Wind Analysis of Composite Building with Bracing System

Mayank Walia, Supervisor, Nirbhay Thakur, Nitish Kumar Sharma

Abstract*: The present investigation shows the research work carried out on the composite structure provided with bracing system. For this investigation, 12 storey irregular building and 16 storey regular building were modelled in staad.pro design software with different types of bracing (i.e. cross bracing, V-type bracing and zigzag bracing) at the edges of the building to provide lateral stability. For this study, steel framed structure was proposed for upper 4 storey of 12 storey building and 16 storey building in order to reduce the dead weight of the structure and wind analysis was performed. All the members were studied in a scrutinized way after the analysis from the post-processing of staad.pro and the performance of the structure was evaluated. The effectiveness of bracing system and introduction of steel framed structure in RCC building was concluded as the final outcome of the present investigational study. In the gist, it has been concluded that minimum displacement was found out in type A and type X building which entails cross type bracing which has proved to be more effective than V type and zigzag type bracing. And building having zigzag bracing entails minimum total quantity whereas, building having cross bracing system uses maximum material quantity. There was slight variation in % of steel as the column sizes were same for same type of building i.e 12 storey irregular building and 16 storey regular building.

***Index Terms*: Wind Analysis, Composite Structure, Bracing System, Staad.Pro.**

I. INTRODUCTION

At present world, there is quick emersion of the new advances related to protected, affordable, stable construction. In such a pattern, earthquake has turned out to be one of the natural challenging factor for the capable construction works. It is one of the prevailing imperatives while structuring the frame building in the earthquake inclined zone like Nepal. Earthquake is a natural phenomenon as old as the historical backdrop of the earth itself and is viewed as most unpredictable which is one of the natural hazard. Presently, engineers and designers are giving more efforts towards the earthquake obstruction while examining and planning any structure to limit the seismic effect. One being a experienced designer needs to manage different structures extending from basic ones like electric poles to progressively complex ones like multi-storied casing structures, bridges, curtailment rods, shell rooftops, and so forth. These structures are exposed to different loads like internal or earthquake load, uniformly distributed loads, dynamic forces, uniformly varying loads, and concentrated loads which are considered in the design stage. The structure exchanges its load to the supports and at last to the ground. While exchanging the loads, the members of the structure are exposed to internal force such as torsional moments, axial forces, bending and shearing forces which are talked about while examining the structures. On the basis of these parameters, the structures are designed. While analysis, frames are examined for seismic tremor as horizontal or lateral load. During the earthquake, structural and non-structural harms happen in which both of two are disastrous to inhabitants. At the point when seismic shaking happens, a structure gets thrown from side to side or here and there. Wind Analysis: External variables and loads influence and effect the life and nature of structures. Forces of nature are probably the harshest tests that these structures are exposed to. From various types of wind loads to seismic loads, impacts of corrosion and sun based radiation – there are numerous variables to consider in the building and plan of structures and structures. Wind is a powerful force that has a lot of impact on structures. There are two kinds of impacts of wind on structures: static and dynamic. The static load for the most part prompts flexible bending and twisting of structure. Loads due to wind can be applied by the motion of air with respect to a structure. Wind load may not be a critical for little, massive, low-level structures; however, it picks up significance with the increase of height. A structure's design wind speed is normally decided from historical records with extreme value theory to foresee abnormal wind speeds that may happen later on.

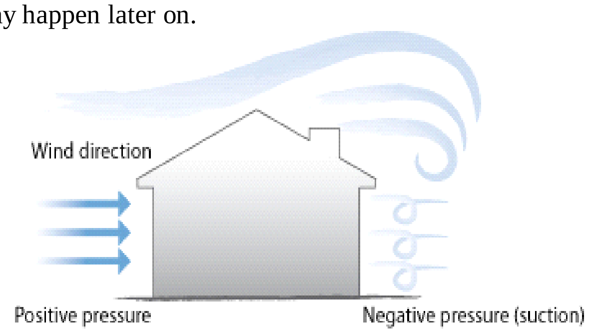

Figure 1: Wind effect on Structure

The components of winds are applied horizontal force which is considered during designing the building.

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Mayank Walia, PG Student, Civil Department, Chandigarh University Gharuan, Mohali (Punjab), India.

Nirbhay Thakur, Supervisor ER. Assistant Professor, Civil Department, Chandigarh University Gharuan**,** Mohali (Punjab), India

Nitish Kumar Sharma, Co-Supervisor ER. Assistant Professor, Civil Department, Chandigarh University Gharuan, Mohali (Punjab), India.

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The wind loads calculation based on the two factors, namely size of the building and velocity of wind. Complete informations of calculating wind load on structures are given below (by the IS-875 (Part 3) -1987).

expression shall be used:

$Vz = k1*k2*k3*Vb$

Where;

Vb = basic wind speed

k1 = Risk coefficient

k2 = Coefficient based on terrain, height and structure size.

k3 = Topography factor

The design wind pressure is given by ‘pz’

$pz = 0.6 Vz2$

where pz is in N/m2 at height Z and Vz is in m/sec. Up to a height of 30 m, the wind pressure is considered to act uniformly. Above 30 m height, the wind pressure increases.

II. Materials and Methods

The research method of present study entails various steps which helped in achieving the objectives of this study. The comparison between different types of bracing system in composite building is unique in its own way. The methodology of this research is divided into different phases which is mentioned below.

Phase I: Modelling (General Input Data of Various Models)

Analyzing and designing has been done in software Staad.pro with wind analysis. Following are the parameters of various models:

- Type A: 16 storey Regular building with X-bracing.
- Type B: 16 storey Regular building with V-bracing.
- Type C: 16 storey Regular building with Zigzag-bracing.
- Type X: 12 storey Irregular building with X-bracing.
- Type Y: 12 storey Irregular building with V-bracing.
- Type Z: 12 storey Irregular building with Zigzag-bracing.
- Single storey height: 3 m.
- No. of bays for regular building: 6 bays in each direction.
- Panel size for regular building: 6 m x 5 m.
- No. of bays for Irregular building: as per plan (See fig. 5).
- Panel size for irregular building: 5 m x 5 m.

Note: the 16 storey regular building is divided into two portions i.e. Lower 12 floors comprises of RCC framed building and rest 4 floors entails steel framed structure. And 12 storey irregular building is also divided into two portions i.e. Lower 8 floors comprises of RRC framed building and rest 4 floors entails steel framed structure.

Dead Load:

Exterior Wall Load: 12.4 kN/m

Interior Wall Load: 6.2 kN/m

Concrete Floor load: 6 kN/m2

Deck Slab Load: 4 kN/m2

Live Load:

Floor load: 3 kN/m2

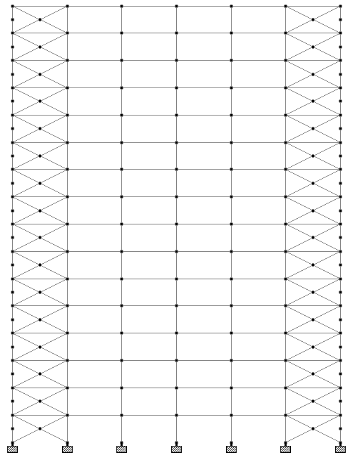

Figure 2: Typical Elevation of 16 Storey Building with Cross Bracing

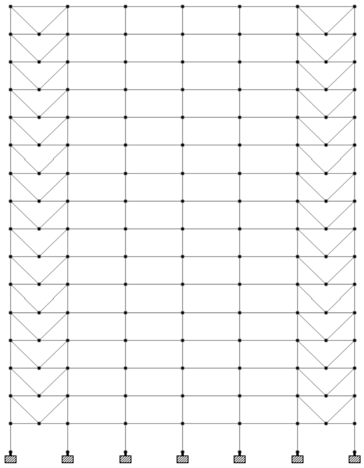

Figure 3: Typical Elevation of 16 Storey Building with V-Bracing

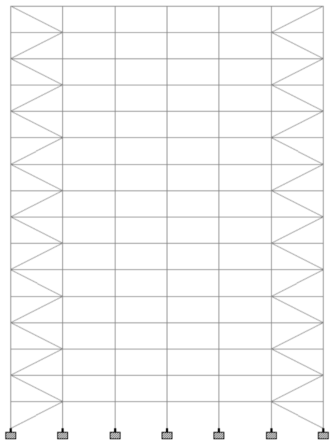

Figure 4: Typical Elevation of 16 Storey Building with Zigzag bracing.

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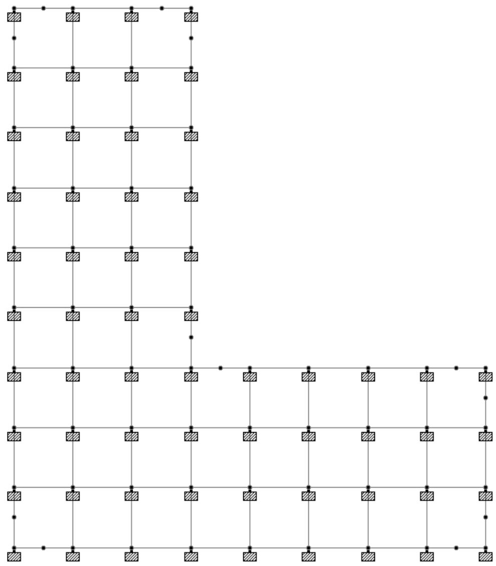

Figure 5: Typical Plan of 12 Storey Building

Phase II: Wind Analysis

Wind pressure is calculated as per Indian Code IS: 875 Part III. Four load cases were formed for wind analysis in software Staad.Pro as mentioned below:

- Wind in X Direction
- Wind in –X Direction
- Wind in Z Direction
- Wind in –Z Direction

Calculation of wind load is as under:
Basic wind speed (Vb): 47 m/sec
Factors (k1, k2, k3): 1
Therefore,
Vz: Vb*k1*k2*k3
: 47 m/sec
Pz: 0.6* Vb2
: 0.6*(47)2
: 1325.4 N/m2 = 1.35 kN/ m2
: 1.5 kN/ m2 (Say)

This wind pressure is applied on columns by converting it in uniform distributed load. Figure 6 and 7 shows the wind load in +X and +Z direction on 16 storey building. Figure 8 and 9 shows the wind load in the +X direction and +z direction on 12 Storey Building.

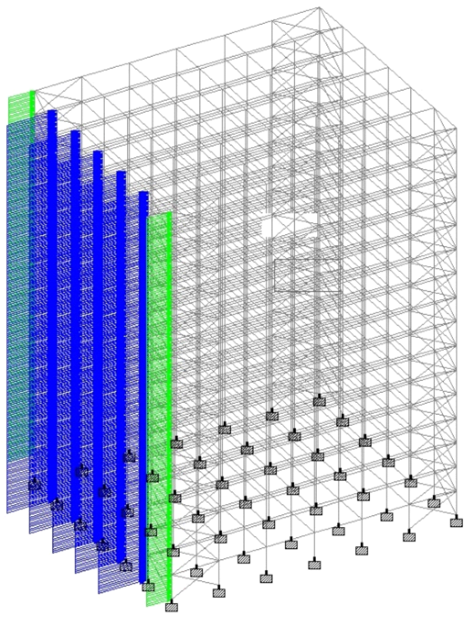

Figure 6: Wind in X direction on 16 Storey Regular Building.

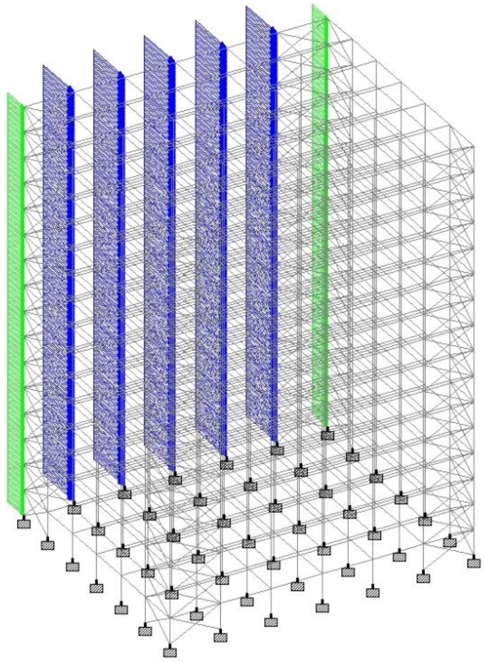

Figure 7: Wind in Z direction on 16 Storey Regular Building

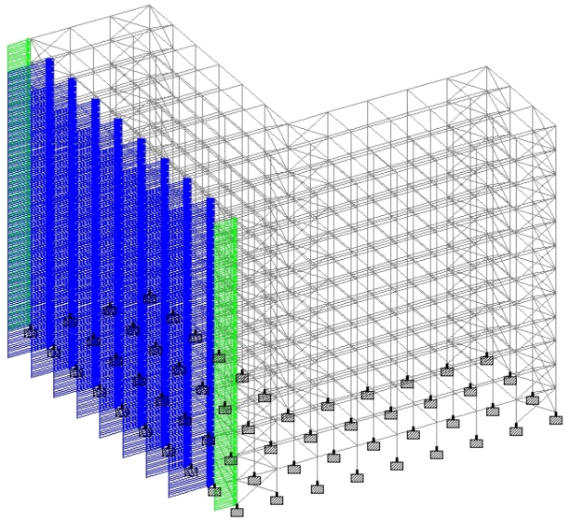

Figure 8: Wind in X direction on 12 Storey Irregular Building

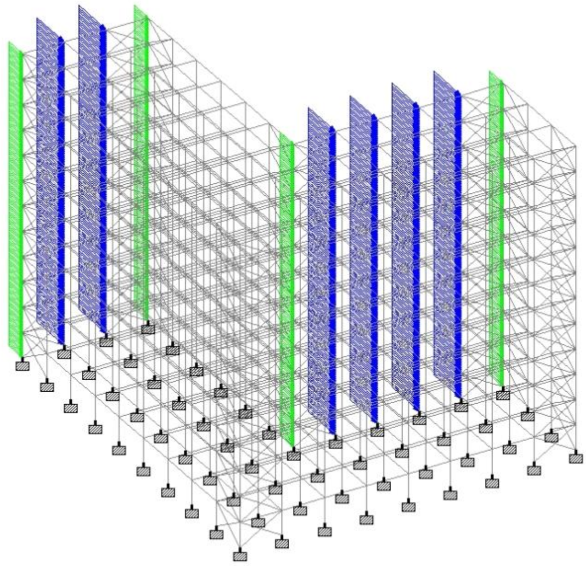

Figure 9: Wind in Z direction on 12 Storey Irregular Building

III. RESULTS AND DISCUSSION

Results of 16 Storey Regular Building:

As the column is designed in staad.pro, % of steel was calculated from the critical case values of axial force and bending moment. There is a slight variation in the percentage of steel of columns between type A, type B and type C Building. The results of the same are represented in Figure 10. Maximum and minimum value is 1.12% and 0.8% respectively.

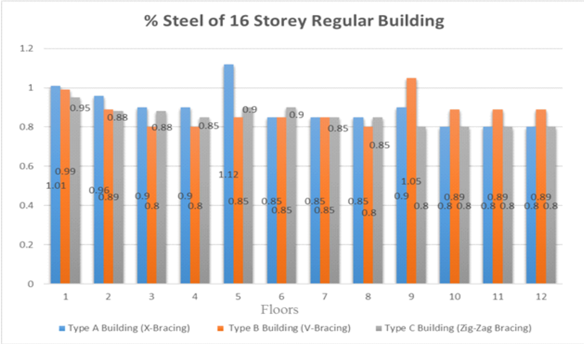

Figure 10: Variation in % of Steel in Column for 16 Storey Building

Figure 11 shows the maximum displacement results of column in X and Z direction when the building was subjected to wind loading in staad.pro software. It was concluded that type B shows higher displacement values than type A and type C.

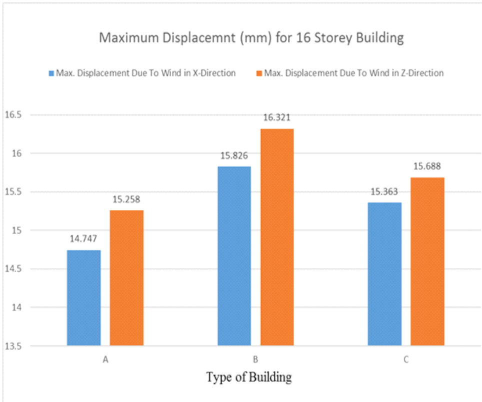

Figure 11: Maximum Displacement for 16 Storey Building

For better comparison of the present investigation, total quantities of RCC portion (Concrete quantity and Reinforcement quantity) along with the quantities of steel sections of steel Portion of the building were recorded. Table 1 show the comparison of the total quantity between the various types of 16 storey buildings i.e. type A, type B and type C.

Table 1: Total Quantity for 16 Storey Building

	Concrete (m^3)	Steel (kN) for RCC Portion	Steel (kN) for Steel Portion
Type A	2033.2	1244.417	2575.16
Type B	1959.2	1223.009	2552.28
Type C	1946.3	1210.681	2542.5

Results of 12 Storey Irregular Building

The percentage of steel in RCC columns was calculated from the critical case values and it is shown in the table below and in the figure 12 for comparison purpose. The results of the same shows that there is less variation in the percentage of steel values of various models.

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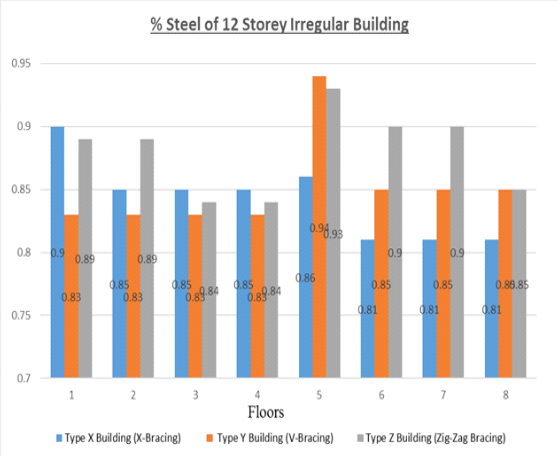

Figure 12:Variation in % of Steel in Column for 12 Storey Building

Figure 13 shows the maximum displacement of column when the building was subjected to X-direction and Z direction. And it was concluded that the type Y has higher displacement values than any other type of building.

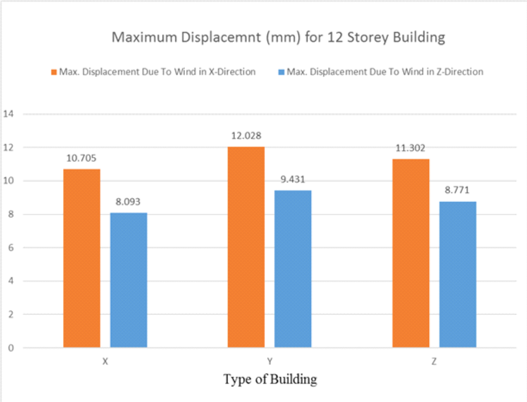

Figure 13. Maximum Displacement for 12 Storey Building

Total quantities of RCC portion (Concrete and Reinforcement) along with the quantities of steel sections of steel Portion of the building were recorded. Table 2 shows the total quantity of different type of buildings i.e. type X, type Y and type Z.

Table 2: Total Quantity for 12 Storey Irregular Building.

	Concrete (m^3)	**Steel (kN) for RCC portion**	**Steel (kN) for Steel portion**
Type X	1203.5	795.157	2555.93
Type Y	1135.7	755.961	2527.24
Type Z	1124.8	747.898	2512.50

IV. CONCLUSION

All the results were studied in a scrutinized way from tables and figures. The final outcomes which have been drawn from them for the present investigational study are mentioned in the following section.

- As the percentage of steel in column of 16 storey building has been calculated from the critical combination of axial load and bending moment, a slight variation was found in the values of % of steel between the various types of buildings.
- As minimum displacement was found out in type A building, therefore, it is concluded that cross type bracing is more effective than V type and zigzag type bracing.
- Type A building entails maximum quantity of material for both RCC and steel framed portion whereas, Type C uses minimum quantity.
- For all the models of 12 storey irregular building, small variation in percentage of steel in columns was found.
- Again, the displacement results of 12 storey irregular building show that cross bracing (Type X building) is the most suit bracing for resisting the horizontal displacement as it shows minimum displacement.
- But due to cross-bracing in 12 Storey building, there was a slight increase in the material quantity from the other type of bracing as it uses maximum quantity of material in the building.

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AUTHORS PROFILE

MAYANK WALIA, Student of Master of Technology in Structural Engineering in department of civil engineering in Chandigarh University, Punjab, India. Completed B.Tech in Civil Engineering from Green Hills Engineering College, Solan, Himachal Pradesh, India. Completed School Education from ARUNODAYA SENIOR SECONDARY SCHOOL, KULLU, HIMACHAL PRADESH . Not having any type of membership in any journal.

Nirbhay Thakur, Assistant Professor in department of civil engineering in Chandigarh University, Punjab, India. Completed Master of Technology in Structural Engineering from Amity University, Noida, India. in year 2016. Hometown is in Himachal Pradesh, India. Five research paper published in different journals in national journals as well as international journal. Two year teaching experience in Chandigarh University, India. Four M.Tech students guided in research work in various research topics which also includes research work related to civil Engineering designing Software.

Nitish Kumar Sharma, Assistant Professor in department of civil engineering in Chandigarh University, Punjab, India. Completed Master of Technology from Jaypee University of information Technology, India. Completed B.Tech in civil engineering from Chitkara University, Himachal Pradesh India. 15 research paper published in different journal of civil engineering field. Now pursuing Phd from Chitkara University, India. 10 M.Tech student guided for completion of research work. Having Three year of teaching experience and won best teaching award in 2018 in department of civil engineering.

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