Wind Effects On Multi-Storied Braced Steel Building

Mrs. Priyanka S. Shinde[1], Mr. Abhijeet S. Tambade[2], Prof. Rohit R. Zanjad[3], Vishakha P. Padmawar[4]
[1, 2] Dept of Civil
[3]Assistant Professor, Dept of Civil
[1, 2, 4] JSPM NTC, Savitribai Phule Pune University, Pune, India
[3]Sinhgad Collage, Savitribai Phule Pune University, Pune, India

Abstract- *Lateral Stability is important for the steel structures in seismic load and wind load application. Effective way to increase the lateral strength of structure by means of angle bracing system and tubular bracing system. An attempt is made to analyze the effect of wind force on bay framed high rise building with bracing system and also find the effective type bracing and shape of bracing. The Bay Framed steel Building is modeled and analyzed using ETABS and sections are selected based on their capability to control the maximum lateral storey displacements. The wind load pattern as per IS 875 - 1987 part 3 selected for study. Various parameters such as, storey displacement and bracing forces of angle and tubular bracing were studied. From the study it can be concluded that for multistory steel bay framed building, with tube bracing gives the effective results as compare to the angle bracing in terms of Storey displacement, dead load of the steel structure and cost of the structure.*

Keywords- steel building, bracing, lateral displacement, wind

I. INTRODUCTION

Most of the steel structure is done with a type of steel Mild Steel. Grate advantage of steel building is immense strength and Flexibility. One of the biggest advantage of steel building is its ability to withstand strong wind both during extreme weather condition and during the everyday wear and tear of high winds, since steel buildings are cost effective and they are great for almost any purpose like high-rise buildings, Industrial buildings, Industrial buildings, Warehouse buildings, Temporary structure, Residential building. Due to the low weight of steel buildings means they have to be firmly bolted to the foundation to resist wind Forces. Steel performs for better in Wind Forces than other material because of these properties.

II. PROBLEM DEFINITION

Over the years as more number of hurricanes, tornados and strong winds have damages the steel buildings. To reduce the loss of structure, to reduces the human loss due to wind also to reduce the lateral deflection of steel building by providing a suitable shape of bracing and effective system of bracing.

III. STRUCTURAL MODELING

For the Purpose of study, eight models of high rise bay framed steel building (G+8) with different types of bracings and different shape of bracings, were selected in order to determine the behavior of steel structure during wind activity by using the ETABS Software. The columns are fixed at the ground and are taken as restrains. The building height is 24m. The length of the building in X-direction 14.5m and in Y-direction is taken as 20m Figure1 and 2 shows the geometrical configuration of the building. Table 1 gives the material properties of the members. The material properties are selected on the basis of displacement limitation and strength as per the IS 800–2007.

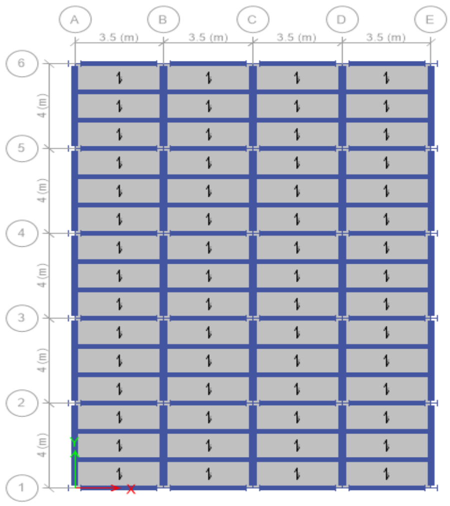


Fig: - 1 Plan of High Rise Steel Bay Frame Building

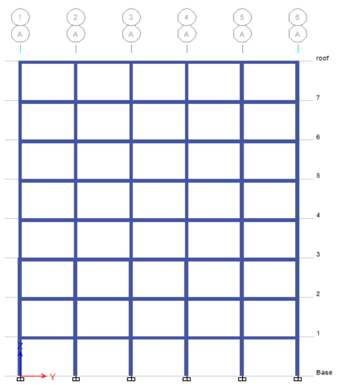


Fig: - 2 Elevation view of Steel Structure

1. Studied Structural Configuration

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

Table 1: Material and Member Properties

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 (L)	14.5m
7	Distance in Y-Direction (B)	20m
8	Distance in Z-Direction (H)	24m
9	Floor to Floor Height	3m
10	Secondary Beam Spacing	1.33m

The building is analyzed for the wind force for the location Pune with different type of bracing and different shape of bracing. The building is subjected to following loads as per IS 875 (part 1, 2, 3) – 1987:

- Floor Finish: 1.2 KN/m^2
- Live Load: 3 KN/m^2
- Live Load on Roof: 2 KN/m^2

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

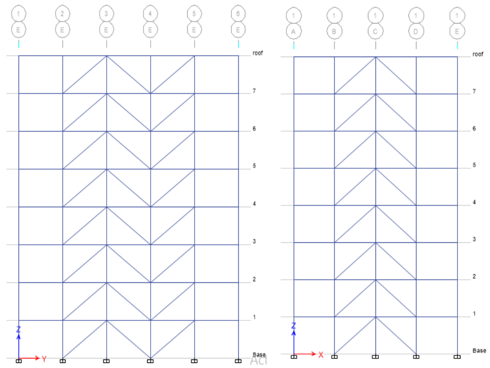


Fig: - 3 Type 2 Bracing

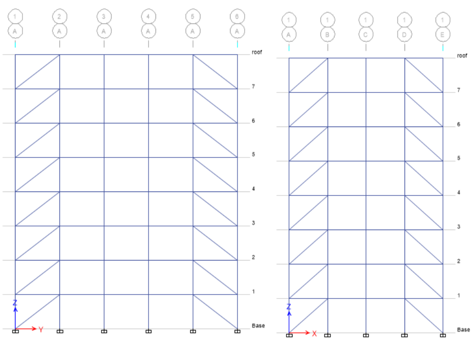


Fig: - 4 Type 3 Bracing

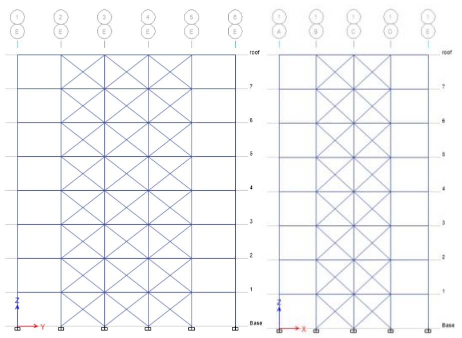


Fig: - 5 Type 4 Bracing

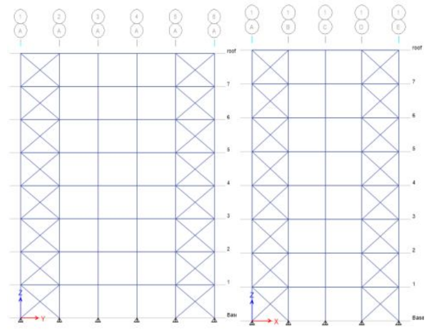


Fig: - 6 Type 5 Bracing

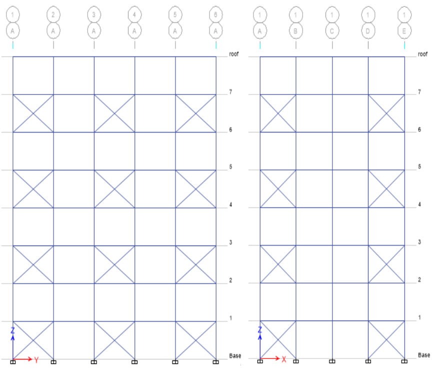


Fig: -7 Type 6 Bracing

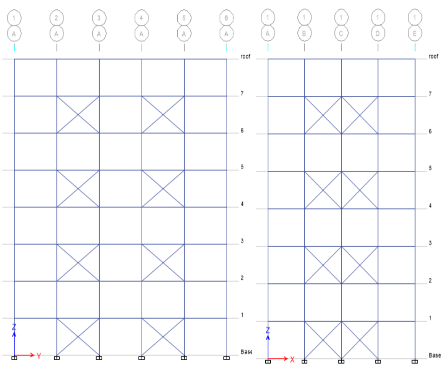


Fig: - 8 Type 7 Bracing

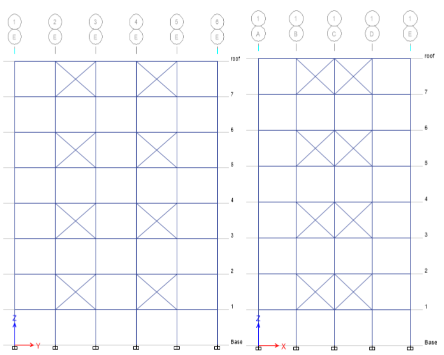


Fig: - 9 Type 8 Bracing

2. Wind Load parameters from IS 875:1987

- Location of the structure - Pune
- Wind velocity – 39 m/sec
- An structure height – 24m
- Terrain class – 3
- Structure class – B
- Terrain factor K_2 can be got from table for class B interpolating between 20m and 30m K_2 = 1
- The ground is assumed to be plain so the topography factor is K_3 = 1
- Design life of structure 50 years, Risk coefficient from IS 875:1987 Table 1
- Design wind speed (V_z) = Vb x K_1 x K_2 x K_3

  = 39 x 1.96 x 1 x 1

  =76.44 m/sec

- Design wind pressure (Pz) = 0.6 x Vz^2

  = 0.6 x 76.44^2

  3505.844 N/m^2

- External wind pressure coefficient (Cpe) taken as 1.2 form IS 875:1987.
- Internal wind pressure coefficient (Cpi) is depends on the opening of structure in above all models Cpi value taken as 0.5.

4. Load Combination Taken in Consideration

a. 1.5(DL+LL+SDL)
b. 1.2(DL+LL+SDL+WLx)
c. 1.2(DL+LL+SDL+WLy)

IV. RESULTS AND DISCUSSION

Wind analysis of Multi-storey steel bay frame building for various bracing system with shape of both Angle shape bracing and Tube shape bracing is carried out for the analysis. The results are tabulated such as Maximum storey displacement of Structure with no bracing provision, Angle shape bracing and Tube shape bracing with Types of bracing is noted.

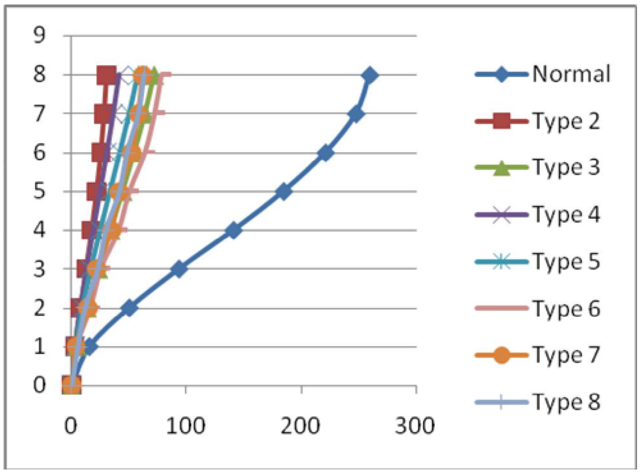
1. Maximum Storey Displacement of Structure with Angle Bracing Provision:

Table 2: Maximum storey displacement and Dead Load of model with Angle bracing provision

No.	Type of Model Angle Bracing	Maximum Storey Displacement In X (mm)	In Y (mm)	Dead Load of the Structure (KN)
1	Normal model	259.8	152.6	20002
2	Type 2 Bracing	30.3	13.5	20148
3	Type 3 Bracing	71.7	42.1	20104
4	Type 4 Bracing	41.9	13.2	20251
5	Type 5 Bracing	58.2	33	20204
6	Type 6 Bracing	78	68.7	20130
7	Type 7 Bracing	62.3	73	20103
8	Type 8 Bracing	63.6	78.2	20105

Table 3: X – Direction Angle Bracing Joint Displacement

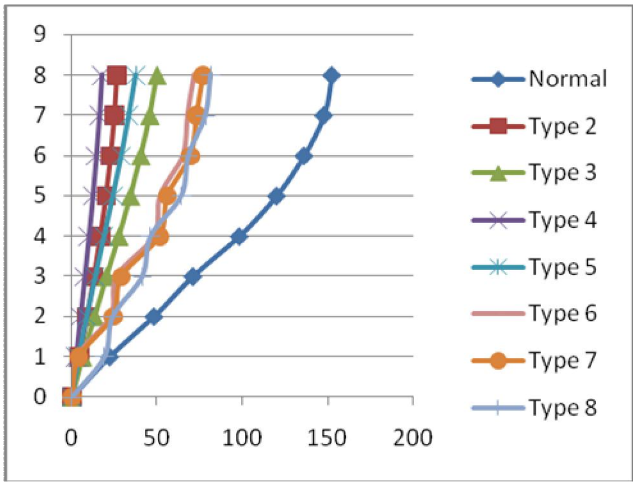
Model	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Normal
Base	0	0	0	0	0	0	0	0
1	2.8	4.9	2.9	3.3	4.3	3.9	5.6	15.6
2	7.6	13.5	7.7	9.5	16.3	14.5	12	50.4
3	12.6	23.3	13.1	16.8	25.3	21.7	23.1	93.7
4	17.4	33.9	19	25.1	40.7	34.7	30.2	141.2
5	21.7	44.4	25.2	33.8	50.3	41.7	42.2	184.9
6	25.3	54.4	31.1	42.4	63.7	52.5	48.7	221.3
7	28.1	63.8	36.8	50.7	72.1	58.2	58.7	247.8
Roof	30.3	71.7	41.9	58.2	78	62.3	63.6	259.8



Graph 1: Joint displacement (mm) for various bracing type of Angle Bracing in **X** - Direction

Table 4: Y – Direction Angle Bracing Joint Displacement

Model	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Normal
Base	0	0	0	0	0	0	0	0
1	2.3	4.4	1.5	2.6	1.8	2.7	18.9	22.2
2	4.7	9.7	3.2	6.2	21.3	22.4	22.5	48.2
3	6.8	15.3	5	10.4	24	26.2	39.5	71.1
4	8.8	21.3	6.8	15	46	48.4	43.5	98.3
5	10.5	27.1	8.6	19.8	48.9	52.4	61.5	120.2
6	11.8	32.6	10.3	24.4	62.2	65.8	65.2	136.3
7	12.8	37.7	11.8	28.9	64.8	69.2	75.2	147.9
Roof	13.5	42.1	13.2	33	68.7	73	78.2	152.6



Graph 2: Joint displacement (mm) for various bracing type of Angle Bracing in **Y** - Direction

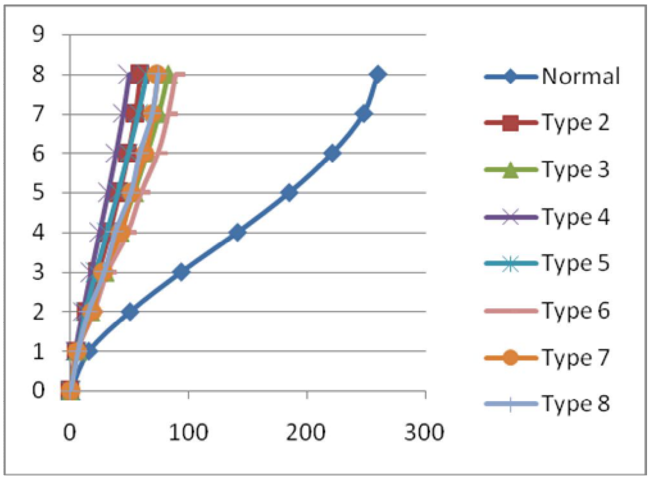
2. **Maximum Storey Displacement of Structure with Tube Bracing Provision:**

Table 5: Maximum storey displacement and Dead Load of model with Tube bracing provision

No.	Type of Model Tube Bracing	Maximum Storey Displacement In X (mm)	In Y (mm)	Dead Load of the Structure (KN)
1	Normal Model	259.8	152.6	20002
2	Type 2 Bracing	59.9	26.8	20091
3	Type 3 Bracing	82.7	50.1	20059
4	Type 4 Bracing	49.3	17.4	20138
5	Type 5 Bracing	65	37.4	20129
6	Type 6 Bracing	89.1	72	20074
7	Type 7 Bracing	73.6	77	20059
8	Type 8 Bracing	74.2	81.5	20060

Table 6: X – Direction Tube Bracing Joint Displacement

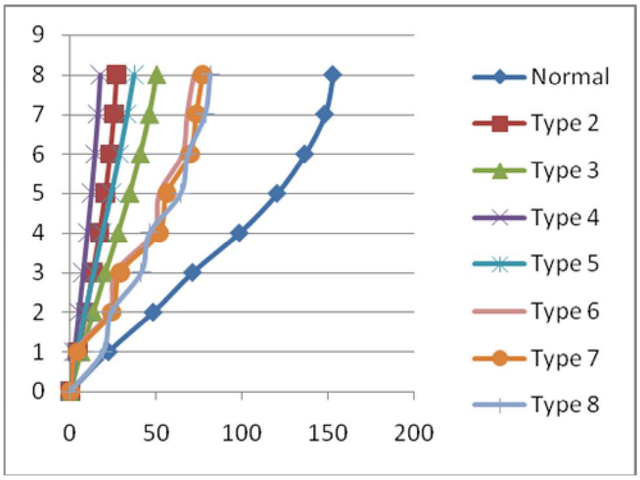
Model	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Normal
Base	0	0	0	0	0	0	0	0
1	5.1	6.1	3.9	5.6	5.7	5.3	6.4	15.6
2	14	17	10.3	12.8	19.7	18	15.2	50.4
3	23.5	29.2	17.2	21.6	31.2	27.8	28.6	93.7
4	32.8	41.9	24.4	30.9	48.5	42.8	37.7	141.2
5	41.2	54	31.5	40.3	59.8	51.5	51.1	184.9
6	48.6	65.1	38.2	49.4	74.1	63.2	58.7	221.3
7	54.7	75	44.3	57.7	83	69.4	69.2	247.8
Roof	58.9	82.7	49.3	65	89.1	73.6	74.2	259.8



Graph 3: Joint displacement (mm) for various bracing type of Tube Bracing in **X** – Direction

Table 7: Y – Direction Tube Bracing Joint Displacement

Model	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Normal
Base	0	0	0	0	0	0	0	0
1	4.5	6.3	2.4	3.9	2.9	4.1	19.1	22.2
2	9	13.4	5	8.5	22.6	24.1	24	48.2
3	13.1	20.4	7.5	13.6	26.2	29.1	41.4	71.1
4	16.9	27.7	9.9	18.7	48.4	51.5	46.2	98.3
5	20.3	34.5	12.2	23.9	51.8	56.1	64.4	120.2
6	23.1	40.6	14.2	28.8	65.3	69.6	68.5	136.3
7	25.3	45.9	16	33.2	68	73.3	78.6	147.9
Roof	26.8	50.1	17.4	37.2	72	77	81.5	152.6



Graph 4: Joint displacement (mm) for various bracing type of Tube Bracing in Y – Direction

3. Tube Bracing and Angle Bracing Joint Displacement Difference for Various Models in Percentage

	Angle Bracing		Tube Bracing		% Difference	
Model Type	X	Y	X	Y	X	Y
Normal	259.8	152.6	259.8	152.6	0	0
2 Type	30.3	13.5	59.9	26.8	49	50
3 Type	71.7	42.1	82.7	50.1	13	16
4 Type	41.9	13.2	49.3	17.4	15	24
5 Type	58.2	33	65	37.4	10	12
6 Type	78	68.7	89.1	72	12	5
7 Type	62.3	73	73.6	77	15	5
8 Type	63.6	78.2	74.2	81.5	14	4

4. Tube Bracing and Angle Bracing Dead Load Difference for Various Models in Percentage

	DL of Angle Bracing Model (KN)	DL of Tube Bracing Model (KN)	Weight Difference (KN)
Model Type			
Normal	20002.37	20002.37	0
2 Type	20147.77	20091.25	56.525
3 Type	20103.64	20058.78	44.86
4 Type	20251	20137.95	113.05
5 Type	20204.89	20129.51	75.38
6 Type	20129.99	20073.45	56.54
7 Type	20103.64	20058.78	44.86
8 Type	20105.33	20060.47	44.857

V. CONCLUSIONS

From the above result it can be concluded that:

- The Angle shape bracing and Tube shape bracing in the building reduces the lateral displacement or joint displacement due to Wind load effects in Multi-storey steel building as compare to the Multi-storey steel building without any bracing provision.
- From this study it can be seen that, Angle bracing Type 4 model gives the minimum lateral displacement as compare to other angle bracing models. Also Type 4 Tube bracing model gives the minimum lateral displacement as compare to other tube bracing system models.
- It is also observed that, steel framed buildings with Tube bracing system have less joint displacement than Normal building. Also Tube bracing steel structure has less weight than Angle bracing steel structure.
- Tube bracing steel structure is much effective in terms of Joint displacement, Dead load of entire structure.

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