National Conference on 'Advances in Engineering, Technology and Applied Sciences' - NCAETAS-2019
© 2019 IJSRSET | Volume 5 | Issue 6 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099

Seismic Performance of RC Structures for Various Zones Considering Different Classes of Building

Anup Diwakar Malekar[1], D. P. Telang[2], Laxmikant N. Vairagade[3]

[1]M-Tech Student (SE), Department of Civil Engineering, GHRAET, Nagpur, Maharashtra, India

[2] Assistant Professor, Department of Civil Engineering, GHRAET, Nagpur, Maharashtra, India

[3]Assistant Professor, Department of Civil Engineering, GHRAET, Nagpur, Maharashtra, India

ABSTRACT

The behavior of a building throughout earthquakes depends critically on its overall form, size and type of building. Earthquake resistant of buildings depends upon providing the building with strength, stiffness and spring less deformation capability that area unit nice enough to face up to a given level of earthquake generated force. This is typically accomplished through the choice of associate degree applicable building configuration and also the careful particularization of structural members. Configuration is essential to smart seismic performance of the buildings. The necessary aspects moving seismic configuration of buildings area unit overall geometry, structural systems, and load paths. The building slenderness ratio and the building core size are the key drivers for the efficient structural design. This paper focuses on the result of each Vertical aspect ratio (H/B ratio i.e. Slenderness Ratio) and Horizontal or set up ratio (L/B ratio), wherever H is that the total Height of the building frame, B is the Base width and L is the Length of the building frame with completely different set up Configurations on the seismic Analysis of high-rise Regular R.C.C. Buildings. The check structures area unit unbroken regular in elevation and in set up. Here, height and also the base dimension of the buildings area unit varied consistent with the side Ratios. The values of side Ratios area unit thus appointed that it provides completely different configurations for Low, Medium and High-rise building models.

Keywords : RC Structure, Vertical Aspect Ratio, Slenderness Ratio, Aspect Ratio

I. INTRODUCTION

All structures especially high-rise structures are design for dynamic loads which include loads due to earthquake and wind. Major consideration is given to earthquake loads in earthquake prone areas and that to wind loads in cyclones prone areas. For very tall structure wind is considered as predominant load. Relevant standards and specifications, analysis procedure clearly indicates significant variations in calculation of wind and earthquake forces on structures. As per as earthquake force as considered zone factor, height of building and type of subsoil are relevant in estimation of earthquake force. For wind load base dimensions, height, basic wind speed, terrains category and many more factors include permeability are required for estimation of forces due to wind. Structures are designed for the effect of earthquake forces and wind forces in addition to gravity load.

Earthquake forces are estimated as per the provision of IS 1893(Part 1):2002 while the wind forces are estimated by IS 875(Part 3):1987. As per the historical wind velocity data India is divided into no. of zones and designed wind velocity is considered according to wind map of India. While the country is divided into four different seismic zone as per geological features and seismic history as per provision of IS 1893(Part 1):2002. Earthquake and maximum wind cannot be considered simultaneously thus it is required to have both wind analysis and seismic analysis of structure. To understand the dynamic effect due to wind the complex formulations is adopted in IS: 875(Part-III). The IS 875(Part 3):1987 as categorized building into three different classes depending upon their size as per clause 5.3.2.2:

Class-A: Structure and their component such as cladding, glazing, roofing, etc. having greatest vertical or horizontal dimensions less than 20m.

Class-B: Structure and their component such as cladding, glazing, roofing, etc. having greatest vertical or horizontal dimensions between 20 and 50m.

Class-C: Structure and their component such as cladding, glazing, roofing, etc. having greatest vertical or horizontal dimensions greater than 50m.

This indicates that the largest dimension plays major role in estimating wind forces on structures. Overlooking other dimensions and various tables given inIS875 (Part 3):1987 and give coefficients according to classes. However, earthquake force gives significance to height of structure as the time period of structure is linked to height of structure. Looking at the complexity arising due to significant variation in the consideration of building dimensions a need is realize in estimating wind and earthquake forces on typical A, B, C Class structures and investigate the performance of the structures against earthquake loads.

II. METHODS AND MATERIAL

In the present study, I.S. Code (1893:2002) based Dynamic Analysis (Response Spectrum Analysis) is performed. This study includes comparative study of behaviour of Low, Medium, High-Rise R.C.C. building frames considering different geometrical plan configurations based on different aspect ratios under earthquake forces. Following steps of methods of analysis are adopted in this study:

Step-1: Selection of different models having different building geometry, No. of bays for Horizontal Aspect Ratio and No. of storeys for Slenderness Ratio.

Step-2: Selection of seismic zone.

Step-3: Formation of load combination.

Step-4: Modelling of building frames using Staad Pro software.

Step-5: Analyses each models considering each load combinations for (No of Model Cases) by Seismic Analysis.

Step-6: Comparative study of results in terms of Base shear, Storey overturning moments, Storey drift, Storey displacement and Modal period of vibration.

M-25 grade of concrete and Fe-415 grade of reinforcing steel are used for all the frame models used in this study. Elastic material properties of these materials are taken as per Indian Standard IS 456 (2000). The short-term modulus of elasticity (Ec) of concrete is taken as: $E_c = 5000\sqrt{F_{ck}}$

III. RESULTS AND DISCUSSION

For calculation of forces, moments and displacement consider two important load cases for the analysis for corner column.

1.5(DL+EQ-X) – for earthquake analysis.

1.5(DL+EQ-z) – for earthquake analysis.

A. Analysis results

Axial force for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure

TABLE 1 : Axial force for central column 16-16-18 m structure for earthquake load

Sr. No	Maximum Axial force central column due to earthquake load			
	16 X 16 X 18 = Aspect Ratio 1			
	Zone III (Z)	Zone III (X)	Zone IV (Z)	Zone IV (X)
1	441.091	441.891	441.091	441.891
2	884.415	884.415	884.415	884.415
3	1324.962	1324.962	1324.962	1324.962

4	1764.927	1764.927	1764.927	1764.927
5	2203.913	2203.913	2203.913	2203.913
6	2639.927	2639.927	2639.927	2639.927

TABLE 2: Axial force for central column 08-16-18 m structure for earthquake load

Sr. No	Maximum Axial force central column due to earthquake load			
	08 X 16 X 18 = Aspect Ratio 2			
	Zone III (Z)	**Zone III (X)**	**Zone IV (Z)**	**Zone IV (X)**
1	428.550	428.550	428.550	428.550
2	843.417	843.417	843.417	843.417
3	1263.007	1263.007	1263.007	1263.007
4	1686.417	1686.417	1686.417	1686.417
5	2115.219	2115.219	2115.219	2115.219
6	2552.075	2552.075	2552.075	2552.075

Displacement for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure

TABLE 3: Displacement for central column 16-16-18 m & 08-16-18 m structure for earthquake load

Sr. No	Maximum Displacement (mm) of central column due to earthquake load			
	16 X 16 X 18 = Aspect Ratio 1			
	Zone III (Z)	**Zone III (X)**	**Zone IV (Z)**	**Zone IV (X)**
1	0	0	0	0
2	18.841	10.215	28.131	15.082
3	43.287	25.679	64.74	38.197
4	67.138	41.291	100.479	61.564
5	88.628	55.406	132.693	82.709
6	105.698	66.631	158.29	99.536
7	115.944	73.636	173.658	110.045
	08 X 16 X 18 = Aspect Ratio 2			
	Zone III (Z)	**Zone III (X)**	**Zone IV (Z)**	**Zone IV (X)**
1	0	0	0	0
2	15.928	9.553	20.793	12.368
3	36.544	24.614	47.786	32.073
4	56.621	40.085	74.087	52.334
5	74.672	54.224	97.745	70.862
6	88.993	65.628	116.518	85.811
7	97.589	73.057	127.79	95.556

Bending Moment for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure

TABLE 4: Bending Moment for central column 16-16-18 m & 08-16-18 m structure for earthquake load

Sr. No	Maximum Bending Moment central column due to earthquake load			
	16 X 16 X 18 = Aspect Ratio 1			
	Zone III (Z)	**Zone III (X)**	**Zone IV (Z)**	**Zone IV (X)**
1	94.054	89.587	141.081	134.381
2	160.548	159.834	240.821	239.751
3	203.931	210.297	305.896	315.445
4	227.092	239.288	340.638	358.931
5	237.202	258.081	355.803	387.121
6	247.858	297.783	371.786	446.674
	08 X 16 X 18 = Aspect Ratio 2			
	Zone III (Z)	**Zone III (X)**	**Zone IV (Z)**	**Zone IV (X)**
1	78.959	85.296	103.546	111.856
2	134.666	155.491	176.598	203.908
3	171.216	208.441	224.53	273.347
4	191.017	239.263	250.496	313.766
5	199.863	262.385	262.097	344.088
6	209.002	278.431	274.082	365.13

Shear Force for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure

TABLE 5: Shear Force for central column 16-16-18 m & 08-16-18 m structure for earthquake load

Sr. No	Maximum Shear Force central column due to earthquake load			
	16 X 16 X 18 = Aspect Ratio 1			
	Zone III (Z)	Zone III (X)	Zone IV (Z)	Zone IV (X)
1	68.744	75.377	103.116	113.066
2	111.139	117.924	166.708	176.886
3	138.441	147.185	207.661	220.778
4	152.55	161.996	228.825	242.993
5	157.381	166.221	236.071	249.331
6	148.454	153.999	222.681	230.998

Sr. No	Maximum Shear Force central column due to earthquake load			
	08 X 16 X 18 = Aspect Ratio 2			
	Zone III (Z)	Zone III (X)	Zone IV (Z)	Zone IV (X)
1	57.704	71.444	75.672	93.691
2	93.229	113.735	122.26	149.15
3	116.254	144.273	152.454	190.155
4	125.185	145.003	168.307	211.003
5	128.343	160.901	173.922	218.892
6	132.624	166.916	164.165	189.198

Compressive Stresses for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure

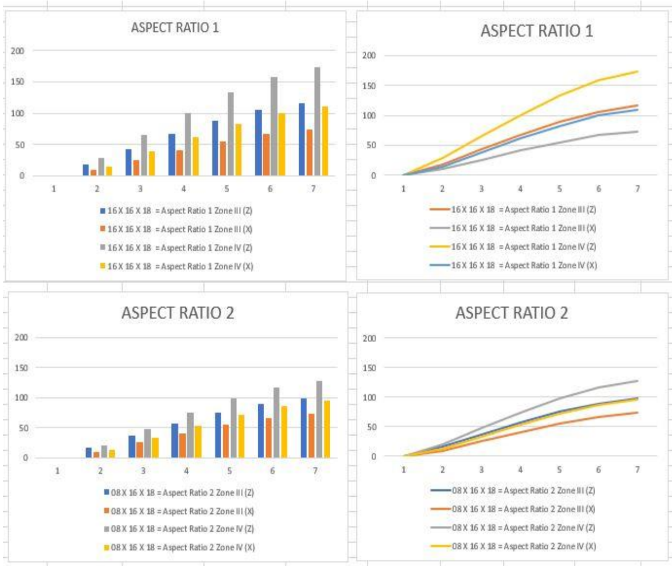
TABLE 6: Compressive Stresses for central column 16-16-18 m & 08-16-18 m structure for earthquake load

Sr. No	Maximum Compressive Stresses (N/mm²) central column due to earthquake load			
	16 X 16 X 18 = Aspect Ratio 1			
	Zone III (Z)	Zone III (X)	Zone IV (Z)	Zone IV (X)
1	17.797	13.763	25.275	19.225
2	28.839	21.305	40.364	29.063
3	36.912	27.228	51.005	36.478
4	42.401	31.396	57.772	41.264
5	46.32	35.339	62.133	45.662
6	50.647	41.422	67.171	53.333
	08 X 16 X 18 = Aspect Ratio 2			

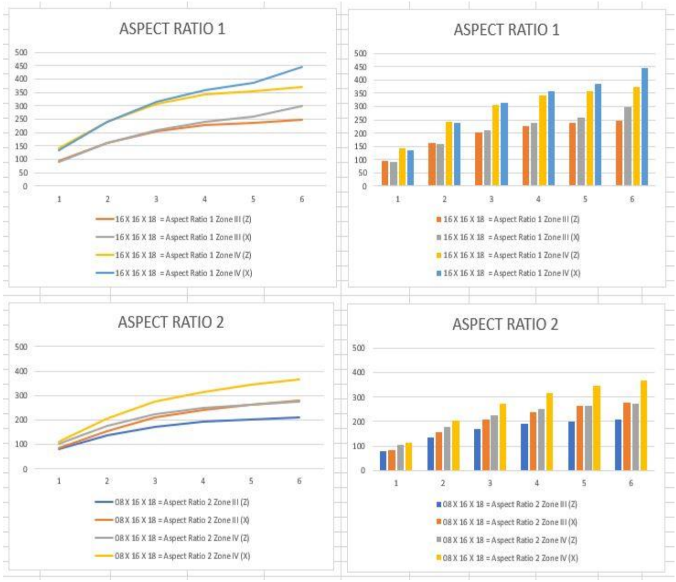
	Zone III (Z)	Zone III (X)	Zone IV (Z)	Zone IV (X)
1	15.305	13.074	19.214	16.288
2	24.853	20.374	30.874	25.001
3	31.987	26.439	39.358	32.083
4	37.005	30.612	45.06	36.676
5	40.75	35.092	49.048	41.629
6	44.881	39.288	53.558	46.224

B. Graphs

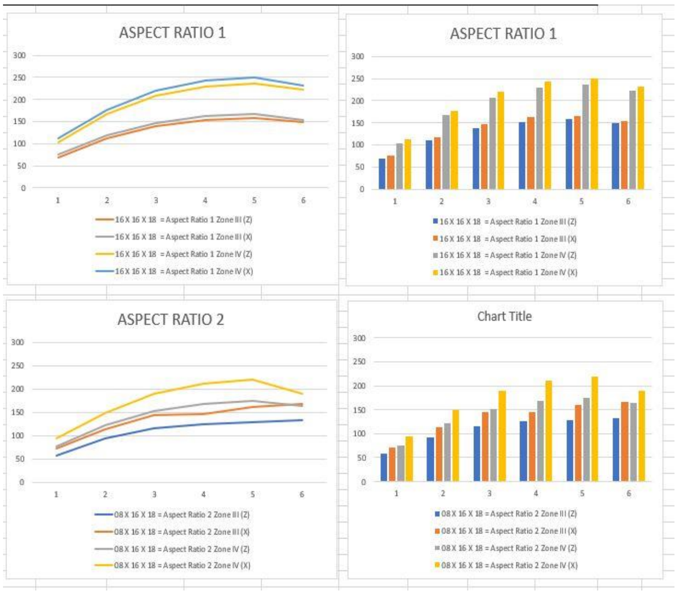
Graphs for Displacement with diff Zones factor for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure



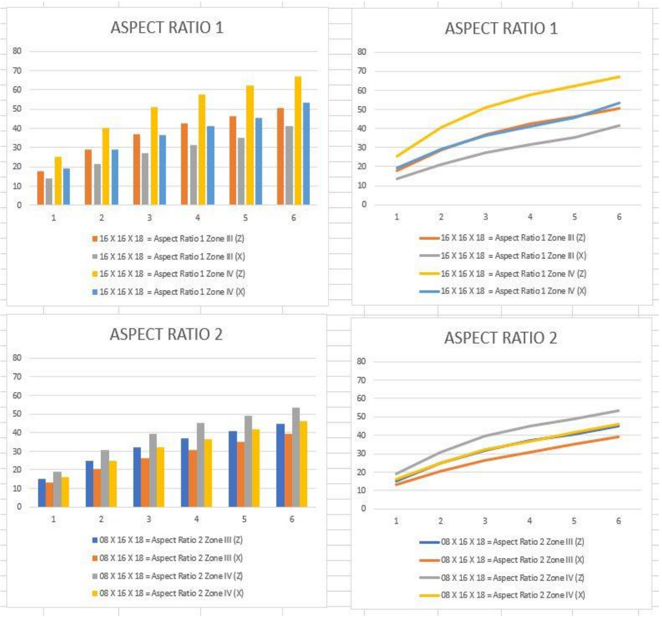
Graphs for Bending moment with diff Zones factor for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure



Graphs for Shear Force with diff Zones factor for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure



Graphs for Compressive Stresses with diff Zones factor for Aspect Ratio 1 & 2 of structure with varying base dimensions for Class – A structure



IV. CONCLUSION

1. In case of Seismic force the shear force, bending moment, compressive stresses and displacements developed in the columns increase as seismic zone is changed from III to IV for same Aspect ratio.

2. In case of Seismic force the axial force developed in the columns remains same as seismic zone is changed from III to IV for same Aspect ratio.

3. In case of Seismic force the axial force, shear force, bending moment, compressive stresses and displacements developed in the columns decrease as seismic zone is changed from III to IV as the Aspect ratio changed from 1 to 2.

4. In case of Seismic force the axial force developed in the columns decreases as the seismic zone is changed from III to IV as the Aspect ratio changed from 1 to 2.

5. In case of Different Class of building i.e, as the height of building increases the difference in axial force developed in the columns decreases as the seismic zone is changed from III to IV as the Aspect ratio changed from 1 to 2.

6. Earthquake forces are dependent on height as well as base dimensions, they increase with the increase in height as well as base dimensions.

7. In case of earthquake if the height of structure is increased the shear force at top floor is found lesser than floor immediately below.

8. For the same Aspect ration the shear force remains the same for different zone i.e III & IV in both the direction i.e X & Z.

9. The orientation of column plays a very important role when we consider the earthquake forces as we conclude that from the results that bending moment, compressive stresses and displacements decreases for the same aspect ratio in the same earthquake zone.

10. The orientation of column plays a very important role when we consider the earthquake forces as we conclude that from the results that shear force increases for the same aspect ratio in the same earthquake zone.

11 As the aspect ratio increase the building become more critical as the height of building increases.

12 The tall building should have small aspect ratio i.e sides of the building should be nearly equal in size, which will make it less critical.

V. REFERENCES

[1] Dr. K. R. C. Reddy, Sandip A. Tupat, "The effect of zone factors on wind and earthquake loads of high-rise structures" Department of Civil Engineering, Kavikulguru Institute of Technology and Science. Ramtek-441106, Dist. Nagpur, India'

[2] Dr. SuchitaHirde, Mr. VinayMagadum, "Severity of Earthquake Forces against Wind Forces for Multistorey RCC Building" Professor, Applied Mechanics Department, Govt. College of Engineering, Karad 415 124, India 2PG Student, Civil-Structures, Govt. College of Engineering, Karad 415 124, India

[3] Kostatalaganov, Mihailgarevski, Daniloristic and Vladomicov, "comparative dynamic stability study of a high –rise structure exposed to seismic and wind effects – case" STUDY 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 778

[4] Prof_Arya, "Steps for safe design and construction of Multistorey reinforced concrete buildings" Fundamentals_for_seismic_design_of_RCC_buildings.

[5] Azlan Adnan and SuhanaSuradi, "Comparison on the effect of earthquake and wind loads on the Performance of reinforced concrete buildings" Structural Earthquake Engineering Research, D04, Structure and Material Laboratory, Faculty of Civil Engineering-UniversitiTeknologi Malaysia 1azlan_fka_utm@yahoo.com, 2sueana80@yahoo.com

[6] Khaled M. Heiza and Magdy A. Tayel, "Comparative Study of The Effects of Wind and Earthquake Loads on High-rise Buildings" Civil Engineering Department, Faculty of Engieering, Menoufiya University, EGYPT

[7] AnupamRajmani and Prof PriyabrataGuha, "Analysis of wind & earthquake load for different shapes of high rise building" Narula Institute of Technology, 81,Nilgunj Road, Agarpara, Kolkata,West Bengal

[8] Syed Rehan and S.H.Mahure, "Study of Seismic and Wind Effect on Multi Storey R.C.C. Steel and Composite Building" Final Year Student (M.E. Structure) Professor & HOD Department Of Civil Engineering, BabasahebNaik College of Engineering PusadDistYavatmal Maharashtra.

[9] DatDuthinh and Emil Simi, "Safety of Structures in Strong Winds and Earthquakes:Multihazard Considerations" Journal of structural engineering © asce / march 2010

[10] SanhikKarMajumder and Prof. PriyabrataGuha, Comparison Between Wind And Seismic Load On Different Types Of Structures,M.Tech (Structural Engineering) Narula Institute of Technology , Agarpara,Kol-109, W.B., India

[11] Nicola Storgaard, “Earthquakes and their effects on buildings” Constructing Architect, 7th semester

[12] Hany J. Farran “Wind & Earthquake Response in Very Long Span CableStayed and Suspension Bridges”

[13] Gana A.J, “Wind effects on structures [a case study of buildings in irepodun local government area of kwara state” Civil Engineering Department College of Sciences and Engineering Landmark University, Omu-Aran, Kwara State

[14] AbdurRahman, SaiadaFuadi Fancy and ShamimAra Bobby, “Analysis of drift due to wind loads and earthquake loads on tall structures by programming language c”

[15] Xinzhong Chenand Ahsan Kareem, Evaluation of Equivalent Static Wind Loads on Buildings, Assistant Professor of Civil Engineering, Texas Tech University, Texas, USA, xinzhong.chen@ttu.edu, and Professor of Engineering, University of Notre Dame, Indiana, USA, kareem@nd.edu

[16] BimalaPillai, PriyabrataGuha, “Comparison between RCC and steel structure with wind and earthquake effect using Staad pro”

[17] Baldev D. Prajapati and D. R. Panchal, “Study of seismic and wind effect on multi storeyr.c.c., steel and composite building” M.E. Research Scholar & Assistant Professor, Applied Mechanics & Structural Engg. Deptt., Faculty of Techno. & Engineering, M. S. University of Baroda, Vadodara – 390001, Gujarat, India.

[18] B. Dean Kumarand B.L.P. Swami, “Wind effects on tall building framesinfluence of dynamic parameters” Department of Civil Engineering, JNTU College of Engineering, Hyderabad-500085, India, and Department of Civil Engineering, Vasavi College of Engineering, Ibrahim Bagh-500031, India

[19] P. Mendis, T. Ngo, N. Haritos, A. Hira and B. Samali Wind Loading on Tall Buildings, The University of Melbourne, Australia, and University of Technology Sydney, Australia, J. Cheung Monash University, Australia

[20] By Jonathan P. Stewart, Gregory L. Fenves, and Raymond B. Seed, “Seismic soil-structure interaction in buildings. I: analytical methods” 3 Members, ASCE

[21] UmakantArya, AslamHussain and Waseem Khan, “Wind Analysis of Building Frames on Sloping Ground” Rura Engineering Services, M .P , India, Civil, UIT R.G.P.V Bhopal, M.P,India

[22] HosseinMoravej, Mahdi Hatami, Reza Naghshbandi and YaserMousaviSiamakani, “Wind load analysis of buildings in hill-shape zone” Faculty of Civil Engineering, UniversitiTeknologi Malaysia

[23] Swati D.Ambadkar and Vipul S. Bawner, “Behaviour of multistoried building under the effect of wind load” Assistant Professor, Department of Civil Engineering, P.R.M.I.T.&R, Badnera, Amravati. Post Graduate Student, Department of Civil Engineering, P.R.M.I.T&R ,Badnera, Amravati

[24] Ryan Merrick and GirmaBitsuamlak, “Shape effects on the wind-induced response of high-rise buildings” Technical Coordinator, RWDI Inc., Guelph, Ontario, Canada, email: Ryan.Merrick@rwdi.com and Assistant professor, Department of Civil and Environmental Engineering/International Hurricane Research Center, Florida International University, Miami, Florida, 33174, email: bitsuamg@fiu.edu

[25] D. Boggs and J. Dragovich, “The Nature of Wind Loads and Dynamic Response”

[26] IS : 1893 (Part1) : 2002 – “Criteria for Earthquake resistant design of structures”