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# Comparative Study of Analysis and Design of R.C. and Steel Structures

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**Abstract**— The use of steel structure in India as compared to other countries is less, as India is developing country. In cities like Delhi and Mumbai, horizontal expansion is restricted therefore vertical growth of building becomes predominant. . Infill walls are probably the most important non-structural element in the context of seismic design. They helps in resisting the lateral forces. Due to their significance in-plane stiffness and strength, infill walls modify the anticipated seismic performance of a building. In the present work, three dimensional models of steel & RCC structures are analyzed by using equivalent static method under the provision of IS 1893: (2002) with the help of ETABS software. Where design and cost estimation is carried out using MS-Excel programming for all structures. Comparative study of bare & infill frame of four models of (G+6) & (G+10) RC & steel structures is carried out which is situated in seismic zone five (v).Masonry infill is modeled by Equivalent Diagonal Strut method.

**Index Terms**— Bare Frame, Base shear, cost ratio, Displacement, Infill frame, Inter -Storey drift, Strut.

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## 1 Introduction

Steel industry is growing rapidly in almost all parts of the world. Time is most important parameter from the construction point of view and steel structure is built in a short short period. Steel structures are more advantageous than that of RC structure, because they have better response during earthquake. In the present work, comparative study of bare and infill frame of RC & steel structure (G+6 & G+10) is included. The comparative study includes base shear, maximum point displacement, axial forces and bending moments in the columns, material consumption and cost comparisons of RCC & steel structure.

A steel building is a metal structure fabricated with steel for the internal support and for exterior cladding, as opposed to steel framed buildings which generally uses other materials for floors, walls, and external envelope. Steel buildings are used for a variety of purposes including storage, work spaces and living accommodation.

## 2 STRUCTURAL DETAILS

A typical plan of building is selected for comparative study of RCC and steel structure having plan dimensions 22.5m X 12m as shown in Fig 1.

| | |
|---|---|
| Foundation | 1.5m below |
| Depth | G.L. |
| Storey height | 3m each |
| Walls | 0.15m thick all |
| Slab depth | 150mm thick |

The beams and column location considered for comparisons of different analysis parameters is studied by grouping them.

Group 1: Interior beams and columns.

Group 2:Longer direction pheripheral beams & columns.

Group 3: Corner columns.

### 2.1 Modeling with ETABS

3-D model is being prepared for the frame analysis of building in ETABS. Following basic parameters are used for the analysis and design of structures:

#### 2.1.1 Material Properties

| | |
|---|---|
| Unit weight of masonry | 20 kN/m³ |
| Unit weight of R.C.C | 25 kN/m³ |
| Unit weight of steel | 78 kN/m³ |
| Grade of concrete | M25 for R.C.C and Steel structure |
| Grade of reinforcing steel | Fe 415 HYSD bars |
| Grade of structural steel | Fe 250 |
| Modulus of Elasticity for R.C.C | 25 KN/m² |
| Modulus of Elasticity for Steel | 210 KN/m² |
| Dead load | Self-weight of structural elements |
| Live load | 4 kN/m² |
| Floor finish load | 1 kN/m² |

#### 2.1.2 Earthquake parameters:

| | |
|---|---|
| Seismic Zone | V (0.36) |
| Soil type | Hard (Type 1) |
| Importance factor | 1 |
| Time period | Program Calculated |
| Earthquake load in | X & Y direction |
| Type of diaphragm | Rigid |

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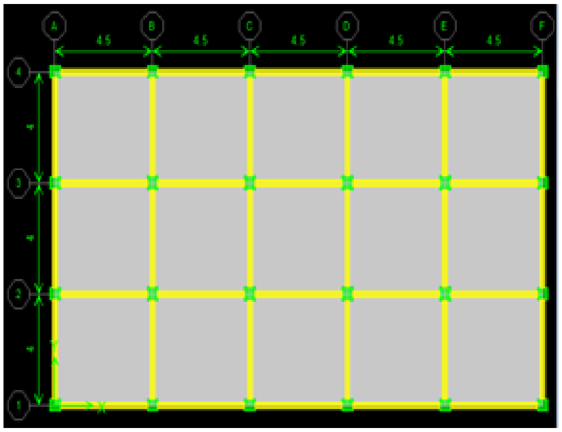



Fig 1: Plan view of building

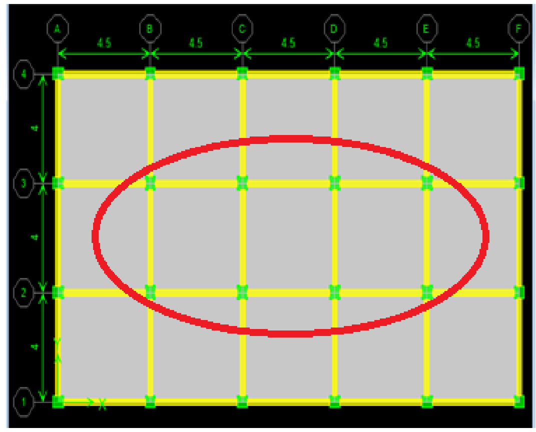



Fig 2: Interior beams and columns (Group1)

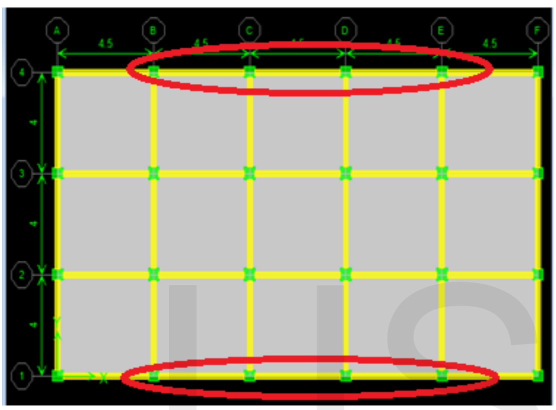



Fig 3: Longer direction peripheral Beams & Columns (Group 2)

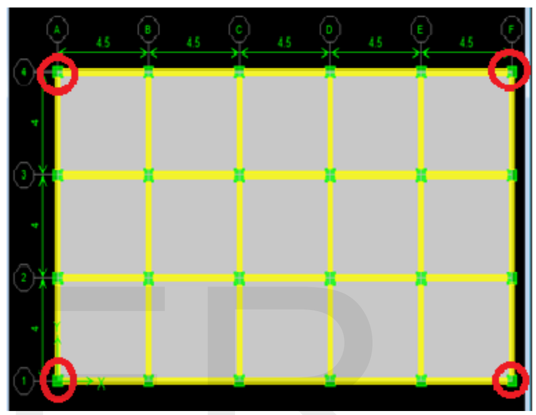



Fig 4: Corner columns (Group3)



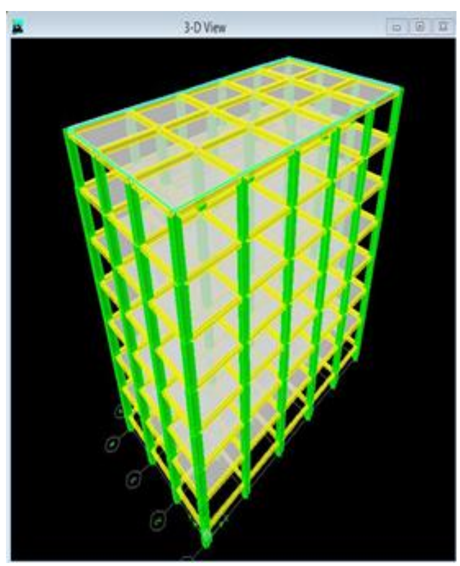



Fig 5: 3D View of Building

R.C. and Steel model has been made. Different column and beam sizes were provided. The analysis and design is carried out for all structures, the result obtained are tabulated and graphically summarized below.

# 3. COMPARISION OF BASE SHEAR AND DISPLACEMENT OF DIFFERENT MODEL:

## 3.1 Base Shear Comparisons:

**Table 1 Base Shear Comparison of (G+ 6) Models**

| Base Shear | RC Bare Frame | Steel Bare Frame | RC Frame with masonry Infill | Steel Frame with masonry Infill |
|---|---|---|---|---|
| In X-Direction | 600.51kN | 431.78 kN | 735.29 kN | 660.96 kN |
| In Y-Direction | 567.85 kN | 260.83 kN | 574.04 kN | 437.19 kN |

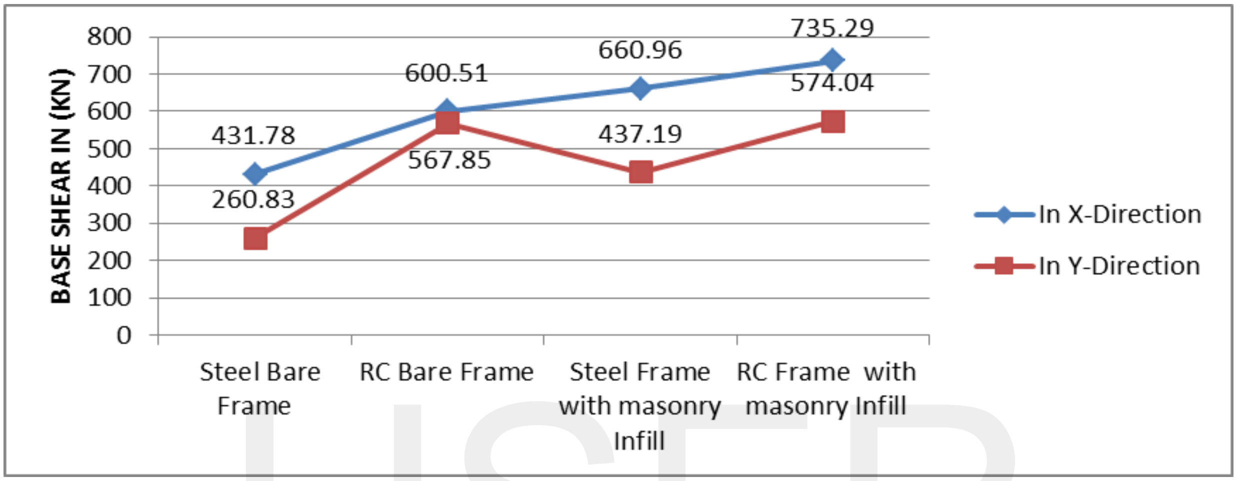



**Fig.6: Comparison of Base Shear of (G+ 6) Models**

**Table 2 Base Shear Comparison of (G+ 10) Models**

| Base Shear | RC Bare Frame | Steel Bare Frame | RC Frame with masonry Infill | Steel Frame with masonry Infill |
|---|---|---|---|---|
| In X-Direction | 719.42 kN | 479.98 kN | 858.67 kN | 687.07 kN |
| In Y-Direction | 656.67 kN | 323.37 kN | 744.57 kN | 472.75 kN |

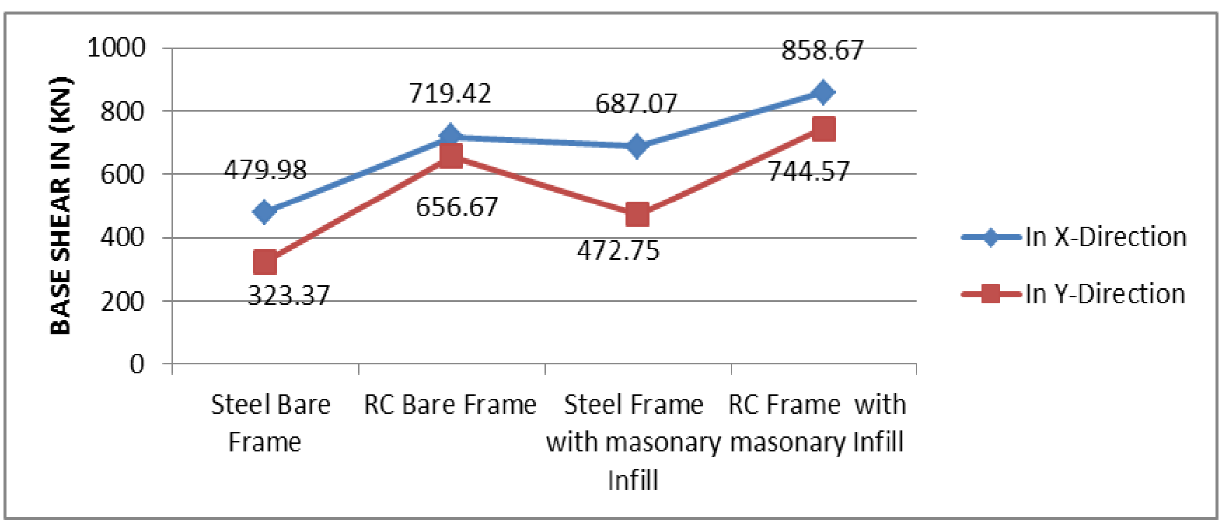
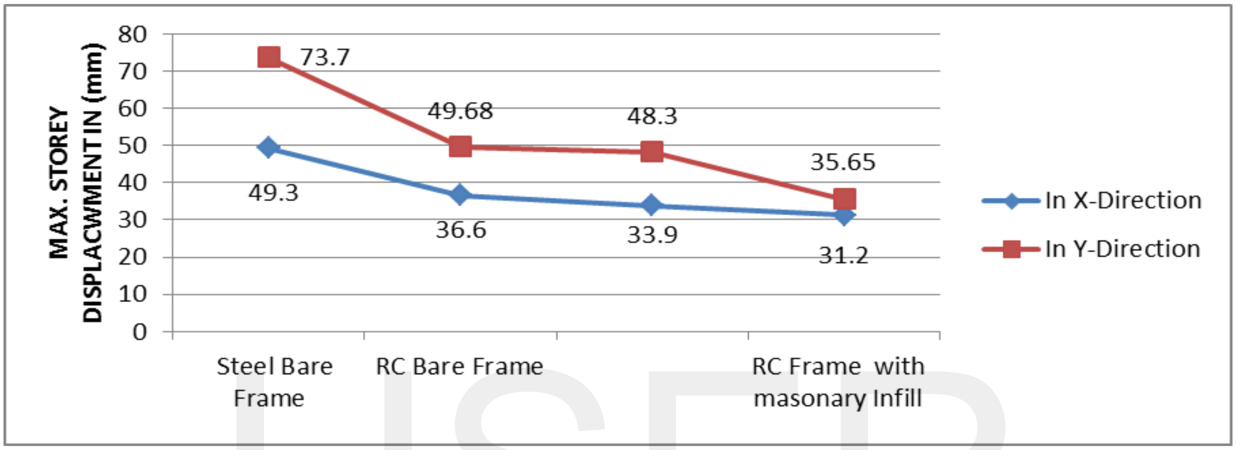



**Fig. 7: Comparison of Base Shear of (G+ 10) Models**

### 3.2 Max. Storey Displacement Comparisons:

**Table 3: Maximum Storey Displacement Comparison of (G+ 6) Models**

| Displacement | RC Bare Frame | Bare Frame Steel Structure | RC frame with masonry Infill | Steel frame with masonry Infill |
|---|---|---|---|---|
| In X- Direction | 36.6 mm | 49.3 mm | 31.2 mm | 33.9 mm |
| In Y-Direction | 49.68 mm | 73.7 mm | 35.65 mm | 48.3 mm |




. **Fig. 8: Comparison of Maximum Storey Displacement of (G+ 6) Models**

**Table 4: Maximum Storey Displacement Comparison of (G+ 10) Models**

| Displacement | RC Bare Frame | Steel Bare Frame | RC Frame with masonry Infill | Steel Frame with masonry Infill |
|---|---|---|---|---|
| In X- Direction | 30.2 mm | 34.1 mm | 19.62 mm | 22.1 mm |
| In Y-Direction | 36.28 mm | 56.4 mm | 23.22 mm | 32.5 mm |

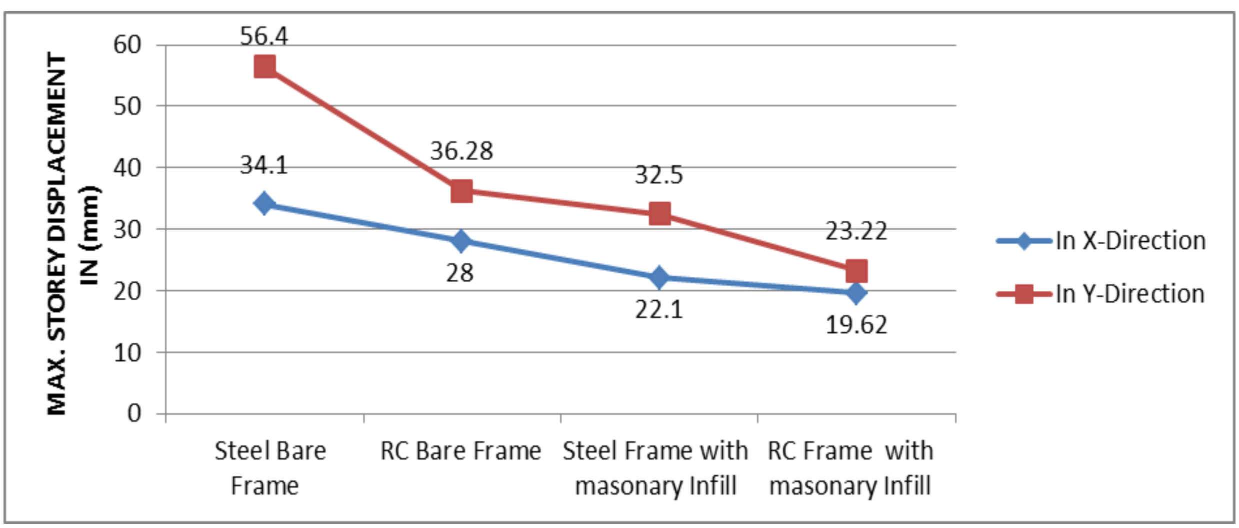



**Fig. 9: Comparison of Maximum Storey Displacement of (G+ 10) Models**

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## 4 Axial Forces, Bending Moment, Support Reaction, Storey Drift Comparisons:

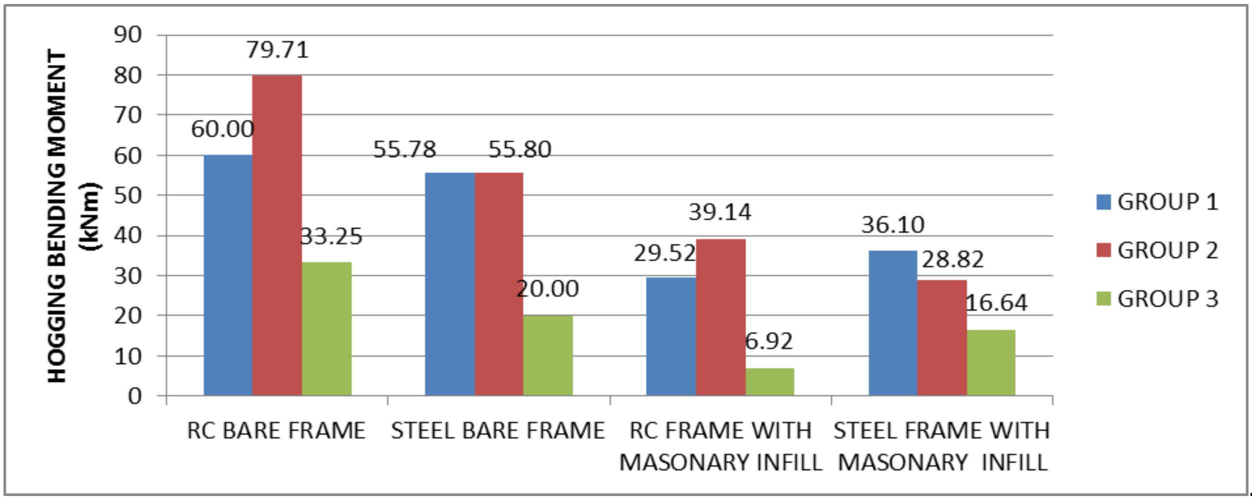


**Fig. 10 Bending Moment in Columns of (G+6) Models**

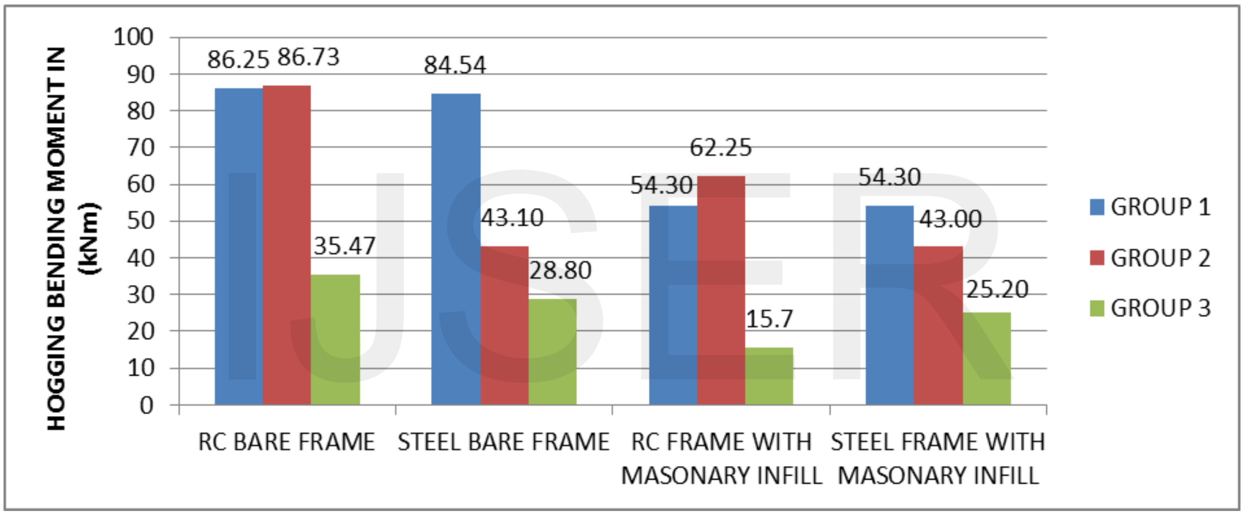


**Fig.11: Bending Moment In Columns of (G+10) Models**

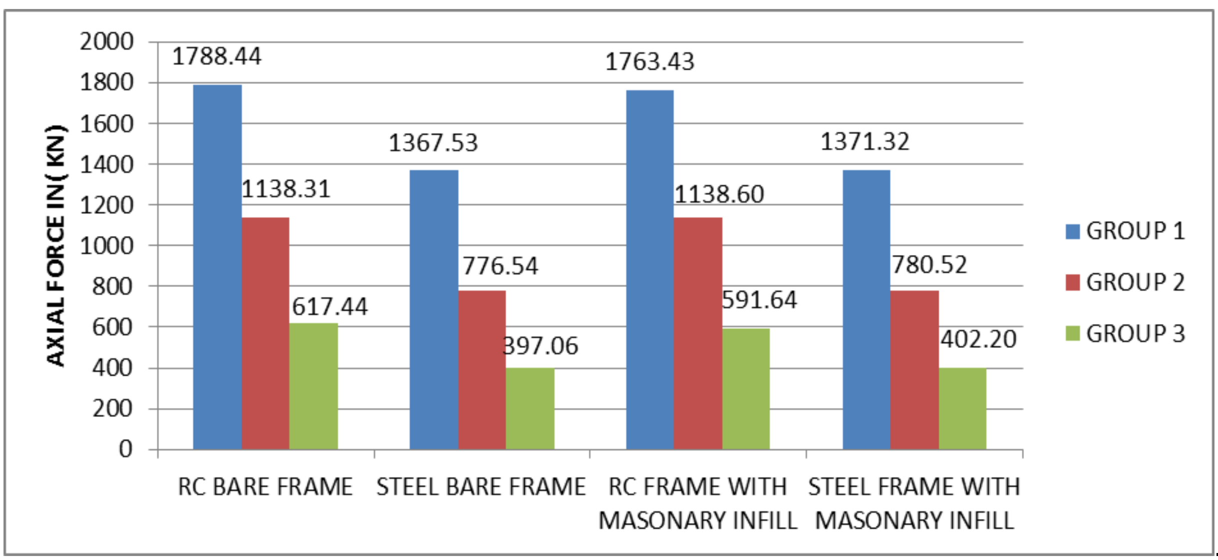


**Fig. 12: Axial Forces In Columns of (G+6) Models**

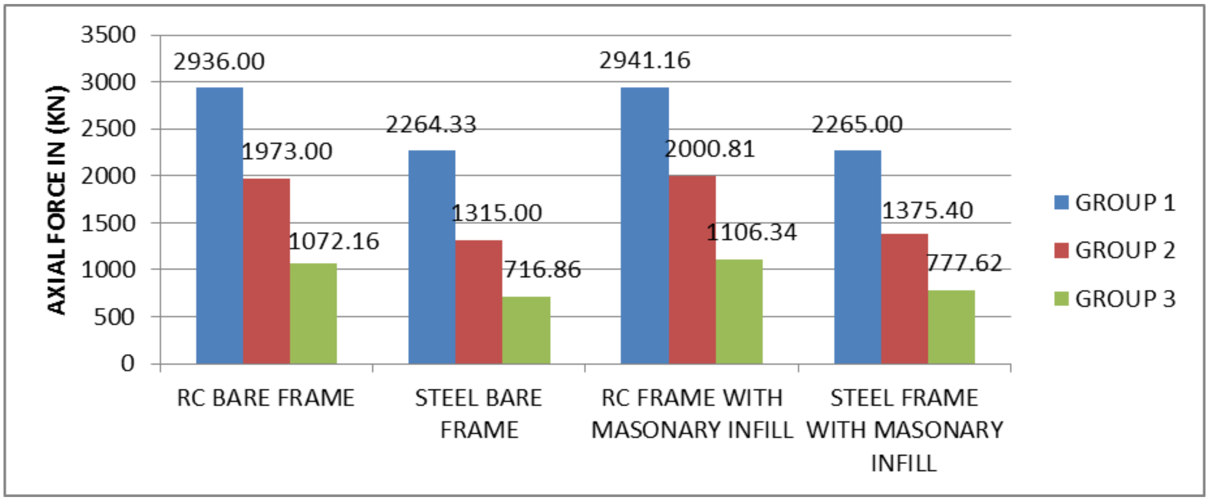


**Fig. 13: Axial Forces In Columns of (G+10) Models**

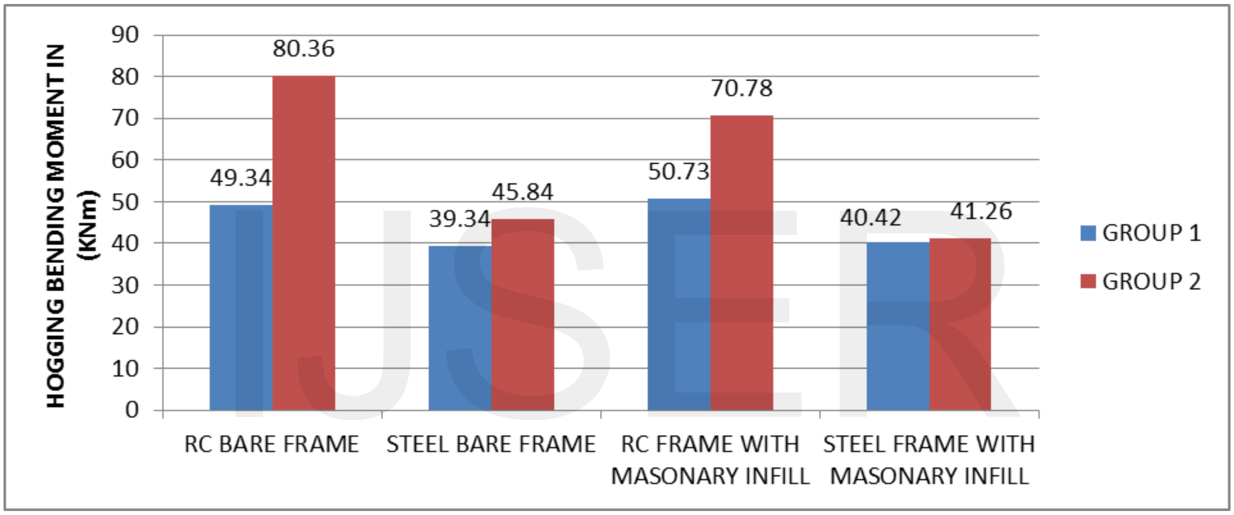


**Fig. 14: Bending Moment In Beams of (G+6) Models**

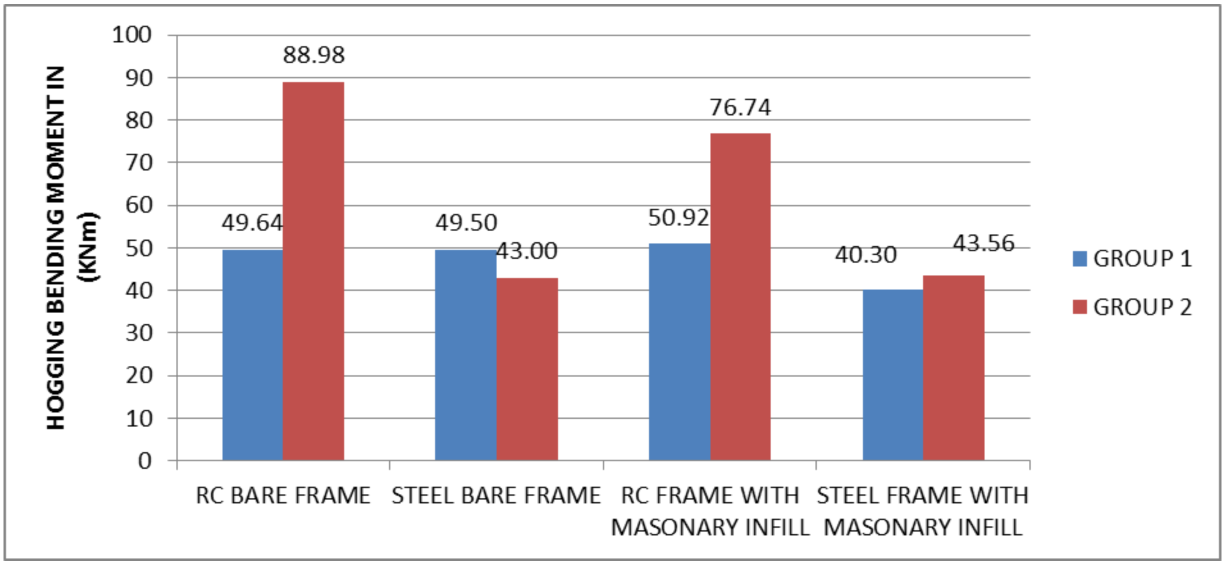


**Fig. 15: Bending Moment In Beams of (G+10) Models**

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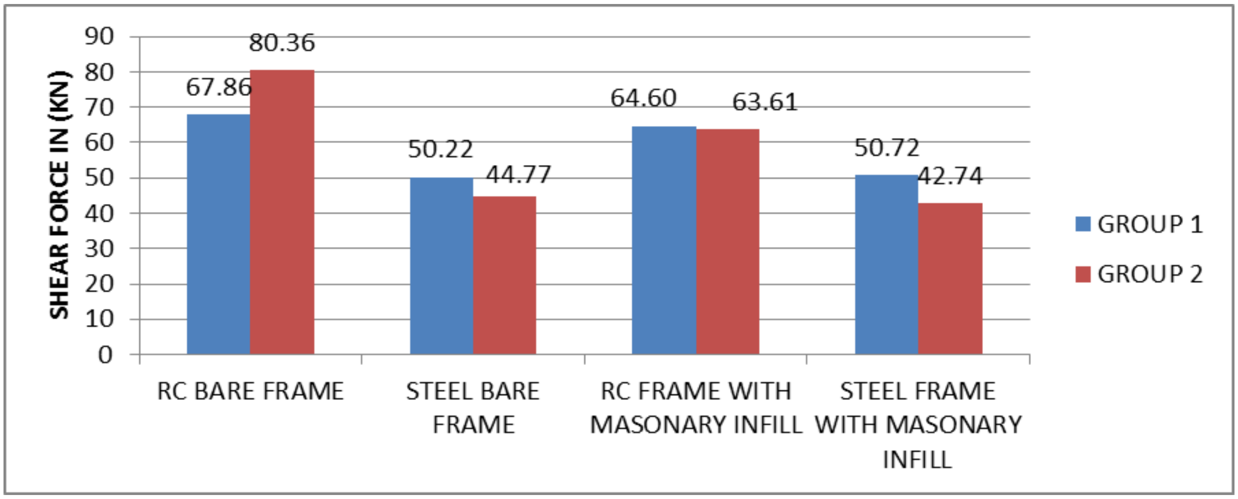


**Fig.16:Shear Forces In Beams of (G+6) Models**

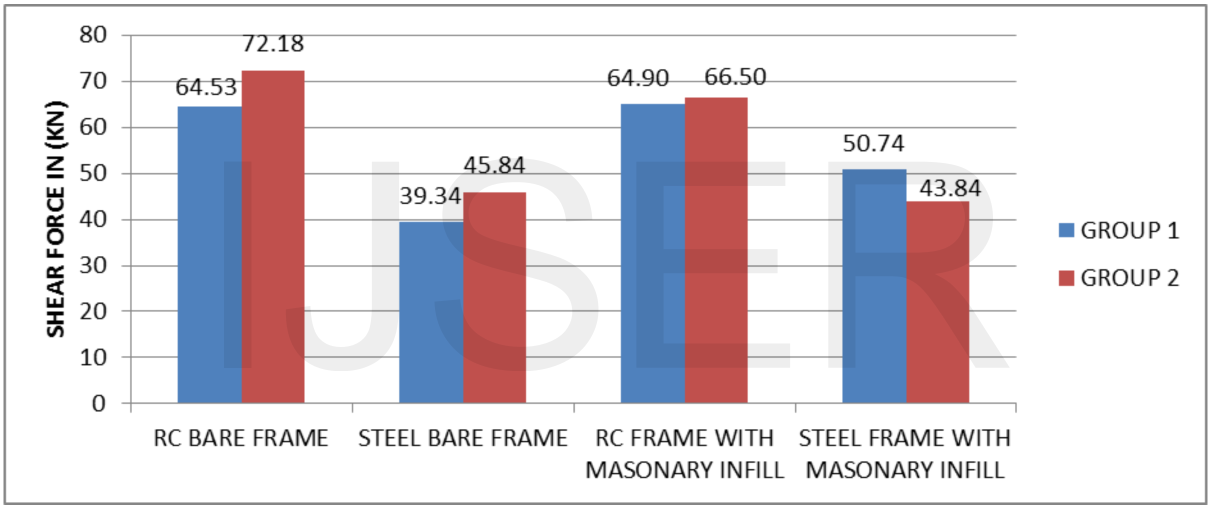


**Fig. 17: Shear Forces In Beams of (G+10) Models**

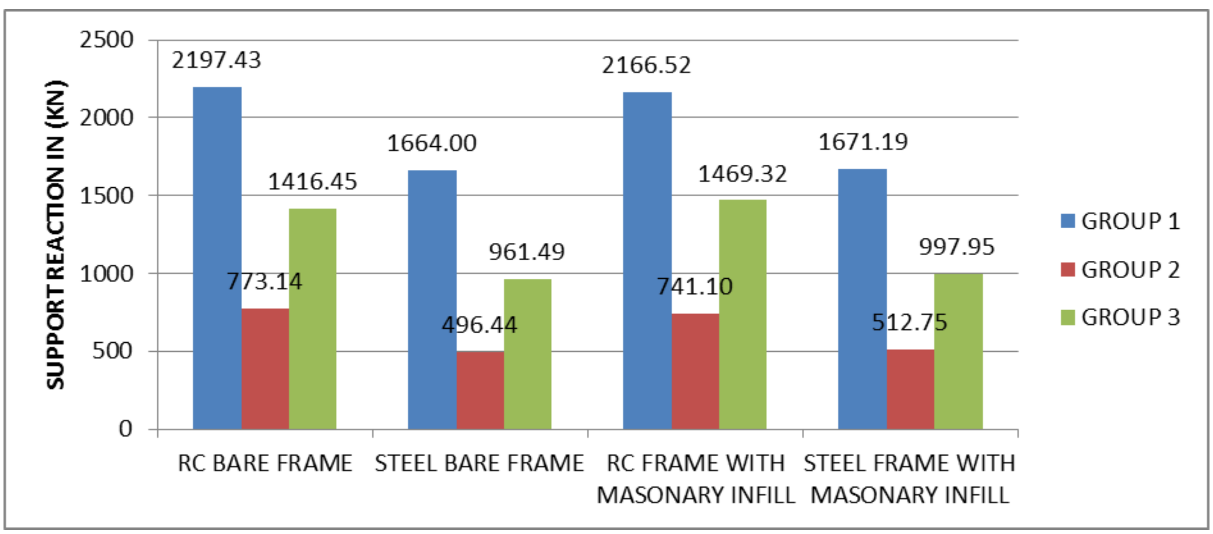


**Fig. 18: Support Reactions of (G+6) Models**

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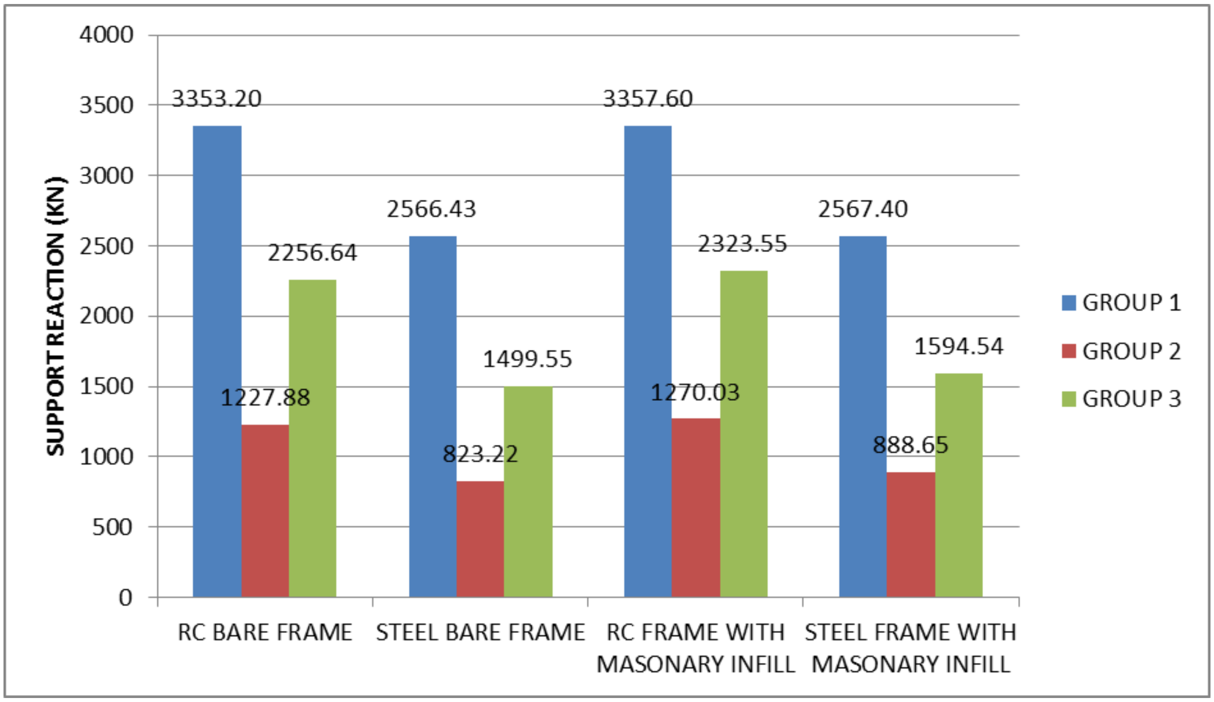


**Fig. 19: Support Reactions of (G+10) Models**

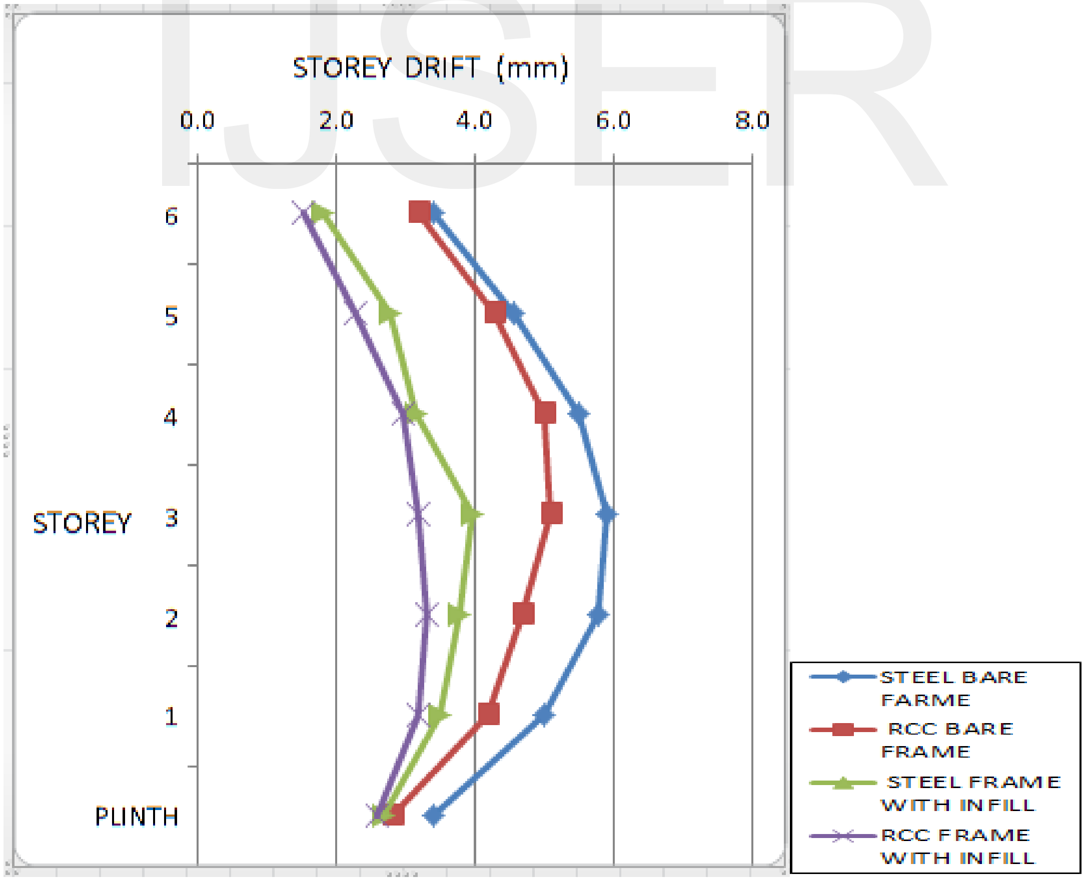


**Fig. 20: Inter-Storey Drift of (G + 6) Models**

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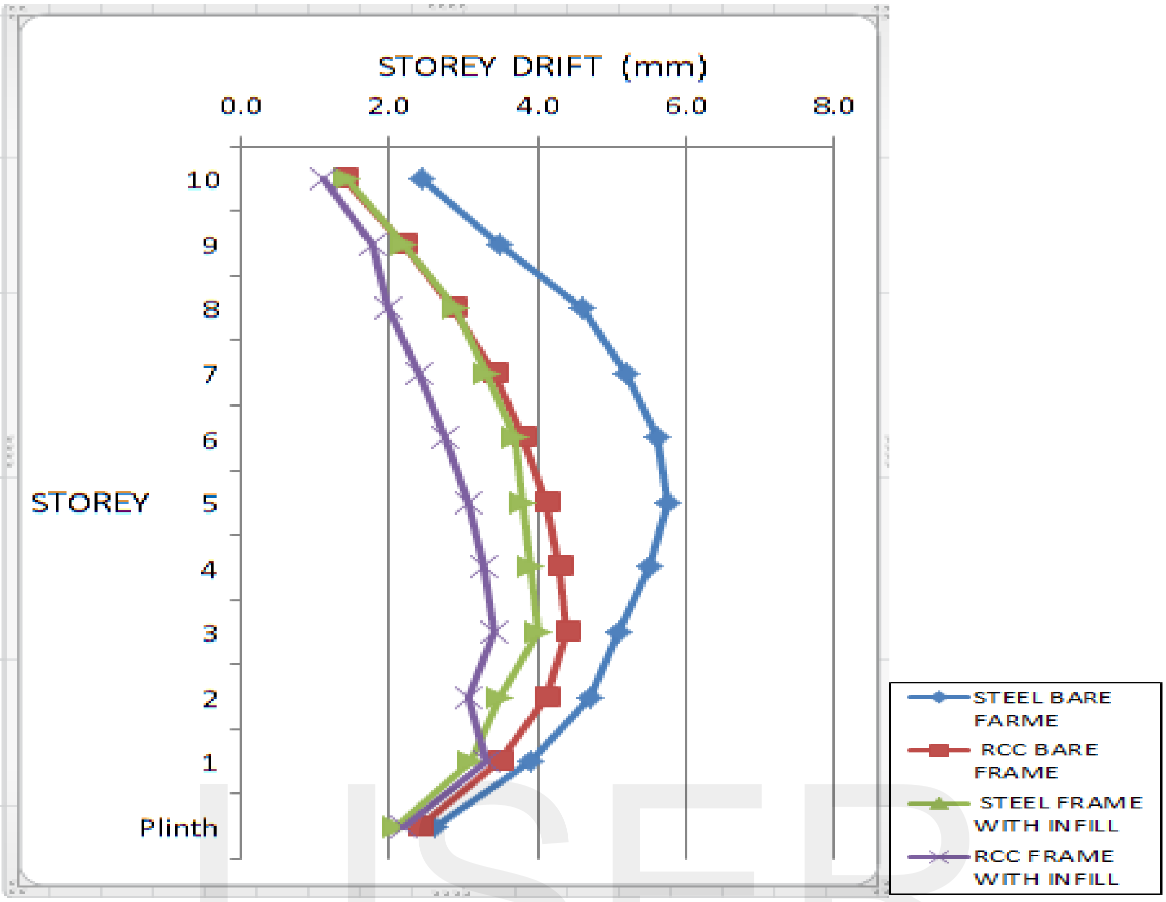


Fig. 21: Inter-Storey Drift of (G + 10) Models



## 5. COST COMPARISONS:

**Table 3 Cost Comparison of Bare Frame (G+6) Models**

| | RC Bare Frame (1) | | | Steel Bare Frame (2) | | | Cost ratio (2/1) |
|---|---|---|---|---|---|---|---|
| **Material** | **Quantity** | **Unit Rate** | **Cost** | **Quantity** | **Unit Rate** | **Cost** | |
| Concrete ($m^3$) | 505.54 | 4000 | 2022160 | 283.52 | 4000 | 1134080 | |
| Reinforcement (tonne) | 45.59 | 45000 | 2051550 | 7.86 | 45000 | 353700 | |
| Structural Steel (tonne) | ----- | ---- | ----- | 98.84 | 45000 | 4448700 | |
| **Total Cost** | | | 40.73 lac. | | | 59.36 lac. | 1.45 |

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**Table 4 Cost Comparison of Infill Frame (G+6) Models**

| | RC Frame with masonry Infill (1) | | | Steel Frame with masonry Infill (2) | | | Cost ratio (2/1) |
|---|---|---|---|---|---|---|---|
| **Material** | **Quantity** | **Unit Rate** | **Cost** | **Quantity** | **Unit Rate** | **Cost** | |
| Concrete ($m^3$) | 479.44 | 4000 | 1917760 | 283.52 | 4000 | 1134080 | |
| Reinforcement (tonne) | 36.96 | 45000 | 1663200 | 7.86 | 45000 | 353700 | |
| Structural Steel (tonne) | ----- | ---- | ----- | 94.72 | 45000 | 4262400 | |
| **Total Cost** | ----- | ----- | **35.81 lac.** | ----- | ----- | **57.50 lac.** | **1.6** |

**Table 5 Cost Comparison of Bare Frame (G+10) Models**

| | RC Bare Frame (1) | | | Steel Bare Frame (2) | | | Cost ratio (2/1) |
|---|---|---|---|---|---|---|---|
| **Material** | **Quantity** | **Unit Rate** | **Cost** | **Quantity** | **Unit Rate** | **Cost** | |
| Concrete ($m^3$) | 818.8 | 4000 | 3275200 | 445.53 | 4000 | 1782120 | |
| Reinforcement (tonne) | 70.63 | 45000 | 3178350 | 12.35 | 45000 | 555750 | |
| Structural Steel (tonne) | ----- | ---- | ----- | 166.81 | 45000 | 7506450 | |
| **Total Cost** | | | **64.53 lac.** | | | **98.44 lac.** | **1.52** |

**Table 6 Cost Comparison of Infill Frame (G+10) Models**

| | RC Frame with masonry Infill (1) | | | Steel Frame with masonry Infill (2) | | | Cost ratio (2/1) |
|---|---|---|---|---|---|---|---|
| **Material** | **Quantity** | **Unit Rate** | **Cost** | **Quantity** | **Unit Rate** | **Cost** | |
| Concrete ($m^3$) | 788.32 | 4000 | 3153280 | 445.53 | 4000 | 1782120 | |
| Reinforcement (tonne) | 68.98 | 45000 | 3104100 | 12.35 | 45000 | 555750 | |
| Structural Steel (tonne) | ----- | ---- | ----- | 170.29 | 45000 | 7663050 | |
| **Total Cost** | | | **62.57 lac** | | | **1 cr.** | **1.6** |

## 6. RESULTS AND DISCUSSION

1. In steel bare frame, base shear is decreased by 28% as compared to RCC along X-direction and 54% along Y-direction for (G+6) frame.
2. In steel frame with masonry infill, base shear is decreased by 10% as compared to RC along X-direction and 23% along Y-direction for (G+6) frame.
3. In steel bare frame, base shear is decreased by 33% as compared to RC along X-direction and 50% along Y-direction for (G+10) frame.
4. In steel frame with masonry infill, base shear is decreased by 20% as compared to RC along X-direction and 36% along Y-direction for (G+10) frame.
5. In steel bare frame maximum storey displacement is increased by 13% as compared to RC along X-direction and 55% along Y-direction for (G+6) frame.
6. In steel frame with masonry infill, maximum storey displacement is increased by 12% as compared to RC along X-direction and 40% along Y-direction for (G+6) frame.
7. In steel bare frame, maximum storey displacement is increased by 35% as compared to RC along X-direction and 48% along Y-direction for (G+10) frame.
8. In steel frame with masonry infill, maximum storey displacement is increased by 8% as compared to RC along X-direction and 35% along Y-direction for (G+10) frame.
9. Bending moment in beams and columns of steel frames is less as compared to RC frames.
10. An axial force in steel frames is less than RC frames.
11. Shear force in beams of RC frames is more than steel frames.
12. Support reactions in RC structures are increased by 23% as compared to steel structures due to less self-weight.
13. Storey drifts of steel structures are comparatively more than RC structures within permissible limit.
14. Cost of steel bare frame is increased by 31% as compared to RC frame for (G+6) frame.
15. Cost of steel frame with masonry infill is increased by 37% as compared to RC frame for (G+6) frame.
16. Cost of steel bare frame is increased by 34% as compared to RC frame for (G+10) frame.
17. Cost of steel frame with masonry infill is increased by 37% as compared to RC frame for (G+10) frame.

## 7. CONCLUSIONS

1. Base shear in steel structure is less than the RC structures because of less seismic weight which gives better response during earthquake.
2. Maximum point displacement and storey drift of Steel bare frame is more than RC bare frames.
3. Due to presence of infill in structure maximum point displacement and storey drift reduces slightly.
4. Bending moment in beams and columns of RC structures is more as compared to steel structures except in RC masonry infill structures at corner column.
5. Axial forces and support reactions in columns of RC structures are more as compared to Steel structures.
6. Shear forces in beams of RC structures are more as compared to Steel structures.
7. Cost ratio of steel and RC bare frame (G+6) is 1.45.
8. Cost ratio of steel and RC bare frame (G+10) is 1.52.
9. Cost ratio of both (G+6) and (G+10) structures of steel and RC frame with masonry infill is 1.6.



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