Seismic Analysis of Multi Storey Steel Building with Different Bracings Using ETABS Software

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Abstract- *Lateral stability is important for the steel structures in the seismic zones. Effective way to increase the lateral strength is by means of bracing system. An attempt is made to analyze the effect of seismic force on Steel framed high rise building with different bracing system and also to find the best bracing system. The building is modeled and analyzed using ETABS and sections are selected based on their capability to control the maximum lateral storey displacements. The Zone III as per IS 1893-2002 is selected for the study. Analysis is carried out by Response Spectrum Method. Various parameters such as, displacement, base shear and brace force were studied. From the study it can be concluded that for building, cross bracings are the best bracing system for reducing the storey displacement. It is also observed that base Shear is high in cross bracing system because of the increased stiffness.*

Keywords- Response Spectrum Analysis, Lateral displacement, Base Shear, Bracing System

I. INTRODUCTION

The bracing system provides the structure more capacity to soak up energy while it is under seismic excitation. Steel Structures in tectonic prone zones are needed to be designed such that they resist considerable horizontal loads. The designs of structures require a good amount of balance between strength, stability, and energy Dissipation. A number of structural steel systems (such as ordinary Concentric Braced Frames, Ordinary Moment Resisting Frames, and Eccentric Braced Frames) satisfy a part of these requirements. But none of the mentioned systems are intended to resist a major earthquake within the elastic limit of the materials and will require post-earthquake repairs.

Steel has become the predominate material for the construction of bridges, buildings, towers and other structures. Its great strength, uniformity, light weight and many other desirable properties makes it the material of choice for numerous structures such as steel bridges, high rise buildings, towers and other structures. Bracing element in structural system plays vital role in structural behavior during earthquake. Steel bracing is an effective and economical solution for resisting lateral forces in a framed structure. In the present study, response of the steel braced frame under response spectrum analysis were performed using computer software ETABS 2013.

II. STRUCTURAL MODELING

For the purpose of this study, seven models of high rise steel frame building (G+8) with different types of bracings models, were selected in order to determine the behavior of structural steel during seismic activity in seismic. The columns are fixed at the ground and are taken as restrains. The building height is 24m storey height 3m in structure. The length of the building in X-direction is taken as 14m and in Y-direction is taken as 20m. Figure 1 show the geometrical configuration of the building. The model was prepared for bare frame and with different bracing systems. Table 1 gives the material properties of the members. The material properties are selected on the basis of displacement limitation and strength as per IS 800-2007.

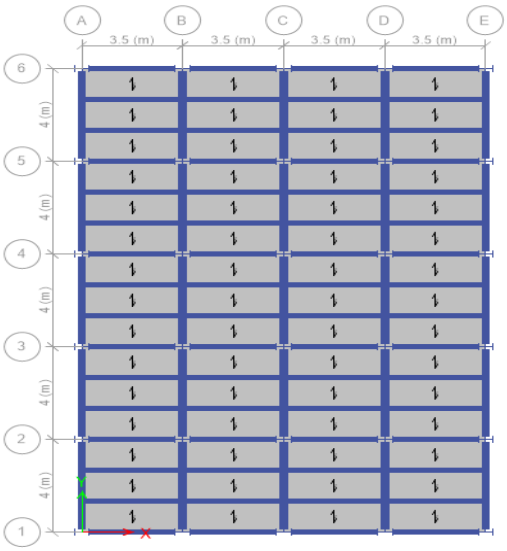


Figure 1: Plan of High Rise Steel Bay Frame

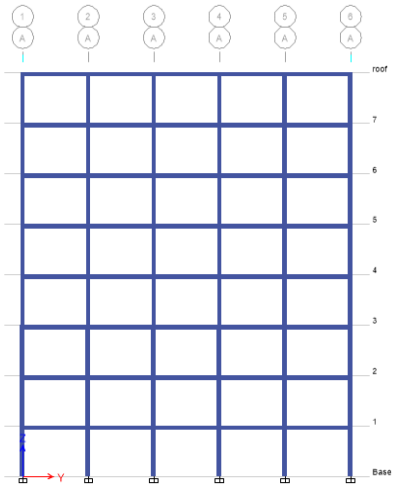


Figure 2: Elevation view of Steel Structure

1. Studied Structural Configuration

a. G+8 Steel Framed structure without bracing
b. G+8 Steel Framed Structure with different bracing pattern with Tube shape bracing

Table 1: Material, Member size of Beam, Column and Bracing

Sr. No.	Material Properties	
1	Column Details	a. Built-up I section for bottom 3 Storey of area 12672mm^2 b. ISHB 350 - 2 for above 3 Storey c. ISHB 250 – 2 For above 2 Storey
2	Beam Details	a. ISHB 200-2 b. ISHB 150-3 c. ISHB 225-2 d. ISHB 300-2 e. ISHB 250-2
3	Angle Bracing Details	ISA 150X150X15
4	Tube Bracing Details	ISB 172X92X4.8
5	Grade of Steel	Fe 250
6	Concrete of density 2500 Kg/m^3	M20
	Distance in X-Direction (Length)	14.5m
7	Distance in Y-Direction (Width)	20m
8	Distance in Z-Direction (Height)	24m
9	Floor to Floor Height	3m
10	Spacing of Secondary Beam	1.33m

The building is analyzed for the earthquake forces with different vertical bracing system. Both eccentric and concentric bracing systems are selected for symmetric and unsymmetrical building. Table 2 gives the details of different of models modeled with different bracing system. The building is subjected to following Loads as per IS 875 (part 1 and 2)-1987:

1. Super Dead Load: 1.2 KN/m2
2. Live Load: 3.0 KN/m2
3. Live Load on Roof: 2.0 KN/m2

2. Different Types of Bracing Patterns Used in the Study
Different types of bracing pattern used in the study are shown in figure 3 to 9

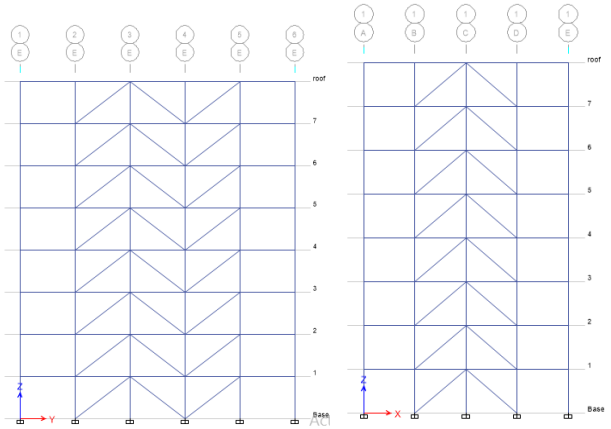


Figure 3: Type 1 Bracing

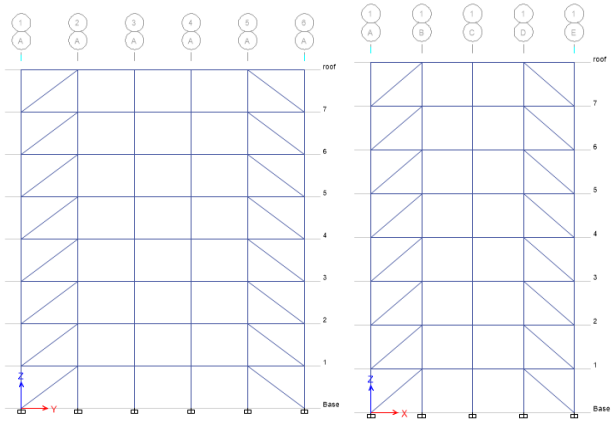


Figure 4: Type 2 Bracing

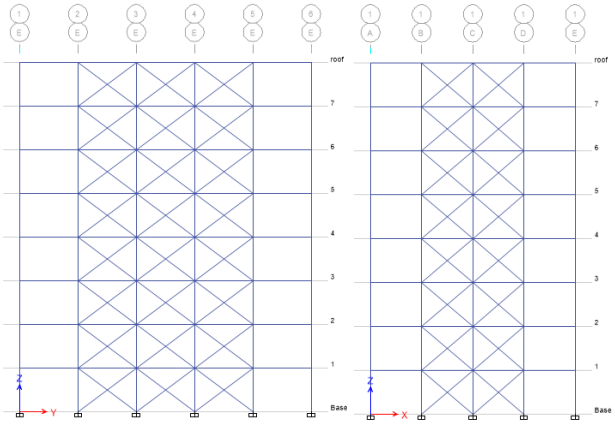


Figure 5: Type 3 Bracing

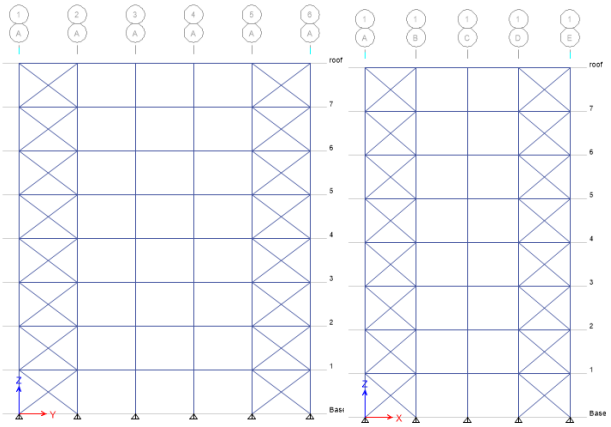


Figure 6: Type 4 Bracing

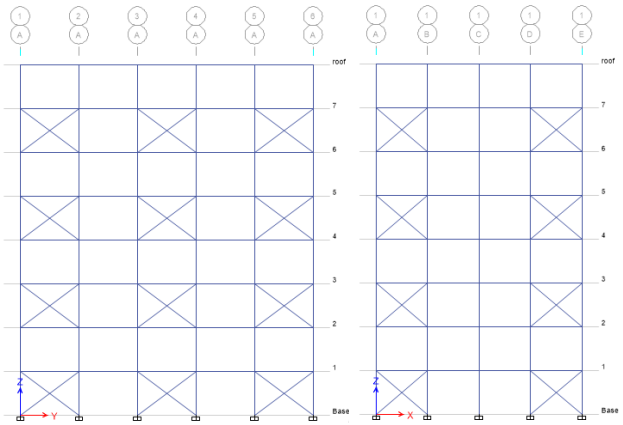


Figure 7: Type 5 Bracing

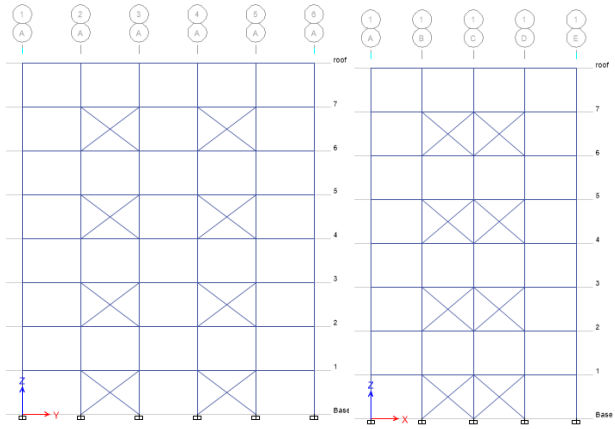


Figure 8: Type 6 Bracing

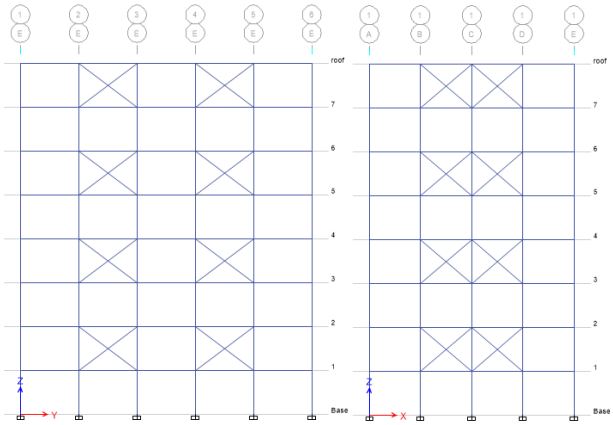


Figure 9: Type 7 Bracing

III. METHOD OF ANALYSIS

1. Response Spectrum Method

This is the most widely used method in seismic analysis. In this method, a multi-storey structure is idealized as multi storey shear building by assuming the mass is lumped at the floor and roof diaphragm levels, that the diaphragms are infinitely rigid and the columns are axially in extensible but laterally flexible. The dynamic response of the system is represented by the lateral displacements of the lumped masses with the number of degrees of dynamic freedom or modes of vibration being equal to the number of masses. This concept provides a conceptual basis for using response spectra based on single mass system for analyzing multi storey buildings. Given the period, mode shape and mass distribution of a multi-storey building, we can use response spectra of a single degree of freedom system for computing the deflected shape, storey accelerations, forces and moments.

Table 3 gives the earthquake parameter where considered in the in the analysis. The zone III is the zone to

earthquake damages and the type of the building is Commercial which is a public building.

Table -2: Earthquake Parameter

Sr. No.	Model Description	
1	Zone	III
2	Zone Factor	0.16
3	Type of building	Bay framed
4	Response Reduction Factor	5 (SMRF)
5	Importance Factor	1.2
6	Building Height	24
7	Soil Condition	Medium
8	Damping Ratio	5%

IV. RESULTS

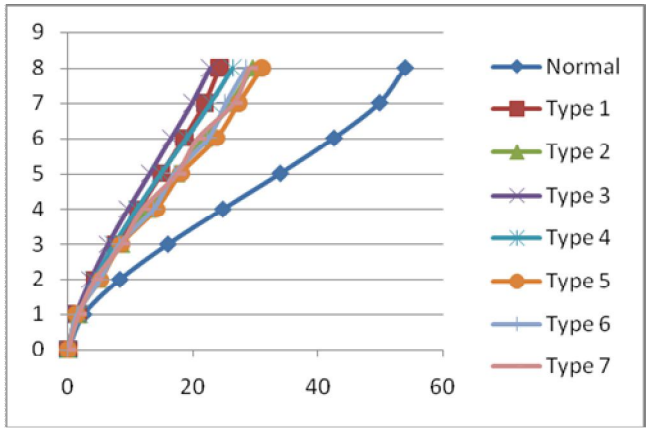
Seismic analysis of Multi-storey steel bay frame building for various bracing system with Tube shape bracing is carried out for the analysis. Results Seismic analysis of multi storey steel bay framed structure is carried out for the analysis. The buildings are analyzed with bare frame and by providing different types of bracings. The results are tabulated such as, Maximum storey displacement, storey shear are noted.

1. Storey Displacement

The top storey displacement is calculated in Steel bay frame building in the x direction by dynamic analysis
Maximum Storey Displacement of Structure with Tube Bracing Provision:

Table 3: Maximum storey displacement (mm) In X-Direction by dynamic analysis

Sr. No.	Type of Model	Maximum Storey Displacement		% Difference
	(Tube Bracing)	Without Bracing	With Bracing	
2	Type 1 Bracing	54	24.3	55.00
3	Type 2 Bracing	54	29.5	45.37
4	Type 3 Bracing	54	22.8	57.78
5	Type 4 Bracing	54	26.4	51.11
6	Type 5 Bracing	54	31.1	42.41
7	Type 6 Bracing	54	28.5	47.22
8	Type 7 Bracing	54	29	46.30

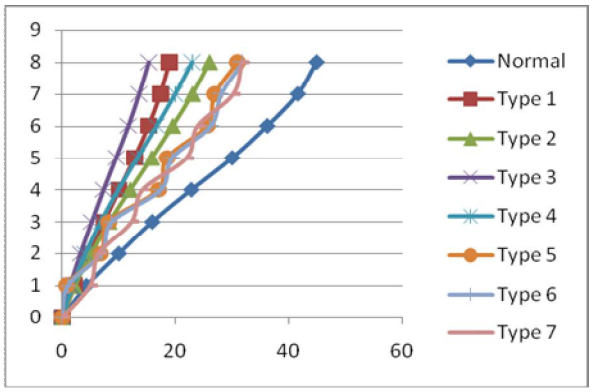


Graph 1: Joint displacement (mm) for various bracing type of Tube Bracing in X – Direction

From the Table 3 and Graph 1 Type 3 bracing (cross bracings) here gives the least displacement and the displacement is reduced by 57.78% and Type 5 bracing gives the largest displacement.

Table 4: Maximum storey displacement (mm) In Y-Direction by dynamic analysis

Sr. No.	Type of Model	Maximum Storey Displacement		% Difference
	(Tube Bracing)		In Y-Direction (mm)	
2	Type 1 Bracing	44.9	19	57.68
3	Type 2 Bracing	44.9	26	42.09
4	Type 3 Bracing	44.9	15.3	65.93
5	Type 4 Bracing	44.9	23	48.78
6	Type 5 Bracing	44.9	31	30.96
7	Type 6 Bracing	44.9	31.8	29.18
8	Type 7 Bracing	44.9	31.6	29.63



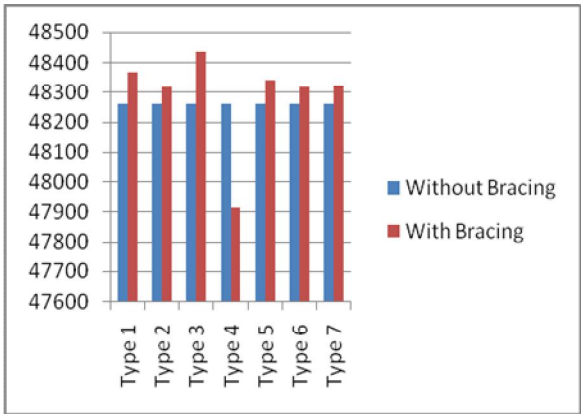
Graph 2: Joint displacement (mm) for various bracing type of Tube Bracing in Y – Direction

From the Table 4 and Graph 2 Type 3 bracing (cross bracings) here gives the least displacement and the displacement is reduced by 65.93% and Type 6 bracing gives the largest displacement.

2. Base Shear

Table 5 - Base Shear for multi-storey Steel Building in Zone III by Seismic Analysis

Sr. No.	Type of Bracing	Type of Bracing	
		Without Bracing	With Bracing
1	Type 1	48259.75	48366.37
2	Type 2	48259.75	48317.67
3	Type 3	48259.75	48436.43
4	Type 4	48259.75	47913.77
5	Type 5	48259.75	48339.68
6	Type 6	48259.75	48317.67
7	Type 7	48259.75	48320.21



Graph 3: Variation of Base Shear for Steel building with Different Bracings in Zone III by Seismic Analysis

From the table 2 and Graph 3 it can be observed that, using Dynamic Method in Zone III the Type 3 bracing (Cross Bracing) has the highest amount of Base Shear.

V. CONCLUSIONS

From the above result it can be concluded that:

- The bracing in the building reduces the storey displacement in multi-storey steel building as compared to the building without bracings for lateral loads.
- For multi-storey steel building, Cross bracings gives less storey displacement.
- Type 3 bracing (Cross bracings) has more base shear and Type 4 bracing has the least amount of base shear.
- Use of bracing system increases the stiffness of the structure and attracts more lateral force.

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[5] **IS 875** Code of practice for design loads (other than earthquake) for buildings and structures, (**Part 1**) Dead loads – Unit weight of building material and stored materials.

[6] **IS 875** Code of practice for design loads (other than earthquake) for buildings and structures, (**Part 2**) Imposed loads.

[7] **IS 1893** (Part 1):2002 Criteria for earthquake resistant design of structures