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Effectiveness of Bracing in High Rise 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 behavior during earthquake. The pattern of the bracing can extensively modify the global seismic behavior 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.**

***Index Terms*— Bracing System, Time period, Frequency, Displacement, Peak Storey shear.**

I. INTRODUCTION

When a tall building 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 stares, 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.

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II. BEHAVIOUR

Lateral loading on a Structure is reversible, braces will be subjected in turn to both tension and compression, and consequently, they are usually designed for the more stringent case of compression. For this reason, bracing systems with shorter braces, for example X bracing, may be.As an exception to designing braces for compression, the braces in the double diagonal is designed to carry in tension the full shear in panel.

III. MODEL DETAILS AND LOAD CALCULATIONS

Table .1 Plan Specifications

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

Dead loads

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

Live loads

Live load on Roof = 1.5 kN/m^2
Live load on Floor =3.5 kN/m^2

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^2
Weight of Floor Finish = 0.5 kN/m^2
Weight of Water Proofing = 1.5 kN/m^2
Weight of Slab = 3.75 kN/m^2
Total Lumped Mass at Roof Level = 7.75 kN/m^2

Lumped Mass on Floors

Weight of Slab = 3.75 kN/m^2
Weight of Walls = 4.6 kN/m^2
Weight of Floor Finish = 0.5 kN/m^2
Total Lumped Mass on Floor = 8.85 kN/m^2

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

Percentage of imposed load to be considered in seismic weight calculation are mentioned in table 3

TABLE .3 Percentages of Imposed Loads

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

Live load on roof to be taken = 1.875 kN/m^2 as per code
Live Load on floors to be = 5.25 kN/m^2 taken as Per Code

Computation of Time Period

Computation of time period was done as considering steel frame

Ta = 0.085 × 36$^{0.75}$= 1.249 sec

Computation of Spectral Acceleration Co-efficient

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

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

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

IV. ANALYSIS 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.

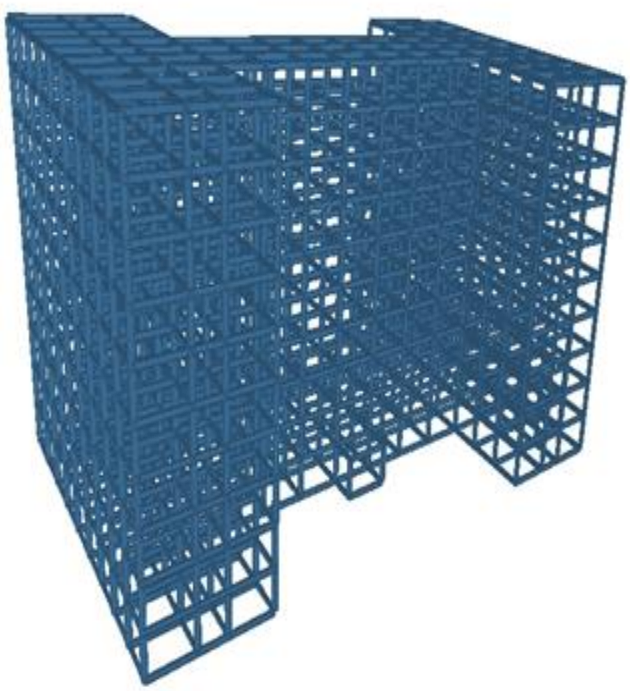

Fig .1 Frame without Bracing

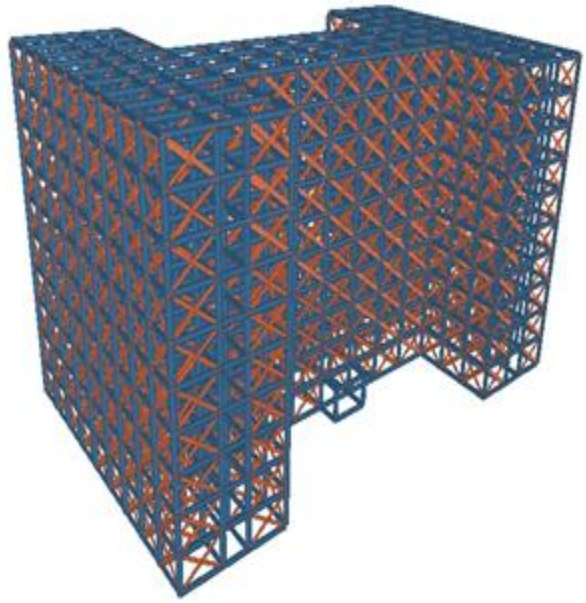

Fig .2 Frame with Bracing

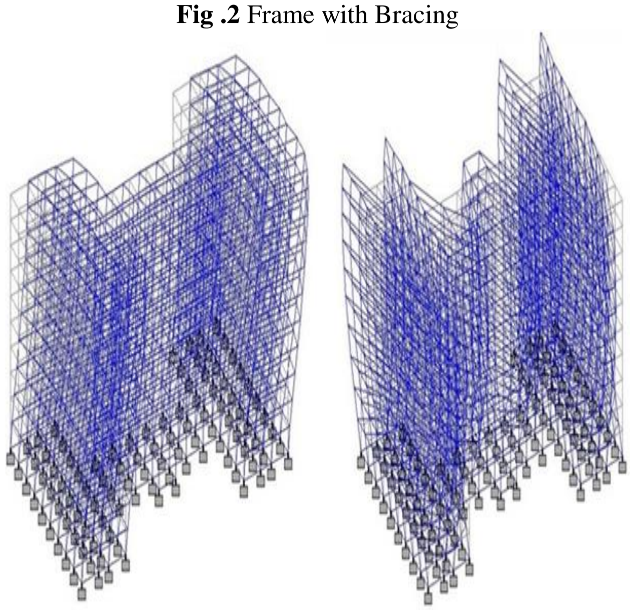

Fig .3 Mode Shape for Unbraced Structure

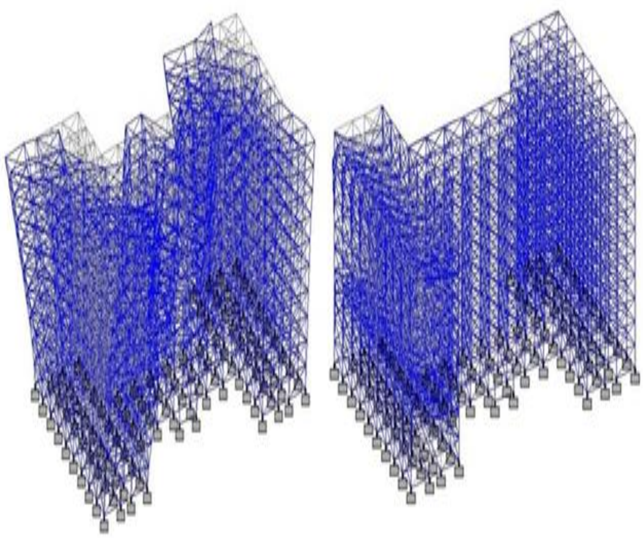

Fig .4 Mode Shape for Braced Structure

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.

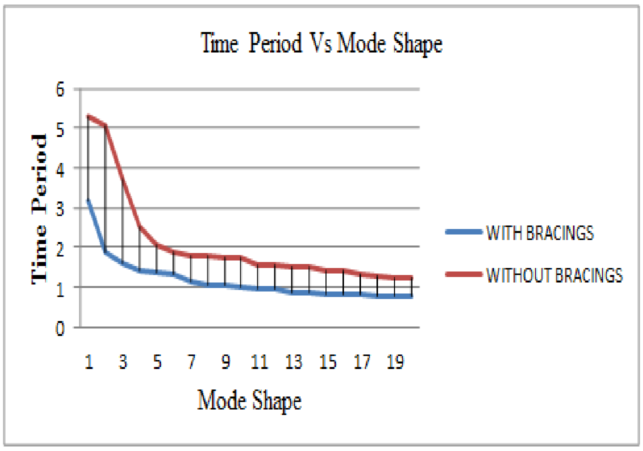

Fig .5 Time Period Vs Mode Shape

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 their will not case of formation of plastic hinges.it won't be incorrect to say that the with less time period the structure remains within elastic limit and the chances of failure are reduced.

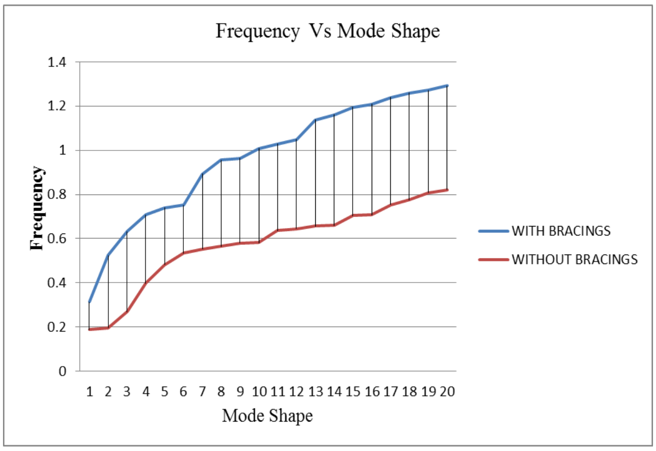

Fig .6 Frequency Vs Mode Shape

As it is again observed from the above figure the frequency is more in case 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 regains its original shape is less hence there will be no large deformations in the structural members which may cause straining of the elements and my lead to the development of plastic hinges and ultimately cause the failure in the structure.

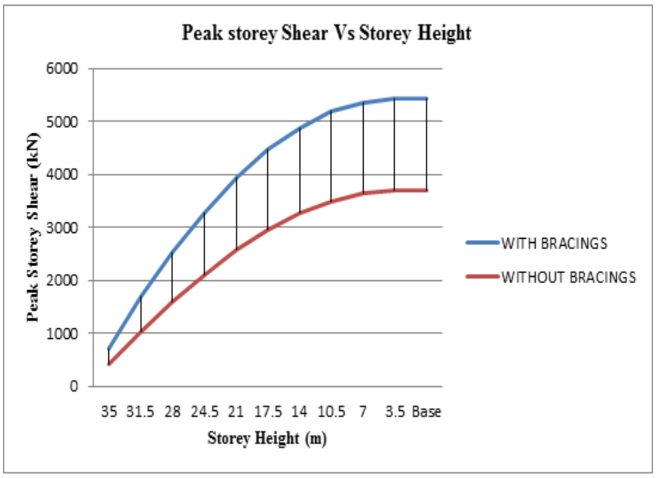

Fig .7 Peak Storey Shear Vs Storey Height in X direction.

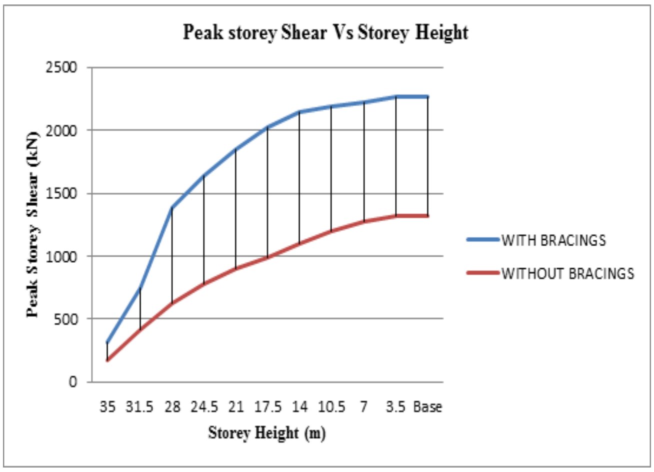

Fig .8 Peak Storey Shear Vs Storey Height in Z direction

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.

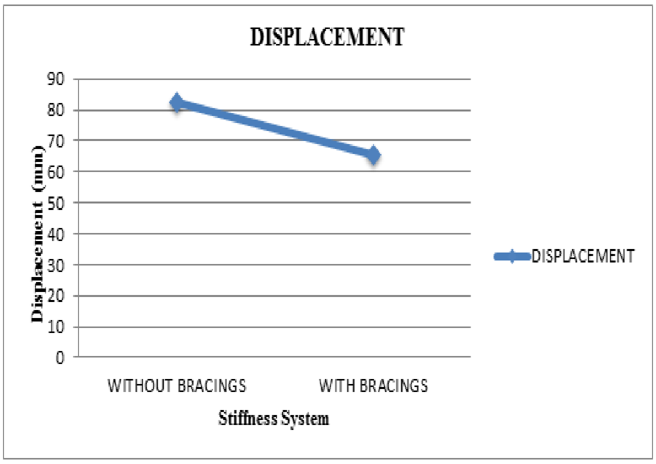

Fig .9 Displacement of Steel Structure.

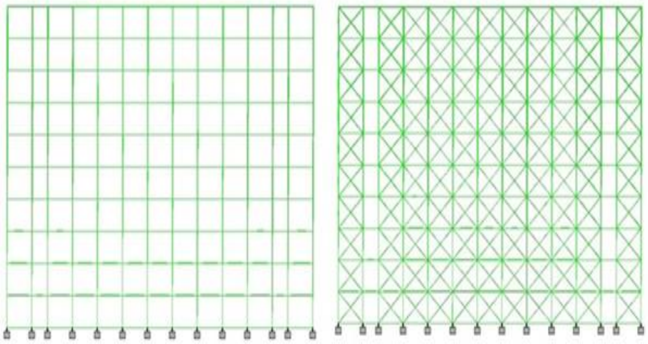

Fig .10 Displacement of Steel Structure.

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

V. CONCLUSION

1. Percentage reduction in time period of the braced frame to that of the unbraced frame is 36.43%.

2. Percentage increase in frequency of the braced frame to that of the unbraced of the is
36.37%.

3.Percentage reduction in the lateral displacement of the braced frame was 20.81%.

4.Percentage increase in peak storey in both X and Z direction is given by 32.15% and 41.73%.

5.Bending moments get reduced in the structural elements hence structure can be optimized to cost effectiveness and economy.

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