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# Seismic Evaluation of Steel Frames Using Different Sections of X Bracing

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**Abstract:** ***Braced frames are a very common form of construction, being economic to construct and simple to analyse. Bracing is an effective upgrading strategy to enhance the global stiffness and strength of steel frames. In the present study, a typical 10 storey steel frame is analyzed with X bracing for different IS steel sections with different depths. The building is situated in seismic zone III. Response spectrum analysis will be carried to investigate seismic performance of a multi storey steel frame building and to find the most effective section in resisting lateral loads. The software used for this study is ETABS. The main parameters considered in this study are storey shears, maximum storey drifts, maximum storey displacements and joint displacements.***

**Keywords:** Braced Frames, Maximum storey displacements, Response Spectrum, Storey Drifts, Storey Shears

## 1. Introduction

Steel frame is a building technique with a skeleton frame of vertical steel columns and horizontal I beams constructed in a rectangular grid to support the floors, roofs ,walls, of a building which are all attached to the frame .It can be strengthened by various methods to resist lateral forces. The most widely used method is braced frames. Braced frames are a very common form of construction, being economic to construct and simple to analyse. Economy comes from the inexpensive, nominally pinned connections between beams and columns. In braced construction, beams and columns are designed under vertical load only, assuming the bracing system carries all lateral loads. Bracing enhances the global stiffness and strength of steel frames. It can increase the energy absorption of structures or decrease the demand imposed by earthquake loads. The applications of braced frame includes structures like bridges, aircrafts, buildings, transmission towers.

Bracing can be concentric or eccentric. In concentric braced frames members intersect at a node. These bracings increase the lateral stiffness of the frame and decrease the lateral storey drift. In an eccentrically braced frame the members intersect the girder at an eccentricity „e‟ and hence transmit forces by shear and bending. Eccentric bracings reduce lateral stiffness and improve energy dissipation capacity. Steel bracings can be arranged like diagonal, cross bracing X, V, inverted V or Chevron as shown in figure 1.

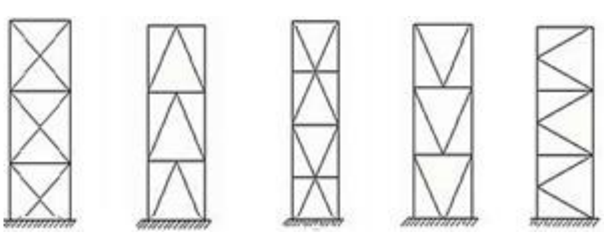

**Figure 1:** Different Types Of Bracings

## 2. Objectives

a) To investigate seismic performance of a multi storey steel frame building.
b) To analyze the steel frame with X bracing for different IS steel sections.
c) To determine which section is more effective in resisting lateral loads.

## 3. Methodology

Response Spectrum method is employed.

### 3.1 Modelling of Building

The software ETABS has been used for the modelling. ETABS is an engineering software product that caters to multi-story building analysis and design. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct-integration time-history analyses may couple with P-Delta and Large Displacement effectsdynamic analysis, non-linear dynamic analysis and non-linear static pushover analysis, etc.

#### 3.1.1 Building Plan and Dimension Details

The steel frame used in this study are 10 storied with 6 m bays along longitudinal direction and 5 m bays along transverse direction as shown in figure 2.Table 1 shows the specification of G+9 storied commercial building located in seismic zone III.

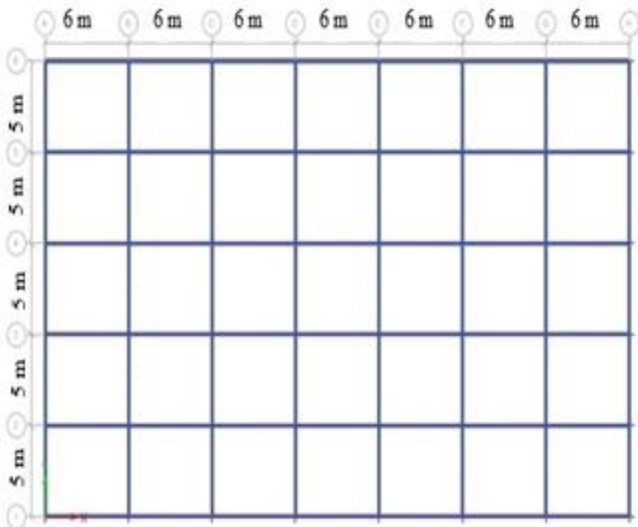


**Figure 2:** Plan of Building

**Table 1:** Details and dimension of the building models

| | |
|---|---|
| Plan type | 42 m × 25 m |
| Seismic Zone | III |
| Grade of reinforcing steel | Fe 415 |
| Number of stories | 10 |
| Floor height | 3.6 m |
| Beam size | ISWB 400 |
| Column size | ISMB 200 |
| Slab thickness | 125 mm |
| Type of bracing used | X bracing |
| Bracing details | ISHB 150,ISHB 200,ISHB 225, ISHB 250 ISHB 300<br>ISMC 150,ISMC 175,ISMC 200, ISMC 225, ISMC 250<br>ISA 100 × 100×10, ISA 110 × 110×10,<br>ISA 130 × 130×10, ISA 150 × 150×10 |

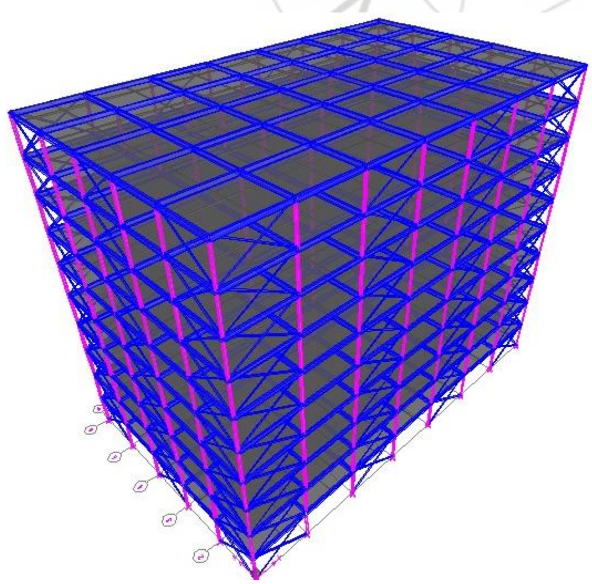

**Figure 3:**Three Dimensional View of Model

### 3.2 Load Formulation

Dead loads are considered as per IS 875 (Part I) – 1987 and steel tables &Live load IS 875 (Part II) -1987. Wind loads are considered as per IS 875 (Part III) - 1987 respectively. In addition to the above mentioned loads, dynamic loads in form of Response Spectrum method are also be assigned.

**Live Load**

Floor load:

Live Load Intensity specified (Public building) = 4kN/m2

Live Load at roof level =1.5 kN/m

**Wind Load**

Design wind speed $V_z = V_b\, k_1 k_2 k_3 = 39 \times 1 \times 1.12 \times 1 = 43.68$ m/s

Design wind pressure $P_z = 0.6\, V_z^2 = 0.6 \times 43.682 = 1144.76$ N/m$^2$

**Analysis**

After assigning the loads to the structure, response spectrum analysis is done to evaluate dynamic results in form of storey shear, storey drift and maximum storey displacements. Response spectrum analysis is a procedure for calculating the maximum response of a structure when applied with ground motion. Each of the vibration modes that are considered are assumed to respond independently as a single degree of freedom system. Design codes (IS; 1893, Part 1) specify response spectra which determine the base acceleration applied to each mode according to its period.

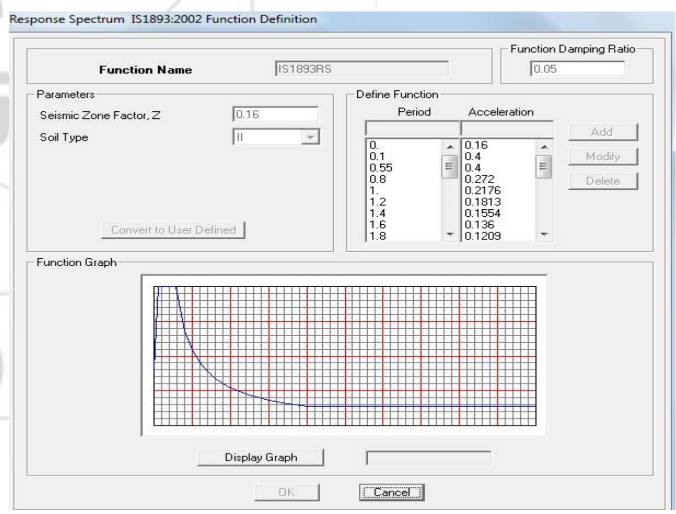


**Figure 4:** Response Spectrum IS 1893:2002 Function definition

## 4. Results and Discussion

After analysing the models various results are obtained. And these results are evaluated by preparing various graphs. The graphs are compared to understand the behaviour of building by increasing the size of bracing section and to determine which section is more effective in resisting lateral loads.

### 4.1 Storey Shears

#### 4.1.1 ISA Section

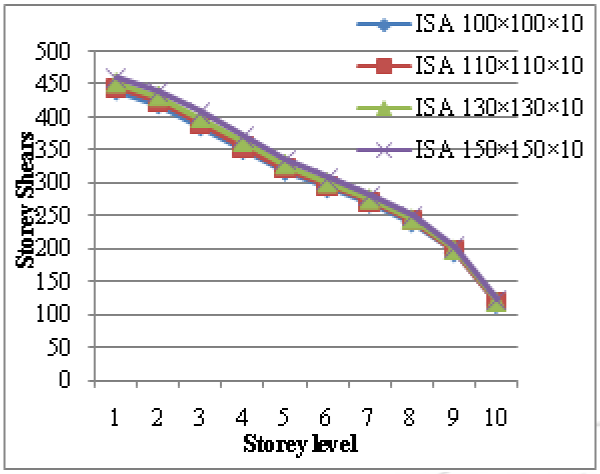


**Figure 5:**Storey shears of ISA section

#### 4.1.2 ISHB Section

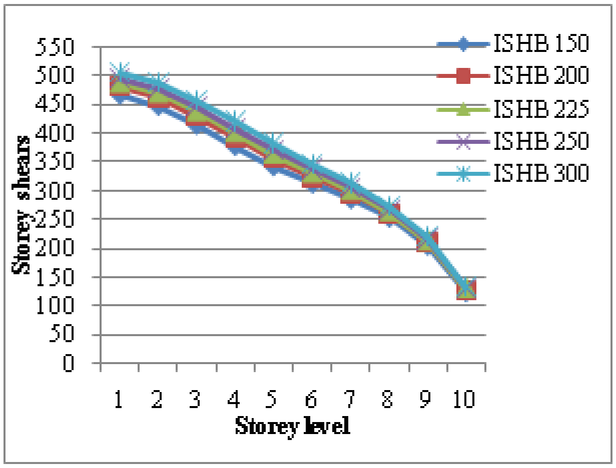


**Figure 6:**Storey shears of ISHB section

#### 4.1.3 ISMC Section

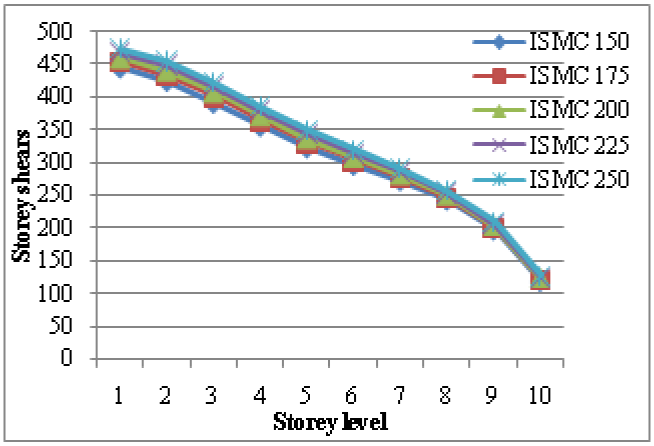


**Figure 7:**Storey shears of ISMC section

From figures 5,6&7 it is clear that as size of section increases storey shear increases. Also the value of shear decreases from bottom storey to top storeyie, the maximum storey shear occurs at the base.

### 4.2 Joint Displacement

#### 4.2.1 ISA Section

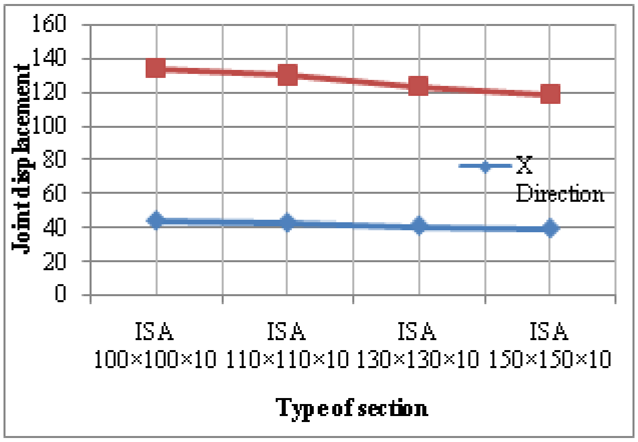


**Figure 8**: Joint displacement (mm) of ISA section in X and Y direction

#### 4.2.2 ISHB Section

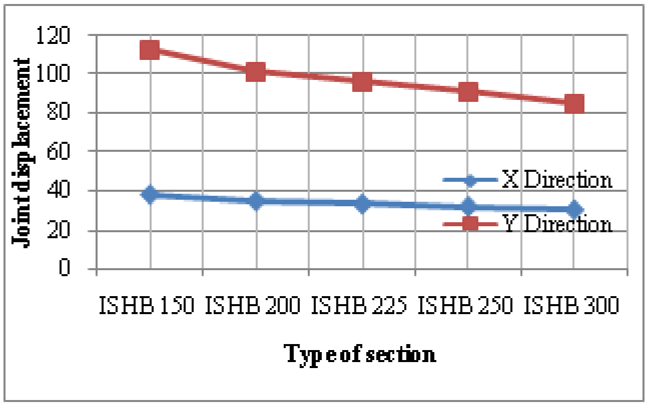


**Figure 9**: Joint displacement (mm) of ISHB section in X and Y direction

#### 4.2.3 ISMC Section

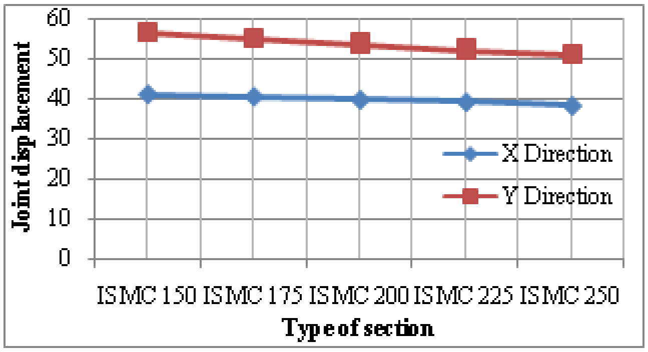


**Figure 10**: Joint displacement (mm) of ISMC section in X and Y direction

From figures 9,10&11 it is clear that as size of section increases joint displacement decreases in both X and Y direction.

### 4.3 Maximum Storey Drifts

#### 4.3.1 ISA Section

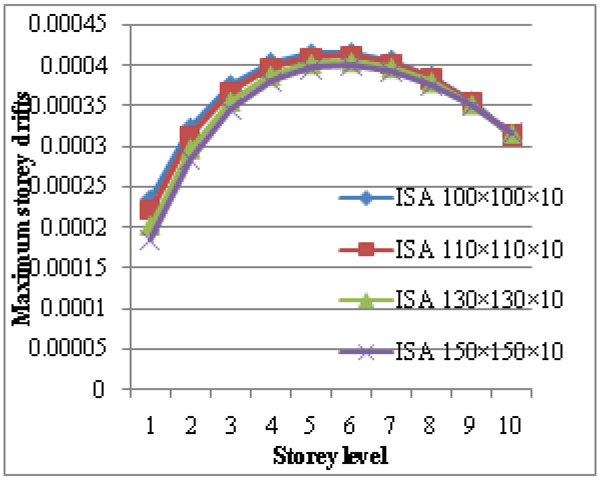


**Figure 11:** Maximum Storey Drifts of ISA Section

#### 4.3.2 ISHB Section

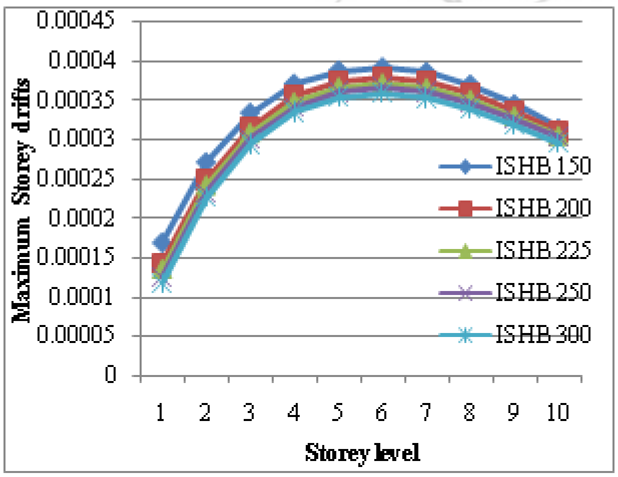


**Figure 12:** Maximum Storey Drifts of ISHB Section

#### 4.3.3 ISMC Section

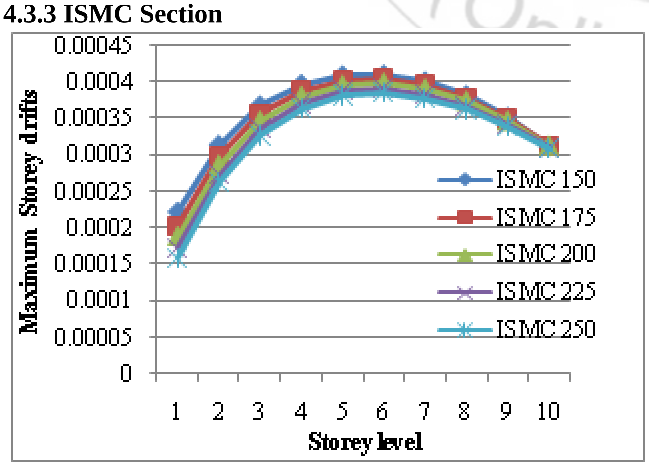


**Figure 13:** Maximum Storey Drifts of ISMC Section

From figures 11,12&13it is found that as size of section increases maximu storey drift reduces and maximum storey drift occurs at 6 th storey level.

### 4.4 Maximum Storey Displacements

#### 4.4.1 ISA Section

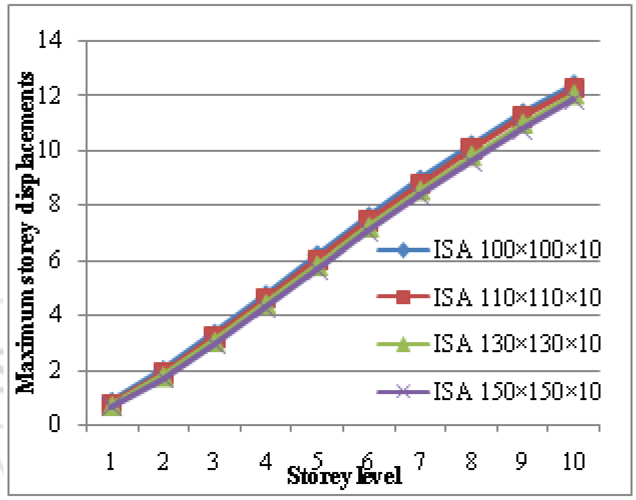


**Figure 14:** Maximum Storey Displacements of ISA Section

#### 4.4.2 ISHB Section

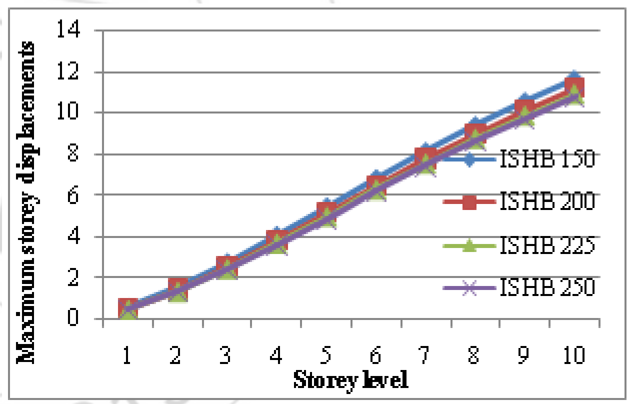


**Figure 15:** Maximum Storey Displacements of ISHB Section

4.4.3 ISMC Section

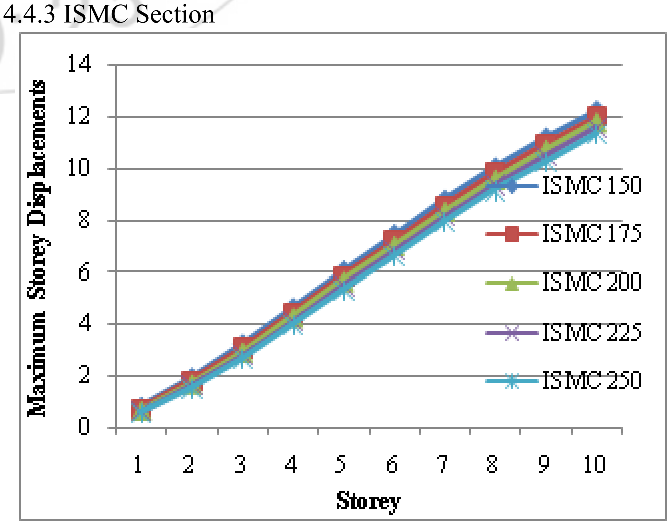


**Figure 16:** Maximum Storey Displacements of ISMC Section

From figures 14,15 &16 it is seen that as size of section increases values of maximum storey displacement decreases for ISA ,ISHB and ISMC sections.

**Table 2**: Comparison of Sections

| *Section* | *Storey shear (kN)* | *Joint displacement (mm)* | | *Maximum Storey drifts* | *Maximum storey displacements (mm)* |
|---|---|---|---|---|---|
| | | *X* | *Y* | | |
| ISA | 460.24 | 39.5 | 119 | 0.00018 | 0.6675 |
| ISHB | 505.71 | 30.5 | 85 | 0.00012 | 0.4295 |
| ISMC | 474.58 | 38.2 | 51.16 | 0.00016 | 0.5761 |

From the table 2, it is clear that the value of storey shear is greater for ISHB section compared to ISA and ISMC sections.The value of joint displacement,maximum storey drifts,maximum storey displacements is minimum for ISHB section.Hence ISHB section is more effective.

## 5. Conclusions

The main conclusions obtained from the analysis of modelsare summarized below:

- As size of section increases the maximum storey displacements, maximum storey drifs, joint displacements decreases for ISA,ISHB and ISMC sections.
- The value of storey shear decreases from bottom story to top story for all the sections.
- The value of storey shear of ISHB section is 9.87% higher than that of ISA section and 6.55% higher than that of ISMC section.
- The value of joint displacement of ISHB section is 29.5% higher than that of ISA section and 20.15 % higher than that of ISMC section.
- The value of maximum storey drifts of ISHB section is 32.43 % higher than that of ISA section and 25 % higher than that of ISMC section.
- The value of maximum storey displacements of ISHB section is 35.6 % higher than that of ISA section and 25.446 % higher than that of ISMC section.
- ISHB section is found to have better performance.

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