Seismic Analysis of Braced Steel Frames

Yatendra Singh, Yudhvir Yadav, Kumari Kshama, Saurav Kumar, Neha

***Abstract:** The study of braced steel frame response is widely studied in many branches of Structural engineering. Many researchers have been deeply studying these structures, over the years, mainly for their greater capacity of carrying external loads. Every Special moment resisting frames undergo lateral displacement because they are susceptible to large lateral loading. As a consequence, engineers have increasingly turned to braced steel frames as a economical means for earthquake resistant loads. The present study consist a Steel Moment Resisting Frame (SMRFs) with concentric bracing as per IS 800 -2007. K bracing, Inverted V bracing, X bracing and an unbraced steel frame is considered for comparative study. Dimensions of each type of steel frame are similar having G+ 9 storeys, 30 m height. Each floor is of 3m height having four no. of bays along length (12m) and width (12m). The analysis is done by using standard package STADD pro. The comparison of these models for different parameters like Shear force, Bending Moment, Displacement, Storey drift and Lateral Forces has been presented by adding different types of bracings. Performance of each frame is studied through Equivalent static analysis.*

***Keywords:** (SMRFs), STADD, (12m) and width (12m)., 800 - 2007, Equivalent, Bending Moment, Displacement,*

I. INTRODUCTION

A. Theoretical Development

Bracing is a highly efficient and economical method to laterally stiffen the frame structures against wind loads. A braced bent consists of usual columns and girders whose primary purpose is to support the gravity loading, and Cross bracing members that are connected so that total set of members forms a vertical cantilever truss to resist the horizontal forces. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing the stiffness and strength against horizontal shear.

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II. TYPES OF BRACINGS

There are two types of bracing systems

1) Concentric Bracing System and
2) Eccentric Bracing System.

The steel braces are usually placed in vertically aligned spans. This system allows to obtaining a great increase of stiffness with a minimal added weight.

Concentric bracings increase the lateral stiffness of the frame thus increases the natural frequency and also usually decreases the lateral storey drift. However, increase in the stiffness may attract a larger inertia force due to earthquake. Further, while the bracings decrease the bending moments and shear forces in columns and they increase the axial compression in the columns to which they are connected.

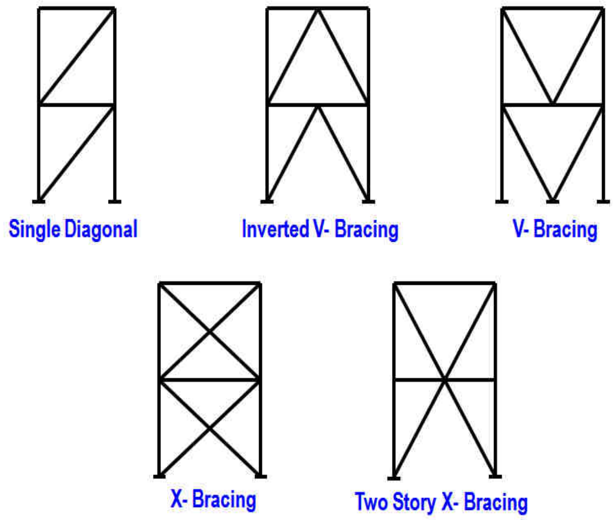

Fig.1. Different concentrically braced frames

Diagonal Bracing is preferred when the availability of the opening spaces in a bay of frame are required. Diagonal bracing is obstructive in nature as it blocks the location of opening which ultimately affects the aesthetic of the building elevation. It also sometimes hinders the passage for use. The full diagonal bracing is not used in areas where a passage is required. In such cases, k-bracings are preferred over diagonal bracing because there is a room to provide opening for doors and windows etc.

Eccentric Bracings reduce the lateral stiffness of the system and improve the energy dissipation capacity. The lateral stiffness of the system depends upon the flexural stiffness property of the beams and columns, thus reducing the lateral stiffness of the frame. The vertical component of the bracing forces due to earthquake causes lateral concentrated load on the beams at the point of connection of the eccentric bracings.

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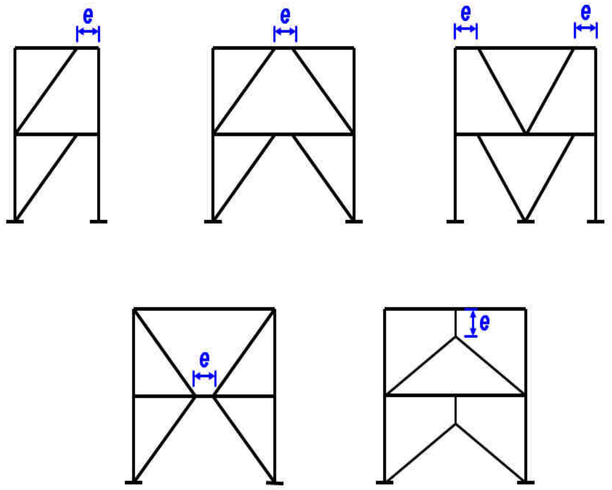


Fig.2. Different Eccentrically Braced Frames

III. STRUCTURAL MODELLING

The structure consisting of G+9 stories with four bays in horizontal direction and four bays in lateral direction is taken. The storey height is 3 metres and horizontal and lateral spacing of bays is 3 metres. The study in this thesis is based on basically on Equivalent Static analysis of steel frames with concentric bracing models. Different configurations of frames are selected such as K bracing, inverted V bracing and X bracing and analysed This chapter presents a summary of various parameters defining the computational models, the basic assumptions and the steel frame geometry considered for this study.

The seismic parameters of building site are as follows

- Seismic zone: 4
- Zone factor, Z: 0.24
- Building frame system: Steel moment resisting frame
- Response reduction factor: 5.0
- Importance factor: 1.0
- Damping ratio: 5%
- Storey height : 3 metres
- Seismic Analysis: Equivalent Static Analysis
- Steel Section used:

  For Beams and Columns- **I100012A40016**

  For Bracings – **ISA120×120×10**

IV. DESIGN OPERATIONS WITH STAAD.PRO

STAAD contains a broad set of facilities for designing structural members as individual components of an analysed structure. The member design facilities provide the user with the ability to carry out a number of different design operations. These facilities may be used selectively in accordance with the requirements of the design problem.

The operations to perform a design are:

- Specify the members and the load cases to be considered in the design.
- Specify whether to perform code checking or member selection.
- Specify design parameter values, if different from the default values

These operations may be repeated by the user any number of times depending upon the design requirements.

Steel Design may be performed according to several codes such as AISC-ASD (9th edition), AISC-LRFD, AISC 13th edition, AISI, AASHTO, etc. A brief description of each is presented in the following pages.

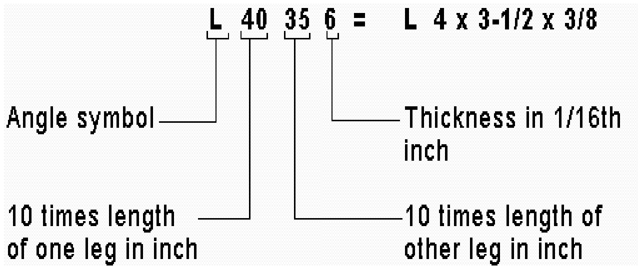
Currently, STAAD supports steel design of wide flange, S, M, HP shapes, tees, angle, double angle, channel, double channel, pipes, tubes, beams with cover plate and composite beams (I shapes with concrete slab on top).

A. Member Properties

For specification of member properties of standard American steel sections, the steel section library available in STAAD may be used. The syntax for specifying the names of built-in steel shapes is described in the next section. AISC Steel Table

B. Angles

Angle specifications in STAAD are different from those in the AISC manual. The following example illustrates angle specifications.



C. Tabulated Results of Steel Design

Results of Code Checking and Member Selection are presented in the output file. The output is clearly marked for the selected specification (ASIC 360).

The following details are presented on Code Checking of any member:

- Result of Code Checking (Pass / Fail) for the member Number.
- Critical Condition which governed the design and the corresponding Ratio and Location.
- Loads corresponding to the Critical Condition at the Critical Location.
- Section Classification
- Slenderness check report
- Section Capacities in Axial Tension, Axial Compression, Bending and Shear in both the directions.

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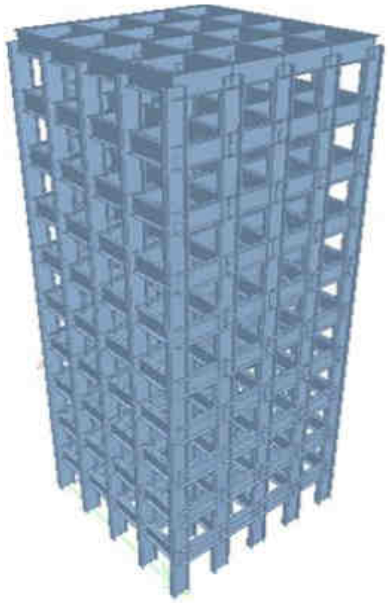

Fig.3. dimensional view of Steel building frame

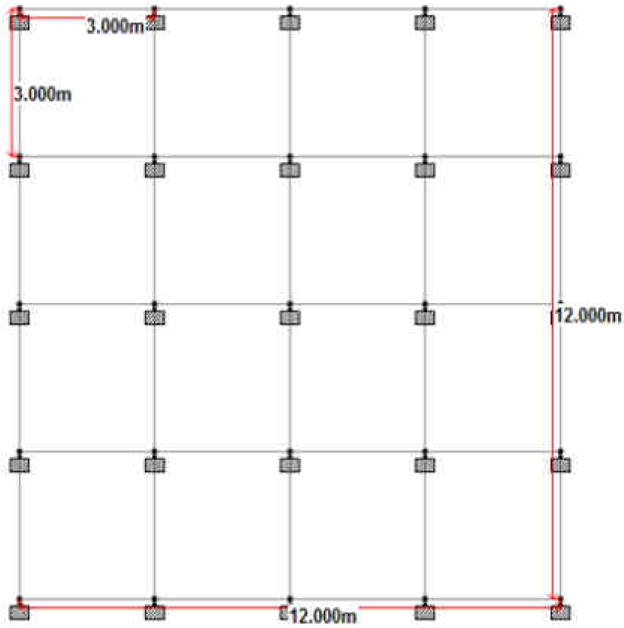

Fig.4. Plan of building

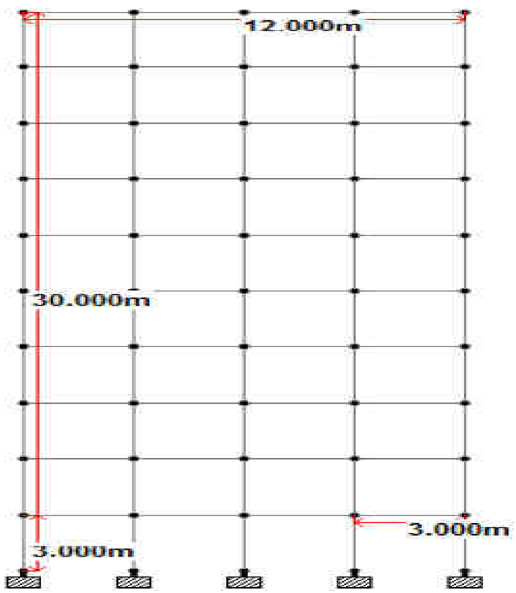

Fig.5. Elevation of building

Table Deflection at each storey level

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Table 1. Axial force at each storey level

Floor Level	Building without Bracings	Building with K Bracings	Building with inverted V Bracings	Building with X Bracings
1	838.933	745.534	830.623	917.543
2	733.231	665.567	745.321	764.435
3	630.253	580.642	652.826	655.453
4	529.612	496.853	550.324	552.564
5	431.853	412.324	448.465	480.563
6	337.922	329.832	373.324	380.453
7	252.344	250.652	284.453	290.453
8	173.93	170.634	200.432	212.453
9	104.397	102.733	106.422	110.675
10	46.045	40.642	54.732	58.453

Table 2. Shear force at each storey level

Floor Level	Building without Bracings	Building with K Bracings	Building with inverted V Bracings	Building with X Bracings
1	46.101	40.876	36.572	34.756
2	40.115	38.312	37.234	25.876
3	37.807	29.553	36.95	23.675
4	36.341	29.444	35.043	22.234
5	34.581	28.671	34.454	20.933
6	32.106	26.762	32.541	19.245
7	28.626	24.342	29.55	17.016
8	23.879	20.859	25.485	14.059
9	17.531	16.303	20.541	10.076
10	8.264	7.567	14.01	6.654

V. RESULT AND DISCUSSION

A. General

The purpose of this project is to study the behaviour of high rise structures in earthquakes zones when bracings are provided at different places and to compare those values obtained to get the desired structure which is best for

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resisting the earthquake action. This is done with the help of STAAD.Pro software.

B. Deflection pattern for different building

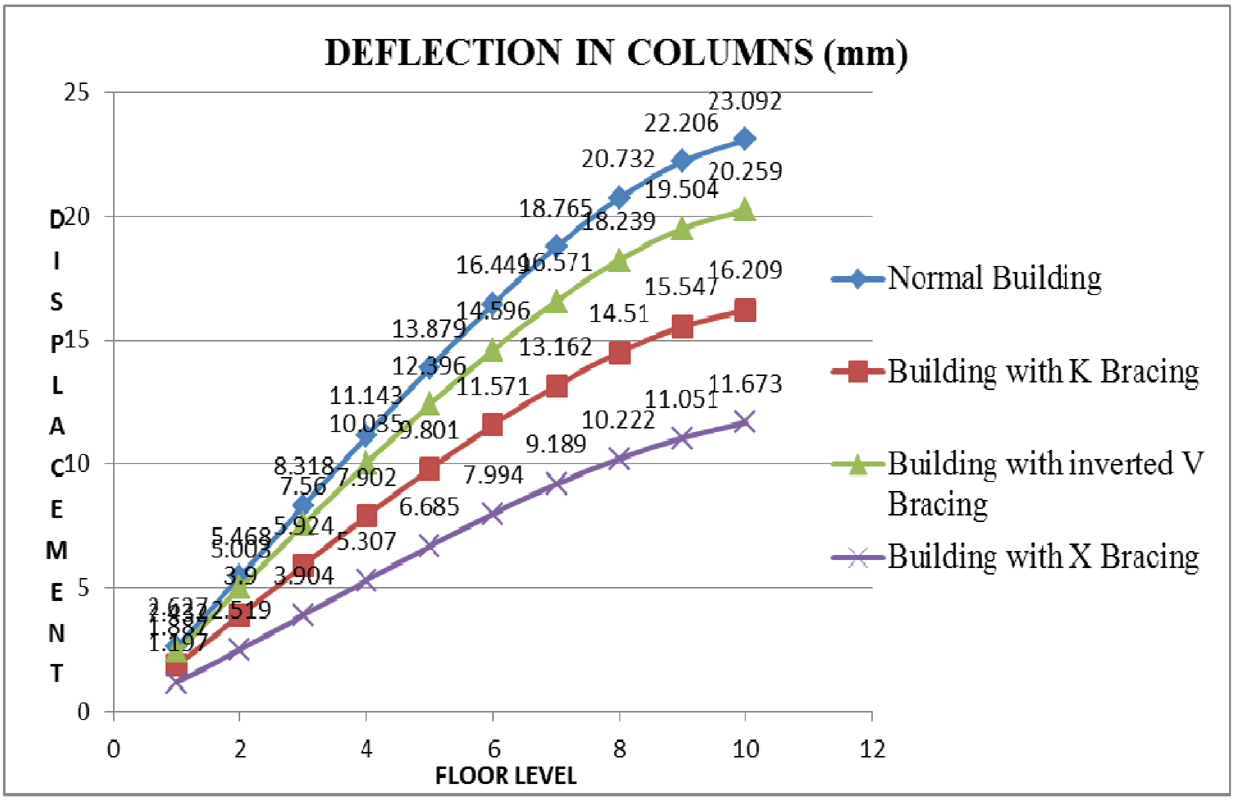

Fig. 6. Graph showing Storey deflection in all four cases

From figure 5.1, it can be observed that the deflection of normal building without bracings is much more as compared to other types of building. The least value of delection occurs in cross bracing throughout the building.

C. Variation of Axial Force,Shear force in Columns

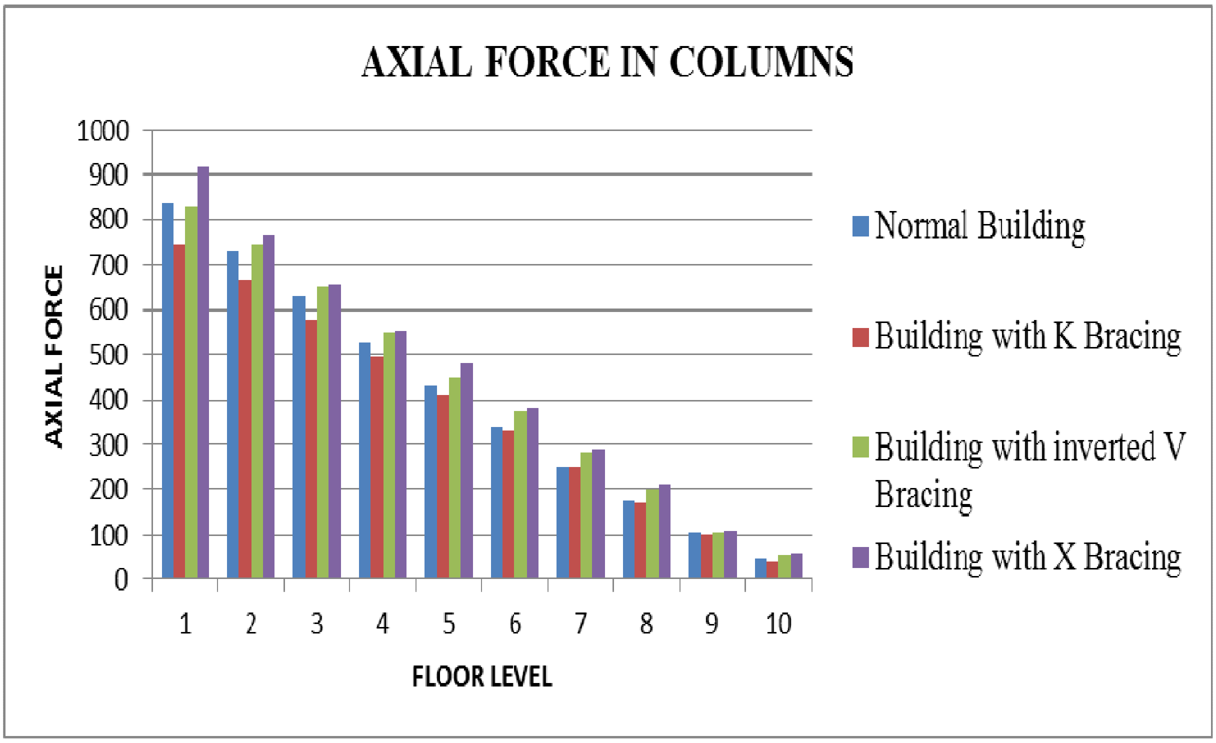

Fig.7. Comparision between axial force in columns

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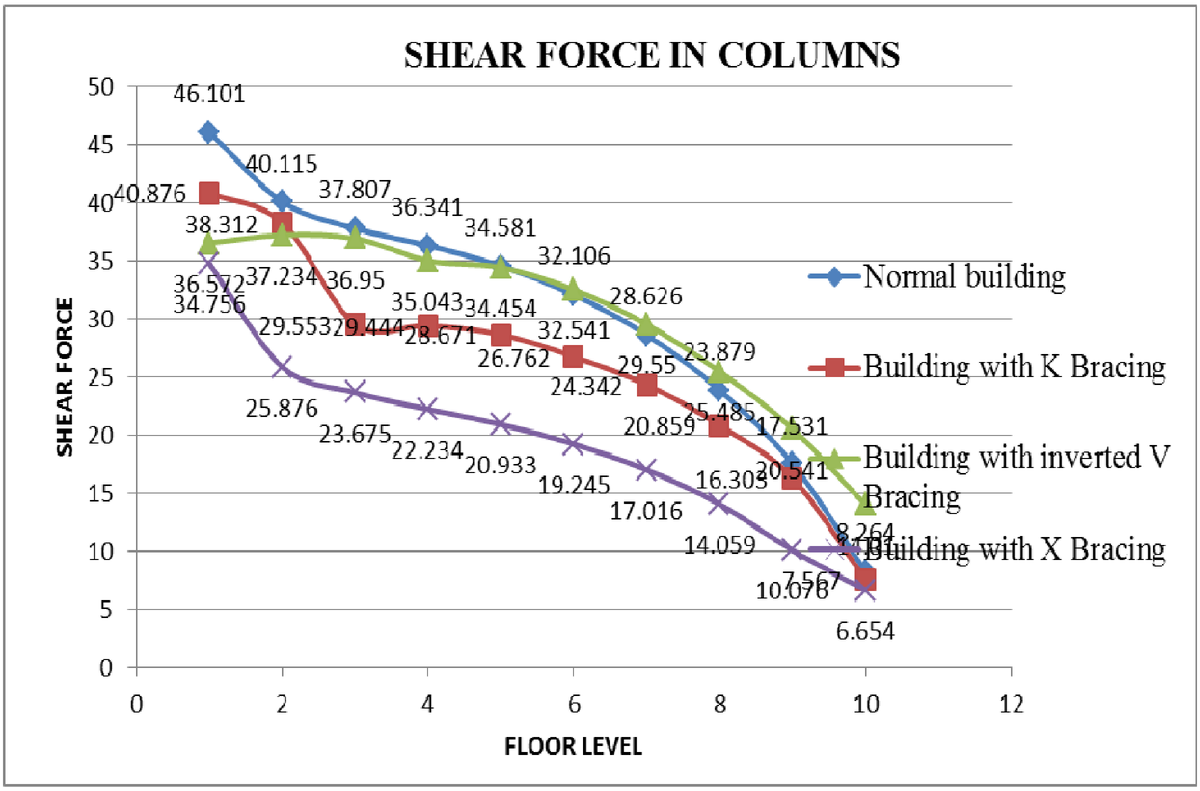

Fig.8. Comparision between Shear force in columns

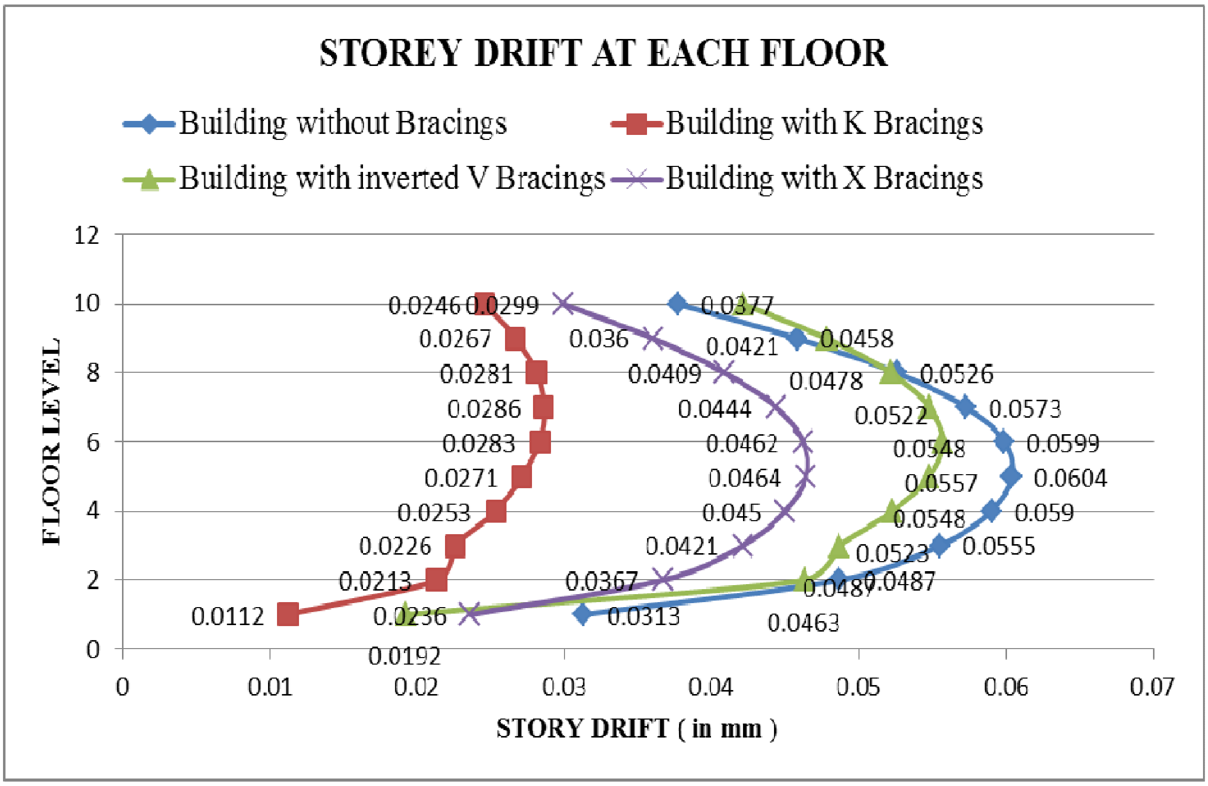

Fig .9. Graph Showing Storey Drift

From figure, the drift value for buildidng with X bracing is lesser than other arrangement of brcings.

VI. CONCLUSION

A. Summary

The selected frame models were analysed using equavalent static method. The 1st model was an asymmetric plan with a without braced moment resisting frame and then it was braced with K bracing, inverted V bracing and cross bracing. The bracings increased the stiffness and the frequency of the frame. Cross bracing is more stiffer than K bracing, inverted V bracing. Hence, for cross bracing maximum base shear was obtained as compared to other braced model and model without bracing. Bracing decrease the lateral displacement of the moment resisting frame. More stiffer the frame least is the story drift.

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B. Conclusion

- Braced steel frame have more base shear than unbraced frames.
- Cross bracing undergo more base shear than diagonal bracing.
- Bracings reduce the lateral displacement of floors.
- Cross bracing undergo lesser lateral displacement than diagonal bracing.
- Cross braced stories will have more peak story shear than unbraced and other braced frames.
- Axial forces in columns increases from unbraced to braced system.
- Shear forces in columns decrease from unbraced to braced system
- Bending moment in column decreases from unbraced to braced system. K braced and inverted V braced column undergo more bending moment than cross braced frame.
- Under the same bracing system and loading, system with larger height or more number of storys will have more base shear than the smaller one.

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