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Wind Analysis of High Rise Building with Different Bracing Systems

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ABSTRACT: The design of high rise reinforced concrete building should involve the good lateral load resisting system along with the vertical loads acting on the building as wind load will govern in high rise buildings. This paper is presented to show the variation of shear force and bending moment that would be developed in high rise buildings with different bracing systems at different locations subjected to wind loading. For this purpose the G+19 storied reinforced concrete building model is used with a constant configuration and with different bracing system such as diagonal bracing, X-bracing, V-bracing, chevron bracing at different locations. A structural analysis of the reinforced concrete building is performed by using software STAAD-Pro V8i and different parameters are studied and compared. The different parameters include shear force and bending moment in the building. The sections of reinforced concrete elements such as beams, columns, slabsare as per IS 456:2000 based on the limit state parameters and steel angles are used for bracing elements as per IS 800:2007. Based on the study it can be concluded that along with the type of bracing the locations of bracings is also of great importance in resisting lateral load.

KEYWORDS: Wind load, high rise building, wind analysis, different brace system and different locations, shear force, bending moment, weight of structure

I. INTRODUCTION

Tall buildings are critically affected by wind loads. Wind exerts forces and moments on the structure and its claddingexerting the wind pressure which is nothing but the air distributed in and around the building. Sometimes because of unpredictable nature of wind it takes so devastating form that it can upset the internal ventilation system when it passes into the building. Hence, it has become of utmost importance to study the effect of wind and air flow on the building and its environment.

A work is presented to show the effect of different types of bracing systems in multi storied steel buildings by Jagadish J. S, et. al. [1].Prof. SaritaSingla, et. al. [2]overviews the behavior of different shapes of the building under wind loading.Shraddha J. Patil, et. al.[3]studied about how wind load analysis plays an important role in designing and analysis of high rise buildings.Suresh P, et. al. [4] deals with the calculation ofwind loads using static and gust factor method for a sixteen storey high rise building and results are compared with respect to drift.K. Rama Raju, et. al. [5] attempts to analyze a RC tall building under wind and earthquake loading and different parameters such as baseshear, roof displacements, inter-storey drifts, accelerations are studied.

II. DETAILS OF THE STRUCTURE

A. Modeling and Analysis

The main aim to carry out analysis on different models is to study different bracing system placed at various location and their behavior. STAAD Pro V8i has been used for the analysis of different models. Initially, G+19 stories reinforced concrete building model is used with a constant configuration and with different bracing system such as diagonal bracing, X-bracing, V-bracing, chevron bracing at different locations. Results of different types of bracing system for buildings at various locations are discussed below. All the building models are subjected to gravity load, wind load and earthquake loads. Analysis of the buildings shows that the building is critical under wind loading. The comparison is made between the diagonal bracing, X-bracing, V-bracing, chevron bracing at different locations as shown in figure 2, 3, 4.

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Full forms of the terms used for representing various braising system configurations

1	WB	Without Bracings			
2	XBCO	X Bracings Corner	13	DBA1	Diagonal Bracings Alternate Config.1
3	XBA	X Bracings Alternate	14	DBA2	Diagonal Bracings Alternate Config.2
4	XBC	X Bracings Center	15	DBA3	Diagonal Bracings Alternate Config.3
5	XBX	X Bracings configuration X	16	DBX	Diagonal Bracings Configuration X
6	XBZ	X Bracings Configuration Zigzag	17	DBZ	Diagonal Bracings Configuration Zigzag
7	DBCO1	Diagonal Bracings Corner Config.1	18	CBCO	Chevron Bracings Corner
8	DBCO2	Diagonal Bracings Corner Config.2	19	CBC	Chevron Bracings Center
9	DBCO3	Diagonal Bracings Corner Config.3	20	CBA	Chevron Bracings Alternate
10	DBC1	Diagonal Bracings Center Config.1	21	VBCO	V Bracings Corner
11	DBC2	Diagonal Bracings Center Config.2	22	VBC	V Bracings Center
12	DBC3	Diagonal Bracings Center Config.3	23	VBA	V Bracings Alternate

B. Assumptions

The plan of the building is 30 m x 12 m with 5 bays in x- direction and 3 bays in z-direction as shown in figure 1. The floor to floor height is 3m. The building is situated in Nagpur and wind speed is 44m/s.The following assumptions are made according to IS 456: 2000 [6]:

Grid Size	: 30 m x 12 m
Total Height	: 60 m
Size of Columns	: 850 mm x 850 mm
Size of Beams at each floor	: 300mm x 450 mm
Grade of Concrete in Columns	: M35
Grade of Concrete in Beams	: M30
Grade of steel	: Fe 500

All supports were assumed to be fixed.

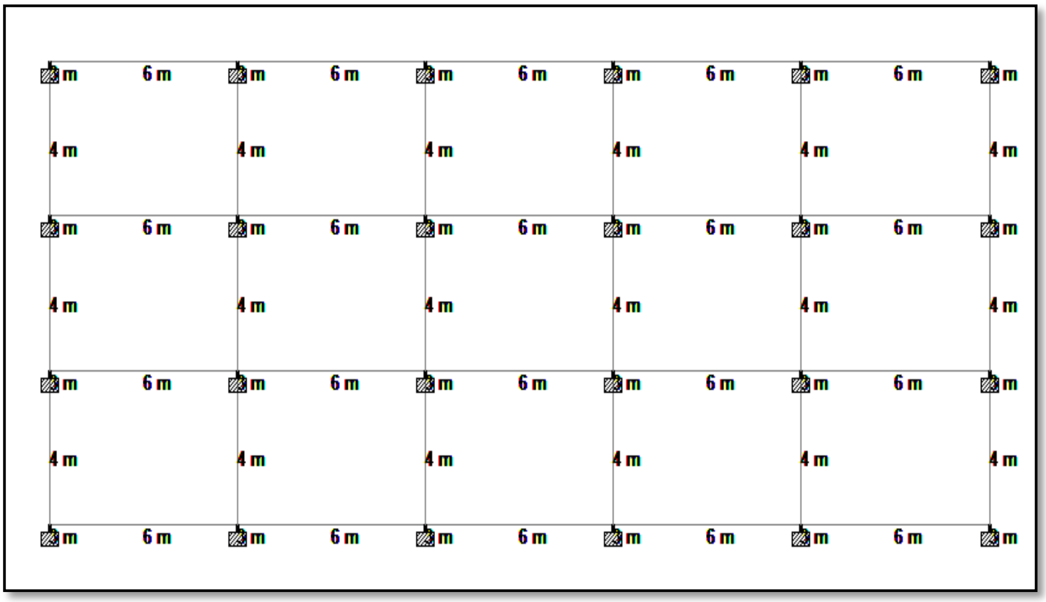

Fig 1: Plan of the building

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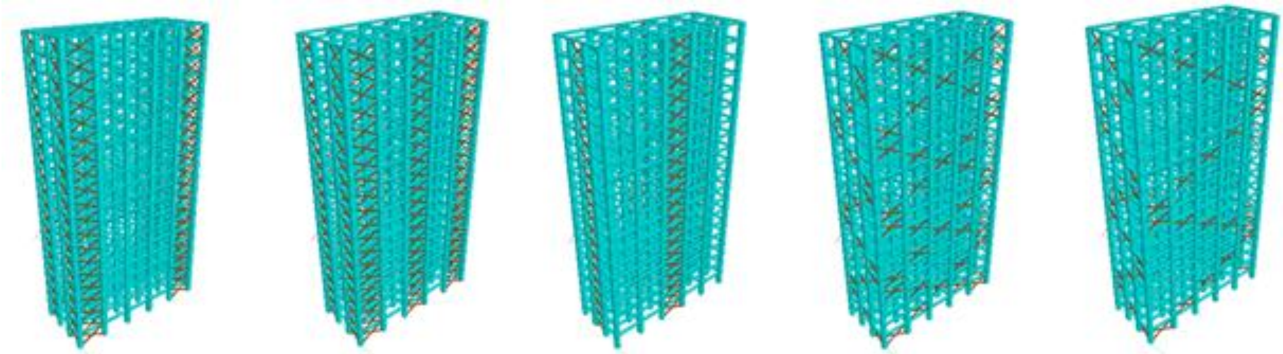

Fig 2: Different Locations of X bracings at Corner, Alternate, Centre, Configuration X and Configuration Zigzag

III. DESCRIPTION OF LOADING

A. Gravity Loading:

The gravity load includes the dead load, live load and floor finish. Floor loads and member loads are considered with reference to the specifications given in IS 875: Part 1 [7]. Live load is considered according to the specifications given in IS 875: Part 2[8] for residential building. The live load intensity is 3 kN/m^2 for all the floors.

B. Wind Loading:

Static wind load is given asper IS 875-part3 [9]. Following assumptions are usedfor calculations.

Location	:Nagpur
Wind speed	: 44m/s
Terrain category	: 2
Class	: C
K1	: 1
K2	: Depending upon the variation of height.
K3	: 1.0(flat topography)

C. Earthquake Loading:

Static earthquake load is given as per IS 1893: 2002 [10]. Following assumptions are used for calculations.

Zone Factor	:0.1
Importance Factor	: 1
Response Reduction Factor	: 5
Soil type	: Medium Soil
Damping Coefficient	: 0.05

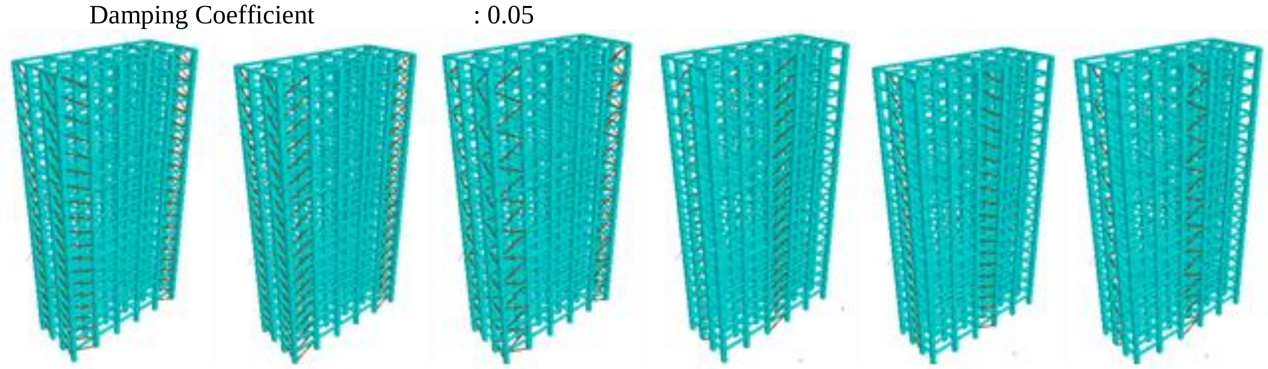

Fig 3: Different Locations of diagonal bracings at corner and center

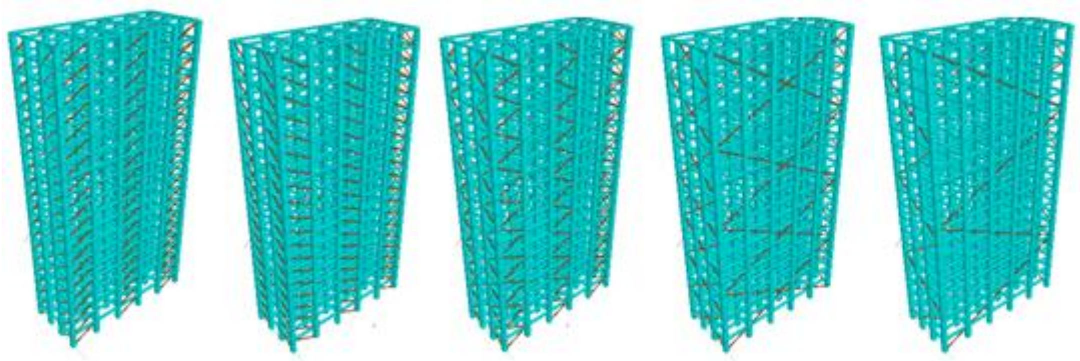

Fig 4: Different Locations of diagonal bracings

IV. RESULTS AND DISCUSSION

For 22 different types and configurations of bracing systems wind analysis is carried out and from the results obtained after analysis we can see significant variation in bending moment of the structure whereas there is negligible or no change is shear force in Y direction and very little variation in Z direction. Following are the table 1, 2, 3 and 4 and graphs for bending moment, shear force and weight of the structure.

Fig 5: Chevron bracings and V bracings at corner,center and alternate locations

Table 1. Maximum Bending Moment My (KN.m)

Sr. No.	Type of Bracings	Max. Bending Moment My (KN.m)
1	WB	460.59
2	XBCO	334.264
3	XBA	334.23
4	XBC	370.976
5	XBX	401.262
6	XBZ	401.17
7	DBCO1	355.447
8	DBCO2	355.447
9	DBCO3	418.972
10	DBC1	433.284
11	DBC2	433.281
12	DBC3	434.471
13	DBA1	406.846
14	DBA2	406.846

Table 2. Maximum Bending Moment Mz(KN.m)

Sr. No.	Type of Bracings	Max. Bending Moment Mz (KN.m)
1	WB	315.518
2	XBCO	249.546
3	XBA	243.615
4	XBC	231.257
5	XBX	229.204
6	XBZ	259.275
7	DBCO1	266.344
8	DBCO2	263.143
9	DBCO3	301.485
10	DBC1	280.21
11	DBC2	280.21
12	DBC3	289.15
13	DBA1	248.127
14	DBA2	248.127

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15	DBA3	418.649
16	DBX	345.905
17	DBZ	439.881
18	CBCO	399.632
19	CBC	381.209
20	CBA	343.158
21	VBCO	430.332
22	VBC	436.961
23	VBA	428.929

15	DBA3	284.711
16	DBX	230.745
17	DBZ	274.543
18	CBCO	262.906
19	CBC	238.645
20	CBA	229.075
21	VBCO	284.801
22	VBC	279.575
23	VBA	254.809

Table 3. Maximum Shear Force Fy(KN)

Sr. No.	Type of Bracings	Max. Shear Force Fy (KN)
1	WB	176.704
2	XBCO	176.725
3	XBA	176.78
4	XBC	176.734
5	XBX	177.084
6	XBZ	178.172
7	DBCO1	177.658
8	DBCO2	177.109
9	DBCO3	177.028
10	DBC1	176.947
11	DBC2	177.092
12	DBC3	176.759
13	DBA1	177.064
14	DBA2	177.721
15	DBA3	177.064
16	DBX	177.599
17	DBZ	177.359
18	CBCO	176.98
19	CBC	177.062
20	CBA	177.042
21	VBCO	176.548
22	VBC	176.678
23	VBA	176.562

Table 4. Maximum Shear Force Fz (KN)

Sr. No.	Type ofBracings	Max. Shear Force Fz (KN)
1	WB	102.592
2	XBCO	106.277
3	XBA	106.263
4	XBC	103.757
5	XBX	124.739
6	XBZ	124.696
7	DBCO1	119.135
8	DBCO2	108.197
9	DBCO3	137.396
10	DBC1	107.801
11	DBC2	121.483
12	DBC3	126.146
13	DBA1	100.564
14	DBA2	100.564
15	DBA3	137.307
16	DBX	95.81
17	DBZ	116.688
18	CBCO	99.837
19	CBC	101.136
20	CBA	99.479
21	VBCO	108.993
22	VBC	114.447
23	VBA	123.258

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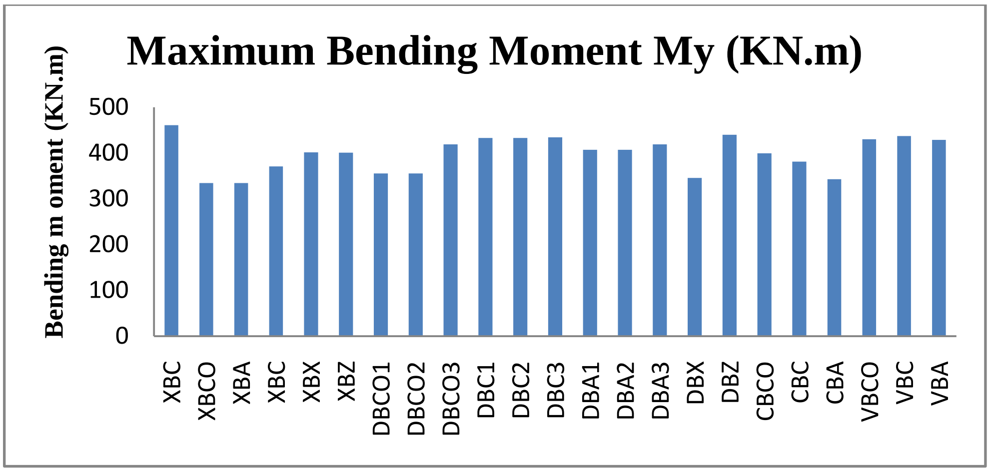

Fig 6.Maximum Bending Moment My (KN.m) for different Bracing Systems

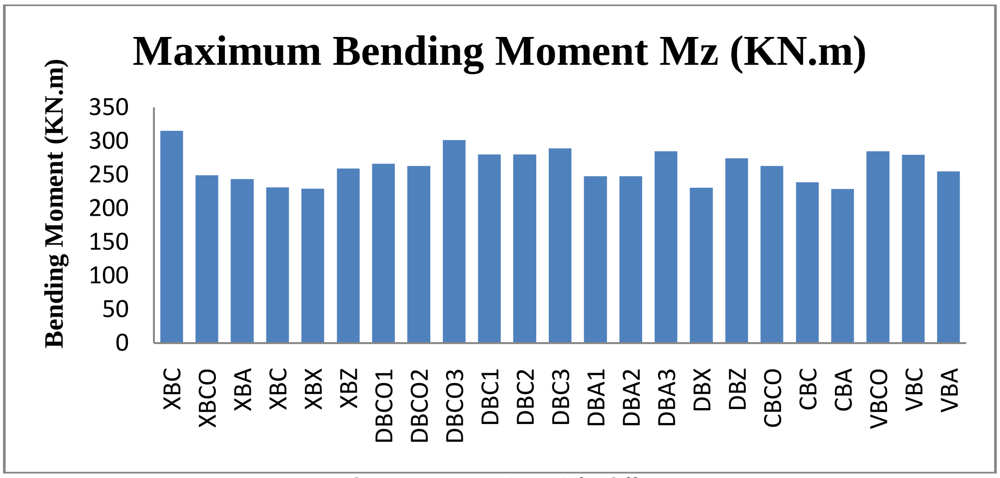

Fig 7.Maximum Bending Moment Mz (KN.m) for different Bracing Systems

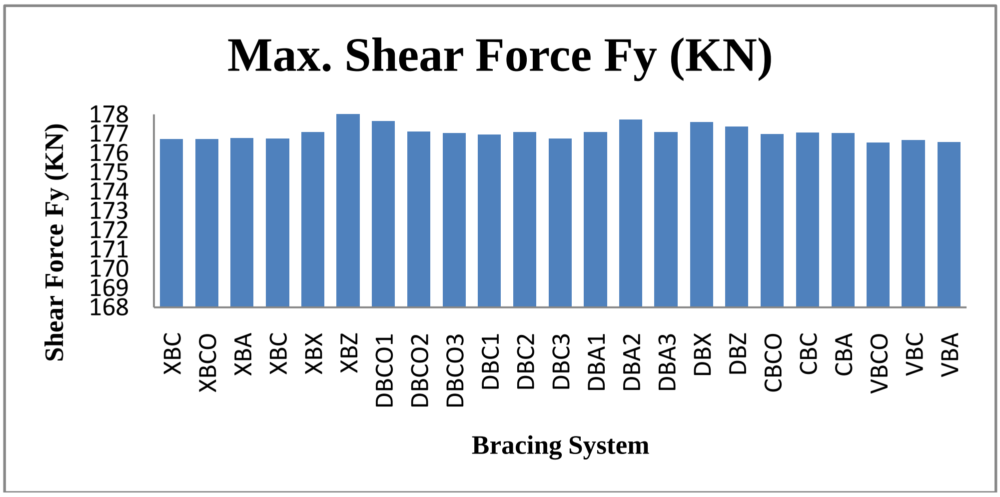

Fig 8. Maximum Shear Force Fy (KN) for different Bracing Systems

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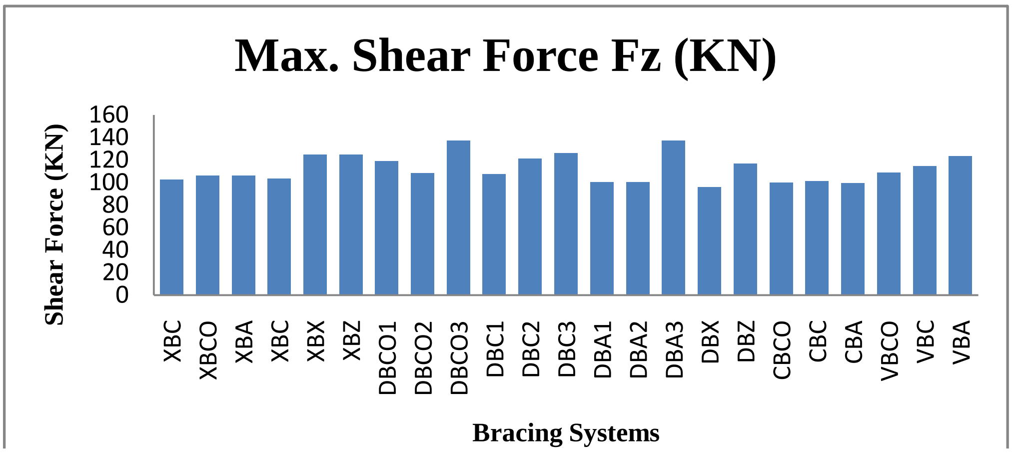

Fig 9. Maximum Shear Force Fz (KN) for different Bracing Systems

Table 5.Weight of Structure (KN)

Sr.No.	Type of Bracings	Weight (KN)
1	WB	127502
2	XBCO	127895
3	XBA	128015
4	XBC	127719
5	XBX	127768
6	XBZ	127684
7	DBCO1	127699
8	DBCO2	127699
9	DBCO3	127699
10	DBC1	127600
11	DBC2	127600
12	DBC3	127600

Sr.No.	Type of Bracings	Weight (KN)
13	DBA1	127758
14	DBA2	127758
15	DBA3	127758
16	DBX	127699
17	DBZ	127600
18	CBCO	127589
19	CBC	127633
20	CBA	127840
21	VBCO	127579
22	VBC	127571
23	VBA	127683

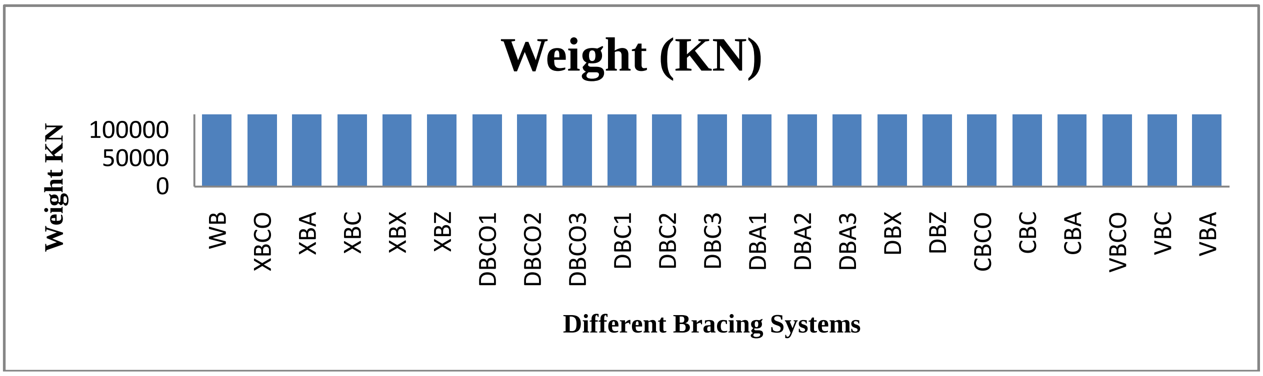

Fig 10.Weight of Structure with different bracing systems

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V. CONCLUSION

From the present study following conclusions are made:

1. On the basis of results of different bracing systems obtained it can be concluded that different bracing systems at different location of the structure can be effectively used to reduce excessive bending moment in column due to lateral (Wind) loading.
2. From the observations made above it can be concluded that Chevron Bracing at alternate bays is most effective in reducing bending moment in column due to lateral (wind) loading reducing bending moment effectively by 34.2% in Y direction and 37.7% in Z direction from that of structure without bracings
3. On the basis of results of different bracing systems obtained it can be concluded that there is no significant variation in Shear Force in both Y and Z direction and is not very useful in reducing shear force in the structure.
4. On the basis of results of different bracing systems obtained it can be seen that there is negligible increase in the weight of structure due to addition of various bracings.
5. Hence we can conclude that bracing systems can effectively improve the performance of structure without adding considerable extra dead load to the structure.

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