International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 05 | May 2022 www.irjet.net p-ISSN: 2395-0072

BEHAVIOR OF MULTI STORIED BUILDING WITH VARYING HEIGHT, SEISMIC ZONE AND SOIL TYPE UNDER CONSTANT WIND SPEED USING STAAD PRO

Tanushyama Banerjee[1], Saptarshi Roy[2], Apurba Pal[3], Biswajit Mondal[4], Ananda Ghosh[5], Mainak Ghosh[6], Soumyajit Bhattacharya[7], Kushal Chakraborty[8]

[1,2,7,8]*Assistant professor, Department of Civil Engineering, C.I.E.M., Kolkata, West Bengal, India*
[3,4,5,6]*B.Tech. Student, Department of Civil Engineering, C.I.E.M., Kolkata, West Bengal, India*

---***---

Abstract - *This work is concerned with the analysis of building structure for the purpose of safety. Wind and earthquake both create dynamic action in the high-rise buildings. But, the calculation for wind force and seismic force are distinctly different. The present paper considered three-building models of G+10, G+15, and G+ 20 with the same plan area. Each building is subjected to different seismic zones and variations in soil type. The parameters selected are nodal displacement and bending moment. Results were traced in tabular format for all parameters value and observed against selected zone like V, IV, III and II with varying soil type. We know earthquake is a disaster-causing event but wind may be more in some cases. This work is also concerned with the zone depending on the height of the building; where wind is more devastating than the earthquake.*

***Key Words*: High rise building, Static analysis, Seismic analysis, Nodal displacement, Bending moment, Wind analysis, STAAD PRO.**

1.INTRODUCTION

Humans are always fascinated with skyscraper or tall building. The tower of babel is the oldest mention of such multistorey building. The romans were the first to build the multistorey building but they are different enough from today's construction and insula in roman architecture was such a construction. With the completion of the LIC Building in Chennai in 1959, the era of skyscrapers in India began. It was the first skyscraper with 12 floors initially in the country and remained tallest in the country until 1961 when it was surpassed by the 25-storied Usha Kiran building in Mumbai. In modern cities, high-rise building plays very important role. First of all, tall building meets the requirement of the modern society and solve the problem of limitation of construction site resources. To analyze the high-rise building some useful software's like STAAD Pro, ETABS etc. are widely used by the designers and researchers in this field. In traditional calculation of model of high-rise building, the following factors affecting the earthquake design of structures are different seismic zones, damping factor of the structure, importance of the building, type of soil, natural frequency of the building, different seismic zones, etc.

A. Purohit.et.al (2017) conducted a study on seismic analysis of g+12 multistorey building varying zone and soil type, where they have analyzed the behavior of a G+12 structure by STAAD pro software. They have conducted various test regarding Zone II and Zone V for soft and medium soil cases. A. Bhaskar.et.al (2020) conducted a study on Seismic design and analysis of (g+6) residential building in zone 3&4 using STAAD Pro. and ultimately cost estimation of the building has been checked. They wanted to estimate some parameters like steel percentage, maximum shear force, maximum bending moment, maximum deflection for different seismic zone. After the analysis they came to a conclusion that (a) the structure is safe in loading like dead load, wind load and seismic load. (b) member dimension (beam, column, slab, footing) are changed by calculating the load type and its quantity applied on it. (c) they found that if a building is converting from zone 3 to zone 4 then if we take 12.5% more steel the building will also be maintained in zone 4. (d) we found that there is a 13.875% variation in cost due to change in the quantity of steel. V.Nagaraju.et.al (2016) conducted a study on Analysis and design of multistorey building under different load combination. They concluded that, design and evaluation of the reinforced concrete building structure for precise results with various loads is a wide and complex problem and proper design of structure with valid results leads to better life and performance of structure under various load combinations. A.A. Wadekar.et.al. (2020) conducted a study on analysis and design of a multistorey building by using STAAD pro and they concluded that for the calculation of design of reinforcement for the concrete section, STAAD Pro plays an effective role. A.K.KADHUM.et.al (2018) has carried out an evaluation on effect of seismic load on reinforced concrete multistorey building from economical point of view, they have concluded that when a building is taken in earthquake consideration the cost of building gradually increases. P. Singh.et.al (2017) performed a study on design and comparison of multistoried building in all seismic zones. they have concluded that the base shear obtained by response spectrum analysis and also comparison of cost effectiveness in all zones. Static analysis is not sufficient for high rise buildings and it's necessary to provide dynamic analysis.

In this paper, analysis of G+10, G+15 and G+20 storey buildings against seismic load and wind load as per IS:875 part (III) and IS 1893 part(I)-2002 using STAAD Pro has been conducted to compare the maximum nodal displacement and maximum bending

moment of the structures. Also, to evaluate the dominating nature of earthquake load and wind load according to the height of the building. The plan dimension remains same for all the models i.e., 15m X 20 m. Seismic zone and soil type of the structures was varied for each model. In the seismic zoning map given in the earthquake resistant design code IS 1893 (Part 1) 2002] assigns four levels of seismicity for India in terms of zone factors. According to that, here we consider four cities Visakhapatnam (Zone II), Kolkata (Zone- III), Jamnagar (Zone- IV), Shillong (Zone-V) with a constant wind speed of 50 m/s. The models are subjected to dead loads, live load, seismic load and wind load. The member forces are calculated using load combinations as per IS 456 :2000.

2.PRELIMINARY DATA OF THE STRUCTURE CONSIDERED FOR ANALYSIS OF MODELS USED BY STAAD PRO

Table -1: Description of structural items required for the design of models

Sl.no.	Description		Structural Properties		
1.	Number of storey		G+10	G+15	G+20
2.	Floor to floor height		3m	3m	3m
3.	Plinth height		0.6 m	0.6 m	0.6 m
4.	Size of column	From GL to 33.6 m	(0.4 X 0.5) m	(0.6 X 0.65) m	(0.7 X 0.8) m
		From 33.6 to 48.6 m		(0.25 X 0.35) m	(0.3 x 0.5) m
		From 48.6 to 63.6 m			(0.3 x 0.4) m
5.	Size of beam		(0.25 x 0.5) m		
6.	Size of Tie beam		(0.25 x 0.4) m		
7.	Slab thickness		0.150 m		
8.	External wall thickness		0.250 m		
9.	Internal wall thickness		0.125 m		
10.	Depth of foundation		1.5 m		
11.	Seismic zones		ALL ZONES OF INDIA		
12.	Type of soil taken		HARD, MEDIUM & SOFT		

Table -2: Description of density of materials used in the study

Sl.no.	Description	Density
1.	Concrete	25.00 KN/m^3
2.	Plaster	20.00 KN/m^3
3.	Floor finish	24.00 KN/m^3
4.	Brick work	18.85 KN/m^3
5.	Compressive strength of concrete	25.00 N/mm2
6.	Ultimate strength of steel	500.00 N/mm2

Table -3: Description of member properties

Sl.no.	Description	
1.	Young's modulus of concrete(M25) (E)	25000.00 N/mm2
2.	Poisson's ratio of concrete	0.17
3.	Co-efficient of thermal expansion of concrete	8x10^{-6} /°C
4.	Co-efficient of thermal expansion of steel	12x10^{-6} /°C
5.	Poisson's ratio of Steel	0.3
6.	Young's modulus of Steel	200000 N/mm^2
7.	Grade of concrete	M25
8.	Grade of steel	Fe 500

Table -4: Description of various combination of loads assigned in the members of the models

Sl.no.	Description	
1.	Member load on peripheral tie beam	16.06 KN/m
2.	Member load on internal tie beam	9.52 KN/m
3.	Member load on peripheral roof beam	12.89 KN/m
4.	Member load of internal roof beam	7.74 KN/m
5.	Member load on Roof beam for parapet wall	2.84 KN/m
6.	Floor load on roof	5.55 KN/m
7.	Floor load on each floor	4.71 KN/m
8.	Live load considered	3 KN/m^2
9.	Wind speed considered	50 m/s

The plan and models for G+10, G+15 and G+20 storey buildings by using STAAD Pro has been shown in Figs. (1-4).

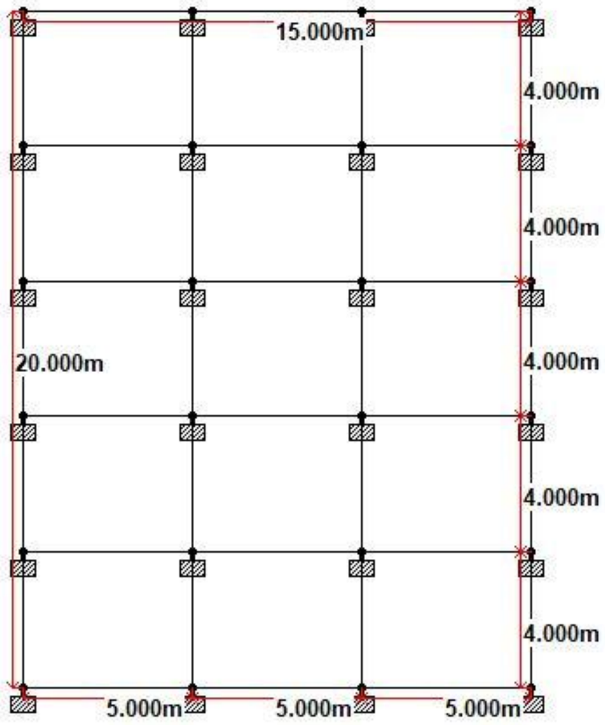

Fig -1: Plan of the models

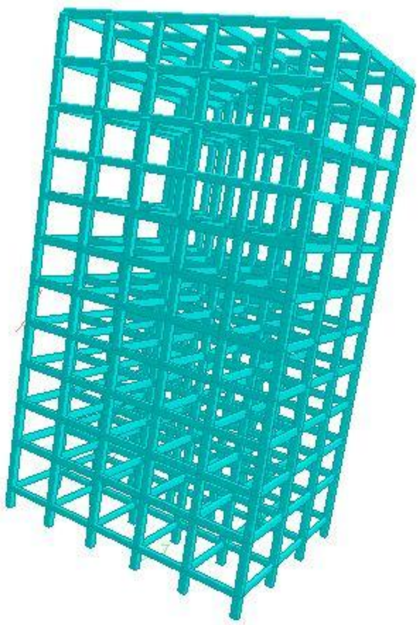

Fig -2: G+10 structure

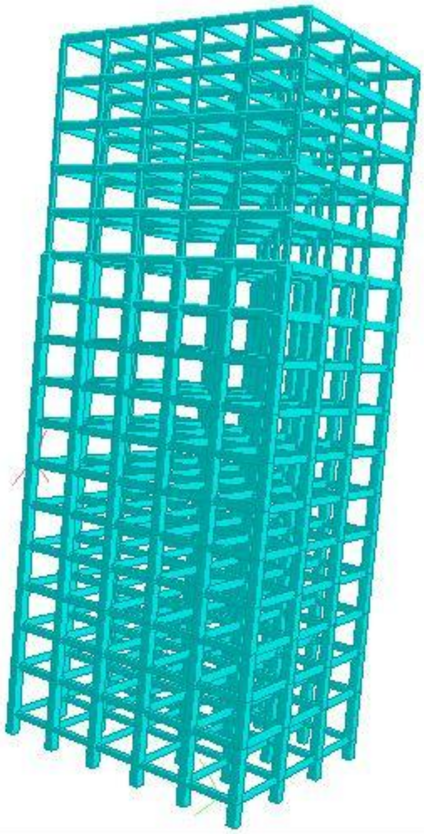

Fig -3: G+15 structure

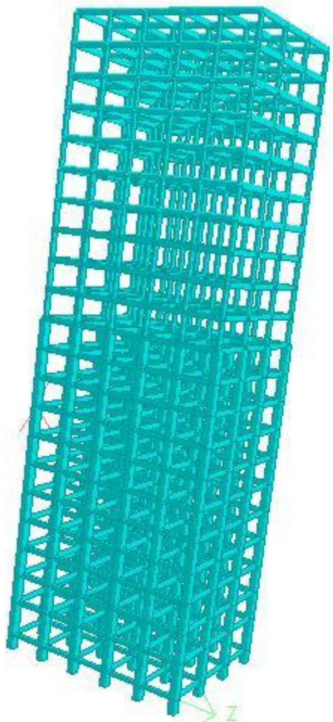

Fig -4: G+20 structure

4.RESULT & DISCUSSION

4.1. Check for maximum nodal deflection under different soil condition

Case -I: Hard Soil Conditions

The details of the variation of nodal deflection with different storey for different load conditions and for different seismic zones has been tabulated in Table 5 and Chart 1 respectively

Table 5 – Variation of maximum nodal displacement and load conditions for different storey and zones

Zone	Storey	Max. Nodal displacement (mm)	Load combination
II	G+10	45.99	1.5 (DL+WL)
	G+15	82.15	1.5 (DL+WL)
	G+20	121.82	1.5 (DL+WL)
III	G+10	61.28	1.5 (DL+EL)
	G+15	95.82	1.5 (DL+EL)
	G+20	121.82	1.5 (DL+WL)
IV	G+10	91.39	1.5 (DL+EL)
	G+15	143.07	1.5 (DL+EL)
	G+20	165.80	1.5 (DL+EL)
V	G+10	136.73	1.5 (DL+EL)
	G+15	214.17	1.5 (DL+EL)
	G+20	247.97	1.5 (DL+EL)

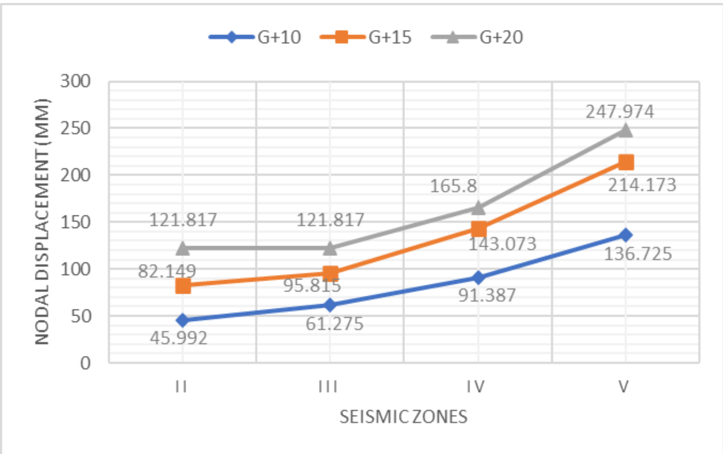

Chart -1: Variation of maximum nodal displacements with seismic zones for different storey

Case -II: Medium Soil Conditions

The details of the variation of nodal deflection with different storey for different load conditions and for different seismic zones has been tabulated in Table 6 and Chart 2 respectively.

Table 6 – Variation of maximum nodal displacement and load conditions for different storey and zones

Zone	Storey	Max. Nodal displacement (mm)	Load combination
II	G+10	52.29	1.5 (DL+EL)
	G+15	82.15	1.5 (DL+WL)
	G+20	121.82	1.5 (DL+WL)
III	G+10	82.94	1.5 (DL+EL)
	G+15	129.82	1.5 (DL+EL)
	G+20	150.50	1.5 (DL+EL)
IV	G+10	124.02	1.5 (DL+EL)
	G+15	194.25	1.5 (DL+EL)
	G+20	224.93	1.5 (DL+EL)
V	G+10	185.77	1.5 (DL+EL)
	G+15	291.08	1.5 (DL+EL)
	G+20	336.93	1.5 (DL+EL)

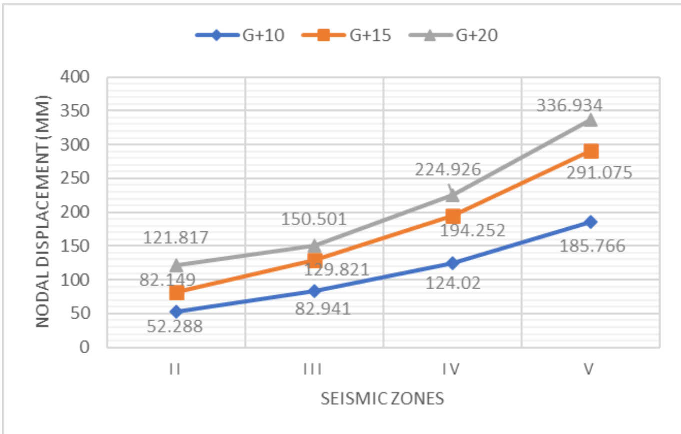

Chart -2: Variation of maximum nodal displacements with seismic zones for different storey

Case -III: Soft Soil Conditions

The details of the variation of nodal deflection with different storey for different load conditions and for different seismic zones has been tabulated in Table 7 and Chart 3 respectively.

Table 7 – Variation of maximum nodal displacement and load conditions for different storey and zones

Zone	Storey	Max. Nodal displacement (mm)	Load combination
II	G+10	63.90	1.5 (DL+EL)
	G+15	99.94	1.5 (DL+EL)
	G+20	121.82	1.5 (DL+WL)
III	G+10	101.65	1.5 (DL+EL)
	G+15	159.18	1.5 (DL+EL)
	G+20	184.40	1.5 (DL+EL)
IV	G+10	152.16	1.5 (DL+EL)
	G+15	238.37	1.5 (DL+EL)
	G+20	275.97	1.5 (DL+EL)
V	G+10	228.04	1.5 (DL+EL)
	G+15	357.34	1.5 (DL+EL)
	G+20	413.57	1.5 (DL+EL)

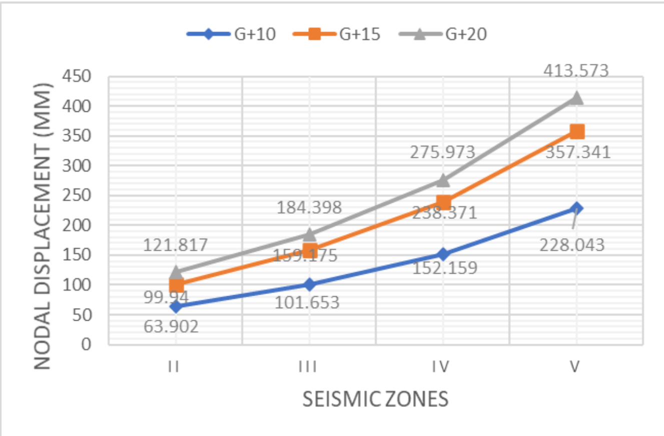

Chart -3: Variation of maximum nodal displacements with seismic zones for different storey

From the above Tables (5-7) & Charts (1-3), it is observed that for different soil conditions with the increase of seismic zones and the height of building, maximum nodal displacement increases. It is also observed that the rate of increase of nodal displacement for G+20 structure from seismic zone II to seismic zone III is linear and beyond seismic zone III, the rate of increase of nodal displacement increases and for G+10 & G+15 the nodal displacement increases rapidly irrespective of zones for hard soil conditions and for other two conditions (medium and soft) the rate of increase of nodal displacement increases rapidly for G+10, G+15 & G+20 buildings.

4.2. Check for maximum Bending Moment under different soil condition

Case -IV: Hard Soil Conditions

The details of the variation of bending moment with different storey for different load conditions and for different seismic zones has been tabulated in Table 8 and Chart 4 respectively.

Table 8 – Variation of maximum Bending moment and load conditions for different storey and zones

Zone	Storey	Max. Bending moment (KN-m)	Load combination
II	G+10	173.1	1.5 (DL+WL)
	G+15	238.7	1.5 (DL+WL)
	G+20	472.1	1.5 (DL+WL)
III	G+10	173.1	1.5 (DL+WL)
	G+15	238.7	1.5(DL+WL)
	G+20	472.1	1.5(DL+WL)
IV	G+10	209.5	1.2 (DL+LL+EL)
	G+15	280.7	1.5(DL+EL)
	G+20	472.1	1.5(DL+WL)
V	G+10	289.6	1.5 (DL+EL)
	G+15	420.8	1.5 (DL+EL)
	G+20	683.2	1.5 (DL+EL)

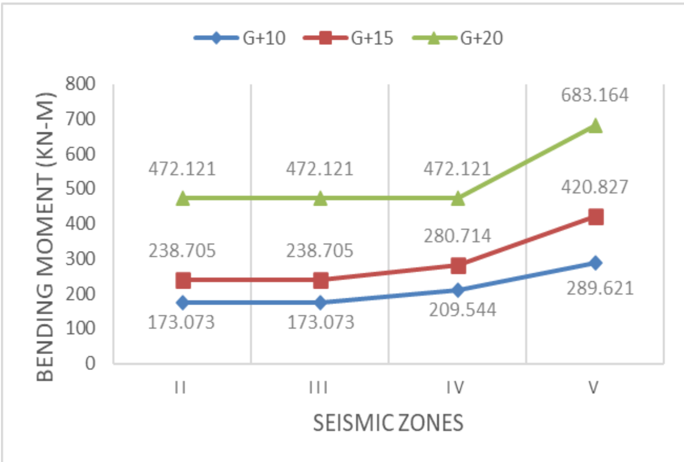

Chart -4: Variation of maximum nodal displacements with seismic zones for different storey

Case -V: Medium Soil Conditions

The details of the variation of bending moment with different storey for different load conditions and for different seismic zones has been tabulated in Table 9 and Chart 5 respectively.

Table 9 – Variation of maximum Bending moment and load conditions for different storey and zones

Zone	Storey	Max. Bending moment (KN-m)	Load combination
II	G+10	173.1	1.5 (DL+WL)
	G+15	238.7	1.5 (DL+WL)
	G+20	472.1	1.5 (DL+WL)
III	G+10	198.7	1.2 (DL+LL+EL)
	G+15	254.6	1.5 (DL+EL)
	G+20	472.1	1.5 (DL+WL)
IV	G+10	266.6	1.5(DL+EL)
	G+15	381.6	1.5(DL+EL)
	G+20	619.5	1.5(DL+EL)
V	G+10	378.6	1.5 (DL+EL)
	G+15	572.	1.5 (DL+EL)
	G+20	928.7	1.5 (DL+EL)

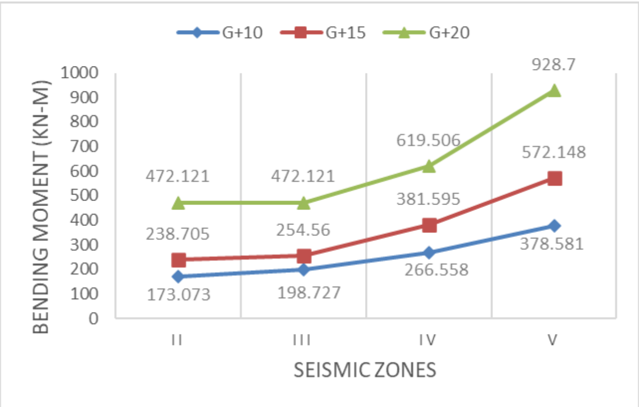

Chart -5: Variation of maximum nodal displacements with seismic zones for different storey

Case -V: Medium Soil Conditions

The details of the variation of bending moment with different storey for different load conditions and for different seismic zones has been tabulated in Table 10 and Chart 6 respectively.

Table 10 – Variation of maximum Bending moment and load conditions for different storey and zones

Zone	Storey	Max. Bending moment (KN-m)	Load combination
II	G+10	175.0	1.2 (DL+LL+EL)
	G+15	238.7	1.5(DL+WL)
	G+20	472.1	1.5(DL+WL)
III	G+10	198.7	1.2 (DL+LL+EL)
	G+15	254.6	1.5 (DL+EL)
	G+20	472.1	1.5 (DL+WL)
IV	G+10	317.7	1.5(DL+EL)
	G+15	468.5	1.5(DL+EL)
	G+20	760.5	1.5(DL+EL)
V	G+10	455.2	1.5 (DL+EL)
	G+15	702.5	1.5 (DL+EL)
	G+20	1140.1	1.5 (DL+EL)

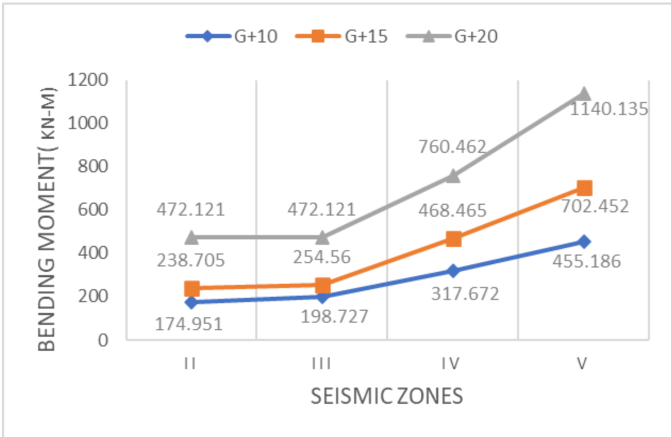

Chart -6: Variation of maximum nodal displacements with seismic zones for different storey

From the above tables & figures (8 to 10), it is observed that for different soil conditions with the increase of seismic zones and the height of building, maximum bending moment increases. It is also observed that the rate of increase of bending moment for G+15, G+10 buildings remains constant upto zone III and beyond that the rate of increase of bending moment increases rapidly and for G+20 building the rate of increase of bending moment remain constant up to zone IV and beyond that the rate of increase of bending moment increases rapidly for hard soil conditions and for other two conditions (medium and soft) for G+20 building the rate of increase of bending moment remain constant up to zone III and beyond that the rate of increase of bending moment increases rapidly and for G+10, G+15 buildings the rate of increase of bending moment increases rapidly with the increase of zones.

5.CONCLUSION

In this study, analysis of G+10, G+15 and G+20 storey buildings against seismic load and wind load as per IS:875 part (III) and IS 1893 part(I)-2002 using STAAD Pro has been conducted to compare the nodal displacement and bending moment of the structures. Also, to evaluate the dominating nature of earthquake load and wind load according to the height of the building.

The conclusion drawn from the study of multistorey building under seismic & wind that one of the reasons behind the failure is nodal displacement. It is observed that the dominating factor load combination for zone II (Visakhapatnam) is wind not the seismic for a constant wind speed of 50 m/s. But for zone III (Kolkata), IV (Jamnagar) & V (Shilong) the dominating factor is seismic not the wind for the same wind speed i.e., 50 m/s. And it is also observed that if the soil type changes from hard, medium to soft, the maximum nodal deflection and bending moment also changes corresponding to the height of building. There are few cases where for maximum bending moment is occurring due to wind but the maximum deflection occurs due to seismic. Generally, always we go for the seismic analysis but wind is also important for the R.C.C building.

REFERENCES

[1] Ankit Purohit (2017): "Seismic Analysis of G+12 Multistory Building Varying Zone and Soil Type" Volume- 4, Issue- 6.

[2] Ankit Bhaskar (2020) "Seismic design and analysis of (G+6) residential building in zone 3&4 using STAAD pro and it's cost estimation" Volume- 7, Issue- 6.

[3] V. Nagaraju (2016): "Analysis and design of multi - storey building under load combination" Volume- 5, Issue- 3.

[4] Adhiraj A. Wadekar (2020): "Analysis and design of a multi-storey building by using STAAD pro" Volume- 8, Issue-4.

[5] Ali Kifah Kadhum (2018): "Effect of seismic load on reinforced concrete multistory building from economical point of view" Volume- 9, Issue-11.

[6] Preeti Singh (2017): "Design and comparison of multistoried building in all seismic zones" Volume- 5, Issue-4.

[7] IS: 456-2000: Indian standard code of practice for plain and reinforced concrete.

[8] IS:875 (part 1) 1987: code of practice for Design loads (other than earthquake) For buildings and structures Part 1 dead loads - unit weights of building materials and Stored materials (second revision).

[9] IS: 875 (part 2)-1987: Code of practice (other than earthquake) part2: imposed loads (Second revision)

[10]IS: 875 (part 3)-2015: Code of practice for Design loads (other than earthquake) For buildings and structures Part 3 Wind loads (Third revision)