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Wind Analysis and Design of Highrise Residential Building by Using STAAD.Pro

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ABSTRACT

Wind load is the one of the loads, is to be considered with respect to the height of the building. As the intensity of wind will increase with increase in the height of building. For tall high-rise buildings and structural design depends on the wind load as its dynamic in nature. Highrise structures are complicated to analyse and it takes lots of time for cumbersome calculations using conventional manual methods. The objective of this study is to analyse the effect of different wind velocities and the effect of wind on different height of the multistoried building. In this Analysis, G+11 storied building is considered and applied various loads like wind load, static load and results are studied. In this project, study of structural behavior of the building is analyzed under wind load cases by using STAAD.Pro

KEYWORDS: *Highrise building, wind load, static load, structural design, STAAD.Pro.*

I. INTRODUCTION

1.1. GENERAL

The design of tall buildings that are located in sites where both extreme winds and hurricanes, or typhoons, occur is a topic of special significance. Wind is the force which acts horizontal to the earth's surface with a greater intensity. Wind force is not a constant one it will change from place to place and time to time. If the place is a hilly area at a country side, the intensity of wind is more. But if it is a plane ground and full of obstructions like buildings and trees, the intensity will be lesser at lower levels but it will increase with increase in the height of the building. The wind intensity can also be varied based on the climatic conditions. Based on the previous studies of the wind catastrophes in Andhra Pradesh, Visakhapatnam is the place where the Hudhud. A tropical cyclone, that causes a extensive damage and loss of life in eastern India and Nepal. That's the reason, the wind analysis and design of the G+11 High-rise multi storey building is done at Vizag, where the max damage occurred due to wind forces.

1.2 OBJECTIVE OF THE PROJECT

1. To design and analysis of a G+11 high-rise residential building by using STAAD.Pro, software.
2. To analyse the effect of wind velocities on different heights of Highrise building.
3. To study the structural behaviour of the Highrise building under wind load.

1.3 HIGHRISE BUILDING

Wind means the motion of the air in the atmosphere. The response of the structure to the wind is depends on the characteristics of the wind. A building having height more than 15 m, as per national building code 2005 of India, it is called as a Highrise building. The building structure consists of beams, columns, slabs and footings, these parts of the building are treated as the structural elements of the building. The design of these structural elements is done by using structural analysing software called STAAD.Pro. Lateral loads are live loads that act, on a structure/building, parallel to the ground. In other words, lateral loads on a building are forces acting in the horizontal direction on a building. These loads can cause a structure to shear or bend along the direction of the forces. There are different types of lateral loads, the most common ones being Wind and Earthquake loads.

1.4 EFFECTS OF WIND FORCE ON HIGH RISE BUILDINGS

Static loads create elastic bending and twisting on the building, while dynamic loads create fluctuating forces all over the structure. Thus, creating motions, most commonly oscillations (thus dynamic). Taller, slender structures are impacted more significantly by dynamic wind load. The wind is the powerful and irregular force affecting high rise buildings at all direction. Highrise building can be defined as a drop anchored in the ground, bending and swaying in the wind along horizontal. This movement, known as wind drift, should be kept within permissible limits. Wind loads on buildings most increase considerably with the increase in building heights. Furthermore, the speed of wind increases with the height of building, and the wind pressures increase as the square of the wind speed act on surface of building.

1.5 SOFTWARES USED FOR WIND ANALYSIS

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

1. **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.
2. **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+11 Highrise residential building is carried out by using STAAD.Prov8i software
3. **STAAD. Foundation:** STAAD. Foundation is extension for STAAD.Pro, in which the designing of foundation is executed. The output of the STAAD.Pro file is exported in to the STAAD. Foundation and the foundation to be analyzed.

II. LITERATURE REVIEW

Madhurima Dutta (2017): He considered a tall G+28 storied building is designed and analysed by design software STAAD pro v8i.The combination of static and wind loads are taken into account**.** In this study a tall G+28 storied building is designed and analysed by design software STAAD pro v8i.The combination of static and wind loads are taken into account. . Due to effect of wind load on the structure, the story wise variation of the result with respect to different parameters are compared and a detailed design of reinforcement is also calculated that will ensure the structural safety of the building.

Vikrant Trivedi (2018): He has done the comparative study of wind loads to decide the design loads of a G+11 building. The significance of this examination is to estimate the design loads for a structure which is subjected to wind loads in a particular region. In the present study a multi-storied building is analyzed for wind loads using IS 875 code. In this Analysis, G+11 storied building is considered and applied various loads like wind load, static load.

III. 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.

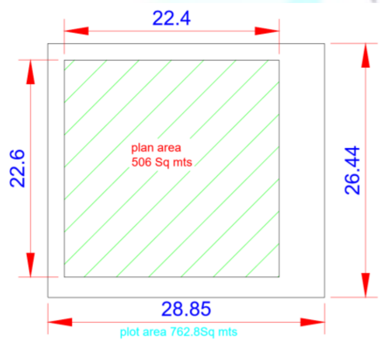


Fig. 3.1 Site Plan

- **CENTER LINE PLAN:** This plan shows the center line of the whole building on the basis of the walls and beams along their position.

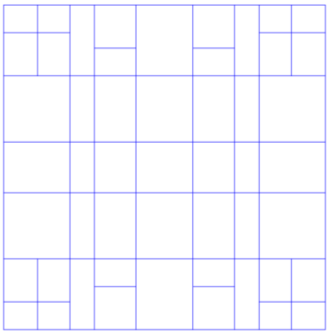


Fig. 3.2 Centre Line Plan

- **DETAILED PLAN:** This plan shows the detailed prescription of the building and its elements like the position of doors, windows, ventilators and walls.

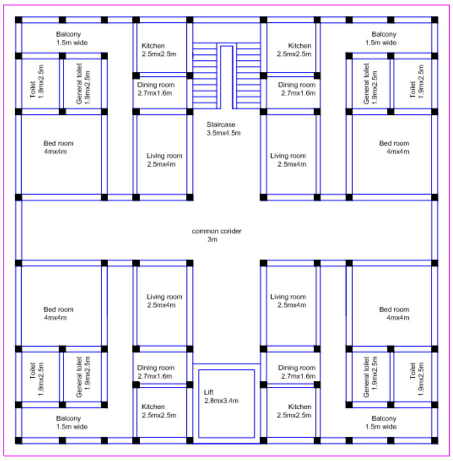


Fig.3.3 Detailed Plan

3.1 DESCRPTION OF THE STRUCTURE

1. Building type : Highrise Residential Building.
2. Location of the building : Vizag, Andhra Pradesh,
3. Period of construction : 20 months.
4. Area of the plot : 762 m^2.
5. Plinth area : 506m^2.
6. No of floors : G+11.
7. Hight of ground floor : 3m.
8. Hight of each floor : 3m.
9. Basic wind speed : 58 Km/hour.
10. Height of water table : 12 m below G.L.
11. Foundation type : Isolated square footing.
12. Depth of foundation : 4.5m.
13. Grade of cement : 43 grade cement.
14. Grade of main reinforcement: fe500.
15. Plinth beam size : 400mm x 400 mm.
16. Ground floor thickness : 200mm.
17. Size of columns : 400mm x 500mm.
18. Size of beams : 600mm x 400mm
19. Thickness of slab : 150mm.
20. Main wall thickness : 300mm thick.
21. Partition wall thickness : 200mm thick.
22. Height of parapet wall : 600 mm.
23. Size of door (D1) : 1200mm x 2100mm.
24. Size of door (D2) : 1000mm x 2100mm.
25. Size of window (W1) : 1000mm x 2000mm.
26. Size of window (W2) : 1000mm x 1000mm.

IV. METHODOLOGY

LOAD CASES DISTRIBUTION IN BUILDING

Loads are a primary consideration in any building design because they define the nature and magnitude of hazards are external forces that a building must resist to provide a reasonable performance (i.e., safety and serviceability) throughout the structure's useful life. The anticipated loads are influenced by a building's intended use (occupancy and function), configuration (size and shape) and location (climate and site conditions). Ultimately, the type and magnitude of design loads affect critical decisions such as material collection, construction details and architectural configuration.

4.1 TYPES OF LOADS ACTING ON A STRUCTURES ARE:

1. **DEAD LOAD**

The first vertical load that is considered is dead load. Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self-weight of structural members, permanent partition walls, fixed permanent equipment and weight of different materials.

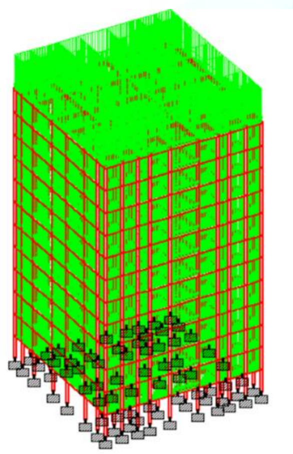


Fig.4.1 Self-weight on building

4.1.1 IMPOSED LOADS OR LIVE LOADS (IL OR LL)

The second vertical load that is considered in design of a structure is imposed loads or live loads. Live loads are either movable or moving loads without any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. The minimum values of live loads to be assumed are given in IS 875 (part 2)–1987.

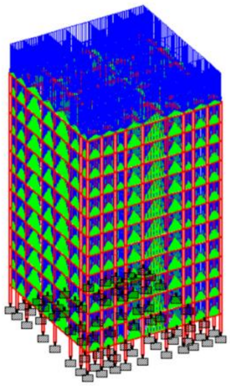


Fig.4.1.1Live load on structure.

4.1.2 WIND LOADS:

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in structural design especially when the heath of the building exceeds two times the dimensions transverse to the exposed wind surface.

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 the components of winds is to be kept in mind while designing is the building. The calculation of wind loads depends on the two factors, namely velocity of wind and size of the building. Complete details of calculating wind load on structures are given below (by the IS-875 (Part 3) -1987).

Using colour code, basic wind pressure 'V_b' is shown in a map of India. Designer can pick up the value of V_b depending upon the locality of the building.

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

$$V_z = k_1 . k_2 . k_3 . Vb$$

Where k_1 = Risk coefficient

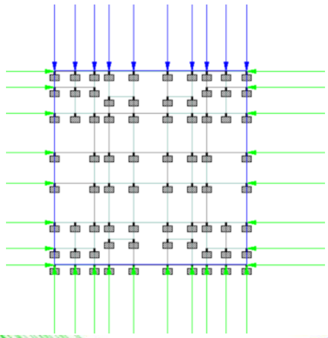
k_2 = Coefficient based on terrain, height and structure size.

k_3 = Topography factor

The design wind pressure is given by

$$P_z = 0.6 V^2_z$$

where P_z is in N/m^2 at height Z and V_z 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.



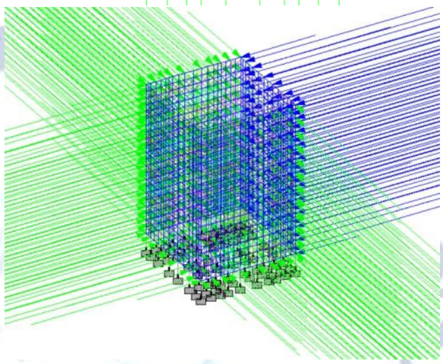


Fig.4.1.2 wind loads on structure

4.1.3 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/m^2 -ve sign indicates that floor load is acting downwards

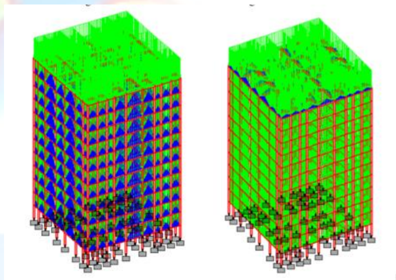


Fig.4.1.3 Floor Load & Roof Load

4.1.4 SNOW LOADS (SL)

Snow loads constitute to the vertical loads in the building. But these types of loads are considered only in the snow fall places. The IS 875 (part 4) – 1987 deals with snow loads on roofs of the building. The minimum snow load on a roof area or any other area above ground which is subjected to snow accumulation is obtained by the expression,

$S = \mu S_0$

Where S = Design snow load on plan area of roof.

μ = Shape coefficient, and

S_0 = Ground snow load.

4.1.5 EARTHQUAKE LOADS (EL)

Earthquake forces constitute to both vertical and horizontal forces on the building. The total vibration caused by earthquake may be resolved into three mutually perpendicular directions, usually taken as vertical and two horizontal directions. The movement in vertical direction do not cause forces in superstructure to any significant extent. But the horizontal movement of the building at the time of earthquake is to be considered while designing.

4.2 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.

4.2.1 STEP BY STEP PROCESS OF METHODOLOGY

i. Preparation of site plan

Based on location and area available, a suitable site plan is prepared.

ii. Preparation of detailed plan

On the basis of requirements of the structure, prepare a plan which helps in resisting the earthquake effects.

iii. Preparation of centreline plan

Using detailed plan as a reference, prepare a centreline plan for building, which is exported in to STAAD.pro. this centreline plan is used as a structural plan in STAAD.Pro.

iv. Preparation of column layout plan

Using detailed plan as a reference, draw a column layout plan which helps in positioning the footings.

v. Model generation

Export DXF file of structural plan, which is drawn in the AutoCAD. By using translation repeat option, construct a G+11 building in STAAD.Pro.

vi. Section properties

Define the sizes of beams and columns. And define the thickness of slabs.

vii. Material Properties

Specify the material such as concrete.

viii. Supports

Define supports at end of columns at bottom.

ix. Loads

Assign loads such as, self-weight, live load, wind load

x. Analysis

Indicate the type of analysis to be performed and associate option.

xi. Design

Specify the suitable commands for concrete and steel design as per IS 456.

xii. Post processing

Give commands to Extract and Review Analysis, Result.

xiii. Creation of model

Open foundation design option and include all the load cases. Then start the foundation design.

xiv. Job setup

Create a new job for isolated square footing. Use Indian standard code and SI units.

xv. Design

Design the isolated footing design.

xvi. Results

Results for each footing is appeared and checks are also be done for each footing.

V. DESIGNING AND ANALYSIS OF STRUCTURE

A. ANALYSIS OF BUILDING SUBJECTED FOR WIND LOADS

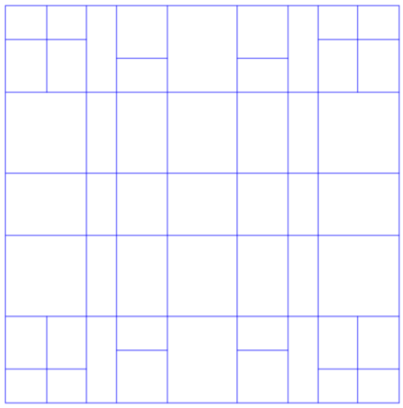


Fig.5.1Structural Plan of Building

B. DESIGN OF HIGHRISE RESIDENTIAL BUILDING BY USING STAAD.PRO WITH WIND LOADS AT MAX INTENSITY

Step - 1:

Creation of centre line plan of the building by using AutoCAD. Save the plan in DXF format.

Step - 2: Export the DXF file into STAAD.Pro.

Here the 2d cad plan is exported. and kept it as Y axis upwards. Use translational repeat option and generate a G+11 building structure.

Step - 3:

3D view of structure. Here we have used the Transitional repeat command in Y direction to get the 3D view of structure.

Step - 4:

Supports and Property Assigning. After the creation of structure, the supports at the base of structure are specified as fixed. Also, the materials were specified and cross section of beams and columns members was assigned.

Step - 5:

3D rendering view. After assigning the property the 3d rendering view of the structure can be shown.

Step - 6:

Assigning of Wind Loads. Wind loads are defined as per IS 875 PART 3 based on intensity calculated and exposure factor. Then loads are added in load case details in W+X, W-X, W +Z, W-Z directions.

Step - 7:

Assigning of Dead Loads. Dead loads are calculated as per IS 875 PART 1 for external walls, internal walls, parapet wall including self-weight of structure.

Step - 8:

Assigning of Live Loads. Live loads are assigned for every floor as 4 kN/m² based on IS 875 PART-2.

Step - 9:

Adding of Load Combinations. After assigning all the loads, the load combinations are given with suitable factor of safety as per IS 875 PART-5.

Step - 10:

Analysis after the completion of all the above steps we have performed the analysis and checked for errors.

Step - 11:

Design Finally concrete design is performed as per IS 456:2000 by defining suitable design commands for different structural components. After the assigning of commands again we performed analysis for any errors.

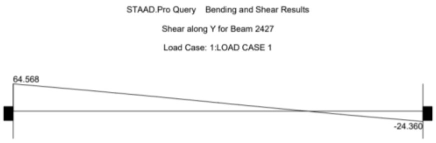


Fig.5.5 Shear Y

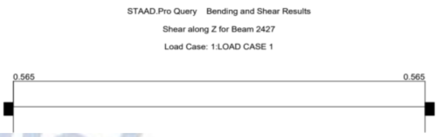


Fig.5.6 Shear Z

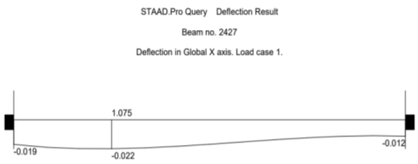


Fig.5.7 Deflection X

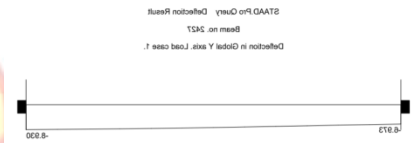


Fig.5.8 Deflection Y

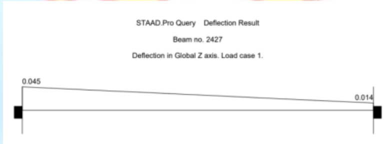


Fig.5.9 Deflection Z

C. *DESIGN OF BEAM*

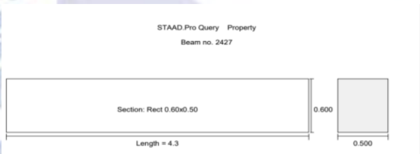


Fig.5.2 Beam Property

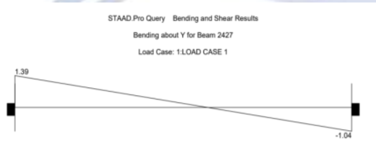


Fig.5.3 Bending Y

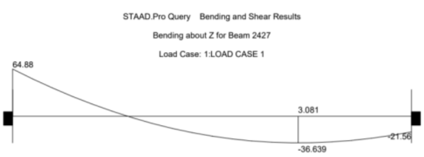


Fig.5.4 Bending Z

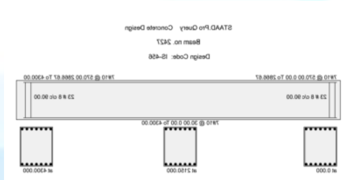


Fig.5.10 Concrete Design

1) *COLUMN DESIGN*

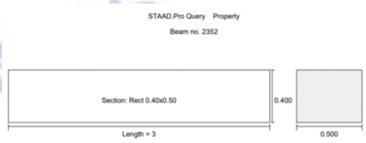


Fig.5.11 Column property

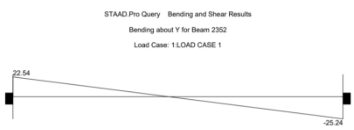


Fig.5.12 Bending Y

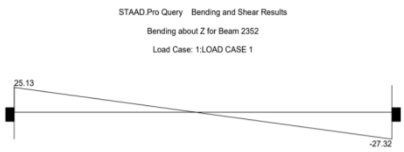


Fig.5.13 Bending Z

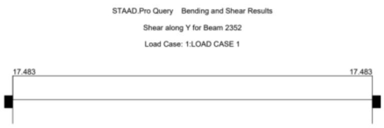


Fig.5.14 Shear Y

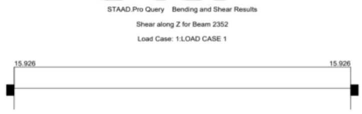


Fig.5.15 Shear Z

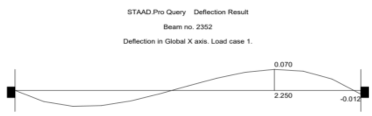


Fig.5.16 Deflection X

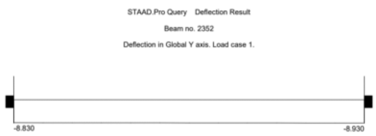


Fig.5.17 Deflection Y

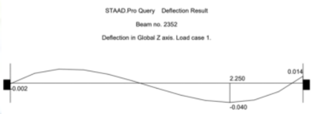


Fig.5.18 Deflection Z

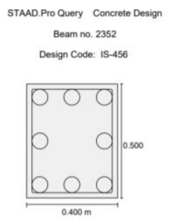


Fig.5.19 Concrete Design

D. *FOUNDATION DESIGNING*

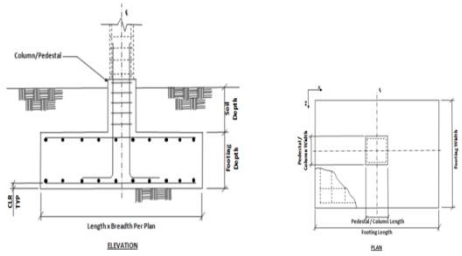


Fig.5.20 Foundation Design of Structure

VI. RESULTS AND DISCUSSIONS

A. RESULTS OF STRUCTURAL MEMBERS DESIGNED AND ANLYSED FOR WIND LOAD INTENSITY.

Table.6.1 Beam Results

	Due to max wind intensities
Beam No	2427
Span, m	3.3
Size	0.4*0.6
Max Axial Force KN	8.039
Max Shear Y KN	54.096
Max Shear Z KN	0.127
Max Torsion KNm	3.214
Max Moment -Y KNm	0.467
Max Moment – Z KNm	46.566
Max Combined Stress N/mm^2	0.746
Max Shear Stress Y N/mm^2	0.094
Max deflection mm	0.29
Top reinforcement	8-12mm dia
Bottom reinforcement	6-10mm dia
Shear reinforcement	2 legged 8mm stirrups @ 130 mm c/c

Table.6.2 Column results

	Due to max wind intensities
Column no	2352
Span, m	3
Size	0.4*0.5
Max axial force KN	2047
Max shear y KN	1.740
Max Shear Z KN	4.837
Max Torsion Knm	0.005
Max Moment -Y	9.711

Knm	
Max Moment – Z Knm	11.284
Max Combined Stress N/mm²	6.168
Max Shear Stress Y N/mm²	0.01
Max deflection mm	0.139
Main Reinforcement	8- 12mm dia
Lateral ties	6 mm dia lateral ties @ 110 mmc/c

Table.6.3 Footing Results

	Due to max wind intensities
Footing No	1
Size	3.55*3.55
Thickness mm	0.355
Governing Moment M_u KNm	378
Limiting Moment of Resistant $M_{u\ Max}$ KNm	1281
Shear Stress τ_v N/mm²	372.1
Shear Strength τ_c N/mm²	401.3
Bottom Reinforcement	Ø8 @ 50.0 mm c/c
Top Reinforcement	Ø8 @ 135 mm c/c

VII. CONCLUSION

1 The wind loads combinations are more than Earthquake load combinations in Bending moment and Shear force.
2 The details of each and every member were obtained by using STAAD.Pro.
3 All the deflections are within their limits.

The deflection of all members is less than 20mm. Hence it is safe.

References

[1] Ashwini S Gudur, "Dynamic Wind Analysis Of Tall Building Provided With Steel Bracing As Per Proposed Draft For Indian Wind Code And Effect Of Soft Storey (Part 2)", International Research Journal of Engineering and Technology, Volume: 03 Issue: 10, Oct -2016.

[2] Abdul Juned Siddiqui[1], Prabhat Soni[2], Aslam Hussain[3], "Analysis and Strengthing of Soft Storey Building with Equivalent Diagonal Strut at Center under Earthquake and Wind Load", International Journal of Engineering Research, Volume No.5, Issue No.2, (2016).

[3] K. N. V. J. Suryanarayana Raju, "Wind Analysis of a Multi Storied Building with Basic Wind Speeds," International Journal of Science Technology & Engineering, Volume 3 Issue01, July 2016.

[4] K.V. Sudheer, "Design and Analysis of a HighRise Building with and without Floating Columns", International Journal for Scientific Research & Development, Vol. 3, Issue 10, 2015.

[5] Madhurima Dutta, "wind analysis and design of a multi storied structural frame considering using STAAD. Pro", International Journal of Advances in Mechanical and Civil Engineering, Volume-4, Issue-5, Oct.-2017.

[6] Tejashree Kulkarni[1], Sachin Kulkarni[2], "Analysis and Design of HighRise Building Frame Using STADD. Pro", International Journal of Research in Engineering and Technology, Volume: 05 Issue: 04, Apr-2016

[7] T. Sasidhar[1], T.B. Manadeep2, "Analysing And Designing Of A HighRise Building (G+10) By STAAD.Pro", International Journal of Civil Engineering and Technology, Volume 8, Issue 4, April 2017.

[8] Vikrant Trivedi[1], Sumit Pahwa[2], "Wind Analysis and Design of G+11 Storied Building Using STAAD.Pro", Volume: 05 Issue03, Mar-2018.

[9] Virendra K. Tembhare, "Analysis and Design of B+G+10 Commercial Highrise Building under Seismic Load and Wind Load by Using Software", International Research Journal of Engineering and Technology, Volume: 06 Issue 06 , June 2019.

[10] IS: 875 (Part 1) – 1987 for Dead Loads, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah ZafarMarg, New Delhi 1100 02.

[11] IS: 875 (Part 2) – 1987 for Imposed Loads, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah ZafarMarg, New Delhi 110002.

[12] IS: 875 (Part 3) – 1987 for Wind Loads, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings And Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah ZafarMarg, New Delhi 110002.

[13] IS: 875 (Part 5) – 1987 for Special Loads and Combinations, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah ZafarMarg, New Delhi 110002.

[14] IS 456-2000, Indian standard code of practice for plain and reinforced concrete Standards, New Delhi, 1980.