International Journal of Technical Innovation in Morden Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2584
Volume 2, Issue 5, May-2016

# Comparison of RCC Braced and Steel "X" Braced RCC Frame Structure

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***Abstract— One of the technologies used to defend buildings from damaging earthquake effects is "Braced Structural System". The idea behind bracing is to resist the building from the seismic forces in such a way that earthquake motions are not transmitted up through the building, or at least greatly reduced. And also balance the force acting by the wind load. The work undertaken is an attempt to recognize the behaviour of "X" type RCC bracing system and Steel bracing system under lateral loading. A model of G+14 story RCC building has been considered with "X" type RCC and Steel bracing. The RCC building with "X" type RCC and Steel braced system is analysed using static, wind load analysis. The present study will carry out the comparison of different parameters like; storey displacement, storey drift, base shear and cost using commonly available, widely used software STAAD Pro V8i is utilize for analysis.***

***Keywords— "X" Bracing, RCC Bracing, Steel Bracing, Cost Optimization, Behaviour of structure, Multy Storey Structure, Wind Loa, Economization.***

## I. INTRODUCTION

Tall building development involves various complex factors such as economics, aesthetics, technology, municipal regulations, and politics. Among these, economics has been the primary governing factor. This new building type itself would not have been possible, however, without supporting technologies.

The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces.

Bracing has been used to stabilize laterally for the majority of the world's tallest building structures as well as one of the major retrofit measures. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear.

The design principals of EBFs can be understood more effectively by investigating the tensile strength of string of chain as illustrated in figure 1.1.

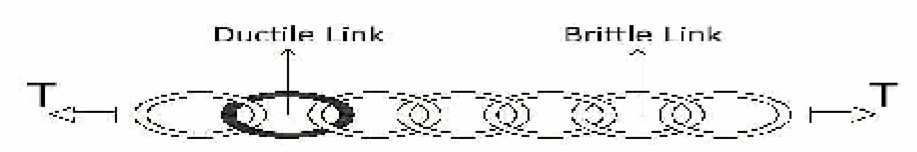


***Fig. 1 Representing EBFs systems as string of chain***

It can be concluded that the ductility of whole chain could be controlled by the ductility of one of its segments. The nominal tensile strength of this segment is supposed to be controlled by its ductility. Whereas other segments of the chain could be brittle and should be designed so that they have strength higher than the maximum strength of the lean segment.

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## II. ANALYSIS OF RCC BRACED AND BARE FRAME STRUCTURE

### 2.1 Geometrical Data

**2.1.1.** No. Of bay in X – dir. : 4,

**2.1.2.** No. Of bay in Y – dir. : 4,

**2.1.3.** Plan Dimension : 20 m x 20 m,

**2.1.4.** Typical Storey Height : 3.0 m,

**2.1.5.** Number of storey : G +14,

**2.1.6.** Type of Building : Residential building,

**2.1.7.** Type of Structure: RCC Structure.

### 2.2 Loading Data

**2.2.1 Floor Finish :** 1 kN/m$^2$

**2.2.2 Live Load :** 2 kN/m$^2$

**2.2.3 Earthquake load in X direction and Y direction**

Zone factor : IV, Importance factor : 1, Response reduction factor : 5

**2.2.4 Wind Load**

Basic wind speed : 47 m/sec, Terrain category : II, Class : C, Topography factor k3 : 1.0

### 2.3 Member Size Data

***Table 1 G + 14 Story RCC Building Section Size***

| G + 14 Story RCC Building | | |
|---|---|---|
| **Storey** | **Column Size (mm)** | **Beam Size (mm)** |
| Story 1 to Story 3 | 600 X 600 | 300 X 450 |
| Story 4 to Story 6 | 550 X 550 | 300 X 450 |
| Story 7 to Story 9 | 500 X 500 | 300 X 450 |
| Story 10 to Story 12 | 450 X 450 | 300 X 300 |
| Story 13 to Story 15 | 350 X 350 | 300 X 300 |

### 2.4 Bracing Size Data

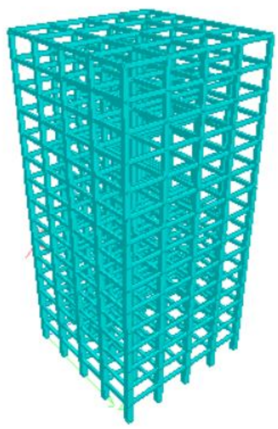
**2.4.1 RCC Bracing :** 230X230 mm

**2.4.2 Steel Bracing :** 240 X 200 X 8 mm (RHS)

### 2.5 Model Details :

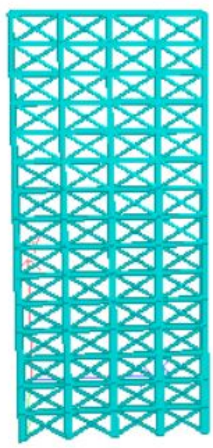
**1. Bare Model**

Elevation View

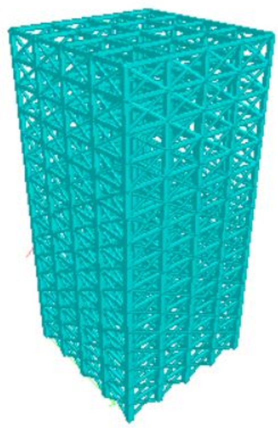


3D View

**2. Model I (RCC Braced)**



Elevation View



3D View

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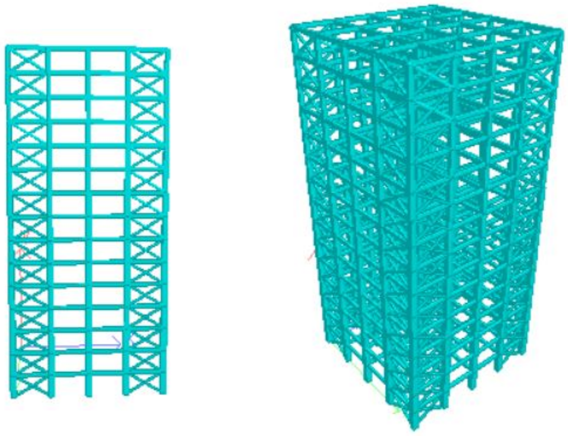
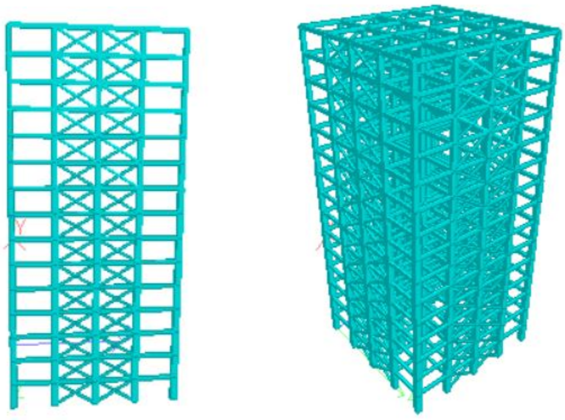
3. **Model II (RCC Braced)**



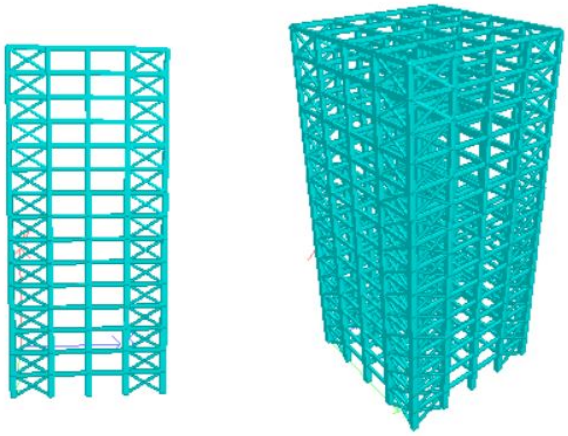
Elevation View 3D View

4. **Model III (RCC Braced)**



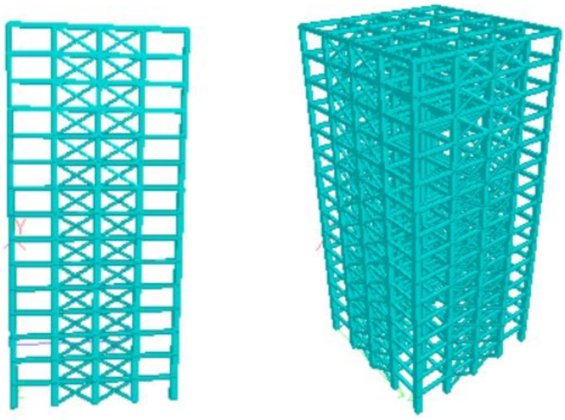
Elevation View 3D View

5. **Model IV (Steel Braced)**



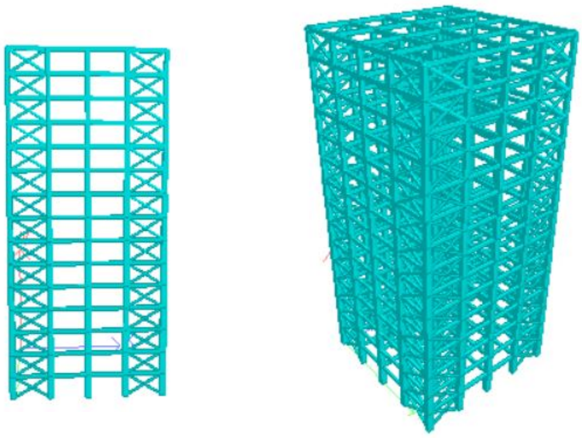
Elevation View 3D View

6. **Model V (Steel Braced)**



Elevation View 3D View

7. **Model VI (Steel Braced)**



Elevation View 3D View

***Figure 2 Model Detailing***

## III. ANALYSIS AND RESULTS

The static analysis is carried out considering wind loads and earthquake loads on structures. Wind analysis of structure is performed as per IS: 875(III) -1987 using STAAD Pro. V8i.

Here, the structure is symmetric so here we present the graphs for only one direction.

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### 3.1. Base Shear :

*Table 2 : Base Shear Ratio*

| Base Shear Ratio | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Model of Structure** | **Bare Model** | **Model I** | **Model II** | **Model III** | **Model IV** | **Model V** | **Model VI** |
| in X Dir. | 1 | 1.0730 | 1.0370 | 1.0370 | 1.0240 | 1.0120 | 1.0120 |
| in Y Dir. | 1 | 1.0730 | 1.0370 | 1.0370 | 1.0240 | 1.0120 | 1.0120 |

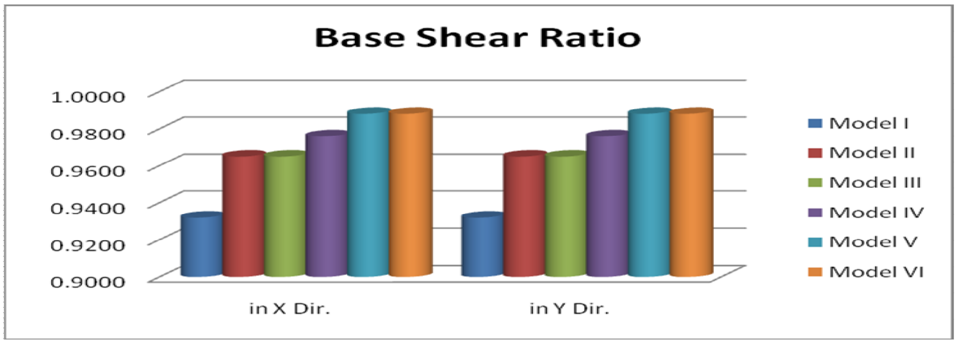


*Figure 3 Base Shear Ratio*

### 3.2. Story Displacement:

*Table 3 : Story Displacement in RCC Braced model*

| Story Displacement in RCC Braced model (mm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Story** | **Height (m)** | **Bare Frame** | | **Model I** | | **Model II** | | **Model III** | |
| | | **X Dir.** | **Y Dir.** | **X Dir.** | **Y Dir.** | **X Dir.** | **Y Dir.** | **X Dir.** | **Y Dir.** |
| Story 15 | 45 | 142.50 | 142.50 | 20.59 | 20.59 | 69.51 | 69.51 | 52.19 | 52.19 |
| Story 14 | 42 | 138.31 | 138.31 | 19.65 | 19.65 | 64.91 | 64.91 | 49.06 | 49.06 |
| Story 13 | 39 | 131.24 | 131.24 | 18.52 | 18.52 | 59.88 | 59.88 | 45.53 | 45.53 |
| Story 12 | 36 | 121.58 | 121.58 | 17.24 | 17.24 | 54.48 | 54.48 | 41.68 | 41.68 |
| Story 11 | 33 | 113.00 | 113.00 | 15.86 | 15.86 | 49.14 | 49.14 | 37.83 | 37.83 |
| Story 10 | 30 | 103.19 | 103.19 | 14.37 | 14.37 | 43.62 | 43.62 | 33.78 | 33.78 |
| Story 9 | 27 | 92.29 | 92.29 | 12.81 | 12.81 | 37.93 | 37.93 | 29.62 | 29.62 |
| Story 8 | 24 | 81.47 | 81.47 | 11.24 | 11.24 | 32.41 | 32.41 | 25.54 | 25.54 |
| Story 7 | 21 | 70.07 | 70.07 | 9.64 | 9.64 | 26.98 | 26.98 | 21.46 | 21.46 |
| Story 6 | 18 | 58.23 | 58.23 | 8.04 | 8.04 | 21.72 | 21.72 | 17.49 | 17.49 |
| Story 5 | 15 | 46.75 | 46.75 | 6.48 | 6.48 | 16.83 | 16.83 | 13.76 | 13.76 |
| Story 4 | 12 | 35.12 | 35.12 | 4.98 | 4.98 | 12.27 | 12.27 | 10.22 | 10.22 |
| Story 3 | 9 | 23.71 | 23.71 | 3.53 | 3.53 | 7.27 | 7.27 | 6.96 | 6.96 |
| Story 2 | 6 | 13.26 | 13.26 | 2.18 | 2.18 | 4.64 | 4.64 | 4.08 | 4.08 |
| Story 1 | 3 | 4.50 | 4.50 | 0.71 | 0.71 | 1.69 | 1.69 | 1.54 | 1.54 |
| Base | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Table 4 : Story Displacement in Steel Braced model*

| Story Displacement in Steel Braced model (mm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Story** | **Height (m)** | **Bare Frame** | | **Model IV** | | **Model V** | | **Model VI** | |
| | | **X Dir.** | **Y Dir.** | **X Dir.** | **Y Dir.** | **X Dir.** | **Y Dir.** | **X Dir.** | **Y Dir.** |
| Story 15 | 45 | 142.50 | 142.50 | 20.28 | 20.28 | 68.47 | 68.47 | 51.41 | 51.41 |
| Story 14 | 42 | 138.31 | 138.31 | 19.35 | 19.35 | 63.93 | 63.93 | 48.32 | 48.32 |
| Story 13 | 39 | 131.24 | 131.24 | 18.24 | 18.24 | 58.98 | 58.98 | 44.85 | 44.85 |
| Story 12 | 36 | 121.58 | 121.58 | 16.98 | 16.98 | 53.66 | 53.66 | 41.05 | 41.05 |
| Story 11 | 33 | 113.00 | 113.00 | 15.62 | 15.62 | 48.40 | 48.40 | 37.26 | 37.26 |
| Story 10 | 30 | 103.19 | 103.19 | 14.16 | 14.16 | 42.97 | 42.97 | 33.27 | 33.27 |
| Story 9 | 27 | 92.29 | 92.29 | 12.62 | 12.62 | 37.36 | 37.36 | 29.17 | 29.17 |
| Story 8 | 24 | 81.47 | 81.47 | 11.07 | 11.07 | 31.92 | 31.92 | 25.15 | 25.15 |
| Story 7 | 21 | 70.07 | 70.07 | 9.49 | 9.49 | 26.57 | 26.57 | 21.14 | 21.14 |
| Story 6 | 18 | 58.23 | 58.23 | 7.92 | 7.92 | 21.39 | 21.39 | 17.23 | 17.23 |
| Story 5 | 15 | 46.75 | 46.75 | 6.38 | 6.38 | 16.58 | 16.58 | 13.55 | 13.55 |
| Story 4 | 12 | 35.12 | 35.12 | 4.90 | 4.90 | 12.08 | 12.08 | 10.07 | 10.07 |

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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Story 3 | 9 | 23.71 | 23.71 | 3.48 | 3.48 | 7.16 | 7.16 | 6.86 | 6.86 |
| Story 2 | 6 | 13.26 | 13.26 | 2.15 | 2.15 | 4.57 | 4.57 | 4.02 | 4.02 |
| Story 1 | 3 | 4.50 | 4.50 | 0.70 | 0.70 | 1.66 | 1.66 | 1.52 | 1.52 |
| Base | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

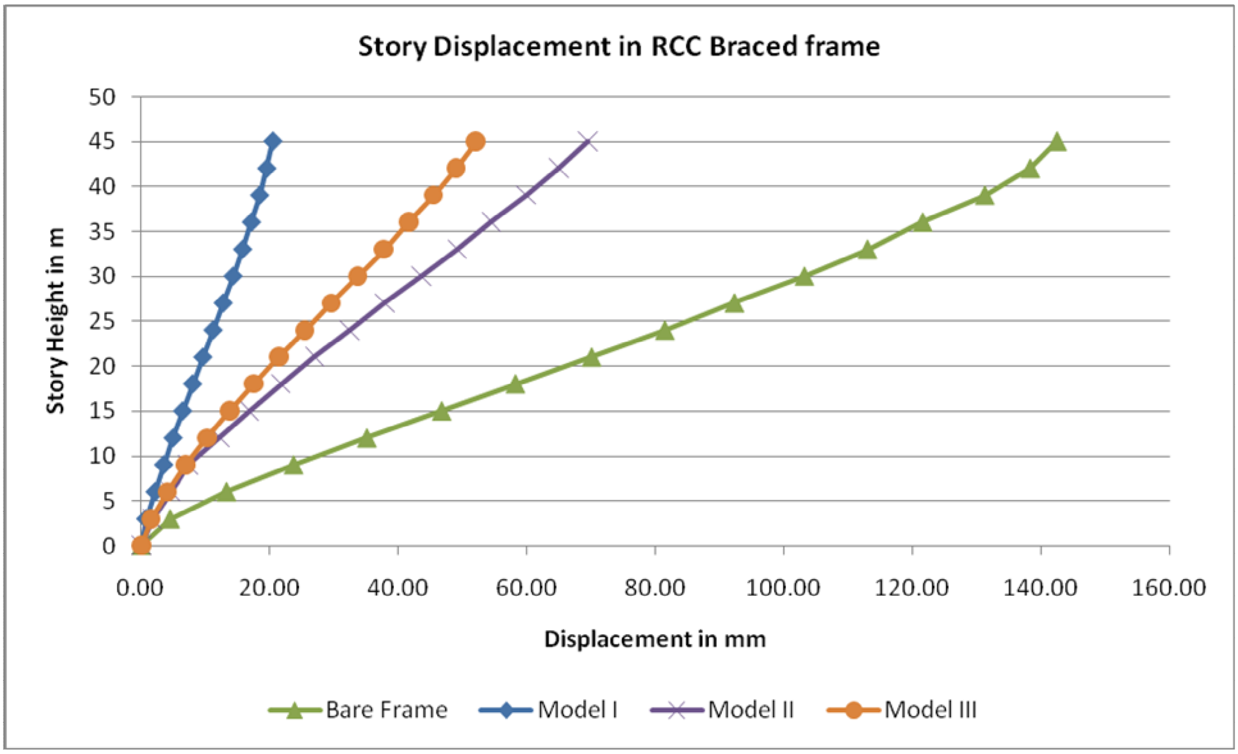


*Figure 4 Story Displacement in RCC Braced model*

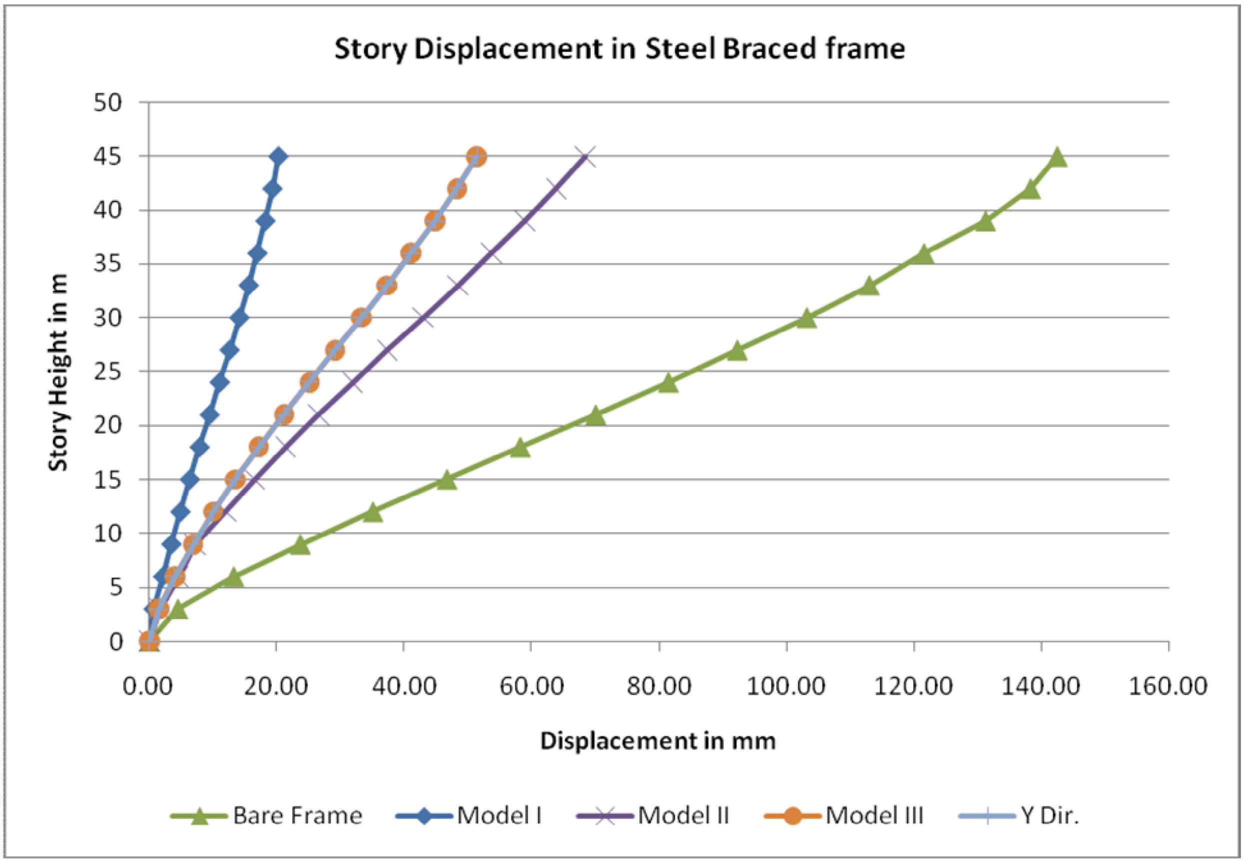


*Figure 5 Story Displacement in Steel Braced model*

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### 3.3. Story Displacement:

*Table 5 : Story Drift in RCC Braced model*

| Story Drift in RCC Braced model (mm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Story | Height (m) | Bare Frame | | Model I | | Model II | | Model III | |
| | | X Dir. | Y Dir. | X Dir. | Y Dir. | X Dir. | Y Dir. | X Dir. | Y Dir. |
| Story 15 | 45 | 4.18 | 4.18 | 0.42 | 0.42 | 2.22 | 2.22 | 1.46 | 1.46 |
| Story 14 | 42 | 7.07 | 7.07 | 0.51 | 0.51 | 2.43 | 2.43 | 1.70 | 1.70 |
| Story 13 | 39 | 8.21 | 8.21 | 0.59 | 0.59 | 2.63 | 2.63 | 1.85 | 1.85 |
| Story 12 | 36 | 8.59 | 8.59 | 0.65 | 0.65 | 2.67 | 2.67 | 1.87 | 1.87 |
| Story 11 | 33 | 9.81 | 9.81 | 0.71 | 0.71 | 2.74 | 2.74 | 2.00 | 2.00 |
| Story 10 | 30 | 10.90 | 10.90 | 0.75 | 0.75 | 2.82 | 2.82 | 2.06 | 2.06 |
| Story 9 | 27 | 10.82 | 10.82 | 0.77 | 0.77 | 2.76 | 2.76 | 2.05 | 2.05 |
| Story 8 | 24 | 11.40 | 11.40 | 0.79 | 0.79 | 2.74 | 2.74 | 2.05 | 2.05 |
| Story 7 | 21 | 11.85 | 11.85 | 0.85 | 0.85 | 2.68 | 2.68 | 2.01 | 2.01 |
| Story 6 | 18 | 11.48 | 11.48 | 0.86 | 0.86 | 2.50 | 2.50 | 1.90 | 1.90 |
| Story 5 | 15 | 11.58 | 11.58 | 0.81 | 0.81 | 2.36 | 2.36 | 1.82 | 1.82 |
| Story 4 | 12 | 11.45 | 11.45 | 0.75 | 0.75 | 2.16 | 2.16 | 1.69 | 1.69 |
| Story 3 | 9 | 10.45 | 10.45 | 0.69 | 0.69 | 1.87 | 1.87 | 1.51 | 1.51 |
| Story 2 | 6 | 8.87 | 8.87 | 0.65 | 0.65 | 1.60 | 1.60 | 1.35 | 1.35 |
| Story 1 | 3 | 4.51 | 4.51 | 0.56 | 0.56 | 1.11 | 1.11 | 0.97 | 0.97 |
| Base | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Table 6 : Story Drift In Steel Braced Model*

| Story Drift in Steel Braced model (mm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Story | Height (m) | Bare Frame | | Model IV | | Model V | | Model VI | |
| | | X Dir. | Y Dir. | X Dir. | Y Dir. | X Dir. | Y Dir. | X Dir. | Y Dir. |
| Story 15 | 45 | 4.18 | 4.18 | 0.41 | 0.41 | 2.19 | 2.19 | 1.44 | 1.44 |
| Story 14 | 42 | 7.07 | 7.07 | 0.50 | 0.50 | 2.39 | 2.39 | 1.67 | 1.67 |
| Story 13 | 39 | 8.21 | 8.21 | 0.58 | 0.58 | 2.59 | 2.59 | 1.83 | 1.83 |
| Story 12 | 36 | 8.59 | 8.59 | 0.64 | 0.64 | 2.63 | 2.63 | 1.84 | 1.84 |
| Story 11 | 33 | 9.81 | 9.81 | 0.70 | 0.70 | 2.70 | 2.70 | 1.97 | 1.97 |
| Story 10 | 30 | 10.90 | 10.90 | 0.74 | 0.74 | 2.77 | 2.77 | 2.03 | 2.03 |
| Story 9 | 27 | 10.82 | 10.82 | 0.76 | 0.76 | 2.72 | 2.72 | 2.02 | 2.02 |
| Story 8 | 24 | 11.40 | 11.40 | 0.78 | 0.78 | 2.70 | 2.70 | 2.02 | 2.02 |
| Story 7 | 21 | 11.85 | 11.85 | 0.84 | 0.84 | 2.64 | 2.64 | 1.98 | 1.98 |
| Story 6 | 18 | 11.48 | 11.48 | 0.85 | 0.85 | 2.46 | 2.46 | 1.87 | 1.87 |
| Story 5 | 15 | 11.58 | 11.58 | 0.79 | 0.79 | 2.32 | 2.32 | 1.79 | 1.79 |
| Story 4 | 12 | 11.45 | 11.45 | 0.73 | 0.73 | 2.13 | 2.13 | 1.67 | 1.67 |
| Story 3 | 9 | 10.45 | 10.45 | 0.68 | 0.68 | 1.84 | 1.84 | 1.49 | 1.49 |
| Story 2 | 6 | 8.87 | 8.87 | 0.64 | 0.64 | 1.58 | 1.58 | 1.33 | 1.33 |
| Story 1 | 3 | 4.51 | 4.51 | 0.56 | 0.56 | 1.09 | 1.09 | 0.96 | 0.96 |
| Base | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

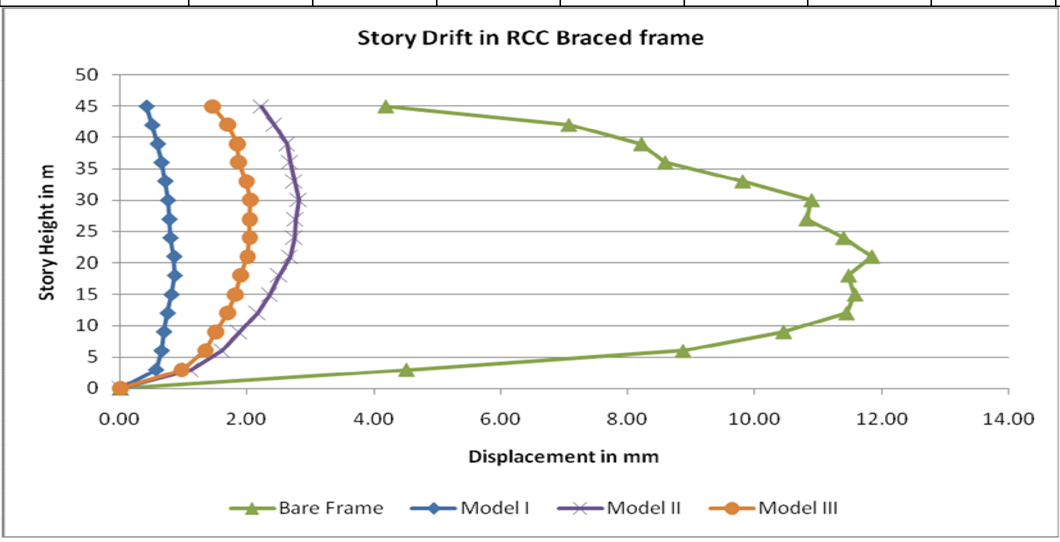


*Figure 6 Story Drift in RCC Braced model*

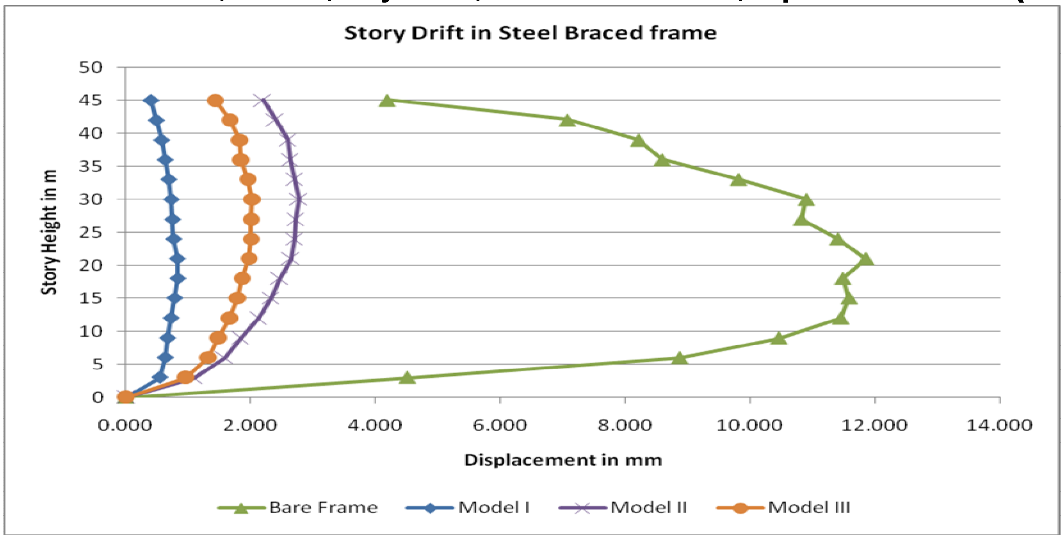


*Figure 7 Story Drift in Steel Braced model*

### 3.5. Material in use Comparison :

After the application of bracing in various patterns, and by applying bracing forces are reduced and by redesign the columns. For newly design column and beams material used is mentioned in table 7.

*Table 7: Material Used*

| Quantity Comparison | | | | |
|---|---|---|---|---|
| **Model** | **Concrete (cum)** | **Steel (kN)** | **Steel Tube (kN)** | **Total Steel (kN)** |
| Bare Frame | 682.4 | 925.41 | 0 | 925.41 |
| Model I | 813.6 | 801.42 | 0 | 801.42 |
| Model II | 738.5 | 839.41 | 0 | 839.41 |
| Model III | 738.5 | 834.07 | 0 | 834.07 |
| Model IV | 665.5 | 654.7 | 1146 | 1800.7 |
| Model V | 665.5 | 741.24 | 573 | 1314.24 |
| Model VI | 665.5 | 732.75 | 573 | 1305.75 |

## IV. CONCLUSIONS

After the comparing of the equivalent steel and RCC bracing for the RCC Frame with wind load, seismic load and Response analysis the result of story drift and displacement are almost same.

Base shear is varying with use of various materials for the same RCC frame using various patterns of applying "X" type RCC bracing.

Above results show that the best economic model is model III, In model III total use steel is very law compare to other models.

That results show that the economically RCC Bracing is economical compare to Steel Bracing.

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