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STUDY THE BEHAVIOUR OF WIND LOAD ON HIGH RISE BUILDING WITH INCREASE LEVEL OF RESPONSIBILITY

Kumar Vanshaj [1], Apurva Gaur[2], Abhishek Mishra[3]

[1] Assistant Professor, CED, Institute of Engineering & Technology, Lucknow, U.P.
[2] M.Tech Scholar, Structural Engineering, CED, Institute of Engineering & Technology, Lucknow, U.P.
[3] Assistant Professor, CED, Institute of Engineering & Technology, Lucknow, U.P

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Abstract - Wind load is one of the loads that must be evaluated in relation to the building's height. As the height of the building rises, so does the intensity of the wind. The structural design of tall high-rise buildings is influenced by the wind load, which is dynamic in nature. High-rise structures are difficult to analyze, and tedious calculations using traditional manual methods take a long time. The goal of this research is to look at the effects of different wind speeds and wind on different heights of multi-story buildings. In this analysis, a G+20, multi-story building is investigated, and various loads such as wind load and static load are applied, with the results analyzed. The research of structural behavior of the structure under wind load situations is investigated in this project utilizing STAAD. Pro.

Key Words: *High-rise building, wind load, static load, structural design, STAAD.Pro*

1. INTRODUCTION

The design of tall buildings in areas prone to both strong winds and hurricanes, or typhoons, is a topic of particular interest. Wind is a force that acts horizontally and with greater strength on the earth's surface. The wind force is not continuous; it varies from location to location and throughout time. The intensity of wind is greater if the location is a mountainous terrain in the countryside. However, if the terrain is flat and free of impediments such as buildings and trees, the intensity will be reduced at lower levels but increase as the building's height rises. The wind's intensity can also be adjusted depending on the weather. The wind analysis and design of the G+20 High-rise multi storey building is done.

2. LITERATURE REVIEW

Dean Kumar et al (2010), this research looked at the impact of wind loads on the design of these towers, which were compared to steel towers. Wind has caused a number of structural disasters in India. The Gust Effectiveness Factor Method is employed in this study, which is more realistic in terms of wind loads on flexible tall slender structures and tall building towers. Overall, the gust effectiveness factor method estimated wind pressures are not only safer for design, but also more sensible and realistic. This is a significant and true aspect to consider when designing extremely tall structures and constructions.

Umakant Arya et al (2014), In this research paper, the effect of wind velocity and structural response of building frame on sloping ground has been studied. For the combination, 60 examples in various wind zones and three distinct building frame heights were examined. The results are analyzed in terms of axial force, shear force, moment, support reaction, Storey-wise drift, and displacement to quantify the impacts of different ground slopes.

S.Vijaya Bhaskar Reddy et al (2015), the software tool ETABS was used to model multistory buildings with 5 and 10 storey in this study. The influence of varying building height on the structural reaction of the building is also discussed in this work. This work is significant because it estimates the design loads of a structure that is subjected to wind loads in a specific region.

A.K.Roy et al (2018), the wind impacts for structural frames with varied plan forms were investigated, and the results were related to the permissible drifts of different buildings. The quantity of drift is greatly modified with respect to the structure's design, and the wind stress on the building is high when it has the most exposed area, according to this analysis.

Vikrant Trivedi et al (2018), this research compares wind loads in order to determine the design loads of a G+11 structure. The purpose of this investigation is to determine the design loads for a structure that is exposed to wind loads in a specific area. The wind loads for a ten-story RC framed structure and an eleven-story RC framed structure are calculated Based on the findings, the following conclusions were drawn: wind loads increase with structure height. For towering structures, wind loads are more important than earthquake loads. For important wind forces, structures should be designed for loads obtained in both directions separately.

3. OBJECTIVE OF THE PROJECT

1. To design and analysis of a G+20 high-rise residential building by using STAAD.Pro, software.
2. To analyze the effect of wind velocities on different heights of High-rise building.
3. To study the structural behavior of the High-rise building under wind load

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4. METHODOLOGY

Method and analysis which is performed in the project is explained and elaborated below step wise with all the relevant details and information.

I. SOFTWRES USED FOR MODELLING -

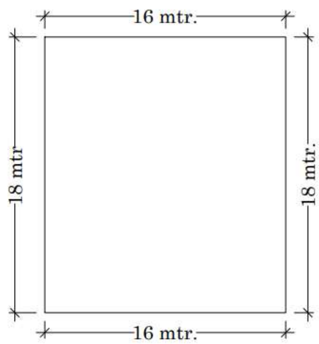
The software tools which are used for design and analysis of High-rise building under wind loads are as follows.

a) **AutoCAD**: Auto CAD is a standard drafting tool developed and maintained by Autodesk. The word auto came from Autodesk Company and CAD stands for computer aided drafting.

b) **STAAD.Pro**: STAAD.Pro is a designing software tool developed and maintained by Bentley. STAAD stands for Structural Analysis and Design. The S.F.D and B.M.D are obtained for each of the structural member. In this project the design and analysis of G+20 High-rise building is carried out by using STAAD.Prov8i software.

II. PLANS AND DESCRIPTION OF BUILDING –

Site plan: The plans which show the layout plan and The site area of the building plot. The below Site plan the dimensions are in meters.



III. DESCRPTION OF THE STRUCTURE

1. Building type: High-rise Building.
2. Location of the building: Bhopal, Madhya Pradesh,
3. Area of the plot: 288 m^2
4. No of floors: G+20.
5. Height of ground floor: 3m.
6. Height of each floor: 3m.
7. Basic wind speed: 39 Km/hour.
8. Grade of cement: 43 grade cement.
9. Grade of main reinforcement: fe500.
10. Size of columns: 600 mm x 600 mm.
11. Size of beams: 450 mm x 450 mm
12. Thickness of slab: 150mm.

IV. LOAD CASES DISTRIBUTION IN BUILDING

External pressures that a building must resist to ensure a suitable performance (i.e., safety and serviceability) during the structure's useful life are defined by loads, which are a major factor in any building design. The intended usage (occupancy and purpose), layout (size and shape), and location of a structure all influence the expected loads (climate and site conditions). Furthermore, design loads have an impact on crucial decisions including material selection, construction details, and architectural configuration.

TYPES OF LOADS ACTING ON STRUCTURES ARE:

a) **DEAD LOAD** - The dead load is the initial vertical load to be addressed. The term "dead loads" refers to loads that remain constant or stable throughout the life of a construction. The self-weight of structural parts, permanent partition walls, fixed permanent equipment, and the weight of various materials are the main sources of dead load.

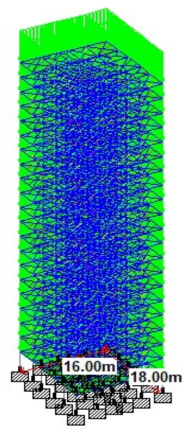


Fig- Dead Load on Whole Structure

b) **IMPOSED LOADS OR LIVE LOADS-** Imposed loads, also known as living loads, are the second type of vertical load that is taken into account while designing a building. Live loads are movable or moving loads that do not accelerate or damage the environment. These loads are supposed to be generated by the building's planned usage or occupancy, including the weights of moveable walls or furniture, among other things. IS 875 (part 2)–1987 specifies the minimum live load values to be assumed.

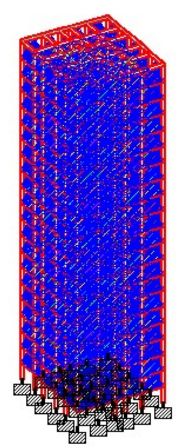


Fig- Live Load on Whole Structure

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c) **WIND LOADS-** The horizontal load induced by the movement of air relative to the earth is known as wind load. When the height of the structure reaches two times the dimensions transverse to the exposed wind surface, wind load must be included in structural design.

Further in limit state method the factor for design load is reduced to 1.2 (DL+LL+WL) when wind is considered as against the factor of 1.5(DL+LL) when wind is not considered. The horizontal forces exerted by wind components must be considered when designing the structure. The calculation of wind loads is dependent on two factors: wind velocity and building size. The IS-875 (Part 3) -1987 provides complete data on estimating wind load on structures.

Using color code, basic wind pressure „Vb" is shown in a map of India. Designer can pick up the value of Vb depending upon the locality of the building.

To get the design wind velocity Vz the following expression shall be used:

$$Vz = k1.\ k2.\ k3.\ Vb$$

Where,

k1 = Risk coefficient

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

k3 = Topography factor

The design wind pressure is given by

$$Pz = 0.6\ V2z$$

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.

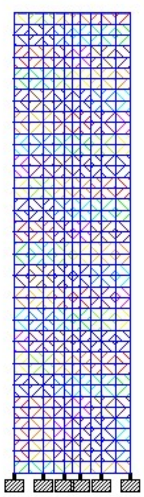

Fig- Wind Load on Structure (Front View)

d) **FLOOR LOAD:**

Floor load is calculated based on the load on the slabs. Assignment of floor load is done by creating a load case for floor load. After the assignment of floor load our structure looks as shown in the below figure. The intensity of the floor load taken is 3.75 kN/m2 -ve sign indicates that floor load is acting downwards

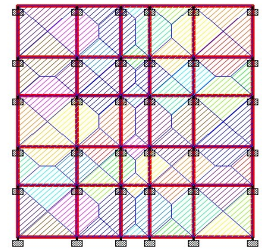

Fig- Floor Load on Structure (Top View)

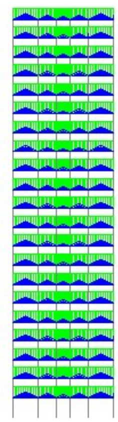

Fig- Floor Load on Structure (Front View)

e) **LOAD COMBINATIONS**

Load combination is termed as the action of more than one load on a specific structure. Generally, the loads acting on the structure are Dead Load (D.L), Live Load (L.L), Wind Load (W.L),

- (D.L + L.L + W.L) for structure subjected for wind load combination

STEP BY STEP PROCESS OF METHODOLOGY

1) Preparation of site plan depending on location and area available, a suitable site plan is prepared.
2) In Staad Pro, using Run Structure Wizard command prepared the detailed model.
3) Model generation.
4) Section properties (Define the sizes of beams and columns. And define the thickness of slabs)
5) Material Properties (Specify the material such as concrete)
6) Supports (Define supports at end of columns at bottom)
7) Loads (Assign loads such as, self-weight, live load, wind load)
8) Analysis (Indicate the type of analysis to be performed and associate option)
9) Design (Specify the suitable commands for concrete and steel design as per IS 456.)
10) Post processing (Give commands to Extract and Review Analysis, Result.)

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5. RESULT & ANALYSIS

These are the results and analysis in tabulated form for a G+20 multistory building.

I. Storey Drift - Storey Height is taken on X-axis and drift are taken on Y-axis. According to IS 1893 (Part 1), 2002 the storey drift due to minimum designed lateral force shall not exceed 0.004 times the storey height. Maximum drift occured at 12mtr for this structure.

STOREY HEIGHT(X-Axis)	STOREY DRIFT (mm) (Y-Axis)
0	0
3	1.335
6	2.209
9	2.405
12	2.415
15	2.337
18	2.259
21	2.172
24	2.079
27	1.981
30	1.878
33	1.771
36	1.66
39	1.546
42	1.429
45	1.309
48	1.188
51	1.065
54	0.941
57	0.817
60	0.696
63	0.592

Table .1 Storey Drift

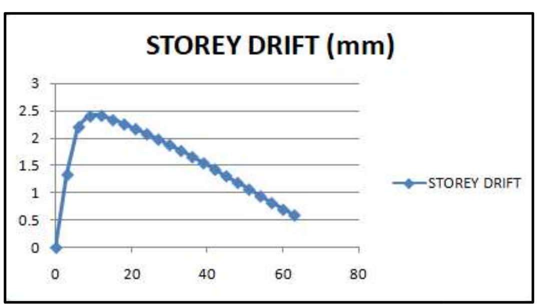

Fig-Storey Height Vs Storey Drift

II. **Storey Displacement-** Storey Height is taken on X-axis and Displacement are taken on Y-axis. Maximum displacement occurs at 63mtr.

STOREY HEIGHT	STOREY DISPLACMENT (mm)
0	0
3	1.335
6	3.604
9	6.025
12	8.425
15	10.762
18	13.021
21	15.193
24	17.272
27	19.253
30	21.131
33	22.901
36	24.561
39	26.107
42	27.535
45	28.844
48	30.032
51	31.097
54	32.038
57	32.855
60	33.551
63	34.143

Table .2 Storey Displacements

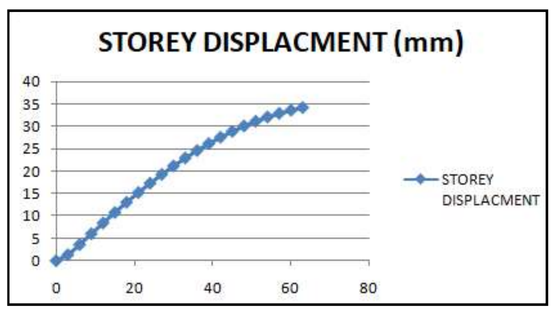

Fig- Storey Height Vs Storey Displacement

III. **Bending Moment-** Storey Height is taken on X-axis and bending moment are taken on Y-axis. The wind load is applied on the outer edge columns from top to bottom and bending moment start decreasing occurs at 54mtr.

STOREY HEIGHT	BENDING MOMENT (Kn-m)
3	26.8
6	32.77
9	36.2
12	38.76
15	40.87
18	42.62
21	44.09
24	45.34
27	46.33
30	47.12

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33	47.7
36	48.13
39	48.41
42	48.54
45	48.51
48	48.39
51	48.16
54	47.83
57	47.32
60	47.63
63	39.17

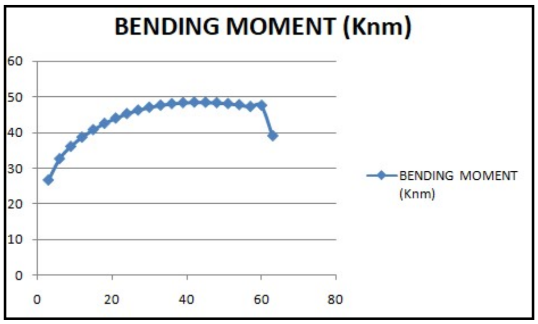


Fig- Storey Height Vs Storey Displacement

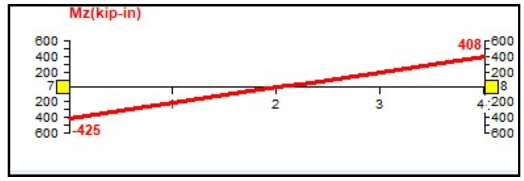


Fig- Moment Graph due to wind load

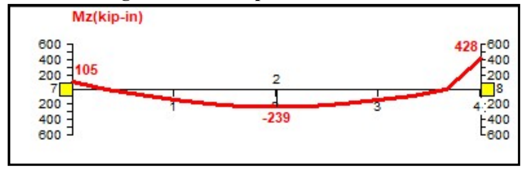


Fig- Moment Graph due to Dead Load

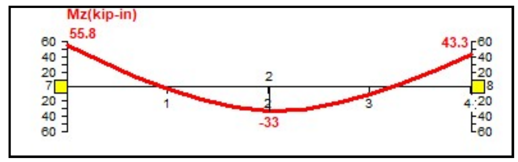


Fig- Moment Graph due to Live Load

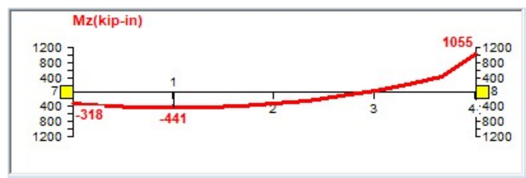


Fig- Moment Graph due to Generated Auto Load Combination

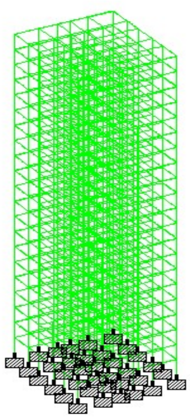


Fig- Section Displacement

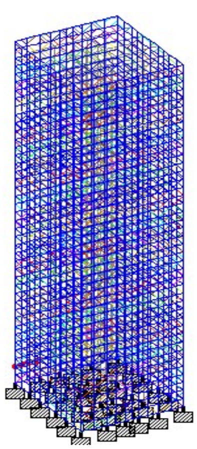
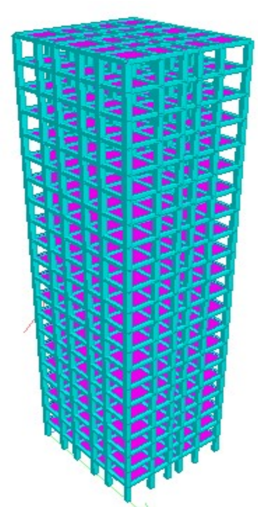


Fig- Due to wind load

6. CONCLUSIONS

The wind loads are estimated for a 20 storied RC framed structure Based on the results obtained the following conclusions are made:

- The wind loads increases with height of structure.
- Wind loads are more critical for tall structures than the earthquake loads
- Structures should be designed for loads obtained in both directions independently for critical forces of wind.
- With increasing wind velocity and building height, maximum BM of different building height rises.



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