study represents the comparison between conventional steel sectional columns and tubular steel section column. For this purpose, twelve storey building with and without bracing systems (such as cross and v bracing) has been chosen. The methodology which was used during the present research is being divided into different phases and is represented below.

Phase I: Staad Models

Total 6 number of models of 12-Storey Building as described in table 1, were analyzed in staad.pro (designing tool) having different conventional and tubular steel section as a column.

Table 1: Description of Various Models

Type	Storey	Steel Section for Column	Type of Bracing
Type A	12 storey Building	Conventional	None
Type B	12 storey Building	Tubular	None
Type C	12 storey Building	Conventional	Cross - Type
Type D	12 storey Building	Tubular	Cross - Type
Type E	12 storey Building	Conventional	V - Type
TypeF	12 storey Building	Tubular	V - Type

Other Structural parameters:

- Height of each storey = 3 m
- No. of bays = 6 x 6
- Size of each bay = 6 x 6 m

Figure 3: Typical Plan of Building

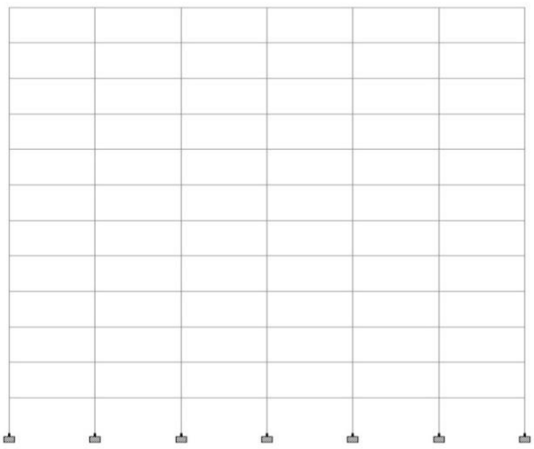

Figure 4: Structure Elevation without Bracing

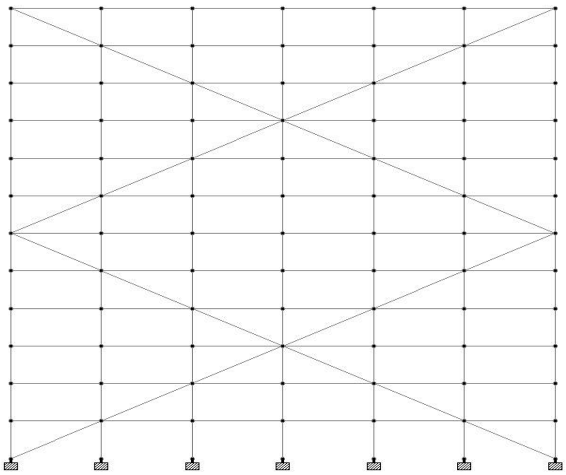

Figure 5: Structure Elevation with Cross-Bracing

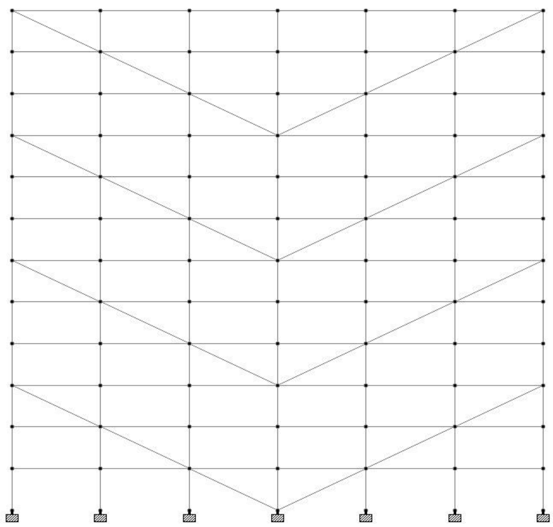

Figure 6. Structure Elevation with V-Bracing

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Table 2: Steel Sectional Properties of Various Member

Type of Building	Floors	Column Size	Beam Size	Bracing Size (mm)
Type – A	1 to 4	2 (ISWB 600H) (Spacing 1.1 m)	ISMB 500 (Plates 300x10 mm)	-
	5 to 8	2 (ISMB 550) (Spacing 0.75 m)	ISMB 450 (Plates 275x10 mm)	-
	9 to 12	2 (ISMB 400) (Spacing 0.5 m)	ISMB 350(Plates 275x10 mm)	-
Type – B	1 to 4	700x700x14 mm	ISMB 500 (Plates 300x10 mm)	-
	5 to 8	550x550x12 mm	ISMB 450 (Plates 275x10 mm)	-
	9 to 12	450x450x8 mm	ISMB 350 (Plates 275x10 mm)	-
Type – C	1 to 4	2 (ISWB 600H) (Spacing 1.1 m)	ISMB 500 (Plates 300x10 mm)	**1 to 6 floor:** 275x275x12
	5 to 8	2(ISMB 550) (Spacing 0.7 m)	ISMB 450 (Plates 275x10 mm)	**7 to 12 floor:** 250x250x10
	9 to 12	2(ISMB 450) (Spacing 0.45 m)	ISMB 350 (Plates 275x10 mm)	
Type – D	1 to 4	700x700x18 mm	ISMB 500 (Plates 300x10 mm)	**1 to 6 floor:** 275x275x12
	5 to 8	550x550x14 mm	ISMB 450 (Plates 275x10 mm)	**7 to 12 floor:**250x250x10
	9 to 12	450x450x8 mm	ISMB 350 (Plates 275x10 mm)	
Type – E	1 to 4	2(ISWB 600H) (Spacing 1.1 m)	ISMB 500 (Plates 300x10 mm)	**1 to 6 floor:**275x275x12
	5 to 8	2(ISMB 550) (Spacing 0.75 m)	ISMB 450 (Plates 275x10 mm)	**7 to 12 floor:**250x250x10
	9 to 12	2(ISMB 450) (Spacing 0.55 m)	ISMB 350 (Plates 275x10 mm)	
Type – F	1 to 4	700x700x18 mm	ISMB 500 (Plates 300x10 mm)	**1 to 6 floor:** 275x275x12
	5 to 8	550x550x14 mm	ISMB 450 (Plates 275x10 mm)	**7 to 12 floor:**250x250x10
	9 to 12	450x450x8 mm	ISMB 350 (Plates 275x10 mm)	

Note: The sectional properties of beams and bracings are being kept same so that the comparison shall be made only with respect to column i.e. sectional properties vary in columns only for different type of building.

Various vertical Loading which was applied on the different models as per the guidelines of IS: 875 part I (Dead Load) and IS: 875 part II (Live Load) is specified below.

DEAD LOAD:

Wall load on outers beams : 11 kN/m
Wall load on inner beams : 5.5 kN/m
Floor slab & finishing load : 3 kN/m^2

LIVE LOAD:

Load on floors : 3 kN/m^2
Load on roof floor : 1.5 kN/m^2

Phase II: Dynamic Seismic Analysis

After completion the modeling of various structures, dynamic seismic analysis was carried out with Response Spectrum Method. Along with the horizontal earthquake effect, vertical earthquake effect has also been taken as the building is being analyzed for seismic zone V (as per code). During this phase, different seismic parameters were taken as mentioned below:

Seismic Zone : IV
Importance Factor : 1.2
Response Reduction Factor : 5
Soil Type : Medium
Type of structure : Steel Building
Damping Ratio : 5%

All the seismic design parameters are as per the new guidelines of Indian Standard 1893: 2016. For loading consideration in seismic case, 100 % dead load and 25 % live load was taken.

III. RESULTS AND DISCUSSION

Columns of all the structures are being evaluated in terms of axial force, bending moment, utility ratio and deflection and the same is represented in this section with the help of graphs and tables. In staad.pro, critical load case is chosen for the design of column which may vary column to column.

Axial force (kN) and bending moment (kN-m)are the basic design parameters of column and the results of all the models (axial force and bending moment) has been represented in the table 3 and table 4 respectively.

Table 3: Axial Force in Column (kN)

Floor	Type A	Type B	Type C	Type D	Type E	Type F
1	2333.2	2393.34	2900.48	2951.86	3037.22	3219.99
2	2113.57	2170.27	2717.47	2736.31	2773.98	3016.68
3	1909.00	1943.54	2505.45	2529.58	2637.73	2804.87
4	1687.19	1711.03	2304.77	2322.48	2152.67	2228.89
5	1463.29	1480.87	2109.62	2123.91	1955.46	2038.14
6	1254.29	1263.52	1923.99	1936.21	1770.02	1837.32
7	1043.81	1045.33	1274.18	1031.13	1380.99	1321.99
8	929.51	833.30	1054.79	1020.37	1159.55	1100.07
9	623.26	469.69	846.99	817.40	943.92	895.78
10	434.14	428.00	652.84	626.80	656.48	638.20
11	198.52	241.67	451.84	425.44	455.17	434.91

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12	89.44	87.43	251.21	234.38	254.20	241.82

Table 4: Bending Moment in Column (kN-m)

Floor	Type A	Type B	Type C	Type D	Type E	Type F
1	300.56	292.62	10.26	230.80	274.68	244.73
2	459.13	96.15	41.56	78.27	46.31	135.23
3	145.74	126.42	108.74	91.42	111.97	96.81
4	133.68	125.93	105.51	95.77	94.33	18.27
5	141.77	115.50	77.85	68.06	90.3	71.38
6	121.92	126.58	95.13	82.84	91.38	10.55
7	111.68	123.38	59.93	86.32	59.64	58.60
8	91.00	111.87	71.57	76.24	72.54	77.86
9	110.40	73.28	52.18	48.73	37.53	48.76
10	88.53	96.58	56.34	55.31	56.85	55.41
11	94.86	90.05	54.58	53.74	54.57	54.14
12	60.04	61.02	53.51	51.18	53.64	51.70

From figure 7(a), 7(b), 7(e) and 7(f), it was found out that the tubular column of Type B and Type F produces slightly more displacement than conventional column of Type A and Type respectively. But tubular column of Type D produces less displacement (19.674 mm) than conventional column of Type C (20.145 mm) as shown in figure 7d and 7c respectively.

Figure 7(a).Displacement in Type A building;
Figure 7(b).Displacement in Type B building;
Figure 7(c).Displacement in Type C building;
Figure 7(d).Displacement in Type D building;
Figure 7(e).Displacement in Type E building;
Figure 7(f). Displacement in Type F building.

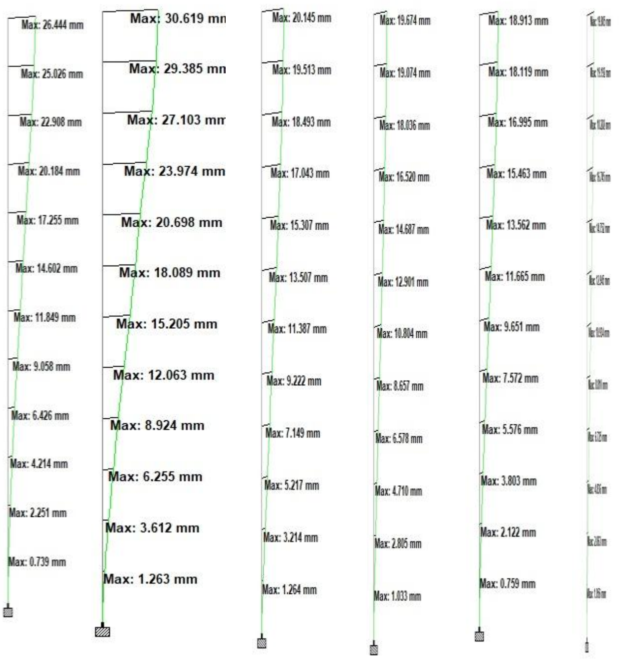

Figure 7(a) Figure 7(b) Figure 7(c) Figure 7(d) Figure 7(e) Figure 7(f)

Total steel quantity which has been recorded from the post-processing of staad.pro is shown in the figure 7 and it has been concluded that building having tubular sections as column is more economical than the building having conventional sections as column.

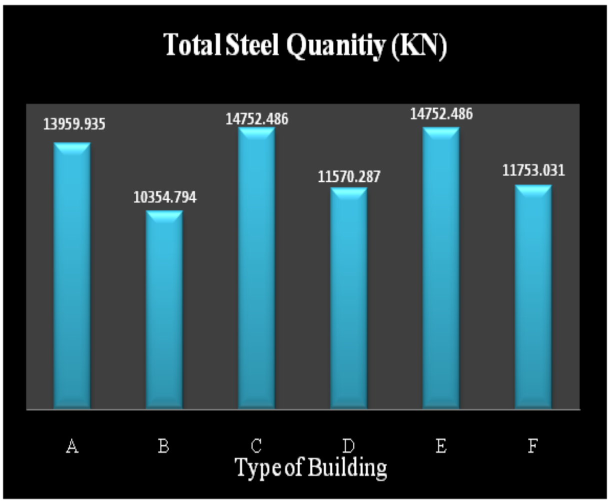

Figure 8: Total Steel Quantity (KN)

IV. CONCLUSION

Based on the results of staad.pro which was represented in previous section, following conclusions are drawn for the present study:

- Ratio of maximum displacement (i.e. Type B to Type A) is found to be 1.16 and the steel quantity of type B is 0.74 times than the steel quantity of Type A.
- Ratio of maximum displacement (i.e. Type D to Type C) is found to be 0.98 and the steel quantity of type D is 0.78 times than the steel quantity of Type C.
- Ratio of maximum displacement (i.e. Type F to Type E) is found to be 1.05 and the steel quantity of type F is 0.80 times than the steel quantity of Type E.

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