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# Effectiveness of Bracing in Skyscraper Structure under Response Spectrum Analysis

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**ABSTRACT:** Presently, Indian standard codal provisions for finding out the approximate time period of steel structure is not considering the type of the bracing system. Bracing element in structural system plays vital role in structural behaviour during earthquake. The pattern of the bracing can extensively modify the global seismic behaviour of the framed steel building. In this paper the Response Spectrum Analysis is carried out on (G+10) rise steel building with X bracing system. Natural frequencies, fundamental, time period, mode shapes and peak storey shear are calculated. The resistance to the lateral loads from wind or from an earthquake is the reason for the evolution of various structural systems. Bracing system is one such structural system which forms an integral part of the frame. Such a structure has to be analysed before arriving at the best type or effective arrangement of bracing. This paper discusses about the efficiency and the effectiveness the use of bracings and with different steel profiles for bracing members for multi- storey steel frames. In this study, an attempt has been made to study the effects of bracing systems and their placement so that to reduce the lateral displacement of the structure.

**KEYWORDS:** Bracing System, Time period, Frequency, Displacement, Peak Storey shear, Skyscraper

## I. INTRODUCTION

When a skyscraper is subjected to lateral or torsional deflections under the action of fluctuating earthquake loads, the resulting oscillatory movement can induce a wide range of responses in the building's occupants from mild discomfort to acute nausea. As far as the ultimate limit state is concerned, lateral deflections must be limited to prevent second order p-delta effect due to gravity loading being of such a magnitude which may be sufficient to precipitate collapse. To satisfy strength and serviceability limit states, lateral stiffness is a major consideration in the design of tall buildings. The simple parameter that is used to estimate the lateral stiffness of a building is the drift index defined as the ratio of them maximum deflections at the top of the building to the total height. Different structural forms of tall buildings can be used to improve the lateral stiffness and to reduce the drift index. In this research the study is conducted for braced frame structures. Bracing is a highly efficient and economical method to laterally stiffen the frame structures against lateral loads. A braced bent consists of usual columns and girders whose primary purpose is to support the gravity loading, and diagonal 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.

## II. RELATED WORK

**Tanawade S. B., Kore P. N. and Swami P.S. (2016)** – In this paper elastic seismic response of reinforced concrete frames with reinforced concrete bracing member in K or A at different level braced pattern with G+11 building with 5 bay structure is analysed in both minor and major direction. This approach focuses on the planning of A-braces in a particular bay, level and its combination, which ultimately reduces lateral deflection so that the economy can eventually be achieved in comparison to the frame of the same moment.

**Umesh .R .Braider, Shivraj Mangalgi (2014)**- Different type of bracings were arranged in outer part of elevation of a multi-storey building subject to earthquake load. Results of comparative study was shown in different graphs for different models. The building was analysed on parameters which induced such as time period and lateral displacement. A building of G+10 storeys of reinforced concrete structure with 25X20 m ground elevation in medium

soil condition was examined. By checking the results from ETABS software in linear static, linear dynamic and pushover condition conclusion was made that results are same that is obtain by considering IS Code method. They found that value of base shear gets changed in different bracing arrangements. They concluded the value of base shear can be reduced by using X bracing or V bracing as compare to frame structure without bracing.

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### III. MODEL DETAILS AND LOAD CALCULATIONS

Specifications	Dimensions	Units
Number of Stories	G+9	-
Length of Building	64.22	Meters
Breadth of Building	38.30	Meters
Height of Building including parapet wall	39	Meters
Ground floor Plan Area	1322.23	Sqm

Table .1 Plan Specifications

#### ❖ Dead loads

Water proofing of Terrace = 1.5  
 kN/m<sup>2</sup> Floor Finish = 0.5  
 kN/m<sup>2</sup>  
 Weight of Walls = 4.6 kN/m<sup>2</sup>  
 Weight of Slab = 3.75 kN/m<sup>2</sup>

#### ❖ Live loads

Live load on Roof = 1.5 kN/m<sup>2</sup>  
 Live load on Floor = 3.5 kN/m<sup>2</sup>

The following load combinations shall be accounted for:

#### ❖ Load Combinations

- 1.7 (DL+IL)
- 1.7 (DL±EL)
- 1.3(DL+IL±EL)

#### ❖ Lumped mass on terrace

Weight of Parapet = 2 kN/m<sup>2</sup>  
 Weight of Floor Finish = 0.5  
 kN/m<sup>2</sup> Weight of Water Proofing =  
 1.5 kN/m<sup>2</sup> Weight of Slab = 3.75  
 kN/m<sup>2</sup> Total Lumped Mass = 7.75



kN/m<sup>2</sup> Roof Level

❖ **Lumped Mass on Floors**

**Weight of Slab** = 3.75 kN/m<sup>2</sup>

Weight of Walls = 4.6

kN/m<sup>2</sup> Weight of Floor Finish =

0.5 kN/m<sup>2</sup> Total Lumped Mass on  
= 8.85

kN/m<sup>2</sup>

Floor revised loads as IS 1893 (Part 1):2002per code

Percentage of imposed load to be considered in seismicweight calculation are mentioned in table: 3

**TABLE: 3 Percentages of Imposed**

Imposed Uniformity Distribution Floor Loads (kN/m <sup>2</sup> )	Percentage Of Imposed Load
Up to and including 3.0	25
Above 3.0	50

**Loads**

Live load on roof to be taken = 1.875 kN/m<sup>2</sup>as per code

Live Load on floors to be = 5.25 kN/m<sup>2</sup>taken as Per Code

❖ **Computation of Time Period**

Computation of time period was done as considering  
steelframe  $T_a = 0.085 \times 36^{0.75} = 1.249$  sec

❖ **Computation of Spectral Acceleration Co-efficient**

The spectral acceleration co-efficient is taken on the basis ontime period obtained and on the type of the soil.

$$\frac{S_a}{g} = 0.80$$

❖ **Computation of Horizontal Coefficient** The design horizontal seismic coefficient A for a structure shall be determined by the following expression:

$$A_h = \frac{Z I S_a}{2 R g}$$

$A_h = 0.032$

### III. EXPERIMENTAL RESULTS

The results drawn from the analysis are plotted below. The Figure.1 is the Steel Frame without Bracing and in the braced structure X bracing is used.

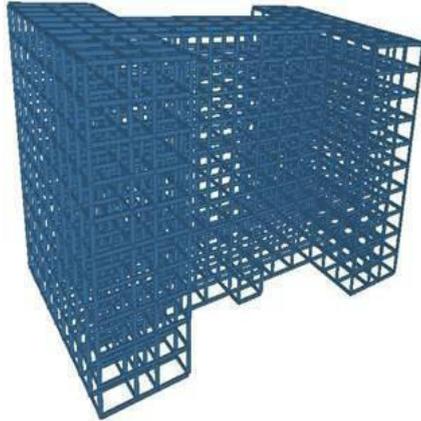


Fig .1 Frame without Bracing

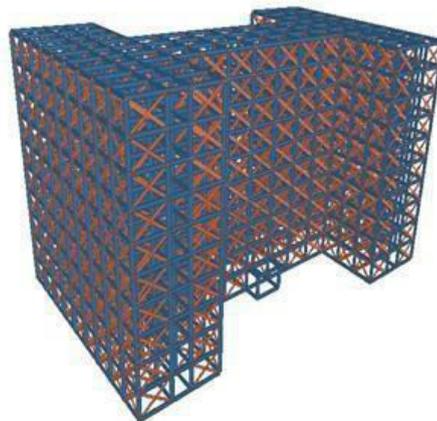


Fig .2 Frame with Bracing

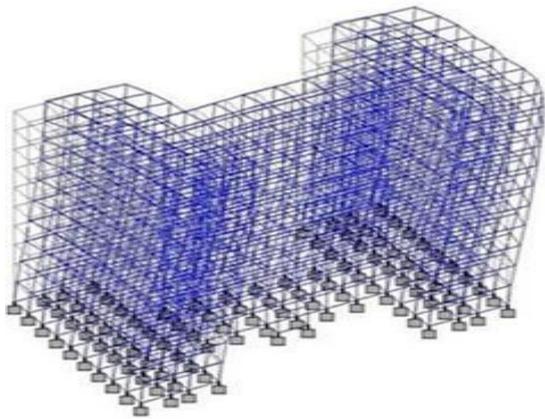


Fig .3 Mode Shape for Unbraced Structure

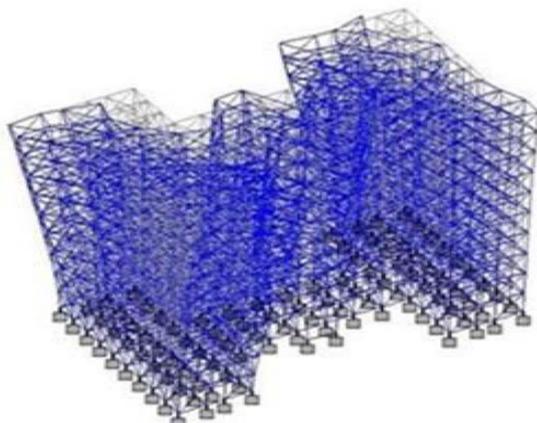
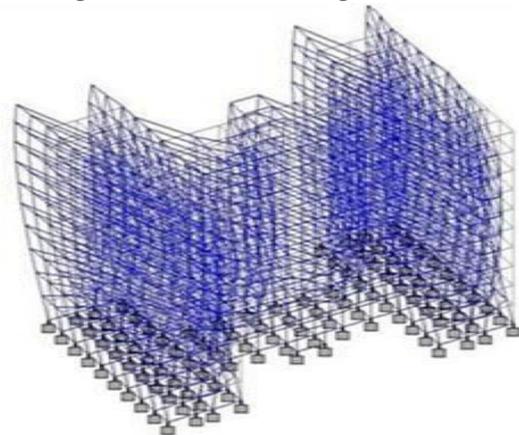
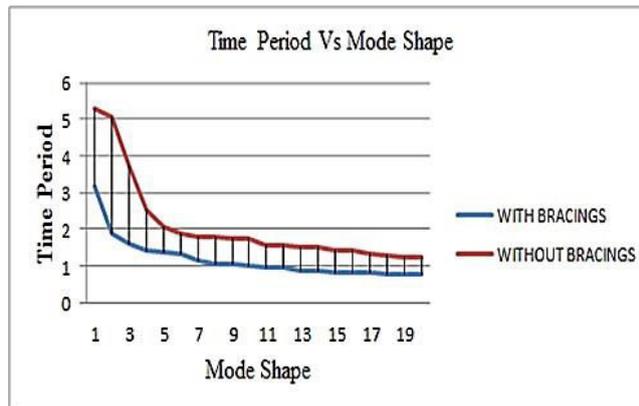


Fig .4 Mode Shape for Braced Structure

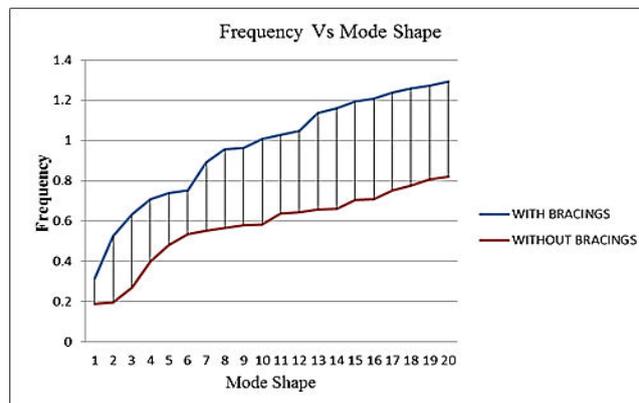


The above figure explains the behavior of the structure under various set of mode shapes. Mode shape may define as the shape of that structure that it will acquire when subjected by lateral deformation. The mode shape can be only considered when the Modal participation of the structure is cent percent. The above figure shows that there is much deformation in the unbraced structure as compared to that of the braced structure. The distortion of the structural elements is reduced which prevents failure in the structure.



**Fig .5 Time Period Vs Mode Shape**

As it is observed from the above figure of time period Vs. Mode Shape that the time period is high in case of unbraced structure and is getting considerably reduced in braced structure. That implies when the time period is less the structure is able to get into its actual place within a short duration of time hence it can be understood that the yielding of the structure is getting reduced and there will not be a case of formation of plastic hinges. It won't be incorrect to say that the shorter time period the structure remains within elastic limit and the chances of failure are reduced.



**Fig .6 Frequency Vs Mode Shape**

As it is again observed from the above figure the frequency is more in case of braced structure when compared to that of the unbraced structure which implies the system is having more vibration in comparison to the unbraced system that explains that the time period of the system or structure to regain its original shape is less hence there will be no large deformations in the structural members which may cause straining of the elements and may lead to the development of plastic hinges and ultimately cause the failure in the structure.

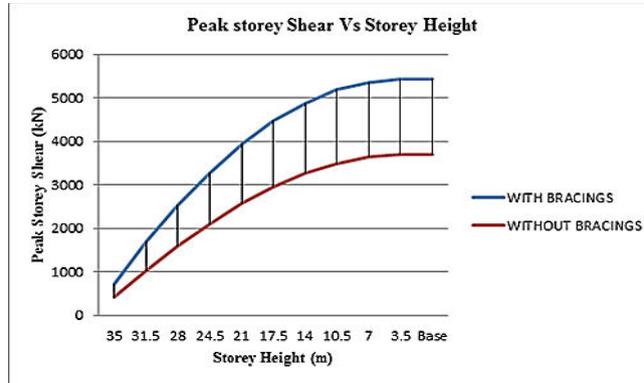


Fig .7 Peak Storey Shear Vs Storey Height in X direction

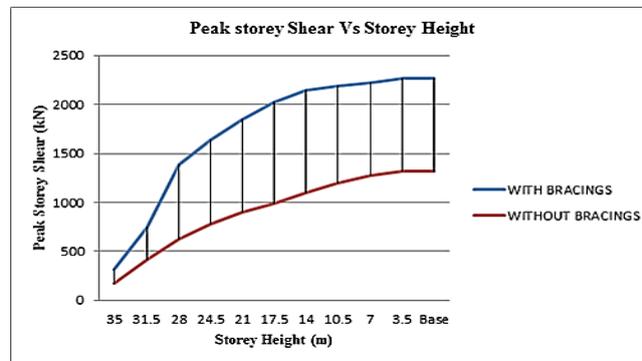


Fig .8 Peak Storey Shear Vs Storey Height in Z direction

Peak storey shear is the sub division of the base shear. If the base shear is divided in the storey height the obtained result will be peak storey shear. Sum total of the peak storey shear is the base shear. As it is observed from the above plotted graph that the peak storey shear is more in that of the braced frame as compared to that of the unbraced frame in both x and z directions that implies the structure is more stable to the lateral forces.

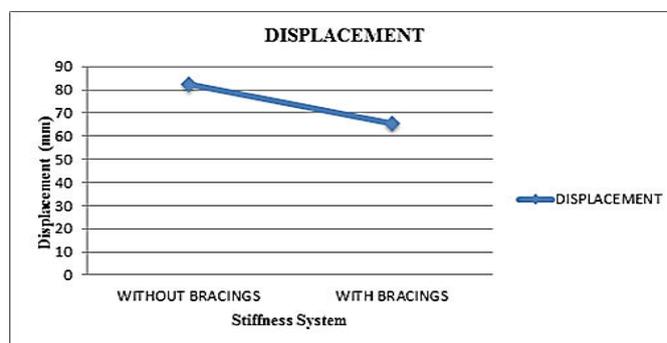
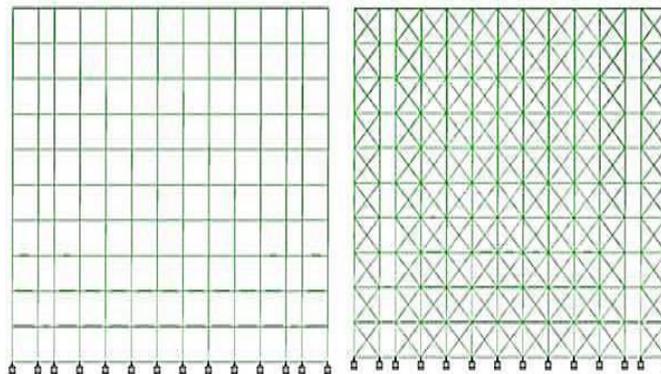


Fig .9 Displacement of Steel Structure.



**Fig .10 Displacement of Steel Structure.**

As observed from the above plotted graph it can be seen that there is reduction in lateral displacement of the Bracedframe.

#### IV. CONCLUSIONS

- Percentage reduction in time period of the braced frame to that of the unbraced frame is 36.43%.
- Percentage increase in frequency of the braced frame to that of the unbraced frame is 36.37%.
- Percentage reduction in the lateral displacement of the braced frame was 20.81%.
- Percentage increase in peak storey in both X and Z direction is given by 32.15% and 41.73%.
- Bending moments get reduced in the structural elements hence structure can be optimized to cost effectiveness and economy.

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