# Seismic Analysis of G+5 Steel Structure using Bracings

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***Abstract—****This paper compares the lateral drift, strain energy released and the stress in the elements of the G+5 steel structure using different orientation of bracings in ANSYS 14.5 to find the most optimum orientation.*

*Keywords—ANSYS 14.5, Lateral drift, Seismic analysis, steel strucutre, bracing profiles*

## I. Introduction

One of the most devastating natural disasters that occur in the world is earthquakes that are generated due to the movement of tectonic plates that lie below the crust and also due to volcanic activity. They have different durations lasting from a few seconds to minutes and also of varying intensity. The ground experiences shaking under the effect of earthquakes which causes structures to experience high frequency movements induced by the inertial forces in the structure and its components, i.e., the structure's tendency to remain in its original position irrespective of ground movement. One of the main difficulties when a building is a seismically active zone is the lateral stability of the structure. This is due to external forces by the earthquakes that cause large deflections which in turn cause large internal forces in the structure. Any structure has its own displacement capacity, i.e., the amount of horizontal displacement induced is limited. This is addressed by using bracings that have large plastic deformation before failure and they are categorized into the eccentric, concentric and knee braced systems. This paper will consider only concentric braced systems.

The X bracing system is found to have the most reduction in lateral sway but it increases the axial load in columns[1]. The pushover analysis, i.e., on a steel frame has found that there is a 70-80 % reduction in displacement of braced frames using iSA, ISMV & ISMB sections as bracings[2]. X Bracing is found to be the most effective in reducing sway at the top in low rise [3]. Knee braced frames are found to be favourable when compared to conventional and unbraced frames[4]. Diagonal bracings arranged in a diagonal pattern reduce bending moment, shear force and lateral displacement for high rise structures[5]. High rise structures best reduction in displacement when using braced frames[6]. Analysis of high rise structures using Y bracings in pushover analysis shows that the energy absorbing is higher when compared to conventional and unbraced frames[7]. High rise SMRF structure shows least sway in case of X braced concentric bracing and even inverted V type bracing system also showed promising values[8].

## II. Research Methodologies

The G+5 structure was modelled in ANSYS 14.5 with base shear corresponding to zone IV according to IS 1893(Part 1) and the base shear was calculated according to the Cl.6.4.2. Throughout the entire analysis the dimensions used for loads is Newton (N) and for distances is millimetre (mm). The geometric portion of the structure was modelled and the sections chosen were inputted into the software. The meshing of the element sections were given during the input of the sections. The material properties of steel such as Poisson's ratio, Young's Modulus and density are also given as input. Then the meshing of the structure is done and the assigning of the section property and material property along with the number of divisions is also specified. The loading conditions of the structure is then assigned according to Cl.6.4.2 IS 1893 (Part 1) and the base of the structure is fixed. The analysis is done for the unbraced structure and also for the braced structures. The following braced systems are used:

- X Bracings
- V Bracings
- Inverted Bracings
- K Bracings
- Reverse K Bracings
- Diamond Bracings

The most effective bracing that reduces lateral sway when compared to the unbraced structure is to be found by comparing the above mentioned bracing systems.

## III. Analytical Study

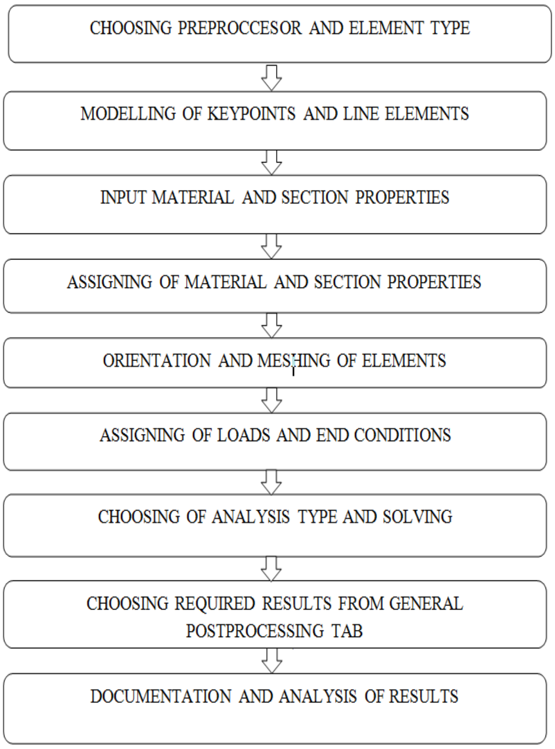


Fig 1. Flow of work in ANSYS

The results are then analysed to find the bracing system with the least deflection along with the corresponding stress in elements and strain energy released

## IV. Analysis

### *A. Data assumed for G+5 Building*

1. No. Of storeys=G+5
2. Plan Area of Structure=21x21 $m^2$ (C/C d/s)
3. Seismic Zone Area=IV (Delhi)
4. Dimensions of beam =ISMB 300
5. Dimensions of Column= ISHB 400
6. Dimensions of Bracings= ISMB 200
7. Height Of storey= 3.5 m
8. Length of Bay=3.5m
9. No. Of bays= 6

### *B. Load Conditions*

1. Self weight of the components
2. Live load of 2 KN/m as per IS 1893 (Part II)
3. Base shear as per CL 6.4.2 IS 1893 (Part 1)

### C. *ANSYS Preferences*

1. Pre-processing type- Structural
2. Element Type- BEAM189
3. Analysis Type- Static
4. No. of divisions of elements-10
5. Support Conditions of Base- Fixed

Table 1. Sectional and Material Properties

| | **Beam** | **Column** | **Bracings** |
|---|---|---|---|
| Name of Section | ISMB 300 | ISHB 400 | ISMB 200 |
| Height of Section | 300 mm | 400 mm | 200 mm |
| Breadth of Flange | 140 mm | 250 mm | 100 mm |
| Thickness of Flange | 12.4 mm | 12.7 mm | 10.8 mm |
| Thickness of Web | 7.5 mm | 9.1 mm | 5.7 mm |
| Weight of Section | 433.6 N/m | 759 N/m | 249.2 N/m |
| Young's Modulus | $2*10^5$ N/mm$^2$ | $2*10^5$ N/mm$^2$ | $2*10^5$ N/mm$^2$ |
| Poisson's ratio | 0.26 | 0.26 | 0.26 |
| Density | $7.681*10^{-5}$ N/mm$^3$ | $7.681*10^{-5}$ N/mm$^3$ | $7.681*10^{-5}$ N/mm$^3$ |

## V. Results and Discussion

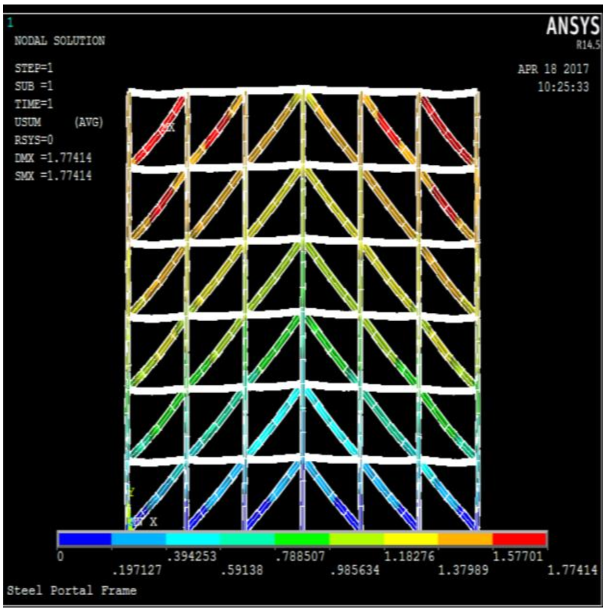


Fig 2. Sample Deflection for Inverted V Bracing System

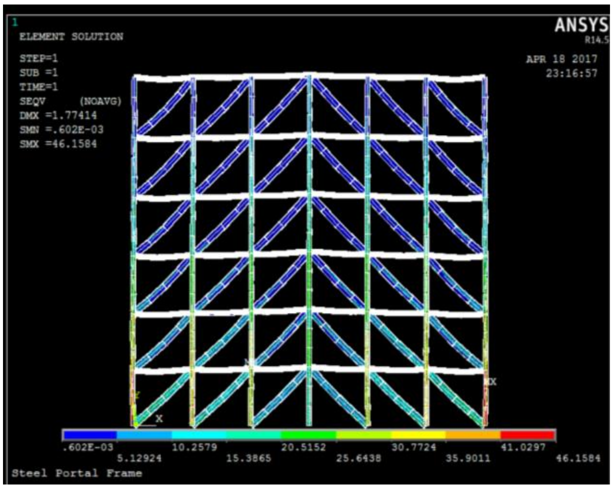


**Fig 3. Sample Von Mises Stress in Inverted V Braced Frame (N/mm$^2$)**

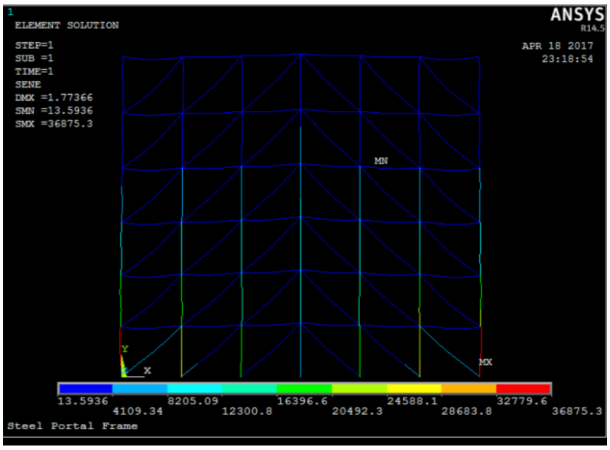


**Fig 4. Sample Strain Energy Released in Inverted V Bracing (N-mm)**

Table. 2. Deflection of storeys in mm

| | **Unbraced System** | **X Braced System** | **Diamond Braced System** | **K Braced System** | **Reverse K Braced System** | **V Braced System** | **Inverted V Braced System** |
|---|---|---|---|---|---|---|---|
| 6th storey | 9.2798 | 1.0209 | 1.6266 | 1.901 | 2.0796 | 0.95181 | 1.5232 |
| 5th storey | 8.486 | 0.98325 | 1.5777 | 1.9349 | 2.0337 | 0.90201 | 1.4957 |
| 4th storey | 7.1249 | 0.89729 | 1.4338 | 1.9275 | 1.9791 | 0.80409 | 1.3877 |
| 3rd storey | 5.2615 | 0.76687 | 1.2002 | 1.9317 | 1.9381 | 0.66225 | 1.1979 |
| 2nd storey | 3.1405 | 0.573 | 0.84176 | 1.4227 | 1.4086 | 0.48705 | 0.91767 |
| 1st storey | 1.1123 | 0.32945 | 0.46252 | 0.78334 | 0.75903 | 0.2839 | 0.53291 |

Table 3. Max Von Mises Stress in Components (N/mm$^2$)

| | **Unbraced** | **X** | **Diamond** | **K** | **Reverse K** | **V** | **Inverted V** |
|---|---|---|---|---|---|---|---|
| Max Stress in components | 32.5723 | 41.984 | 29.8713 | 45.662 | 46.2041 | 35.6579 | 46.1584 |

Table 4. Max Strain Energy released by Structure (N-mm)

| | **Unbraced** | **X** | **Diamond** | **K** | **Reverse K** | **V** | **Inverted V** |
|---|---|---|---|---|---|---|---|
| Max Strain energy released | 12861.8 | 15657.4 | 14102.5 | 12247.6 | 12384.4 | 26518 | 36875.3 |

1. From the data it is clear that the deflection in V braced is the least but the X braced system also can be effective in reducing sway.
2. The strain energy in V is among the larger of the systems considered and though the X bracing system has a slightly higher deflection the strain energy of itself is slightly higher than the unbraced frame.
3. The strain energy is the least in K and reverse K braced systems, even with strain energy lower than that of the unbraced frame.

**4.** In terms of the Von Mises stress induced in the components, Diamond braced system has the least, even lower than the unbraced system, while the max stress is induced in reverse K braced system.

**5.** The Von Mises stress induced in both X and V bracing systems are slightly higher than that of the unbraced system

## VI. CONCLUSION

In this study, the G+5 steel structure undergoes least deflection when using the V braced structure. The deflection in the X braced system is only slightly higher than that of the V braced system.

The Von Mises induced in the components when comparing these 2 systems with that of the unbraced system is only slightly higher with the V braced systems being the lesser of the 2.

The strain energy released in the V braced frame varies greatly, releasing more than twice the energy, when compared with the unbraced frames. The X bracing system is only slightly higher than that of the unbraced frame.

Overall the X bracing is to be preferred even though its deflection reduction and Von Mises stress induced is lower than that of V bracing because of the large amount strain energy dissipation in that system.


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