Performance of High Rise Steel Frame with Different Type of Bracing and Without Bracing

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Abstract**—** *during earthquake most of the structure fail due to weak structural design or lack of structural detailing. So there is need of modified building frame which will withstand during natural calamities. In this paper, a Comparative study of high rise steel frame with and without bracing have been carried out on symmetrical plan by considering the gravity loads and lateral load in the form of Earth quake load . A setup of different type of bracing system is introduced to reduce lateral load on structural element. In this study a G+30 Steel frame structure is analysed for zone III as per IS 1893:2002 using STAAD.Pro. The main Parameter considers in this paper to compare the seismic analysis of Steel Structure are Base Shear, Story Displacement, and Time Factor. From the table values it shows that due to bracings in both directions, base shear increases. The displacements at roof level of the building with different bracing style will reduce. Modal time period is also reducing the bracing shows highly effective and economical design of bracing style.*

Keywords — *STAAD Pro, Response spectrum analysis, base shear, story displacement, time period*

I. INTRODUCTION

In General, during earthquake high rise building are subjected to different forces produced in the building frame such as lateral forces, different moment gets created in the beam column joint etc. So structures may be susceptible to the severe damage. The basically structure design for gravity load, during earthquake structure has to withstand lateral load, which can develop high stresses. Steel is most useful material for building construction in the world and in construction of building steel structure has played an important role in construction industry. The purpose of seismic design provides strength; stability and ductility. Therefore, it is necessary to design a structure to perform well under lateral loads. Now a day, shear wall in R.C. structure and steel bracings in steel structure are most popular system to resist lateral load due to earthquake, wind, blast etc. The shear wall is one of the best lateral load resisting systems which are widely used in construction world. The shear capacity of the structure can be increased by introducing Steel bracings in the structural system. So there is a need of precise and exact modelling and analysis using STAAD Pro to interpret relation between brace frame parameters and structural behaviour with respect to unbraced steel frame lateral load resisting frame.. In this Project, a few of the past research work has been discussed for modelling and seismic analysis of high rise steel frame building without bracing & same building with different types of bracings, co-relation of efficiency and various parameters are compared. From the analysis in software it found that the type of bracing has significant effects to the lateral load resisting capacity of the structure. In this project comparative study of high rise steel frame building without bracings & same building with different types of bracings like Diagonal, X, K,V & inverted V ,Knee braced ,eccentric braced and performance of each frame has been carried out, various parameters of bracing and property of bracing by different researchers is been discussed. Further optimization study was carried out to decide the suitable type of the bracing pattern by keeping the Base shear, total lateral displacement and Time factor within permissible limit

A. Type of Bracing

There are three types of bracing systems

1) Concentric Bracing System 2) Eccentric Bracing System. 3) Knee Bracing

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.

1) Concentric Bracing System :-

Concentric bracings increase the lateral stiffness of the frame as well as increase the natural frequency and also usually decrease 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.

2) Eccentric Bracing System :-

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 o 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.

3) Knee Bracing System :-

Knee bracing Frames with knee bracings (KBFs) provide an effective bracing solution. It can be obtained by providing a new element called "knee" in between the beam and column along with bracings. These bracings limit inter storey drifts, and knee element absorbs the earthquake energy, by providing cyclic deformations in shear or bending. The main advantage with respect to eccentric braced frames is that damage is concentrated in secondary element and it can easily be replaced after destructive earthquakes.

II. STRUCTURAL MODELING

For the analysis work eight model of high rise steel frame building (G+30) Floor The length of building 40m and width is 32m height of typical stories is 3.5m column sizes changes first at 11 storey and then at each 10 storey building is symmetrical about x and y axis. Material concrete grade M25 is used. While steel Fe250 (mild steel) is used. Model damping 5% is considered. For consideration of diaphragm action diaphragm is assigned at each floor. Analytical modelling that includes all components which influence the mass, strength and stiffness. Beam and column are modelled as frame element and joined node to nodes. The effect of soil structure is ignored in analysis the column are assumed to be fixed at the ground level

A. *Studied Structural Configuration*

Following two types of structural configuration is studied.

1. G+30 Steel Framed structure without bracing (MRF)
2. G+30 Steel Framed structure with different bracing patterns such as X- brace, Diagonal Bracing, V-bracing model, Inverted V brace model, Knee Braced, K-brace, Eccentric braced

B. Details of the Building Plan, Member Size and Materials

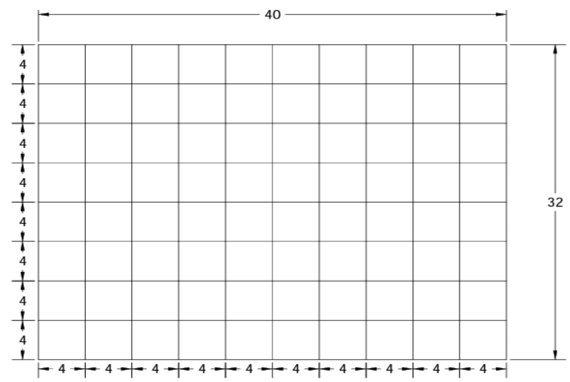

Fig 3.2 Plan of High rise steel frame

C Member Size of the Beams, Columns and Bracing

Table 3.3 Member size used for beams, columns and bracing are shown in

Storey Level	Column Schedule	
	Column. No.	**Size**
1 to 10	C1	ISMB600
11 to 20	C2	ISMB500
21 to 30	C3	ISMB400
Storey Level	**Beam Schedule**	
	Beam No.	**Size**
1 to 10	B1	ISMB550
11 to 20	B2	ISMB450
21 to 30	B3	ISMB350
Storey Level	**Bracing Schedule**	
	Bracing No.	**Size**
1 to 10	BR1	ISA200X150X15
11 to 20	BR2	ISA200X100X15
21 to 30	BR3	ISA150X150X15

D. Material Properties Used For Analysis

Concrete- M 25, Density-2400 Kg/m^3, Young's Modulus E= 22360 N/mm^2, Shear Modulus 8000N/mm^2, Poisson's Ratio-0.2

Structural steel- Fe 250, Density-7850 Kg/m^3, Young's Modulus E= 2.1x10^{5}N/mm^2, Shear Modulus 80000N/mm^2 Poisson's Ratio-0.3

E. Different Types of Bracing Patterns Used In the Study

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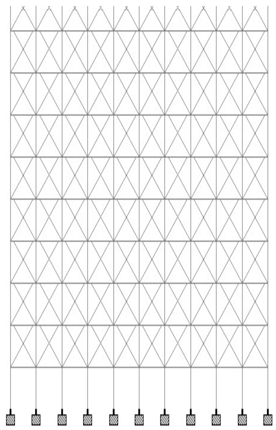

Fig 2.1 without Bracing

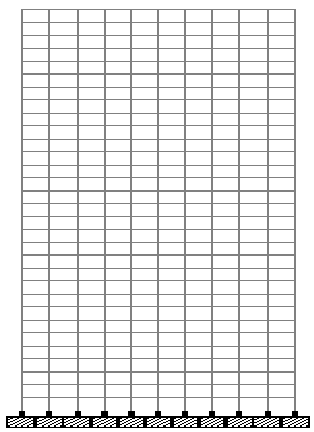

Fig 2.7 Eccentric Bracing

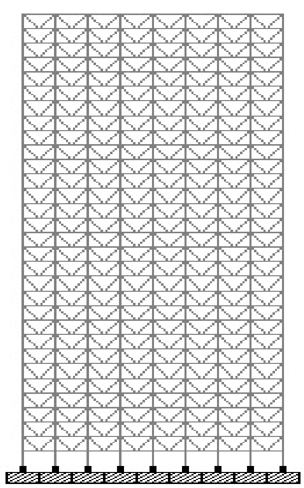

Fig 2.3 V-Bracing

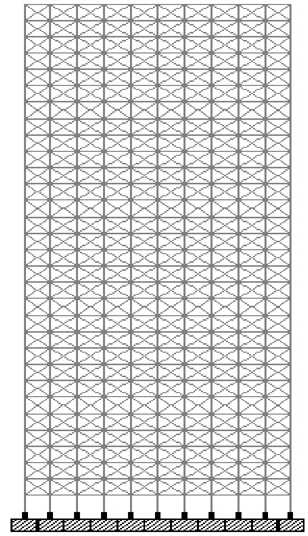

Fig 2.4 X- Bracing

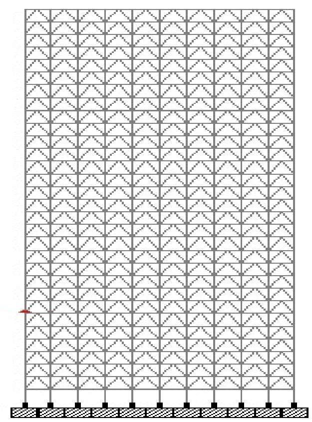

Fig 2.5 Inverted V-Bracing

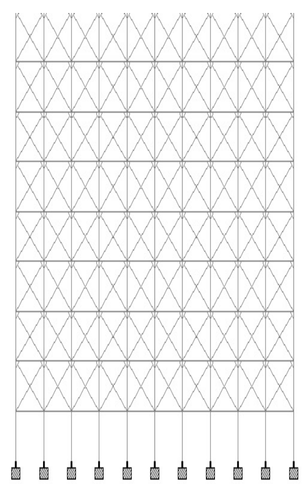

Fig. 2.6 Knee Bracing

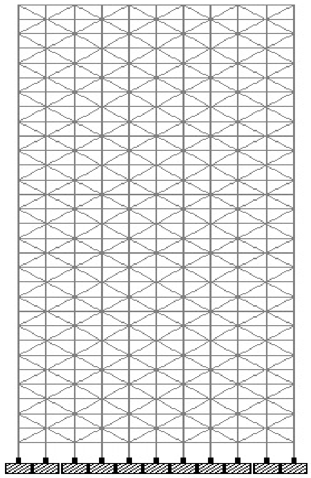

Fig. 2.2 Diagonal Bracing

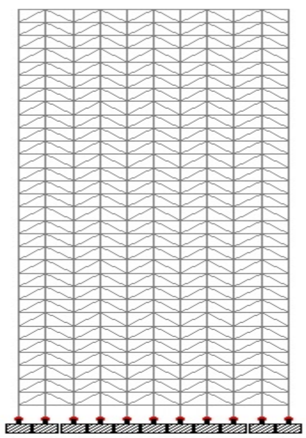

Fig 2.8 K-Bracing

III. LOAD CALCULATIONS

Loads and Load combinations are given as per Indian standards. (IS 875:1984, IS 1893:2002 and IS 800:2007)

A. Gravity loading: - Floor load and member weight are calculated as per general considerations as per IS 875 part1.Live load is taken for residential building without separate storage as 4kN/m^2 and at top floor live load is taken 1.5kN/m2 and floor finish load is 1KN/m^2 as per IS 875 part 2.

B. Seismic Loading: - Seismic load is given as per IS 1893- 2002. Following assumptions are used for the calculation.

a) Zone factor – 0.16
b) Soil type – 2 (medium Soil)
c) Importance Factor – 1.5
d) Damping co-efficient – 5 %

C. Response reduction – 4 (for concentric brace) & 5 (for eccentric brace)

D. Wind loading: - Static wind load is given as per IS 875-

Following assumptions are used for calculation.

a) Wind speed – 39 m/s
b) Terrain category – 3
c) Class – C

E. Wall loading: - Density of brick loading is taken as 20kN/mm^3.

a) Wall thickness – 0.230
b) Height of the wall – 3.5 m.
c) Total wall load on the beam – 16.1 KN/mm^2.

F. The unit weight of concrete = 25 KN/m^3

a) Thickness of slab = 0.125 m.
b) Total load on slab = 12.187 KN/m^2
c) Total load on Roof = 8.437 KN/m^2

IV. CALCULATION OF BASE SHEAR

Table 4.1 Calculation of Base Shear by Response Spectrum Analysis

Sir. No	Type Bracing	Base Shear KN		Difference %
		Without Bracing	With Bracing	
1	Diagonal	6557	8324	21.227
2	X-bracing	6557	8735	24.934
3	V-bracing	6557	8205	20.085
4	Inverted-V	6557	8197	20.007
5	Knee bracing	6557	6575	0.273
6	Eccentric	6557	6565	0.121
7	K-bracing	6557	8191	19.948

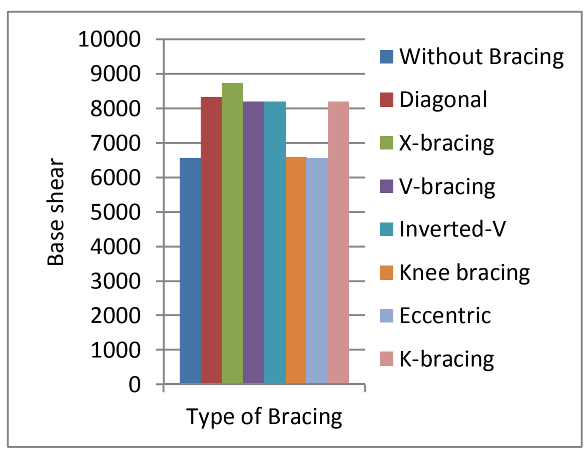

Fig 4.1 Calculation of Base Shear by Response Spectrum Analysis

V. CALCULATION OF TIME PERIOD

Table 5.1 Calculation of Time Period

Type of Bracing	Model Period For 1st Mode shape		
	Without bracing	With bracing	% Difference
Diagonal	15.037	6.976	53.607
X-bracing	15.037	6.195	58.801
V-bracing	15.037	6.863	54.359
Inverted-V	15.037	6.558	56.387
Knee bracing	15.037	6.817	54.665
Eccentric	15.037	6.733	55.223
K-bracing	15.037	6.904	54.086

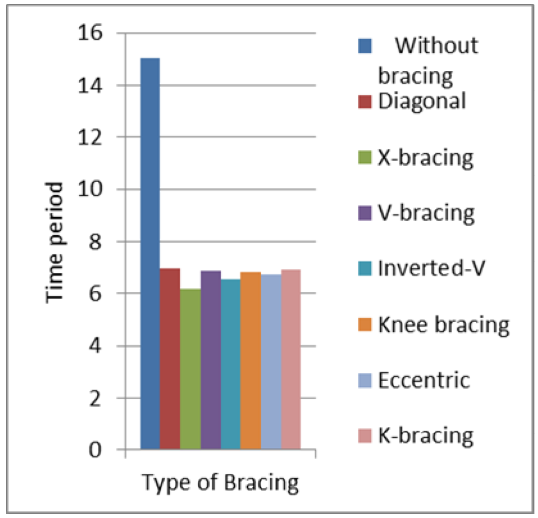

Fig 5.1 Calculation of Time Period

VI. CALCULATION OF STORY DISPLACEMENT

Table 6.1 Calculation of Story Displacement by Response Spectrum Analysis

Floor Level	Without bracing (mm)	X-bracing (mm)	Diagonal bracing (mm)	V-bracing (mm)	Inverted V-bracing (mm)	Knee Bracing (mm)	Eccentric bracing (mm)	K bracing (mm)
30 th	15.1707	8.827	14.338	14.223	13.816	11.528	11.049	13.677
25 th	15.070	8.808	14.309	14.197	13.806	11.500	11.055	13.645
20 th	14.473	8.435	13.727	13.412	13.147	10.952	10.423	13.022
15 th	13.000	7.671	12.244	11.898	11.755	9.766	9.258	11.603
10 th	10.071	6.216	9.456	9.039	9.028	7.429	7.091	8.848
5 th	6.680	4.550	6.187	5.902	5.961	4.826	4.633	5.717
1 th	2.794	2.330	2.525	2.401	2.491	1.980	1.925	2.226

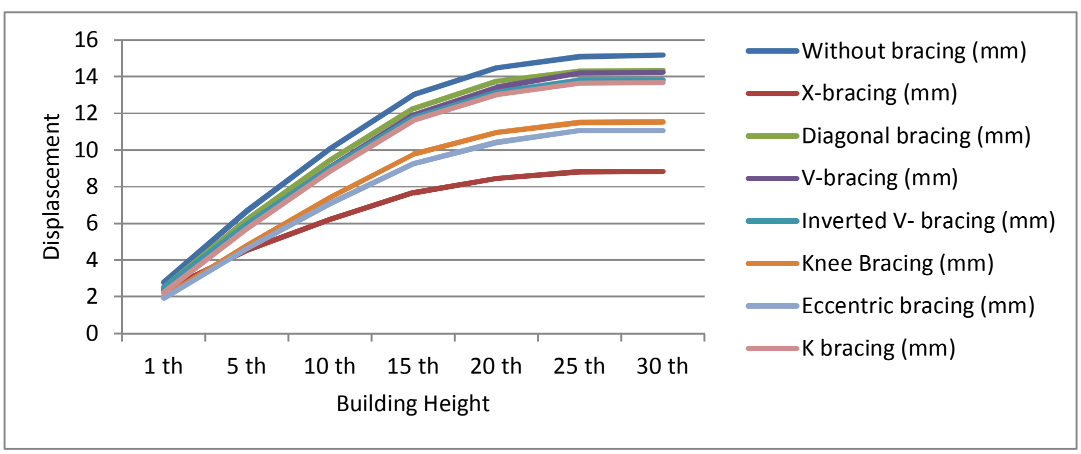

Fig. 6.1 Calculation of Story Displacement by Response Spectrum Analysis

VII. CONCLUSION

Following conclusions are made based on the result discussed from observation table:

1. Bracing plays very important role on structural behaviour under earthquake effect From Table 4.1 its shows that do to different bracing base shear increase up to 25%
2. The Story displacement at roof level of the building do to different bracing style is reduce from 16% to 70%
3. The Time Period is also reduced up to 59%
4. The result of present study shows that X-bracing Highly effectively resist lateral force as compared to other bracing

ACKNOWLEDGMENT

While working on the current paper, I got exposed to field of structural designing due to support of various teachers and friends.

First and foremost, I would like to take this opportunity to express my gratitude to my guide *Prof. Pawar M.M. and Deshmukh M.M.* For providing all resources and great platform to accomplish my goal.

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