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Understanding The Performance And A Comparative Study, Analysis, And Design Of A High Rise G+15 Commercial RCC Building Subjected To Wind And Seismic Loads

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Abstract

Nature has the strong ability to produce high impact by lateral forces in the name of wind and seismic forces on the manmade structures such buildings, bridges, dams, skyscrapers etc. These forces have the significant ability to create various actions on the flexural structures. When any structure is designed using any tool or manually, to fulfil and safety the strength and serviceability conditions of country code. Such types of structures are affected due to various types of forces acting during their service life, such as static forces due to dead and live loads and dynamic forces due to the wind and seismic loads. In this research, A G+15 high rise flexural structural RCC commercial building is designed with the help of STAADPRO. A specific location is considered for calculating the wind force and seismic forces which are create different actions on such as bending moment, shear force, displacement, axial forces, absolute stresses, design concrete, design steel on the high rise building and calibrate the performance and compare the each action between wind force and seismic force. A graphical representation, compare the bending moment, shear force, axial force, displacement, design concrete, design steel for both cases. The principle objective of this project is to analyze and design a RRC framed G+15 structure and compare the characteristics of each action by using building design software StaadPro. In this research study, we observed that percentage of design reinforcement steel required for the wind design is more than 4.7 % as compared to seismic design.

Keywords: *Modeling G+15 RCC framed structure, Wind forces, seismic forces, StaadPro, Analysis, Design, Actions, Graphical representation.*

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I. Introduction

Nature has the strong ability to produce high impact by lateral forces in the name of wind and seismic forces. The air moves in the two directions i.e. vertical and horizontal. The vertical movement of air due to warming of air which is called convection. The horizontal movement of air due to differences of atmospheric pressure. Many factors affect the movement of air such as pressure gradient force, frictional force, coriolis force these causes wind. An earthquake is the sudden shaking of the earth surface. It is one of the worst natural hazards and unfortunately it is a frequent enough occurrence all over the world. The vast majority of earthquakes are two mild to be felt. However the severe ones can be disastrous causing great damage to life and property. Earthquake simply means that shaking of the earth. It is caused due to release of energy which generates waves that travels in all directions. These forces have the significant ability to create various actions on the flexural structures. When any structure is designed using any tool or manually, to fulfil and safety the strength and serviceability conditions of country code**[5]**. Such types of structures are affected due to various types of forces acting during their service life, such as static forces due to dead and live loads and dynamic forces due to the wind and seismic loads**[4]**.

Seismic zones in India **Wind zones in India**

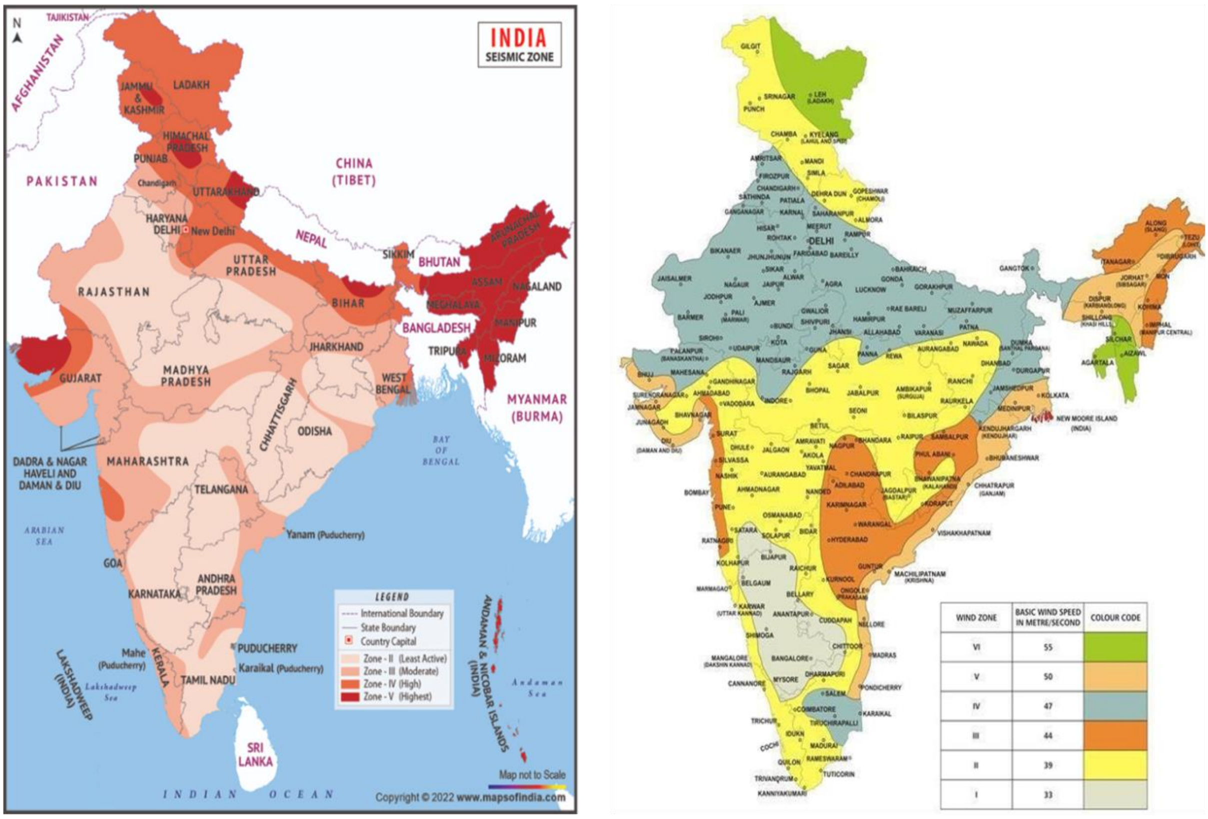

Figure 1 Seismic zones [13] and Wind zones in India [12]

1.1 Objective of the Study

1. Creation of 3D building model for linear dynamic method of analyses.
2. Understanding the seismic behaviour and wind behaviour on tall structure.
3. Co-relating the seismic behaviour and wind behaviour.
4. Comparing the seismic behaviour and wind behaviour interns of analysis and design.
5. Study the influence of vertical regular in the building when subjected to earthquakes and lateral winds.
6. Understand the flexibility and lateral stability of high rise RCC structure when subjected to lateral forces.

1.2 Scope of the present research

1. The scope of the present study is limited to reinforced concrete framed structure designed for seismic load and wind loads separately for Vishakhapatnam.
2. The seismic behaviour and wind behaviour for G+15 of commercial building were studied.
3. The buildings were analysed using Response Spectrum Method Analysis.
4. The study was done by considering the following parameters such as axial force, shear force, bending moment, displacement, plate stress.

II. METHODOLOGY

In the present work structural elements must be collected or assumed based on Indian standard codes (National building code) Building type, dimensions, soil type, nature, and loads existing on the structure, such as dead, live, wind and other dynamic load data. A G+15 high rise framed RCC structure is designed using structural analysis and design programme called StaadPro. and it is analysed and designed by considering and wind and seismic forces for the subject of this investigation. A response spectrum method is used for the seismic analysis. The loads such as dead load, live load, wind load, seismic load, and load combinations are taken with reference to the IS 875-1987 part 1, IS 875- 1987 part 2, IS 875-2015 part 3, and IS1893 (part 1) : 2002 respectively. Table 1 shows the general and technical specifications of the framed flexural high rise structure. Figure 2 & 3 shows the 3D view, plan, isometric view, and loading actions on the G+15 structural frame. To run the Staad programme with the application of seismic and wind forces as shown in The figure 4 & 5. in the X +ve and Z +ve directions.

2.1 Design considerations

Table 1 G+15 high rise commercial RCC building details

1	**Building details**	
i.	Structure	Commercial building
ii.	Number of stories	G+15
iii.	Type of building	Regular and symmetrical in plan
iv.	Plan area	34 m x 26 m
v.	Height of building	60 m
vi.	Storey height	4 m
vii.	Supports conditions	Fixed
2	**Material properties**	
i.	Grade of concrete	M30
ii.	Grade of steel	Fe500
iii.	Density of reinforced concrete	25 kN/m^2
iv.	Young's modules of M30 E_c	27386127.87 kN/m^2
v.	Young's modules of Fe500 E_s	2 x 10^5 MPa
3	**Types of loads & intensities**	
i.	Floor finish	1 kN/m^2
ii.	Live load on floor	4.00 kN/m^2
iii.	Wind load	For zone 2
4	**Seismic Load**	
i.	Zone factor	0.1
ii.	Importance factor I	1.0
iii.	Response reduction factor RF	3.0
iv.	Damping ratio for RCC	0.05
v.	Type of structure	C
vi.	Fundamental natural period	--
vii.	Along x direction T_{ax}	0.926 sec
viii.	Along x direction T_{az}	1.059 sec
ix.	Member load	-3.75 kN/m
x.	Floor weight	-3.75 kN/m^2

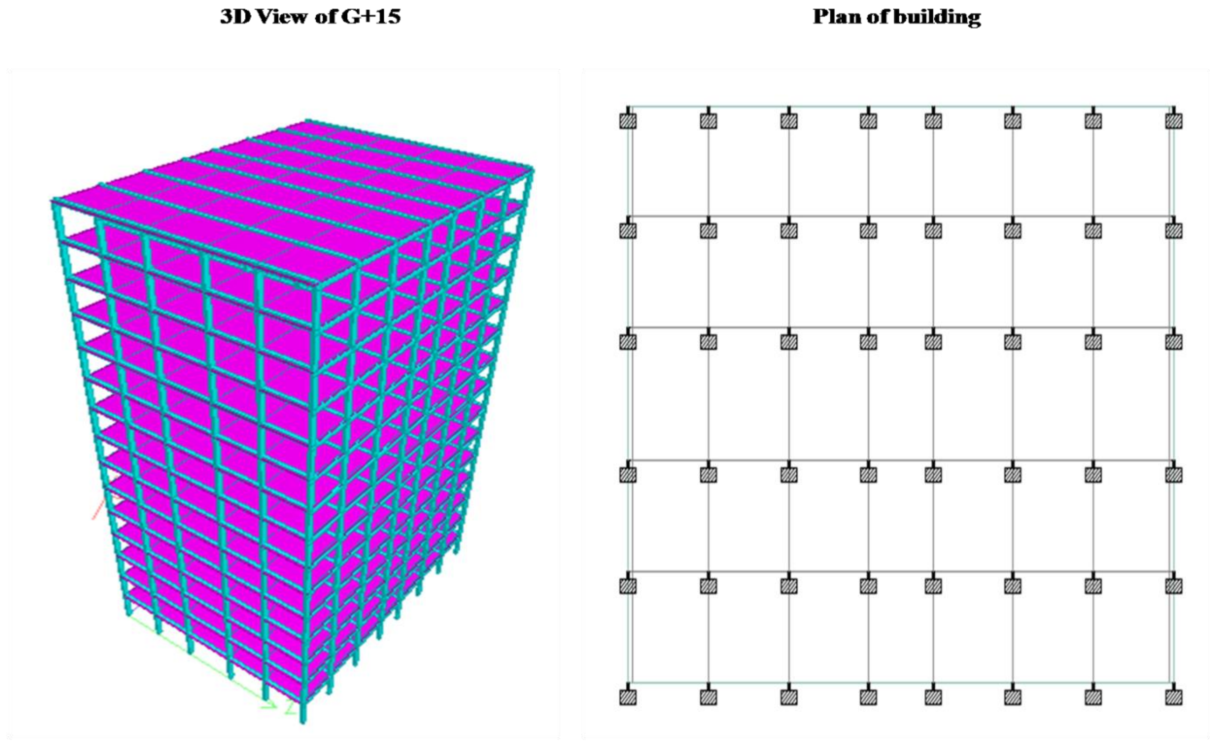

Figure 2 3D and top view of building

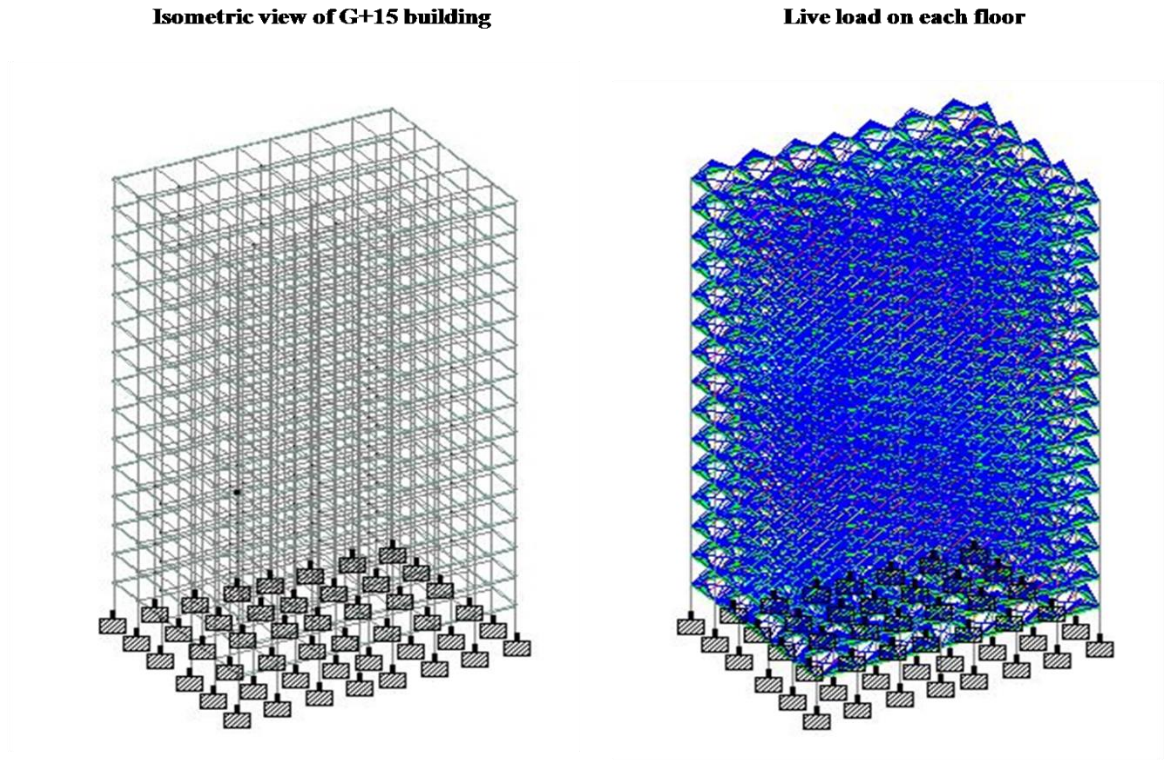

Figure 3 Isometric view and Live load on G+15 building

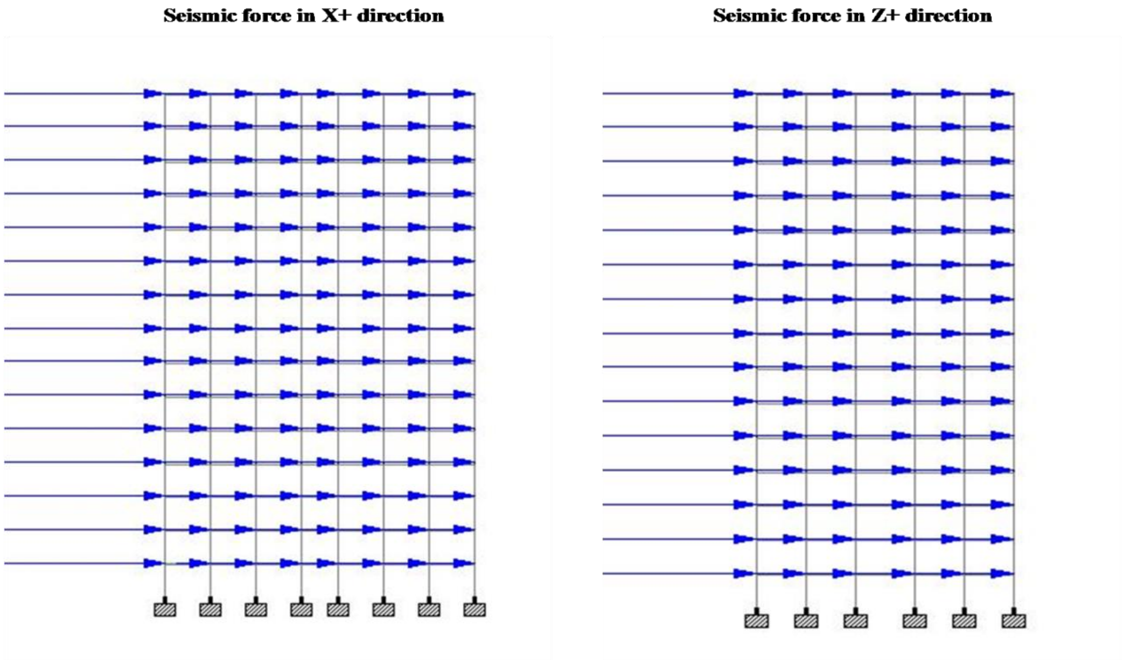

Figure 4 Seismic forces in X+ and Z+ directions

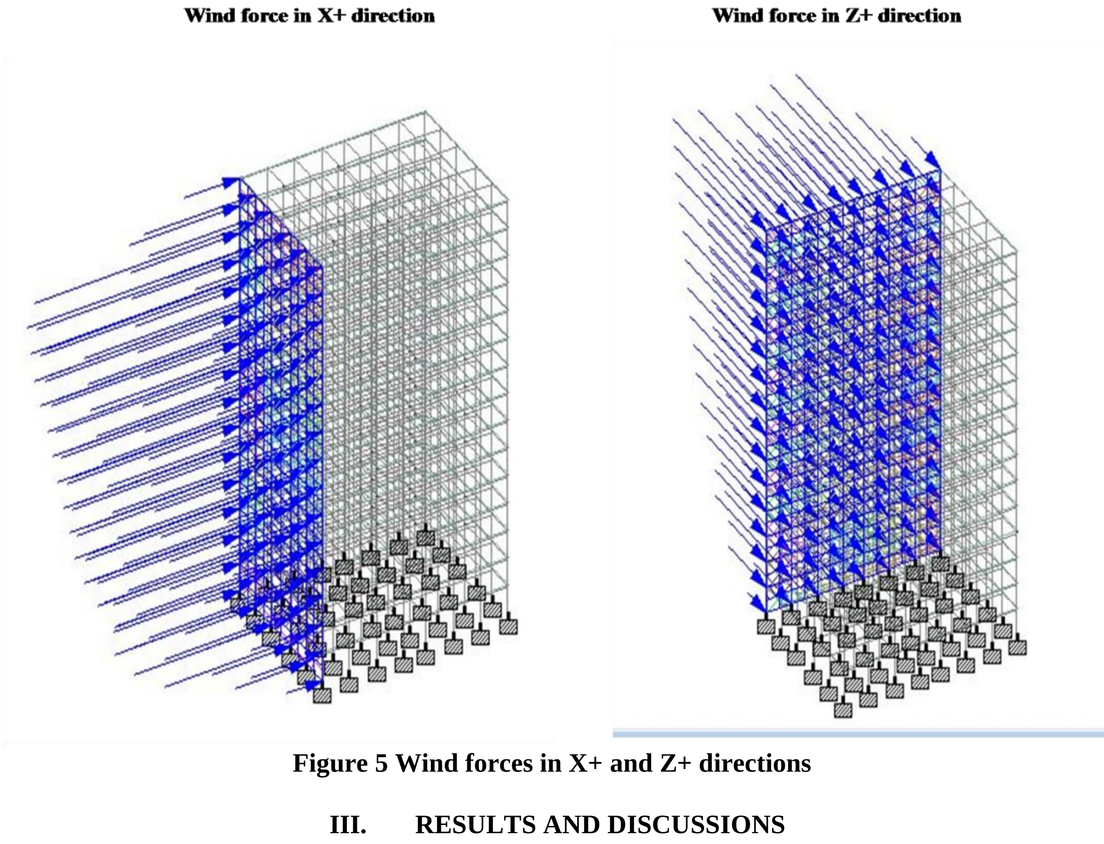

Figure 5 Wind forces in X+ and Z+ directions

III. RESULTS AND DISCUSSIONS

By run the Staad programme, the following results are obtained. Figure 6 shows the successful running of the Staad programme with wind and seismic actions. The figure 7 & 8 shows the axial force and shear force action due to dead load, live load, seismic force, and wind force vertical directions. it is observed that, maximum axial force values of 8850.3 kN and 9588.0 kN and maximum shear force values 126.4 kN and 182.7 kN for seismic load and wind load respectively. The figure 9 & 10 shows the bending moment in Z and Y directions respectively due to dead load, live load, seismic force, and wind force vertical directions. The figure 11 & 12 shows the maximum values of 325.6 mm & 352.5 mm and 0.069 MPa & 0.08 MPa of horizontal displacement and absolute stress due to dead load, live load, seismic force, and wind force lateral directions respectively. Figure 6 shows the design reinforcement and concrete due to seismic force and wind for G+15. It graphically observed that, the percentage of design reinforcement steel required for the wind design is more than 4.7 % as compared to seismic design.

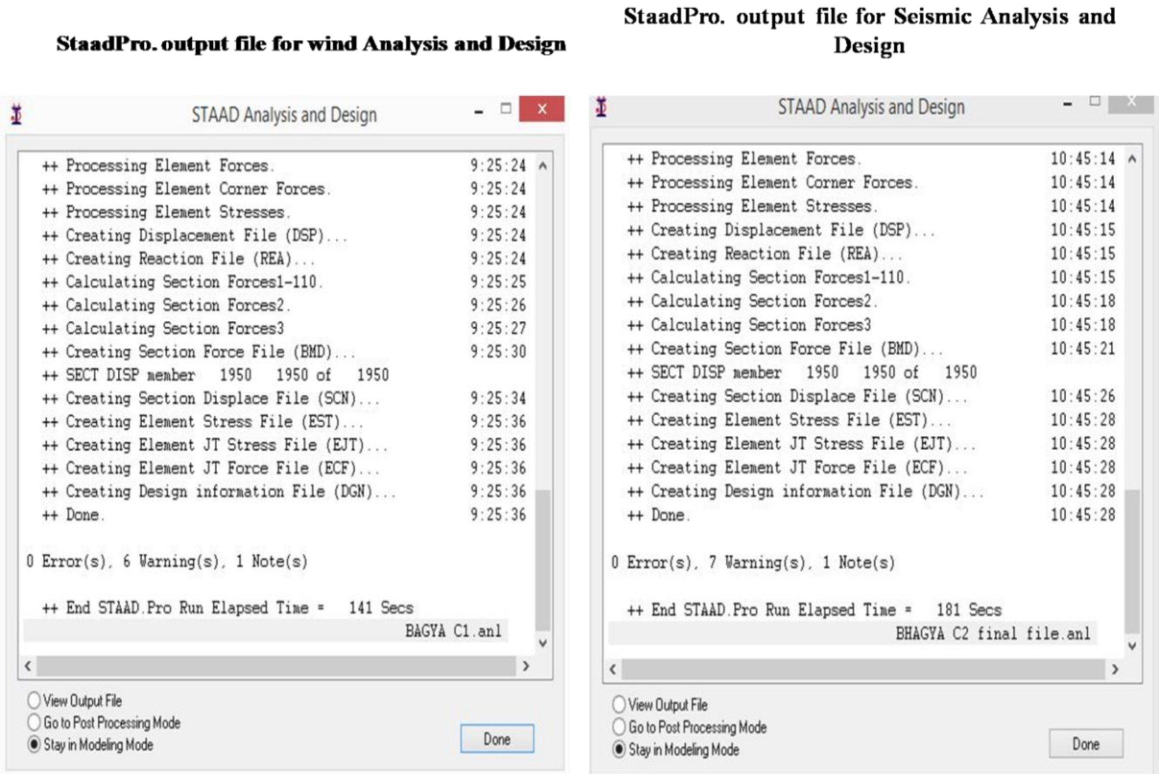

Figure 7 StaadPro. file for wind and seismic forces

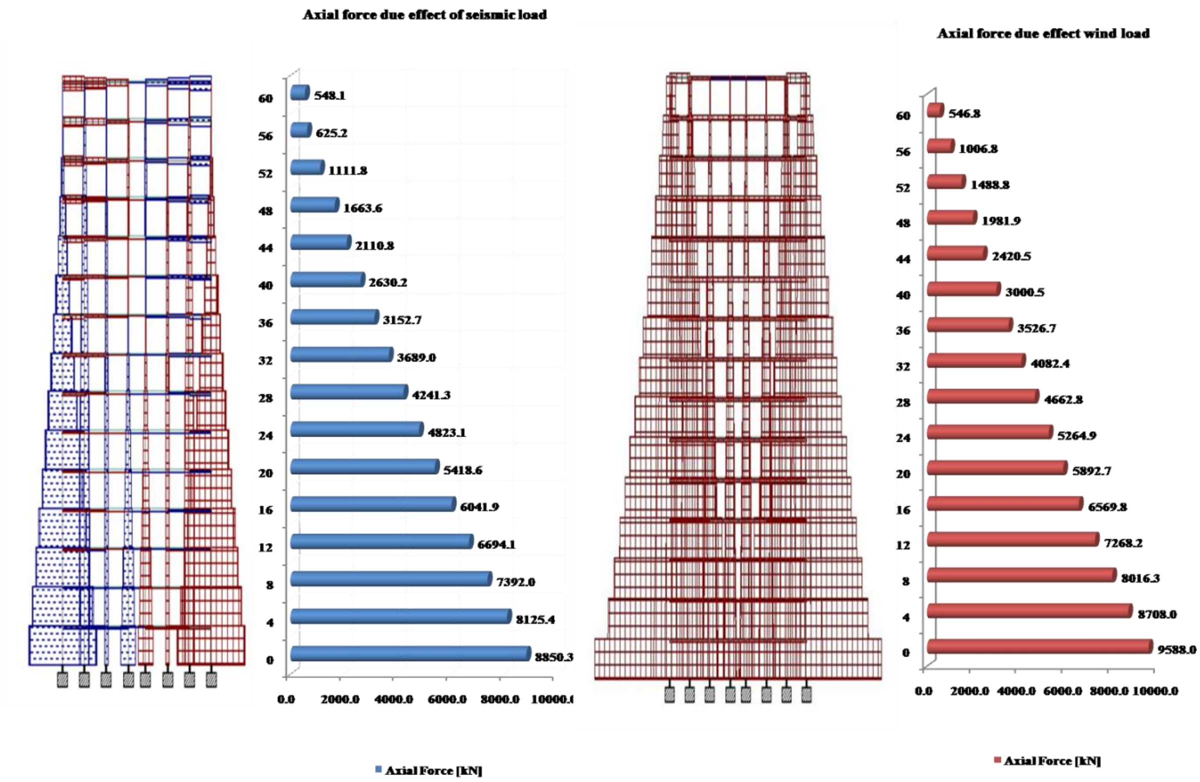

Figure 8 Axial force due to seismic and wind forces

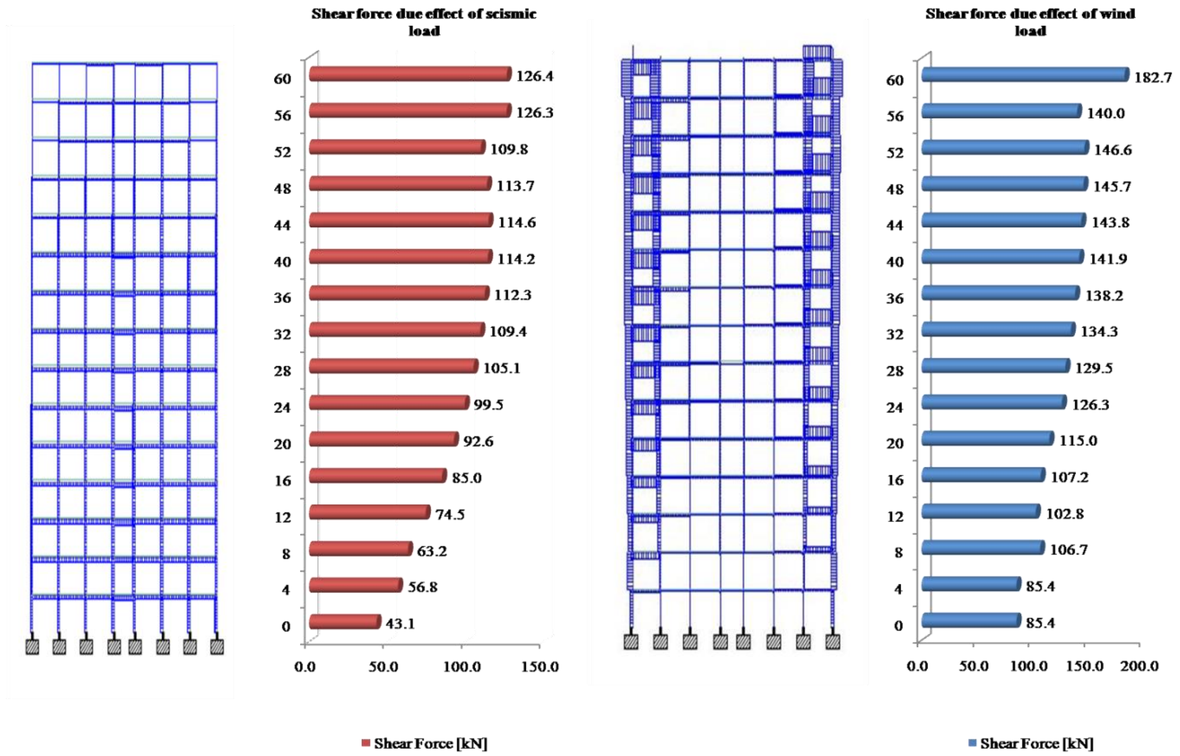

Figure 9 Shear force due to seismic and wind forces

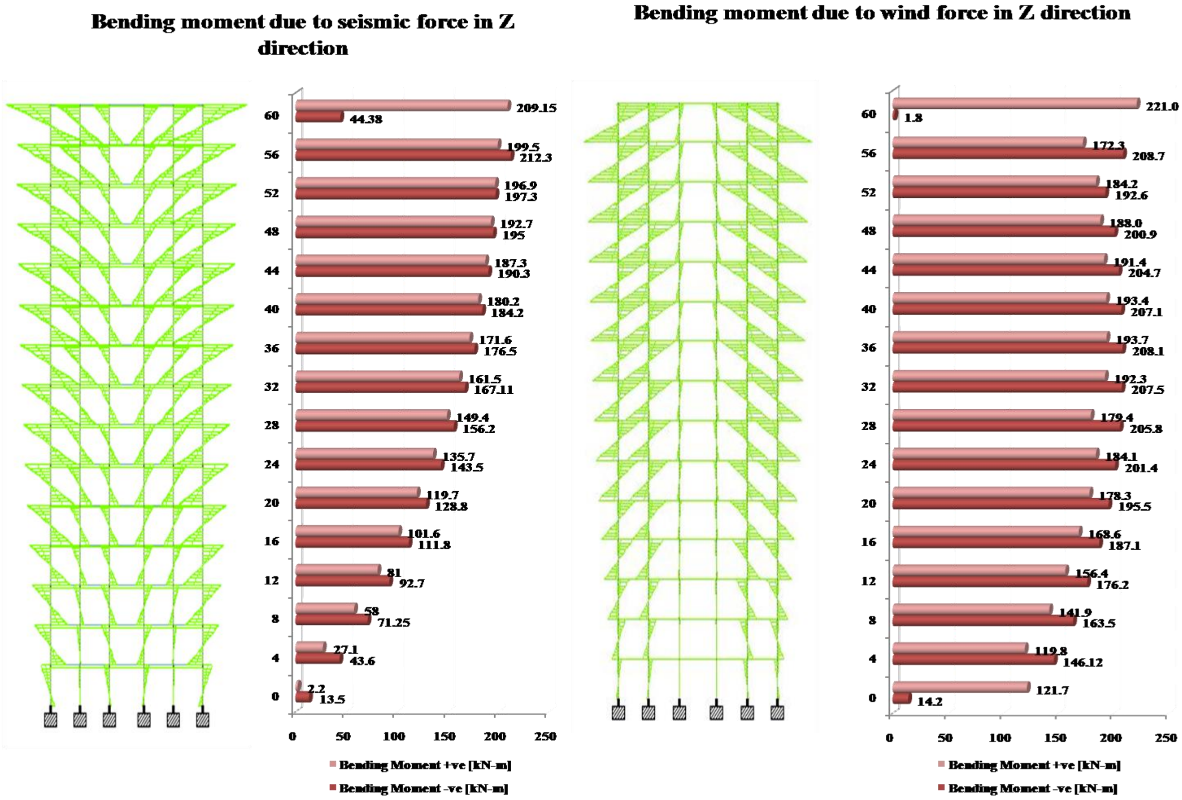

Figure 10 Bending moment due to seismic force and wind in Z direction

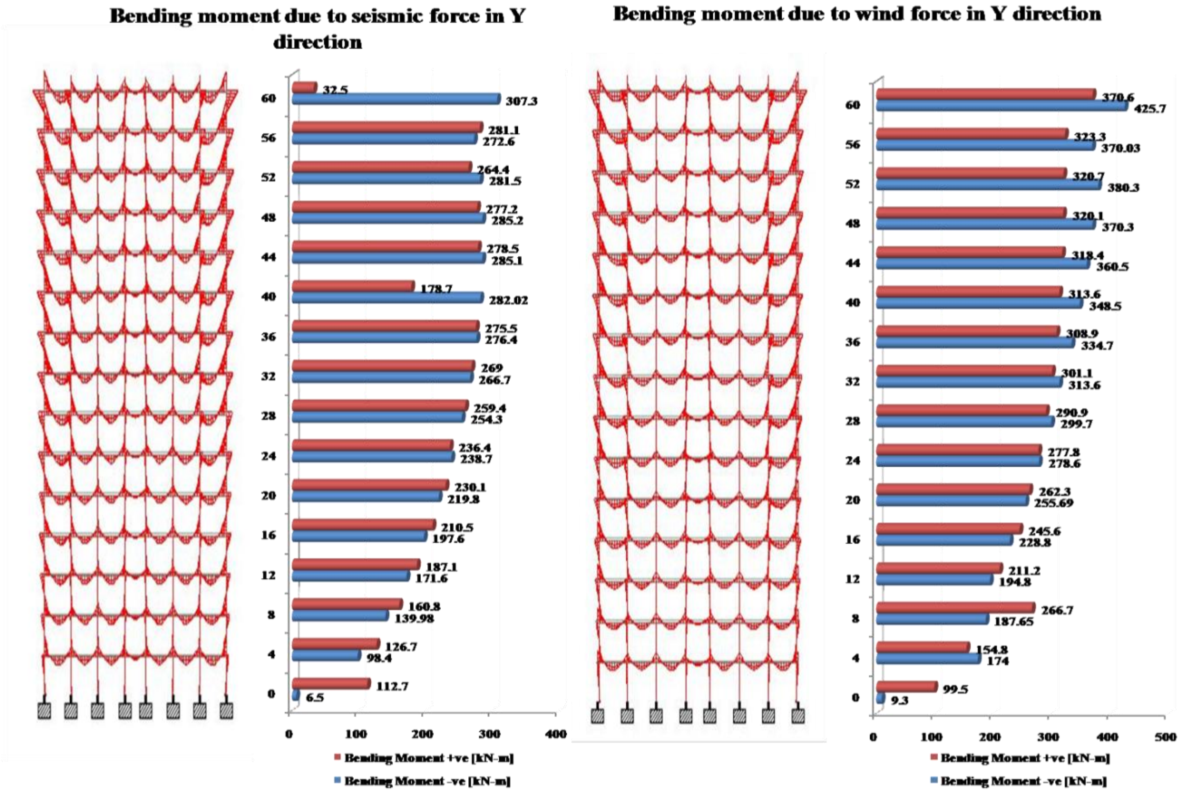

Figure 11 Bending moment due to seismic force and wind in Y direction

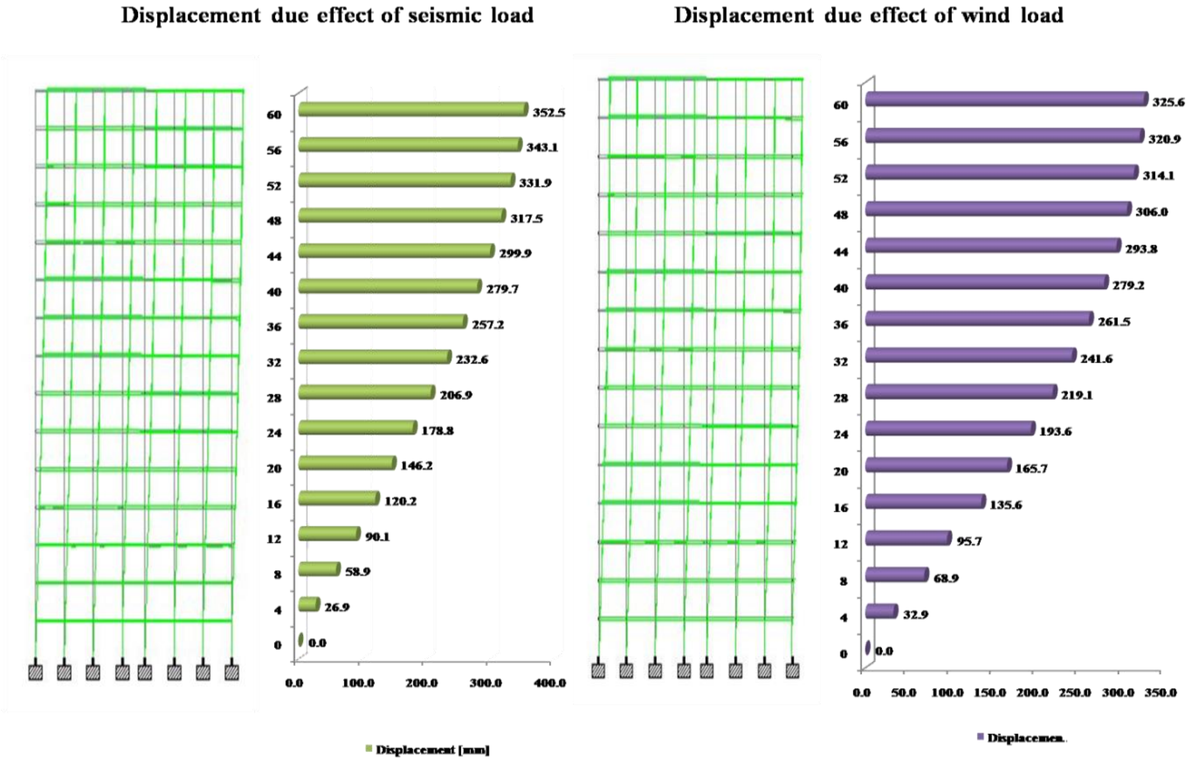

Figure 12 Displacement due to seismic force and wind in Y direction

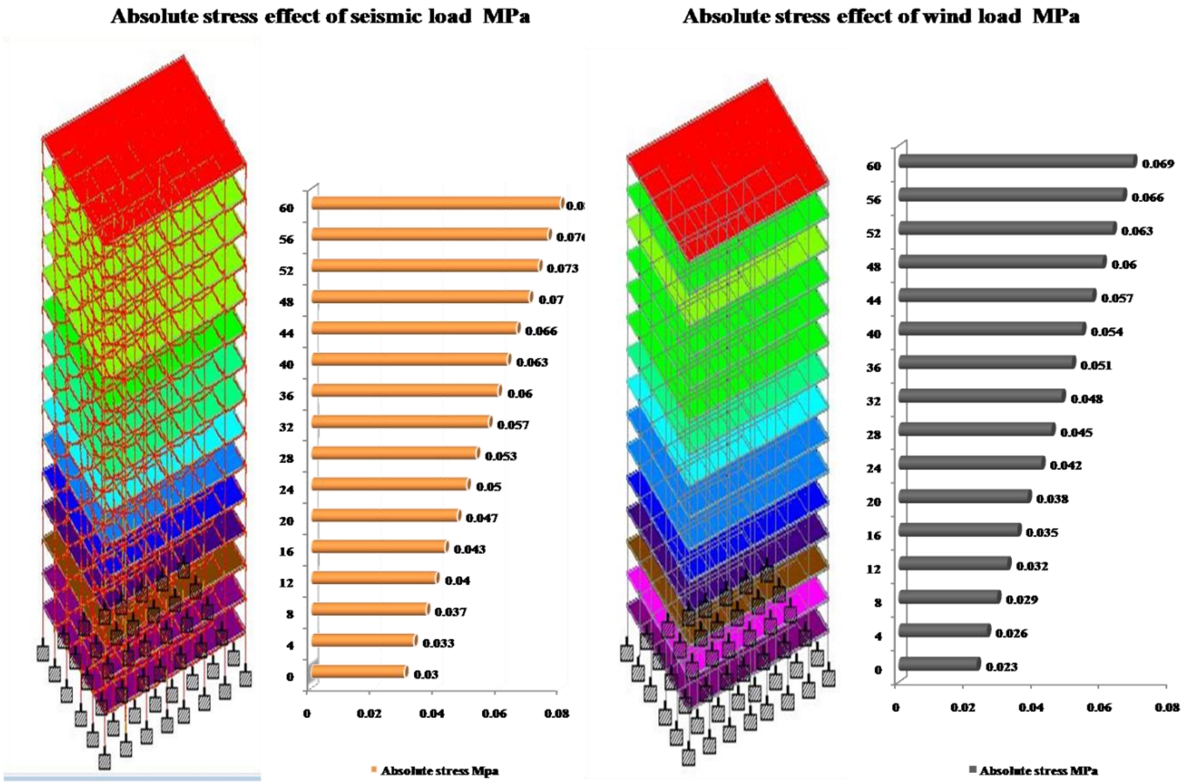

Figure 13 Absolute stress due to seismic force and wind in the slab

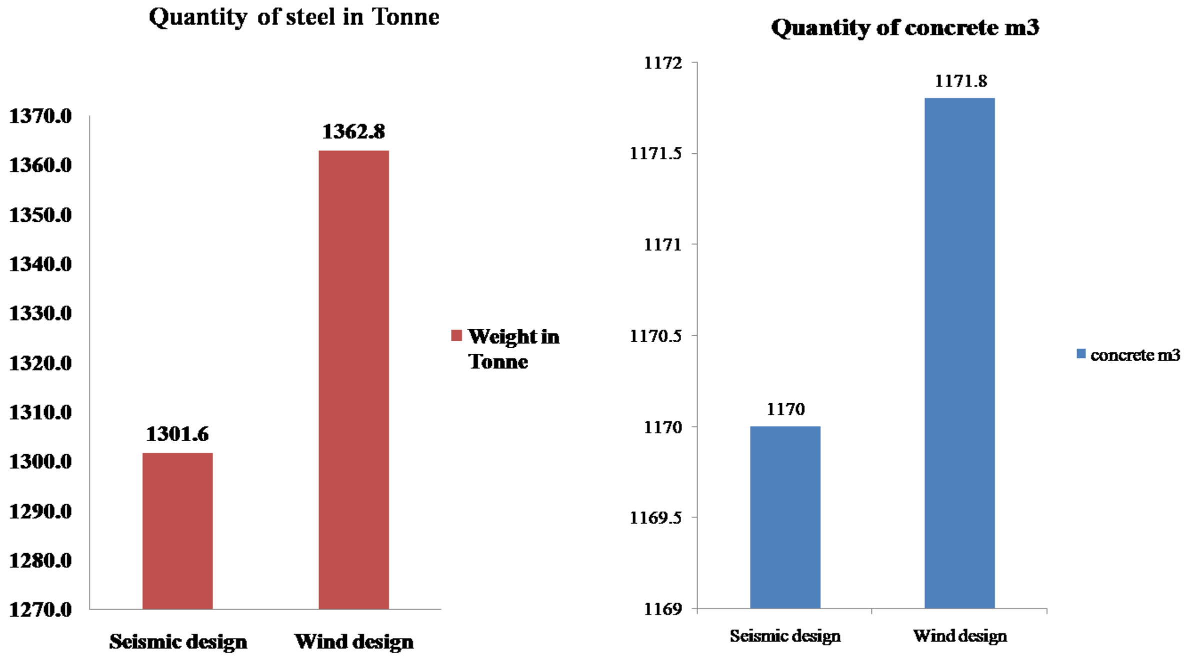

Figure 14 Design reinforcement and concrete due to seismic force and wind for G+15

IV. CONCLUSIONS

Conclusions drawn from the analysis and design of G+15 high rise commercial structures with respect to wind and seismic loads as follows.,

1. The storey axial forces are higher for the G+15 building with wind force as compared to seismic force is higher. The maximum values are 9588.0 kN and 8850.3 kN in respect to wind and seismic forces respectively in Y direction and therefore the vertical axial forces are more for wind design.

2. The storey shear forces are higher for the G+15 building with wind force as compared to seismic force is higher. The maximum values are 182.7 kN and 126.4 kN in respect to wind and seismic forces respectively in Y direction and therefore the shear forces are more for wind design.
3. The vertical storey displacements are higher for the G+15 building with seismic force as compared to wind force is higher. The maximum values are 325.6 mm and 352.5mm in respect to seismic and wind forces respectively in Y direction and therefore the lateral vertical displacements are more for wind design.
4. The storey absolute stress in the plates are higher for the G+15 building with seismic force as compared to wind force is higher. The maximum values are 0.08 MPa and 0.069 MPa in respect to seismic and wind forces respectively in Y direction and therefore the absolute stress in the slabs are more for seismic design.
5. The storey maximum positive bending moments are higher for the G+15 building with wind force as compared to seismic force is higher and occurs at 60 m. The maximum values are 221.0 kN-m and 209.15 kN-m in respect to wind and seismic forces respectively in Z direction and therefore positive bending moment is more for wind design.
6. The storey maximum negative bending moments are higher for the G+15 building with seismic force as compared to wind force is higher and occurs at 56 m. The maximum values are 208.7 kN-m and 212.3 kN-m in respect to wind and seismic forces respectively in Z direction and therefore the negative bending moment is more for seismic design.
7. The storey maximum positive bending moments are higher for the G+15 building with wind force as compared to seismic force is higher and occurs at 60 m for wind force and at 56 m for seismic force. The maximum values are 370.6 kN-m and 281.1 kN-m in respect to wind and seismic forces respectively in Y direction and therefore the positive bending moment is more for wind design.
8. The storey maximum negative bending moments are higher for the G+15 building with wind forces as compared to seismic force is higher and occurs at 60 m. The maximum values are 425.7 kN-m and 307.3 kN-m in respect to wind and seismic forces respectively in Y direction and therefore the negative bending moment is more for wind design.
9. The quantity of design steel HYSD Fe500 grade required for wind force consideration is 1301.6 Tonne and for seismic force consideration is 1362.8 Tonne and therefore the percentage of reinforcement steel required for the wind design is more than 4.7 % as compared to seismic design.
10. The quantity of design concrete M30 grade required for wind force consideration is 1170 m^3 and for seismic force consideration is 1171.8 m^3.

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