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Effect of Steel bracings in Steel Structure

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Abstract*:*

The word 'Bracing' originated from the word 'Brace' which basically means to strengthen or bolster by clasping firmly. Now days in metropolitan cities problem of time required for construction of RCC Structure is more as compare to steel structure. In case of steel structure to resist the lateral force and increase the stiffness of steel frame, bracings play very vital role. Bracing will make structure indeterminate. But it stiffens the structure and also helps to resist the sway of the structure. Bracings are straight member and carry only axial forces. In present study, G+7 storey building model has been analysed considering different types of bracing system under wind loading [1] using STAAD Pro V8i SS6. Results are concluded by comparing the Base reactions, Maximum displacement of member, Nodal displacements, Nodal rotation for a fixed base steel structure.

Key words: bracings, rotation, displacement

INTRODUCTION

For normal RCC (Reinforced cement concrete) structures, the main structural members are beam, column and slab same in case of steel structure. In RCC structures, steel is used along with concrete and hence are heavier than the steel structures. For a particular load case, sections in RCC structures will be heavier than the steel structures.

In case of normal frame of single bay (Refer fig.1) when subjected to lateral load it gets swayed. As the height of structure increases, the sway increase. To reduce this sway bracing are provided. The frames without bracings are called as unbraced frames and with bracings call as braced frames. Bracing stiffen the structure. Bracing carry axial load only, either it may be compression or tension. On other hand the static internal indeterminacy increases whereas kinematic indeterminacy decreases.

A. Types of bracings

Types of bracings are depending on position of the braced member in frame (Refer fig.1);

1) Single diagonal bracing- These are compression as well as tension type bracings. It consists of a single brace instead of two as in case of cross bracing.
2) Cross bracings or X bracings –These are the commonly used bracing systems. Here the diagonals intersect each other to form alphabet X.
3) V bracing- These are also inverted chevron or have the shape of alphabet V.
4) Inverted V bracing- Also called as chevron bracings. Here the braces intersect at the midpoint of the beam.

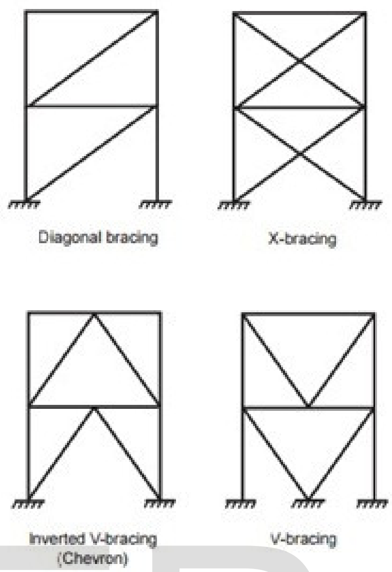

Fig. 1 Types of bracings

The present study is focused on study of behaviour of structure to resist lateral load for different types of bracings. The four types of bracings that are Diagonal bracing, Inverted bracing, V type bracing and X type bracing are compared. Parameter compared are includes Base reactions, Maximum displacement of member, Nodal displacements, Nodal rotation for a fixed base steel structure."

PROBLEM STATEMENT

A. Geometrical data used for analysis purpose is as follows:

- No. of bay in X – dir.:3
- No. of bay in Z – dir.: 3,
- Plan Dimension: 15m X 15 m,
- Typical Storey Height: 3.0 m,
- Bottom Storey Height: 3.0 m
- Height of structure: 24 m
- Number of storey: G + 7
- Type of Building: Steel Structure

B. Loading on steel structure;

- Slab thickness =200mm.
- Live Load: 3kN/m^2
- Basic wind speed: 44 m/sec
- Terrain category: IV
- Class: B
- Risk coefficient factor: 1.0- From table 1-IS 875 (part3)-1987
- Topography factor k3: 1.0-Slope less than 3 deg
- Load combinations: 1.2DL+1.2LL+1.2WL

C. Member Size Data

All members having c/s of 200 mm * 200mm

LOAD CALCULATION

For the analysis purpose, dead, live and wind load is calculated for the frame as shown in Fig. 2.

A. *Dead Load calculations:*

- Density of concrete =25kN/m^3
- Hence, self-weight of Slab = 5 kN/m^2
- Dead load on the outer beam =8.33 kN/m
- Dead load on the inner beam=2 * 8.33=16.67 kN/m

B. *Live load calculations are as follows:*

- Live load on the outer beam=5 kN/m
- Live load on the inner beam=5*2=10 kN/m

C. *Wind load calculation-(IS 875 (part 3)-1987)*

- k_2 at 18m=0.76
- k_2 at 21m=0.777
- k_2 at 24m=0.828
- Using $Vz=k_1 * k_2 * k_3 * V_b$
- Where, Vz=design wind speed at any height z in m/s
- k_1= probability factor(risk coefficient)
- k_2= terrain, height and structure size factor and
- k_3= topography factor
- V_b= basic wind speed in m/s
- Therefore, Vz at 18m=33.44 m/s
- Vz at 21m=34.188 m/s
- Vz at 24m=36.432 m/s
- Using $Pz= 0.6 * Vz^2$
- Where, Pz= design wind pressure in N/m2
- P_z at 18m = 0.6709 kN/m^2
- P_z at 21m = 0.7013 kN/m^2
- P_z at 24m= 0.7937 kN/m^2

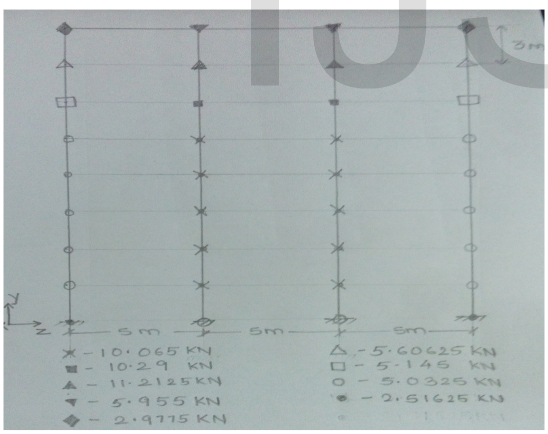

Fig. 2. Structural skeleton

RESULT ANALYSIS

In this paper, G+7 storey building model has been analysed considering different types of bracing system under wind loading using STAAD Pro V8i SS6. Details of analysis of nodal, section displacement and base reaction for unbraced, diagonal, V, Inverted V and X shaped bracing is given in Table 1 and 2.

Table1. Details of nodal, section displacement and base reaction for Unbraced and Diagonal shape bracing

Types of Bracings →		**Unbraced Frame**	**Diagonal bracing**
Nodal Displacement	X mm	17	3
	Z mm	21	3
	Xr	0.011	0.002
	Zr	0.059	0.002
Section Displacement	Max Disp.	31	4
Base Reaction	Rx kN	27.009	57.19
	Ry kN	1661.838	1491.386
	Rz kN	21.641	49.488
	Mx kNm	58.512	31.232
	My kNm	0.262	0.732
	Mz kNm	88.948	65.07

Table 2. Details of nodal, section displacement and base reaction for V, Inverted V and X shaped bracing

Types of Bracings →		**V bracing**	**Inverted V bracing**	**X bracing**
Nodal Displacement	X mm	3	3	4
	Z mm	2	2	4
	Xr	0.001	0	0.001
	Zr	0.002	0.002	0.002
Sec Displacement	Max Disp	1	1	1
Base Reaction	Rx kN	54.361	45.649	249.768
	Ry kN	1493.134	1488.473	1488.346
	Rz kN	63.21	54.841	283.406
	Mx kNm	15.385	33.118	26.799
	My kNm	0.803	0.811	1.621
	Mz kNm	63.608	63.584	71.044

The displacement in unbraced frame is reduced by 87% by providing diagonal bracing and 96% by providing X,V, inverted V bracing as shown in Fig. 3

Nodal displacement in Z direction is reduced by 82% for diagonal, V & inverted bracing, 77% for X bracing. The nodal displacement in Z direction is reduced by 86% for diagonal bracing, 90% for V & inverted bracing, 81% for X bracing (refer Fig. 4).

The nodal rotation in Z direction is reduced by 96% for diagonal , V ,inverted V, X bracing . The nodal rotation in Z direction is reduced by 82% for diagonal bracing, 90% for V & X bracing, inverted V bracing as shown Fig. 5. Though wind load on X and Z direction are same Fig. 6 shows that the base shear in X and Z direction is different. The vertical reaction in case of all bracings is reduced by 10% (refer Fig. 7). The moment in Z direction for diagonal, V, Inverted V bracing is reduced by 27% and for X bracing is reduced by 20% as shown in Fig.8.

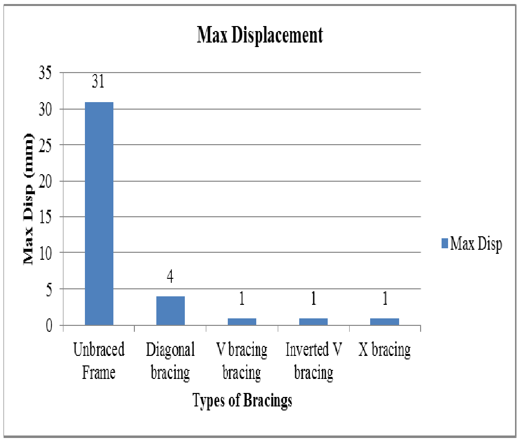

Fig. 3 Maximum displacement

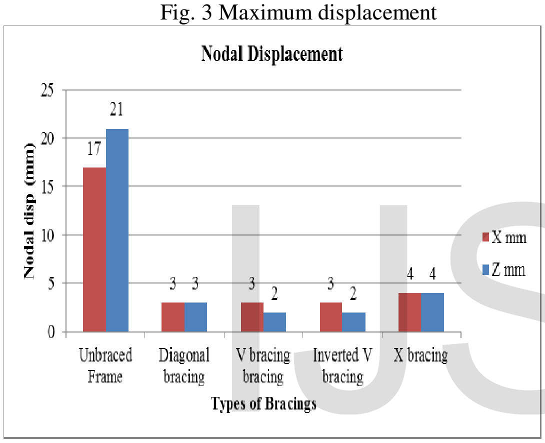

Fig. 4. Nodal displacement

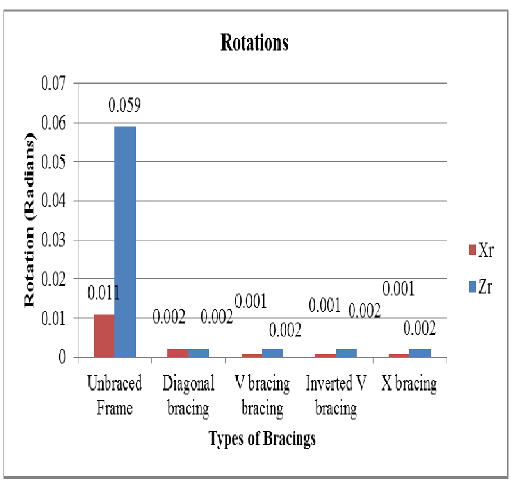

Fig. 5. Rotations

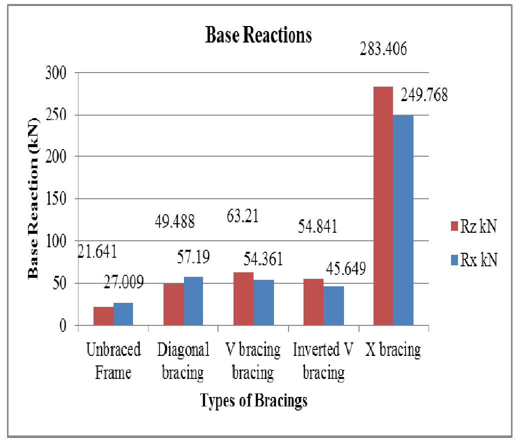

Fig. 6. Base Reaction

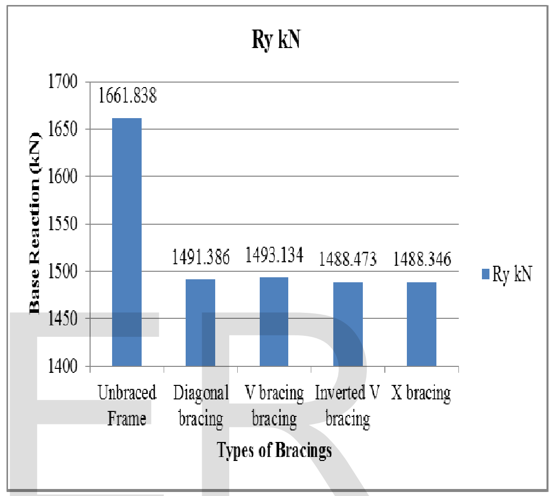

Fig. 7. Vertical reaction

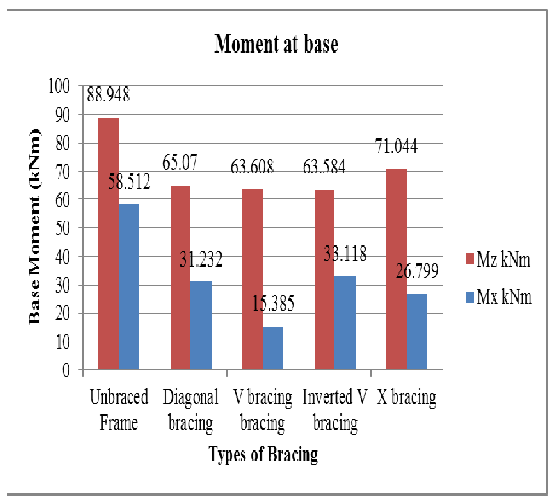

Fig. 8. Moment at the base

The moment in Y direction (torsional moment) is increased for all bracings and same is given in Fig. 9.

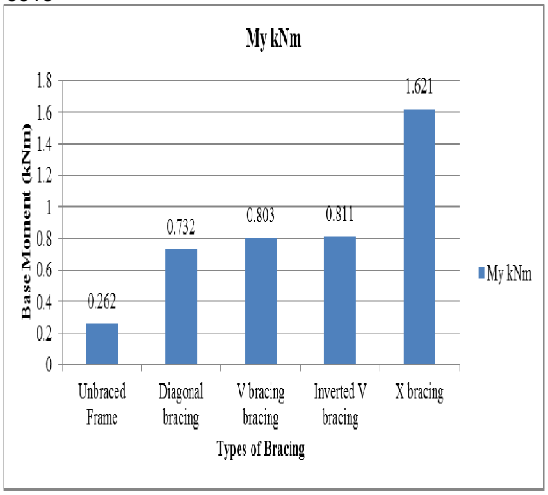

Fig. 9. Moment in Y Direction

CONCLUDING REMARK

G+7 storey building model has been analyzed considering different types of bracing system under wind loading using STAAD Pro V8i SS6. It can be concluded from the analysis of nodal, section displacement and base reaction for unbraced, diagonal, V, Inverted V and X shaped bracing that:

- Due to bracing, displacement of the structure gets reduced considerably that is up to 90% but in case of X-bracing material required will be more and hence V or Inverted V bracing effectively resist the displacement as compared to all other types of bracings.
- The nodal displacement is effectively resisted by V and inverted V bracing
- Rotation is almost negligible but rotation is mainly depending on geometry of the structure and present study structure is symmetric and hence may be the rotation is negligible.
- Axial reaction is reduced and hence the footing size also gets reduced due to provision of bracings.
- Also reduction in moment at base will definitely help to reduce the size of footing.
- Due to bracing the torsional moment in base column increases.

REFERENCE

[1] IS 875(part 3) 1987- Indian Standards- Code of practice for design loads (other than earthquake) for buildings and structures. Part 3-wind loads (second revision)