Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 14; July-September, 2015 pp. 36-41

http://www.krishisanskriti.org/jceet.html

Comparative Study of different Bracing Patterns for different Plan Irregularities of the Buildings

B. Preethi[1] and A. Mallika[2]

[1]PG (M.Tech), Structural Engg., Department of Civil Engineering VNR VJIET, Hyderabad, India,
[2]Department of Civil Engineering VNR VJIET, Hyderabad, India
E-mail: [1]bpreethi126@gmail.com

Abstract—*Tall Buildings are subjected to lateral movements or torsional deflections under the action earthquake loads. To prevent the lateral movement of the structure, the structure must be made sufficiently stiff with respect to lateral loads .To improve the lateral stiffness and lateral stability of the tall buildings, bracing the frame members is one of the methods popularly adopted. The present paper focuses on comparing the structural responses to lateral loads such as base shear, storey drift, lateral deflections and overturning movements for a tall building with different bracing patterns. Various bracing systems perform differently under lateral loads and gravity loads for different plan types. The bracing patterns studied in the present study are diagonal bracing, X-bracing, V-bracing and inverted V-bracing. Buildings with 30 m, 36 m and 42 m heights are considered for the present study and analyzed for dynamic loads and responses mentioned above are compared and presented. Dynamic analysis can take the form of a dynamic time history analysis or a linear response spectrum analysis. In the present paper, ETABS software is used for investigating the structural responses of Tall Buildings.*

Keywords*: Bracing Patterns, Tall Buildings, Storey Drift, lateral displacement, storey shear.*

1. INTRODUCTION

1.1 Irregular buildings

A structure can be classified as irregular if it contains irregular distributions of mass, stiffness and strength or due to irregular geometrical configurations. Different codes prescribe different limits for these irregularities like as per IS 1893:2002, a storey in a building is said to contain mass irregularity if its mass exceeds 200% than that of the adjacent storey. If stiffness of a storey is less than 60% of the adjacent storey; in such a case the storey is termed as „weak storey‟, and if stiffness is less than 70 % of the storey above, then the storey is termed as „soft storey‟. In reality, many existing buildings contain irregularity due to functional and aesthetic requirements. However, past earthquake records show the poor seismic performance of these structures. This is due to ignorance of the irregularity aspect in formulating the seismic design methodologies by the seismic codes *(IS 1893:2002, EC8:2004, UBC 1997, NBCC 1989, NBCC 2005 etc.)*

1.2 Lateral Load Resisting Frame Systems

Tall buildings are subjected to various types of loads during its service life time. It must be so designed to resist the gravitational and lateral forces, both permanent and transitory, that will be called on to sustain during its construction and subsequent service life.

- Gravity loads: i. Dead load

  ii. Live loads

- Lateral loads: i. Wind loads

  ii. Seismic loads

The essential role of the lateral resisting frame systems is to carry the wind and earthquake loads, as well as to resist P-Delta effects due to secondary moments in the columns. They transfer the sideways forces on the building to the ground. These systems could be classified into the following.

i) Moment Resisting Frames
ii) Shear Walls
iii) Braced Frames.

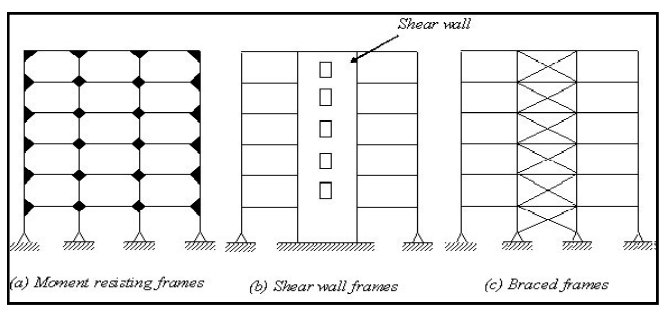

Fig. 1: Lateral load resisting systems

1.3 Braced Frames

Braced Frames (Fig.1) are usually designed with simple beam-to-column connections where only shear transfer takes place but may occasionally be combined with moment resisting frames. In braced frames, the beam and column system takes the gravity load such as dead and live loads. Lateral loads such as wind and earthquake loads are taken by columns, shear walls and bracing systems of braces. In the analysis, only the tension brace is considered effective. Braced frames are quite stiff and have been used in very tall buildings. Trussing, or triangulation, is formed by inserting diagonal structural members into rectangular areas of a structural frame. It helps stabilize the frame against sideways forces from earthquakes and strong winds.

1.4 Behaviour of bracing under Lateral loads:

The design of tall buildings is governed by the lateral forces induced due to wind and earthquakes. Braced frames are considered to be the most efficient to resist these lateral forces in either direction. The primary purpose of bracing is to resist horizontal shear induced due to the lateral forces. The mechanism to resist horizontal shear can be understood by following the path of horizontal shear along the frame. It can be explicated by considering the four types of bracings subjected to lateral loading. When diagonals are subjected to compression, the horizontal web members will undergo axial tension for equilibrium in lateral direction. This will result in shear deformation of braced bent. Forces and deformations in each member of braced bent will be inverted as the building is subjected to lateral loading in antithesis direction.

Behaviour of bracing under Gravity load:

Under the action of gravity loads, columns abbreviate axially due to the compressive loads. As a result the diagonals are subjected to compression and beam will undergo axial tension due to the tying action. In the cases where diagonals are not connected at the cessations of the beams, the diagonal members will not carry any force because no restraint is provided by the beams to develop force. Therefore, such bracing will not take part in resisting the gravity loads.

Types of bracing generally adopted are:
i. X-bracing
ii. Diagonal bracing
iii. V-bracing
iv. Inverted V-bracing

2. LITERATURE REVIEW

The literature review revealed that, there are very few reported research on bracing systems. Some countries are located in the earthquake zones where the buildings are designed to resist lateral loads.

Ashik S. Parasiya[1] has done a comparative study of RC brace frame structure with conventional lateral load resisting frame with different type of bracings and concluded that bracing system increases the stiffness and ductility of the structure on the application of the seismic force. Amlan k. Sengupta [2] has done on seismic vulnerability on residential and commercial buildings for three to ten Stories and concluded that retrofit measures for the structural deficient buildings. Mohamed Fadil Kholo Mokin[3] has done on multistory buildings of 10,20 and 30 stories, was carried out for different seismic zones and soil types. Concluded the values of displacements and base shears obtained in bracing structurural models, does not shows much variations, these values are found to be almost identical, this statement is true in all types of soils, for different heights and for all loading conditions.

3. PRESENT STUDY

In the present study 3 types of buildings with different plans with 3 different heights and with 4 different types of bracing patterns are considered.

In the present study Response Spectrum Method is used to find the responses of the structure.

- Rectangle building 25 m * 16 m in plan (regular)

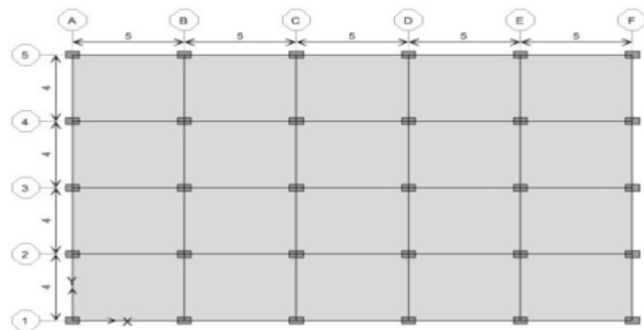

Fig. 2: Rectangular plan

- L-shape building 25 m * 24 m in plan(irregular**)**

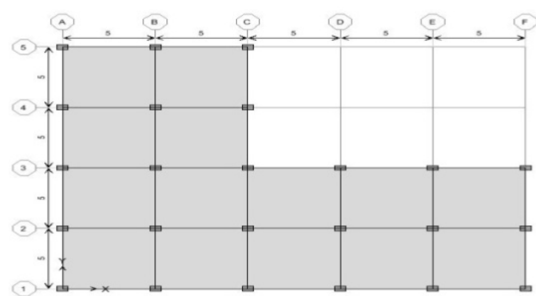

Fig. 3: L-shape plan

- T-shape building 24 m * 24 m in plan (irregular)

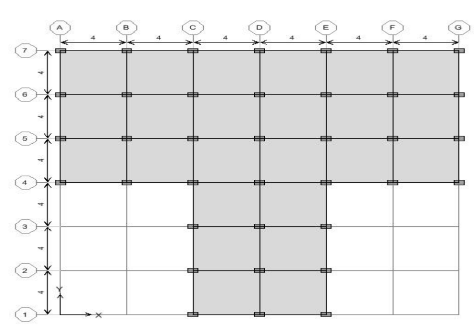

Fig. 4: T- shape plan

Table 1

Parameter	Description
Type of the structure	RCC Framed structure
Number of stories	G+9
floor to floor height	3.0 m , 3.6 m, 4.2 m
Walls thickness	230 mm
Grade of concrete	M 25
Grade of steel	Fe 415
Dead load & live load	IS 875 :1987 (part -1, part-2)
Live load	Floors=3 kN/m² Roofs =1.5 kN/m²
Size of the columns	0.4 m* 0.6 m
Size of the beams	0.4m*0.5 m
Slab thickness	125 mm
Bracing size	0.3 m * 0.3 m
Type of soil	Medium soils (type-II)
Floor finishes	1 kN/m²
Type of wall	Brick masonry
Seismic zone	V

Cases considered

Case (i)

Rectangular Buildings with 30 m, 36m, 42 m

- X –Bracings
- Diagonal Bracings
- V-Bracings
- Inverted V-Bracings

Case (ii)

L-Shaped Buildings with 30 m, 36m, 42 m

- X –Bracings
- Diagonal Bracings
- V-Bracings
- Inverted V-Bracings

Case (iii)

T-Shaped Buildings with 30 m, 36m, 42 m

- X –Bracings
- Diagonal Bracings
- V-Bracings
- Inverted V-Bracings

ETABs software is used to carry 3-D modeling and carryout the analysis. The lateral loads to be applied on the buildings are calculated based on the Indian standard as per IS-1893:2002.

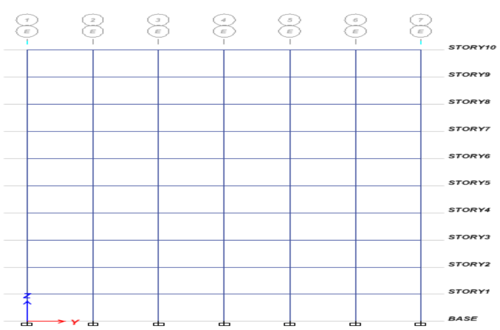

Fig. 5: elevations with different heights (30m, 36m, 42m)

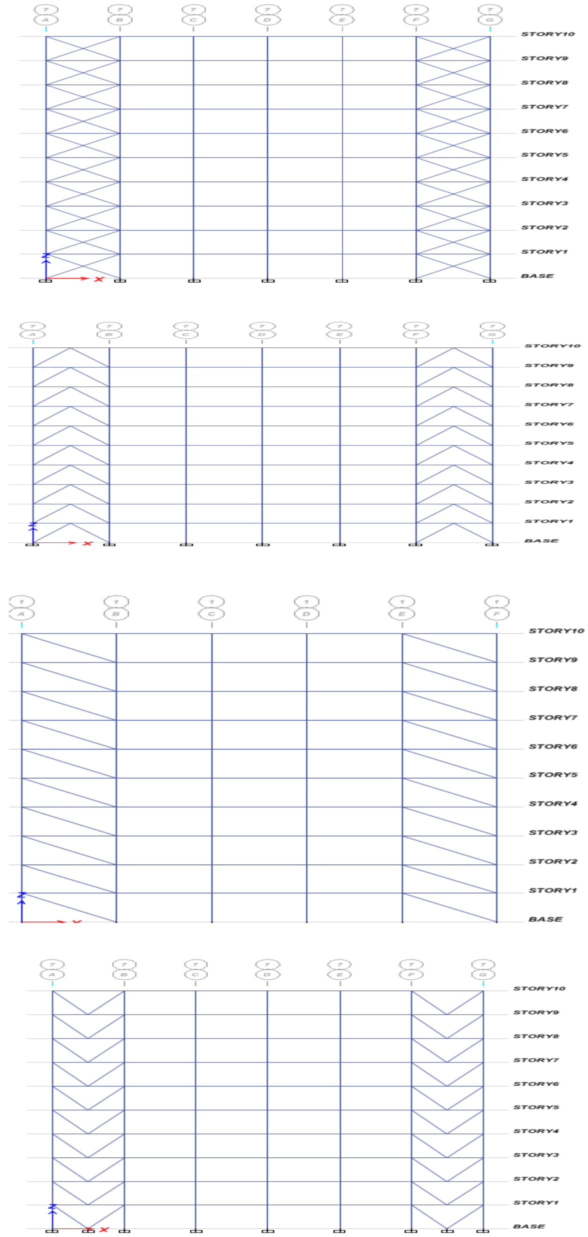

Fig. 6: Different types of bracings

3.1. LOAD CALCULATIONS

Loads and load combinations as per the Indian Standards.(IS 875:1983, IS 1893:2002, IS 456:2000).

➢ **Gravity loads:**

Floor load and member loads are calculated as per general considerations IS 875-part-1.

Live load for floors is taken as 3 kN/m^{2}for Residential Buildings and for roofs 1.5 kN/m^2 as per IS 875-part-2.

➢ **Wall loadings**:

Density of brick loading is taken as 20 kN/m^3, External wall thickness=230 mm, internal wall thickness=150 mm.

Height of the wall=3 m, 3.6 m and 4.2 m

For 3m:

External wall load=13.8 kN/m

Internal wall load=6.9 kN/m

For 3.6m:

External wall load =16.56 kN/m

Internal wall load =8.28 kN/m

For 4.2m:

External wall load =19.2 kN/m

Internal wall load =9.66 kN/m

- **Seismic loading**

Following assumptions are used for the calculation as per IS-1893:2002

Zone factor=0.36

Soil type – 2(medium soil)

Importance factor =1

Damping coefficient = 5%

Response reduction factor = 5

4. RESULTS AND DISCUSSIONS

The 3-D models discussed in the above section are modeled in ETABs software and is analyzed by Response Spectrum Method. The structural responses like lateral displacements, storey shears, storey drifts and over turning moment are compared and presented.

i. Maximum Lateral Displacement in X- direction

The comparative study of Maximum Lateral Displacements in structures with different bracing patterns is shown in graph below.

30 m height:

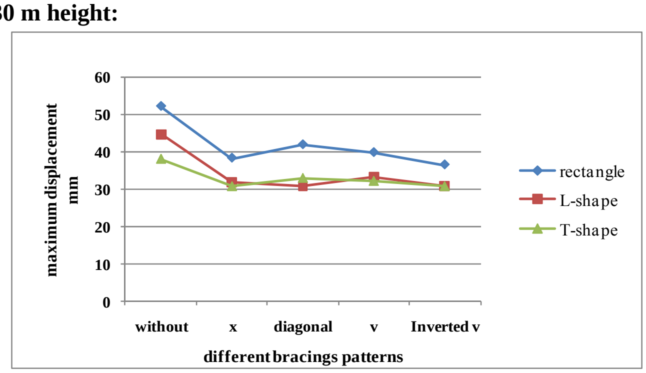

Fig. 7: Different bracing patterns Vs Maximum Lateral Displacement

36m height

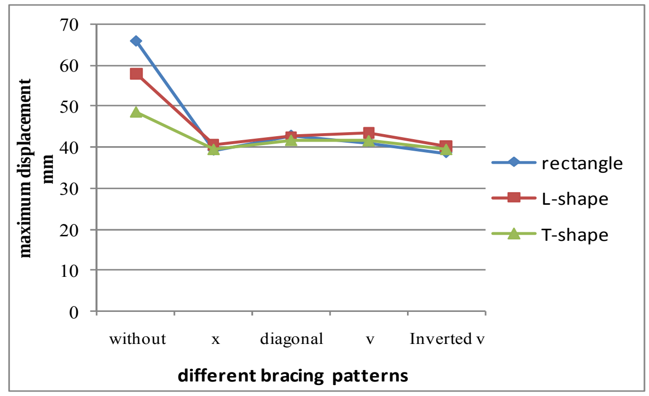

Fig. 8: Different bracing patterns Vs Maximum Lateral Displacement

42m height

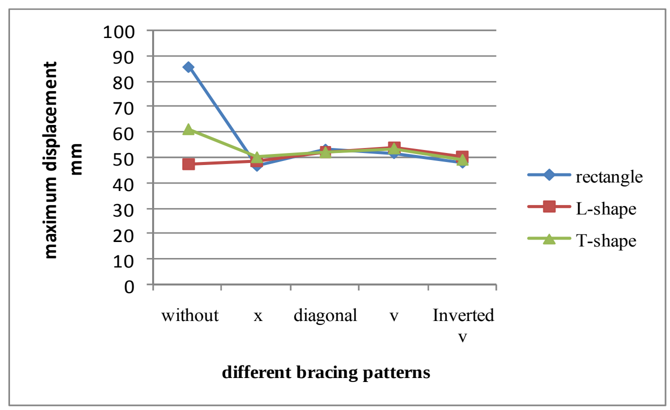

Fig. 9: Different bracing patterns Vs Maximum Lateral Displacement

ii. Maximum Base Shear in X-direction

30m height:

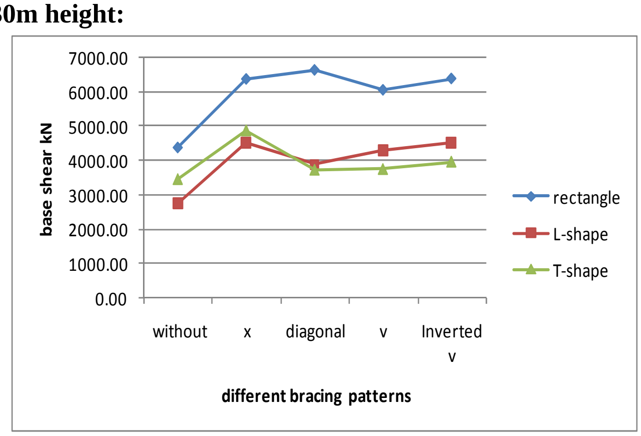

Fig. 10: Different bracing patterns Vs base shear

36 m height

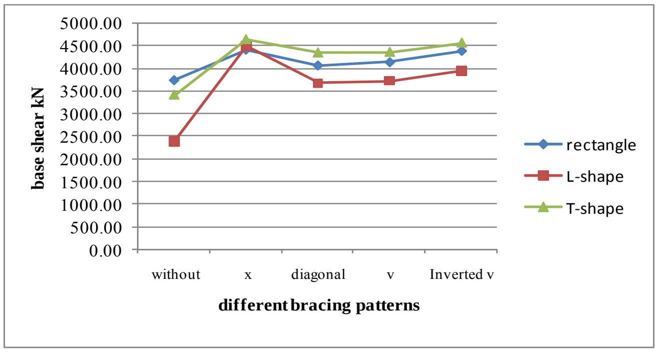

Fig. 11: Different bracing patterns Vs Base Shear

42 m height

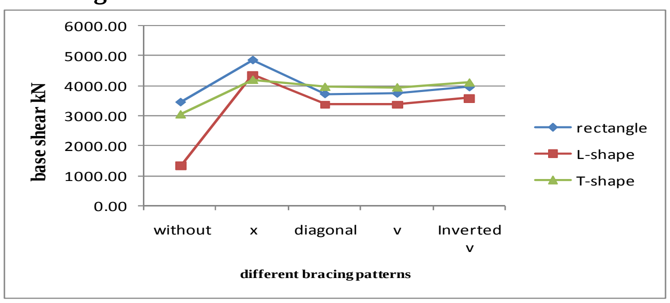

Fig. 12: Different bracing patterns Vs Base Shear

iii. Storey Drift in X- direction:

30 m in height for rectangle plan irregularity

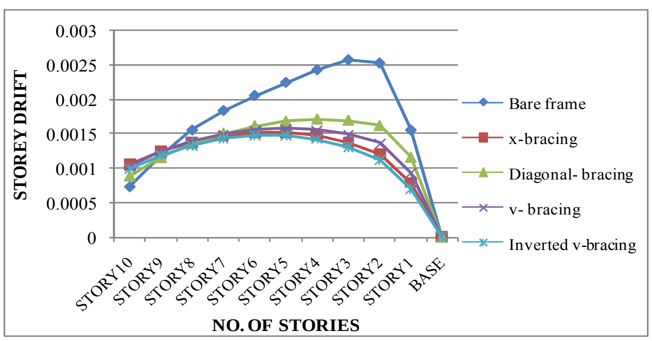

Fig. 13: No. of stories Vs Storey Drift

36 m in height for T-shape plan irregularity

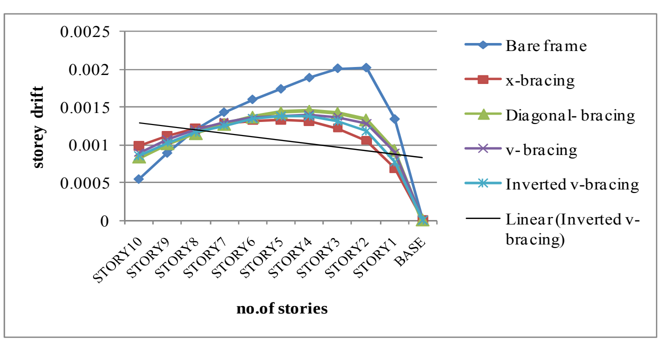

Fig. 14: No. of stories Vs Storey Drift

42 m in height for L-shape plan irregularities

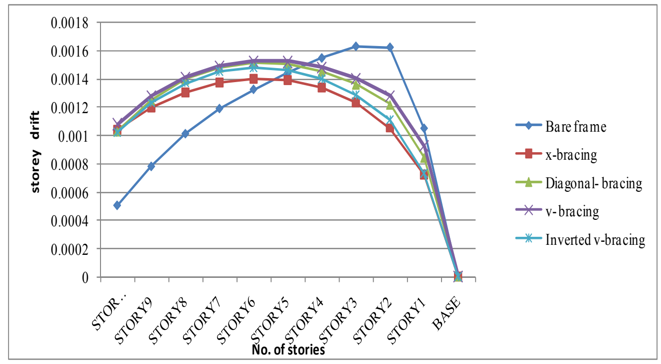

Fig. 15: No. of stories Vs Storey Drift

iv. Overturning Moment in X-direction:

30 m in height for rectangle plan irregularity

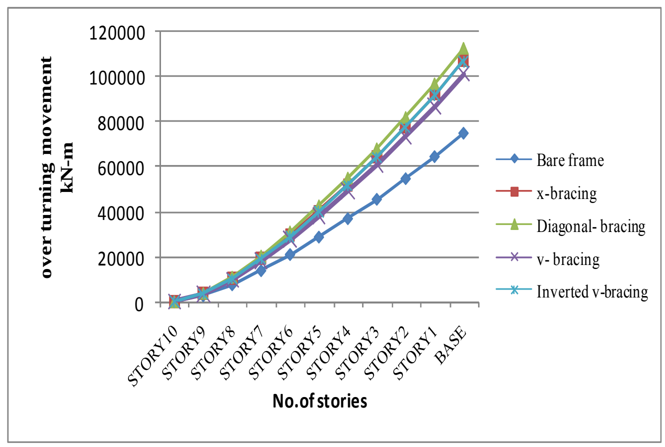

Fig. 16: No. of stories Vs Overturning Moment

36 m in height for T-shape plan irregularity

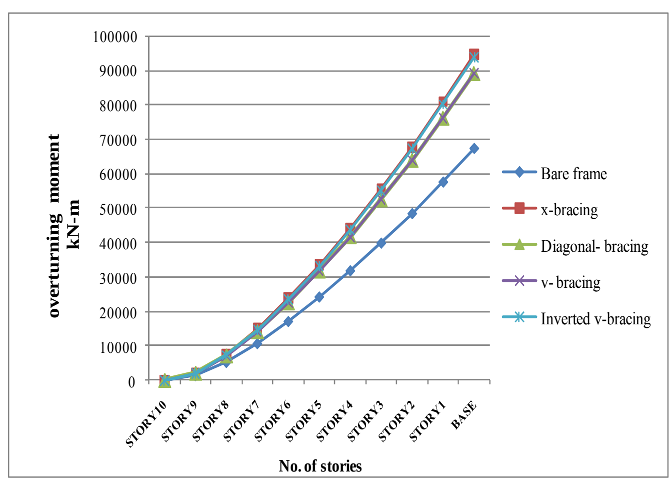

Fig. 17: No. of stories Vs Overturning Moment

42 m in height for L-shape plan irregularities

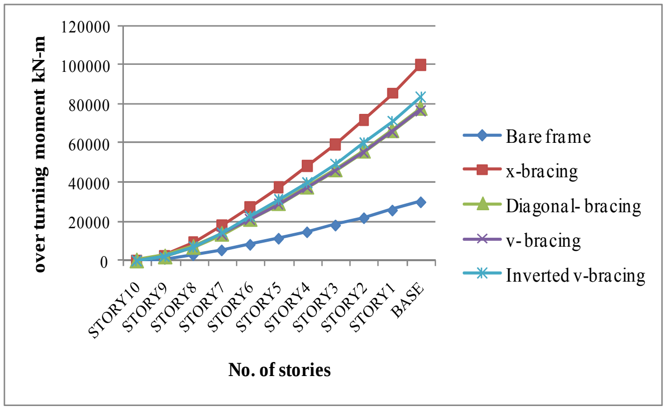

Fig. 18: No. of stories Vs Overturning Moment

5. CONCLUSIONS

The structural responses are compared for different bracing patterns and different plans as mentioned in section 2 and the conclusions are drawn as below:

- Introducing bracing system, considerably reduced the lateral displacements i.e. upto 30% in the present study.
- Minimum storey drift among different bracing patterns is observed in the case of X-bracing. Storey drifts are reduced upto 30% in X bracing, 29% in V- bracing and 26%in inverted V- bracing.
- In case of rectangular building:
  - Maximum lateral displacement in diagonal bracing is 53mm for a height of 42m and minimum lateral displacement is in inverted-V bracing i.e. 36 mm for a height of 30 m.
  - Maximum storey shear is observed diagonal-bracing for a height of 30 m and minimum storey shear is bare frame for height of 42 m.
  - Maximum storey drift is in X-bracing and minimum storey drift in inverted-V bracing.
  - Maximum overturning moments is in diagonal-bracing and minimum overturning moments in V bracing.
- In case of L-shape building:
  - Maximum lateral displacement is in V-bracing frames i.e 54 mm for height of 42 m and minimum lateral displacement is in inverted-V bracing i.e. 30 mm for height of 30 m.
  - Maximum storey shear is in inverted-V bracing for a height of 30 m and minimum storey shear is V-bracing for height of 42 m.
  - Maximum storey drift is in V-bracing and minimum storey drift in inverted-V bracing.
  - Maximum overturning moments is in X-bracing and minimum overturning moments in V bracing
- In case of T-shape building:
  - Maximum lateral displacement is in Bare frames i.e 61.2 mm for height of 42 m and minimum lateral displacement is in inverted-V bracing and X-bracing i.e. 31 mm for height of 30 m.
  - Maximum storey shear is in X-bracing bracing for a height of 30 m and minimum storey shear is bare frame for height of 42 m.
  - Maximum storey drift is in bare frame and minimum storey drift in X-bracing.
  - Maximum overturning moments is in X-bracing and minimum overturning moments in V bracing.
- From the above conclusions, buildings with plan irregularities can be designed in seismic prone zones by using bracings patterns like X-bracing and inverted-V bracing to reduce lateral load effects.

REFERENCES

[1] Ashik S. Parasiya1 Paresh Nimodiya, "Review on Comparative Analysis Of Brace Frame with Conventional Lateral Load Resisting Frame in RC Structure Using Software", *International Journal of Advanced Engineering Research and Studies, Oct.-Dec.,2013/88-93, E-ISSN 2249–8974.*

[2] Amlan k. Sengupta. "Seismic Analysis and Retrofit of Existing Multistoried Buildings in India –An Overview with a Case Study", *13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 2571*

[3] Mohamed Fadil Kholo Mokin[2], "Performance of Lateral Systems in Tall Buildings for Varying Soil Types", *International Journal of Civil Engineering and Technology (IJCIET) Volume 5, Issue 3, March (2014), pp. 15-22.*