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Seismic Behaviour of Steel Structures with Bracings Having Seismic Irregularity

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Abstract - *Steel is an important construction material and plays a very significant role in the developing societies. Construction is an industry where steel is used to a greater extent, exceeding use of 50% of world's steel. Structures such as home, parking lots, gardens, educational institutes, and high rise framed buildings- rely mostly on steel for their ductility and strength. Steel also offers good architectural view and it gives more freedom of design for structural engineers. Steel gives freedom for shape and maximum space of an area to be built with use of steel. The grouping of strength, ductility, attractiveness, preciseness and ductility permits architects wider possibilities to analyze enormous interpretation and establish various solutions.*

The object of the present work is to compare the seismic1732behavior of multi-storey steel buildings with and without bracing systems having seismic irregularities under seismic forces and observe the effect on the parameters as lateral displacement and storey drift. For this purpose three cases of multi-storey steel buildings having rectangular and C shape plan of 28m x 36m are considered having 8 storey, 10 storey and 12 storey. All the three cases are considered having vertical irregularity without bracing and with X and K bracing system and also analyzed for zone III, zone IV and zone V by using software Staad.Pro.

Observation shows that the provision of without bracing system is more flexible for seismic loadings as compared to different bracing systems. From the analysis result parameters lateral displacement and storey drift of the building increases from lower to higher zones because the magnitude of intensity will be more for higher zones.

Present work provides good information on the result parameters lateral displacement and storey drift in the multistory steel buildings having different types of bracings.

Key Words: **CBF, EBF, Vertical irregularity, Lateral displacement, Storey drift.**

1. INTRODUCTION

Steel is one of the most widely used materials for building construction all over countries. The inherent strength and toughness of steel are characteristics that are well suited to a variety of applications, and its high ductility is ideal for seismic design. To utilize these advantages for seismic applications, the design engineer has to be familiar with the relevant steel design provisions and their intent and must ensure that the construction is properly executed. This is especially important when welding is involved.

1.1 Bracing Frames

A braced frame is a structural system commonly used in structures subject to lateral loads such as wind and seismic pressure. The members in a braced frame are generally made of structural steel, which can work effectively both in tension and compression. The beams and columns that form the frame carry vertical loads, and the bracing system carries the lateral loads. The positioning of braces, however, can be problematic as they can interfere with the design of the façade and the position of openings. Buildings adopting high-tech or post-modernist styles have responded to this by expressing bracing as an internal or external design feature. Application on braced frames is typically used in which the beam and column are designed resist vertical loads only. Horizontal loads are resisted by bracing element to achieve lateral stability of the structures. The braced framing system able to achieve material savings with respect to moment resisting frame and control of frame drift due to lateral forces. Wind bracing system can be installed as longitudinal bracing or transverse bracing. A building also can be designed for combination of both longitudinal and transverse bracing. There are two types of braced frames: Concentrically braced frames and Eccentrically braced frames.

Concentrically braced frames are conventionally designed braced frames in which the centre lines of the bracing members cross at the main joints in the structure, thus minimizing residual moments in the frame. The pros and cons of braced frames are essentially the opposite of moment frames; they provide strength and stiffness at low cost but ductility is likely to be limited and the bracing may restrict architectural planning.

In Eccentrically braced frames, some of the bracing members are arranged so that their ends do not meet concentrically on a main member, but are separated to meet eccentrically. The eccentric link element between the ends of the braces is designed as a weak but ductile link which yields before any of the other frame members. It therefore provides a dependable source of ductility and, by using capacity design principles, it can prevent the shear in the structure from reaching the level at which buckling occurs in any of the members. The link element is relatively short and so the elastic response of the frame is similar to that of the equivalent CBF. The arrangement thus combines the advantageous stiffness of CBFs in its elastic response, while providing much greater ductility and avoiding problems of buckling and irreversible yielding which affect CBFs in their post-yield phase.

2. PROBLEM FORMULATION & ANALYSIS

The object of the present work is to compare the seismicbehavior of multi-storey steel buildings with and without bracing systems having horizontal and vertical irregularities under seismic forces. For this purpose rectangular and C shape plan in all the models is considered. Following are the details of the buildings considered:

Shape of building:	Rectangular C shape
Area of building:	28 m x 36 m
Stepped vertical irregularity:	Top 4 storeys
Number of storeys:	8, 10, 12 storey
Storey height:	3.2 m
Column grid:	4 m x 4 m

All the models are analyzed for zone III, zone IV and zone V by using Staad.Pro software. To study the behavior the response parameters selected are lateral displacement and storey drift.

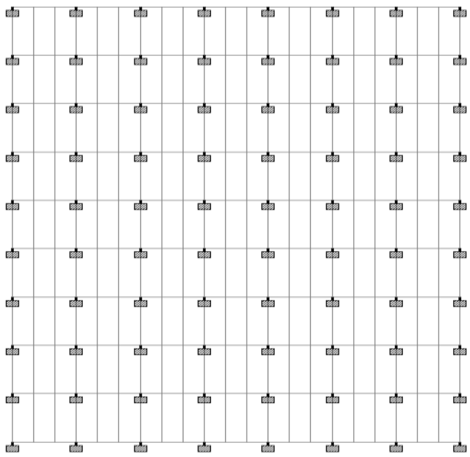

Fig -1: Plan of vertical irregular building

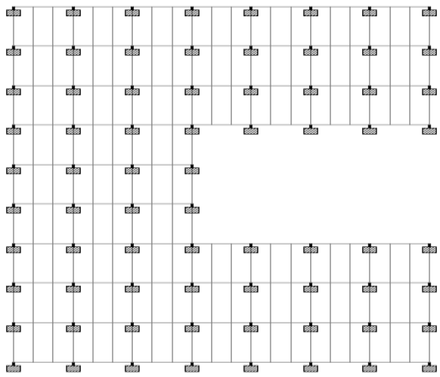

Fig -2: Plan of horizontal irregular building

3. RESULTS AND DISCUSSIONS

The study examines the performance of multi-storey steel buildings with horizontal and vertical irregularities having bracing systems for seismic forces in zone III, zone IV and zone V. As it is discussed earlier that irregularity makes the structure flexible under seismic loading, therefore, in present work it is analyzed by using bracing systems.
To study the effectiveness of all the models considered, the displacement, storey drift and base shear are worked out. The results organized in various tables and figures are discussed in detail.

3.1 Effect of parameters studied on storey drift

1. According to IS:800:2007, clause: 5.6.1 table 6, maximum limit for storey drift is H/300 where H is storey height in mm. Here, for 3.2m height, though maximum drift will be 10.67mm
2. It is observed from results that for all the cases considered drift values follow approximately a parabolic path along floor height with maximum value lying somewhere near the third or fourth storey.
3. It is observed here that in all the models drift values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones.
4. Drift values slightly increases in case of K bracings as compared to X bracings but in comparison to without bracings storey drift is less in with bracings models.
5. From the results it is observed that storey drift values increases with increase in number of storey for all the models both with bracings and without bracings.
6. In all the models as results compared in terms of X and Z directions, storey drift values increases in Z direction models for all the zones.
7. In comparison to horizontal and vertical irregularity the models having horizontal irregularity gives lower values of storey drift than models with vertical irregularity.
8. In the 8 storey models from zone III to zone V for X direction in without bracing drift values varies from 1.52mm to 8.82mm, in X bracing it varies from 2.04mm to 5.46mm and in K bracing it varies from 1.98mm to 5.70mm. Also in Z direction in without bracing drift values varies from 1.55mm to 9.21mm, in X bracing it varies from 2.11mm to 5.77mm and in K bracing it varies from 2.32mm to 5.80mm.
9. In the 10 storey models from zone III to zone V for X direction in without bracing drift values varies from 1.57mm to 8.98mm, in X bracing it varies from 2.14mm to 6.0mm and in K bracing it varies from 2.23mm to 6.52mm. Also in Z direction in without bracing drift values varies from 1.25mm to 7.78mm, in X bracing it varies from 1.96mm to 5.28mm and in K bracing it varies from 2.24mm to 6.05mm.
10. In the 12 storey models from zone III to zone V for X direction in without bracing drift values varies from 1.79mm to 9.85mm, in X bracing it varies from 1.9mm to 6.09mm and in K bracing it varies from 2.09mm to 6.46mm. Also in Z direction in without bracing drift

values varies from 1.26mm to 9.01mm, in X bracing it varies from 1.92mm to 5.62mm and in K bracing it varies from 2.13mm to 5.99mm.

11. As limiting values of storey drift is 10.67 mm, according to this all the models are safe within permissible limits.

3.2 Effect of parameters studied on displacement

1. According to IS:800:2007, clause: 5.6.1 table 6, maximum limit for lateral displacement is H/500, where H is building height. For 8 storey building model it is 51.2mm, for 10 storey building model it is 64mm, for 12 storey building model it is 76.8mm.
2. It is observed from table nos. 6.1 to 6.18 and figure nos. 6.1 to 6.18 that for all the models considered displacement values follow around similar gradually increasing straight path along floor height.
3. In all the models displacement values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones.
4. The lateral displacement is maximum at the top storey and least at the base of the structure.
5. As compared to X bracings and K bracings, values of displacement are more in K bracings for all the models.
6. From the results it is observed that displacement values increases with increase in number of storey for all the models both with bracings and without bracings.
7. In all the models as results compared in terms of X and Z directions, displacement values increases in Z direction models for all the zones.
8. In comparison to horizontal and vertical irregularity the models having horizontal irregularity gives lower values of displacement than models with vertical irregularity.
9. In the 8 storey models from zone III to zone V for X direction in without bracing displacement values varies from 2.75mm to 54.10mm, in X bracing it varies from 1.95mm to 40.07mm and in K bracing it varies from 2.83mm to 43.3mm. Also in Z direction in without bracing displacement values varies from 3.21mm to 57.31mm, in X bracing it varies from 2.06mm to 42.7mm and in K bracing it varies from 3.94mm to 47.73mm.
10. In the 10 storey models from zone III to zone V for X direction in without bracing displacement values varies from 2.48mm to 68.96mm, in X bracing it varies from 1.83mm to 53.93mm and in K bracing it varies from 1.95mm to 57.87mm. Also in Z direction in without bracing displacement values varies from 2.2mm to 58.6mm, in X bracing it varies from 1.71mm to 48.86mm and in K bracing it varies from 1.9mm to 55.06mm.
11. In the 12 storey models from zone III to zone V for X direction in without bracing displacement values varies from 1.95mm to 88.88mm, in X bracing it varies from 1.43mm to 64.38mm and in K bracing it varies from 1.54mm to 67.8mm. Also in Z direction in without bracing displacement values varies from 2.0mm to 78.43mm, in X bracing it varies from 1.47mm to 60.46mm and in K bracing it varies from 1.6mm to 63.75mm.
12. As limiting value of displacement in 8 storey is 51.2mm, in 10 storey is 64mm and in 12 storey it is 76.8mm. In 8 storey models are safe in zone III and zone IV but in zone V it fails in case of without bracing only on top storey although it is safe in case of with bracings models. In 10 and 12 storey models are safe in zone III and zone IV but in zone V it fails in case of without bracing only on top two storeys although it is safe in case of with bracings models.

4. CONCLUSIONS

Within the scope of present work following conclusions are drawn:

1. In all the considered building models drift values follow approximately a parabolic path along floor height with maximum value lying somewhere near the third or fourth storey both in X and Z directions for models with bracings and without bracings.
2. Displacement values follow around similar gradually increasing straight path along floor height.
3. For all the models drift values and displacements are less for lower zones and it goes on increases for higher zones.
4. Displacement values are maximum at top storey and least at the base of structure in all the models both in X and Z directions for with bracings and without bracings.
5. In comparison to horizontal and vertical irregularity the models having horizontal irregularity gives lower values of displacement and storey drift than models with vertical irregularity.
6. It is experienced in all the models that the values of drift and displacement are less in case of X bracings as compared to K bracings models, whereas in comparison to with and without bracings models with bracings are safe within permissible limits.
7. As per the case study review, storey displacement and storey drift values are greater in case of irregular buildings (vertical irregularity) as compared to regular buildings.

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