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COMPARITIVE STUDY OF BUILDINGS WITH VARYING HEIGHTS SUBJECTED TO SEISMIC FORCES IN DIFFERENT ZONES

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Abstract

Buildings are generally classified as Ordinary Moment Resisting Frame (OMRF) and Special Moment Resisting Frame (SMRF) based on response reduction factor. Generally buildings consists of structural members such as slabs, beams, columns and footings, where the subjected loads are transferred between the structural members and finally transferred to the subgrade soil. the behaviour of buildings is different for different types of loadings (dead, live, wind and seismic) and these load effects also changes with respect to the building configuration parameters length, width and height. In the analysis and design of buildings usefully Indian standards codes suggest various loads combinations based on probability of occurance. there are around 42 load combinations and IS codes also suggest the lateral load (wind and seismic) acts independently but the load governing the design of structural members is to be found out. And the present study to investigate the effects of wind and seismic on buildings three structures of different heights (G+5,G+10,G+15) are considered in seismic zones II,III,IV,V where length and width of the structures is kept constant. an earthquake load is calculated as per IS 1893(PART-1)-2002 and wind pressure calculated as per IS 875-1987 (PART III).The analysis is performed using staad.pro software.

Keywords: Regular buildings, STAAD.Pro, Seismic, Wind, High rise buildings.

1. INTRODUCTION

RCC Buildings are generally categorised based upon the height low rise buildings (up to 18m) ,high rise buildings(18m-36m) and skyscrapers (above 36m),buildings are also classified based upon the plan and vertical irregularities. RCC buildings are also classified as type of materials used for construction and errection steel ,concrete ,Timber, composite Structures. Buildings are also classified based upon the occupancy of the structures as per IS :875 PART-2 Effect of lateral loads is an important consideration when the height or vertical linear dimension is increasing when compared with the plan dimensions. RCC Structures are strengthened or reinforced by using high yield strength deformed (HYSD) Bars to take care of tension being develop due to application of load. Ordinary moment resisting frame buildings (OMRF) requires additional force resisting techniques such as dampers, base isolators, bracings and shear walls.RCC buildings are widely constructed across the world because of the bond strength and equal coefficient of thermal expansion between steel and concrete. The axial forces in columns and support reactions on foundation are increasing with increase in the horizontal and vertical loads. The selection of type of foundation is effected by the governing load case. In this Paper we also considered regular Rectangular R.C building with Five, Ten, Fifteen storeys and have been designed using STAAD.Pro for Seismic Zone –II , Zone –III, Zone –IV & Zone –V and wind loads. The comparison of these structures with different parameters like Maximum Displacement ,Storey Drift and Axial Forces. In this paper we considered OMRF structure.

2. MAIN OBJECTIVES

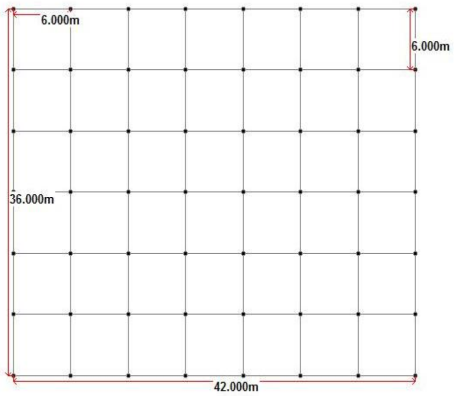
1. The main objective of this paper is to find whether Seismic Force or Wind Force is predominant in high rise Buildings.
2. To find the maximum Displacement and Storey Drift.
3. To find the governing load case in the three type of structure (G+5,G+10,G+15) considered.
4. Comparative study of Structures (G+5,G+10,G+15) in different Seismic Zones.
5.To find adequacy of cross section area of the columns for considered load cases.

2.1 Methodology

2.1.1 Analysis of Design Data

2.1.1 Analysis of Design Data

Materials	M30,Fe415
Loadings	Dead, live, wind, earth quake loads
No. of storeys in Structures Considered	G+5,G+10,G+15
Length of building	7x6 = 42m
width of building	6x6 = 25m
Foundation of depth	2.0m
Height of buildings considered from top of the foundation	G+5=6x3+2 = 20m G+10=11x3+2=35m G+15=16x3+2=50m
Seismic zones	2,3,4,5
Column to column spacing c/c	6m
Brick Wall thickness	0.15m
Floor to floor height	3.0m
Thickness of slab	0.15m
Support conditions	fixed
Size of beam	0.45mx0.25m
Diameter of column	0.8
Structure type	RC Frame Building
Response reduction of structure-1	Ordinary RC moment resisting frame(OMRF)
Type of building	General
Type of soil condition	Hard soil
Exposure of structures to wind load	100%



2.2.3 Analysis of structure :

The analysis of G+5,G+10,G+15 storey buildings in seismic zones (II, III, IV & V) and wind load is carried out using STAAD.Pro(v8i SS5). The results obtained from the analysis are shown in the form of tables and graphs.

2.2.4 Load Calculations:

The structures are subjected to four types of primary loads as per the provisions of IS Code of practice
They are:
Dead Load (From IS: 875-1987(Part-I))
Live Load (From IS: 875-1987(Part-II))

Wind Load (From IS: 875-1987(Part-II))
Seismic Load (From IS: 1893-2002(Part-I))

2.2.4.1 Load Combinations:

1.	DL	2.	1.5DL+1.5EL+Z
3.	LL	4.	1.5DL+1.5EL-Z
5.	EL+X	6.	1.2DL+1.2LL+1.2EL+X
7.	EL-X	8.	1.2DL+1.2LL+1.2EL-X
9.	EL+Z	10.	1.2DL+1.2LL+1.2EL+Z
11.	EL-Z	12.	1.2DL+1.2LL+1.2EL-Z
13.	WL+X	14.	DL+WL+X
15.	WL-X	16.	DL+WL-X
17.	WL+Z	18.	DL+WL+Z
19.	WL-Z	20.	DL+WL-Z
21.	DL+LL	22.	DL+LL+WL+X
23.	DL+EL+X	24.	DL+LL+WL-X
25.	DL+EL-X	26.	DL+LL+WL+Z
27.	DL+EL+Z	28.	DL+LL+WL-Z
29.	DL+EL-Z	30.	0.9DL+1.5WL+X
31.	DL+LL+EL+X	32.	0.9DL+1.5WL-X
33.	DL+LL+EL-X	34.	0.9DL+1.5WL+Z
35.	DL+LL+EL+Z	36.	0.9DL+1.5WL-Z
37.	DL+LL+EL-Z	38.	1.5DL+1.5WL+X
39.	1.5DL+1.5LL	40.	1.5DL+1.5WL-X
41.	0.9DL+1.5EL+X	42.	1.5DL+1.5WL+Z
43.	0.9DL+1.5EL-X	44.	1.5DL+1.5WL-Z
45.	0.9DL+1.5EL+Z	46.	1.2DL+1.2LL+1.2WL+X
47.	0.9DL+1.5EL-Z	48.	1.2DL+1.2LL+1.2WL-X
49.	1.5DL+1.5EL+X	50.	1.2DL+1.2LL+1.2WL+Z
51.	1.5DL+1.5EL-X	52.	1.2DL+1.2LL+1.2WL-Z

2.2.6Assumptions:

1. Material: Concrete is assumed to behave linearly elastic. The modulus of elasticity E_c =5000 $\sqrt{f_{ck}}$ where the specified compressive strength of concrete f_c is assumed equal to 30Mpa.
Modulus of elasticity of steel is E_s =5000 $\sqrt{f_{ck}}$ where f_{ck} is assumed to be Es=2x10^5N/mm^2.
2. Constarints :Supporting bases of all structural models are fixed supports.
3.Wind Calucations :

WIND PRESSURE CALCULATIONS FOR AS PER IS: 875 (PART 3) – 1987

WIND PRESSURE CALCULTION:
Type of structure: RCC Building (G+5) ; Terrain category = 1
Length = 42m, Width = 36m.
Type of city = VISAKHAPATNAM
Basic WIND SPEED (V_b) = 60m/sec.
K_1= Risk coefficient for important buildings/towers = 1
K_2 = terrain, structure height and size factor
K_3 = topography factor = 1 (upwind slope < 3^o)
Design WIND SPEED = $V_Z = V_B K_1 K_2 K_3$
Design WIND PRESSURE = Pz = $0.6V_Z^2$

Table No: G+5 Wind Calcuations

S.NO	HEIGHT (m)	V_B (m/sec)	K_1	K_2	K_3	V_z (m/sec)	P_z (k.N/m^2)
1	3	60	1	1.03	1	61.8	2.29
2	6	60	1	1.03	1	61.8	2.29
3	9	60	1	1.03	1	61.8	2.29
4	12	60	1	1.04	1	62.7	2.35
5	15	60	1	1.07	1	64.2	2.47

Table No: G+10 Wind Calculations

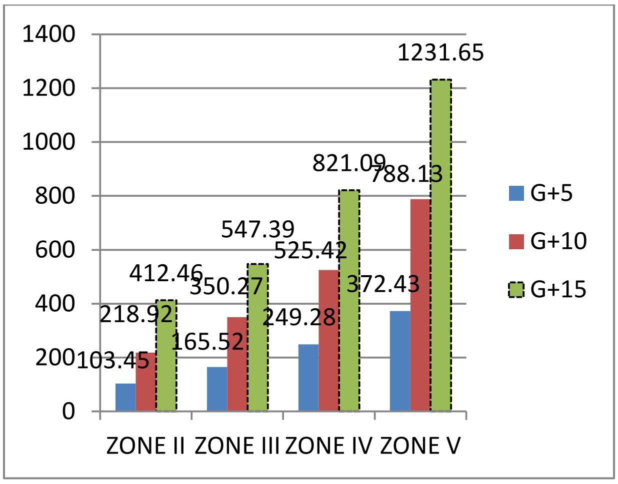
S.NO	HEIGHT (m)	V_B (m/sec)	K_1	K_2	K_3	Vz (m/sec)	Pz (KN/m^2)
1	3	60	1	1.03	1	61.8	2.29
2	6	60	1	1.03	1	61.8	2.29
3	9	60	1	1.03	1	61.8	2.29
4	12	60	1	1.04	1	62.7	2.35
5	15	60	1	1.07	1	64.2	2.47
6	18	60	1	1.08	1	65.2	2.55
7	21	60	1	1.10	1	66.1	2.62
8	24	60	1	1.11	1	66.7	2.67
9	27	60	1	1.12	1	67.2	2.71
10	30	60	1	1.13	1	67.8	2.75
11	33	60	1	1.138	1	68.22	2.79

Table No: G+10 Wind Calculations

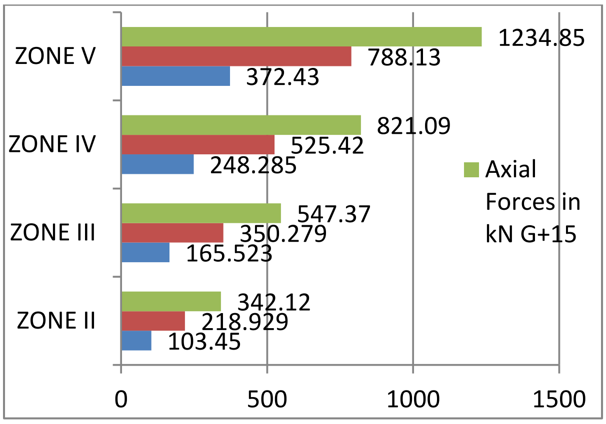
S.NO	HEIGHT (m)	V_B (m/sec)	K_1	K_2	K_3	Vz (m/sec)	Pz (KN/m^2)
1	3	60	1	0.99	1	59.4	2.12
2	6	60	1	0.99	1	59.4	2.12
3	9	60	1	0.99	1	59.4	2.12
4	12	60	1	1.014	1	60.84	2.22
5	15	60	1	1.03	1	61.8	2.29
6	18	60	1	1.04	1	62.88	2.37
7	21	60	1	1.06	1	63.78	2.44
8	24	60	1	1.07	1	64.32	2.48
9	27	60	1	1.08	1	64.86	2.52
10	30	60	1	1.09	1	65.4	2.56
11	33	60	1	1.09	1	65.8	2.60
12	36	60	1	1.10	1	66.3	2.64
13	39	60	1	1.11	1	66.75	2.67
14	42	60	1	1.12	1	67.2	2.71
15	45	60	1	1.127	1	67.65	2.75
16	48	60	1	1.13	1	68.1	2.78
17	50	60	1	1.14	1	68.4	2.81

2.2.7SUPPORT REACTIONS

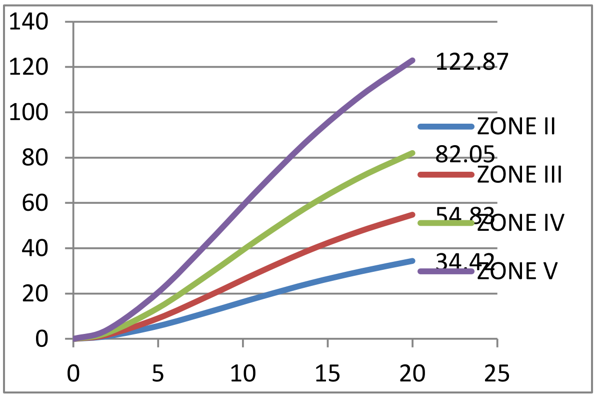
Maximum support reactions along direction Y



2.2.8AXIAL FORCES IN DIFFERENT ZONES

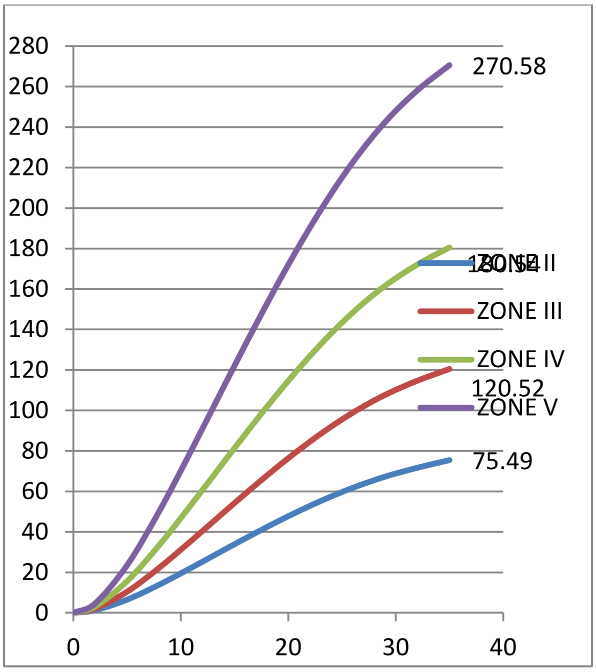


GRAPH FOR MAXIMUM DISPLACEMENTS G+5 IN VARIOUS ZONES



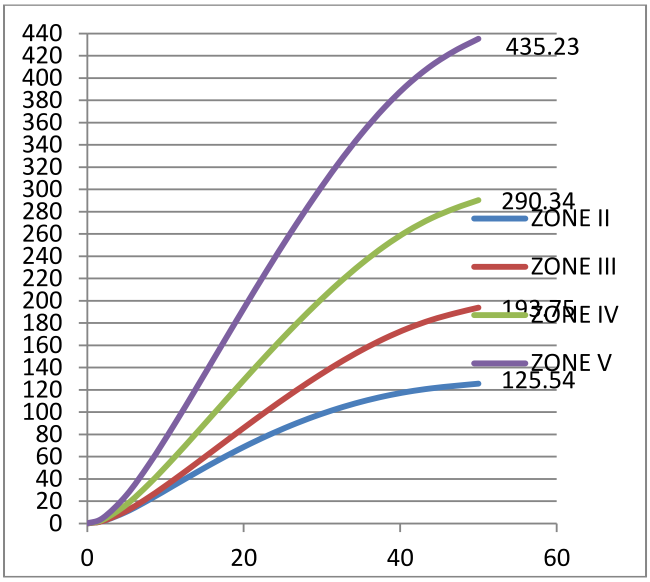
GRAPH FOR G+10 BUILDING IN VARIOUS ZONES

G+10 Displacement Direction :X

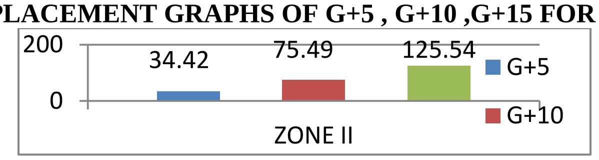


GRAPH FOR G+15 BUILDING IN VARIOUS ZONES

G+15 Displacement Direction :X

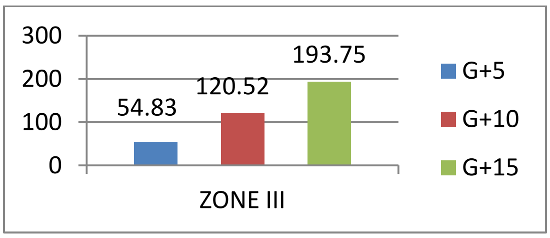


MAXIMUM DISPLACEMENT GRAPHS OF G+5 , G+10 ,G+15 FOR SEISMIC ZONE-I



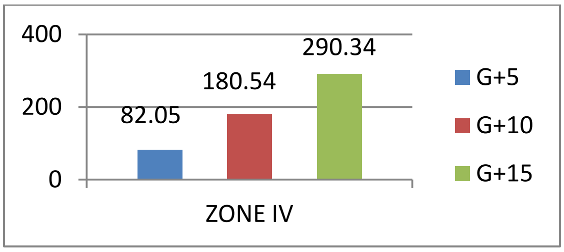
MAXIMUM DISPLACEMENT GRAPHS OF G+5 , G+10 , G+15 FOR SEISMIC ZONE-III

ZONE :III; Displacement direction: X

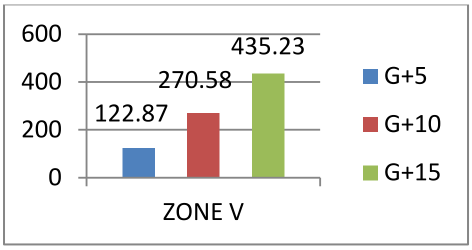


MAXIMUM DISPLACEMENT GRAPHS OF G+5 , G+10 , G+15 FOR SEISMIC ZONE-IV

ZONE :IV; Displacement direction: X



MAXIMUM DISPLACEMENT GRAPHS OF G+5 , G+10 , G+15 FOR SEISMIC ZONE –V



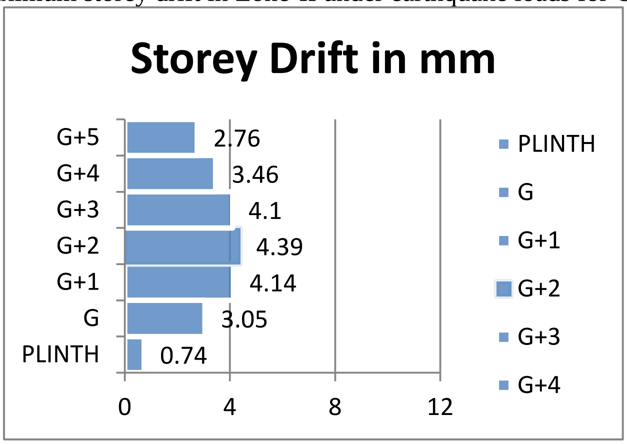
DRIFT STOREY

As per IS: 1893(part 1):2002 Clause 7.11.1, The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times of the storey height(h).

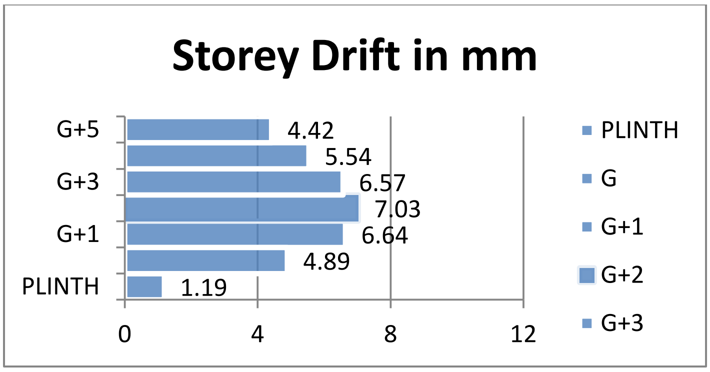
Height of the storey(h) = 3m =3000mm.

Maximum Storey Drift = 0.004x3000 =12mm.

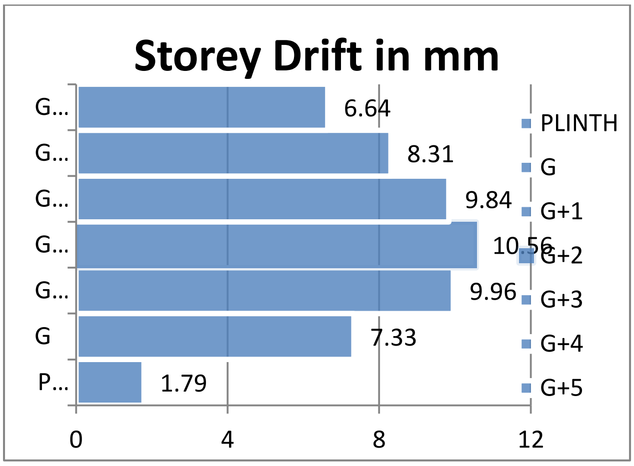
Maximum storey drift in Zone-II under earthquake loads for G+5



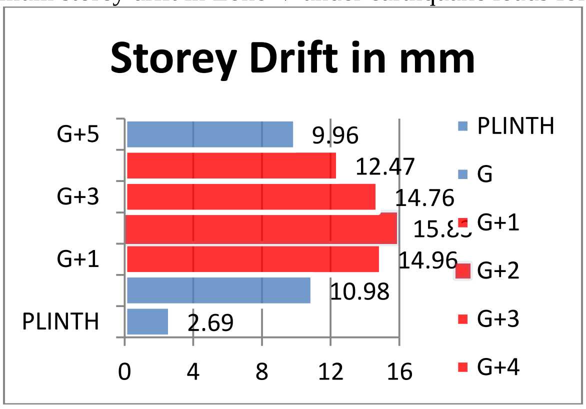
Maximum storey drift in Zone-III under earthquake loads for G+5



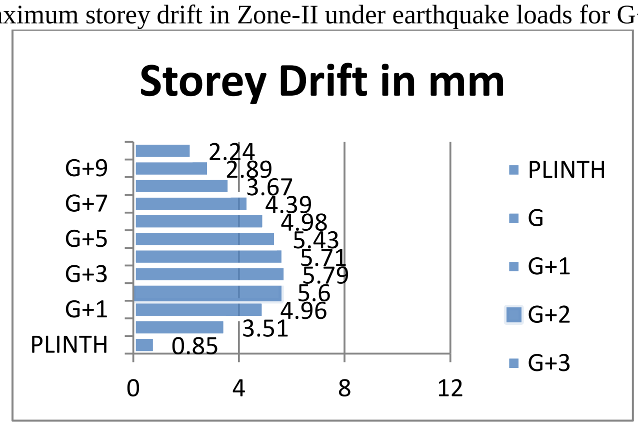
Maximum storey drift in Zone-IV under earthquake loads for G+5



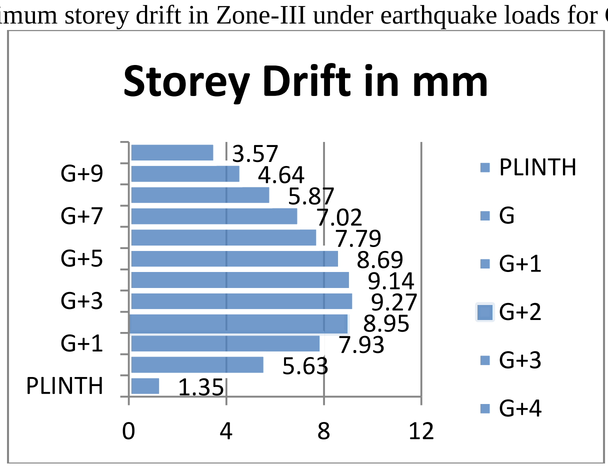
Maximum storey drift in Zone-V under earthquake loads for G+5



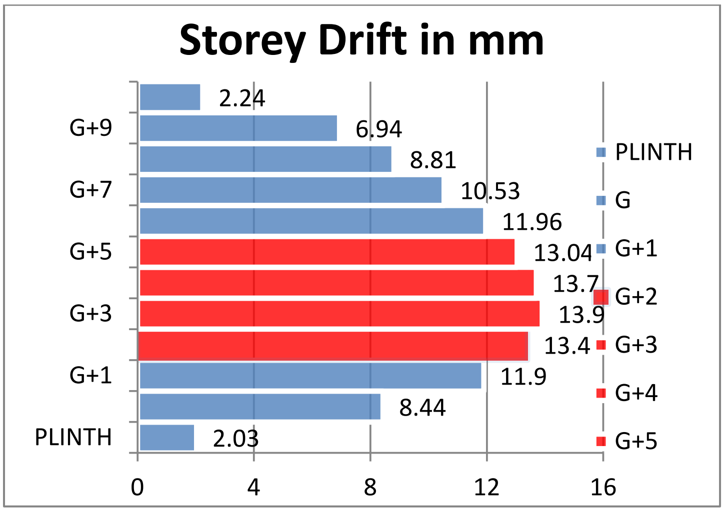
Maximum storey drift in Zone-II under earthquake loads for G+10



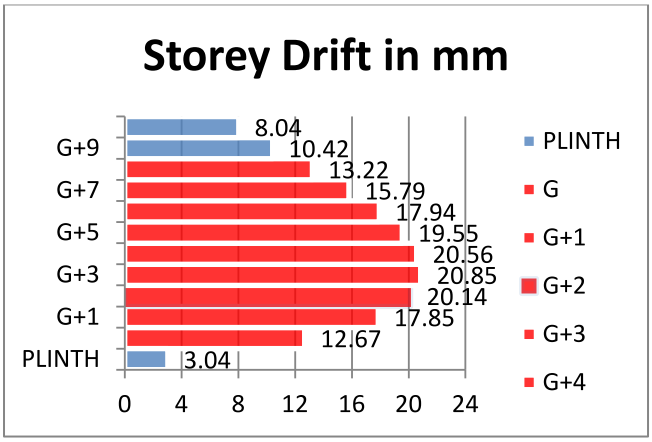
Maximum storey drift in Zone-III under earthquake loads for G+10



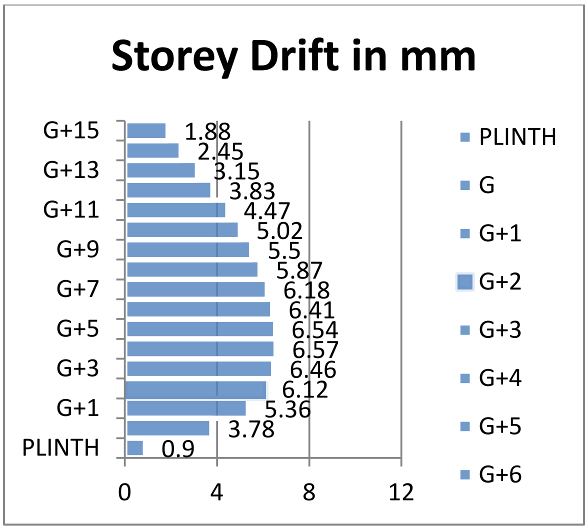
Maximum storey drift in Zone-IV under earthquake loads for G+10



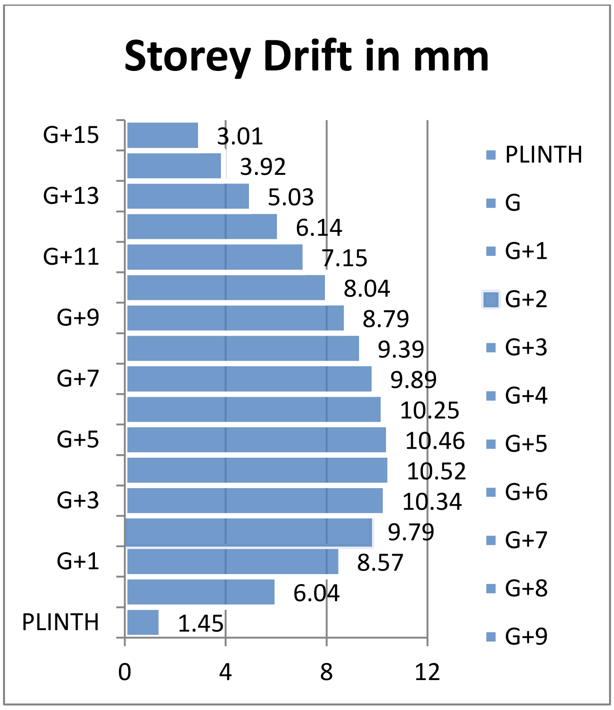
Maximum storey drift in Zone-V under earthquake loads for G+10



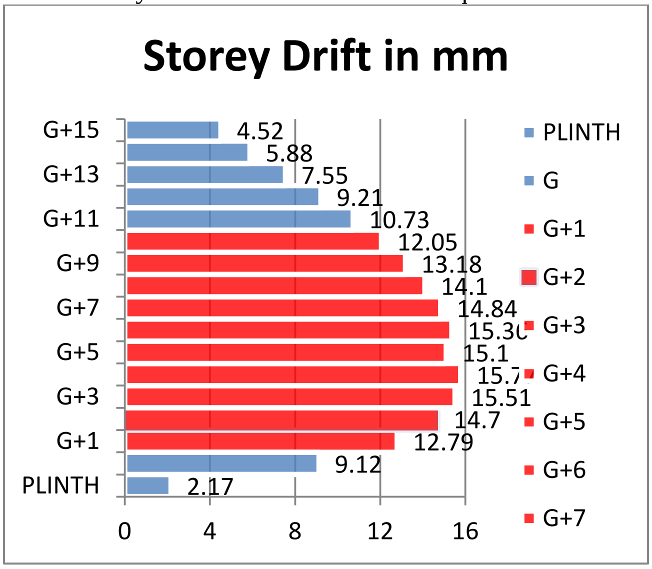
Maximum storey drift in Zone-II under earthquake loads for G+15



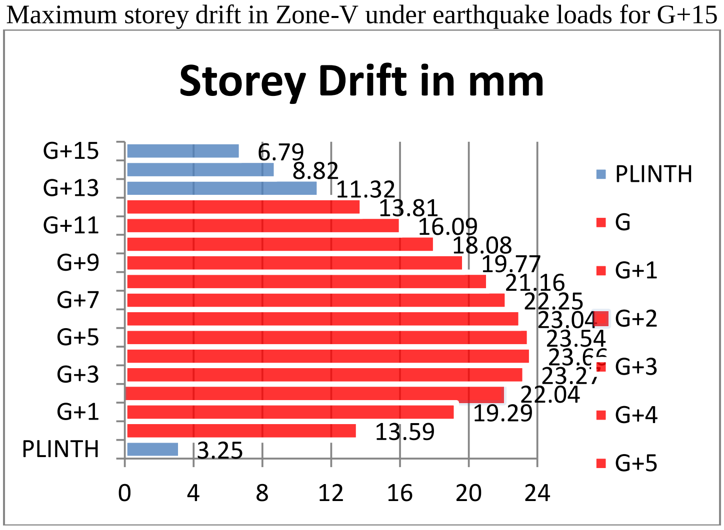
Maximum storey drift in Zone-III under earthquake loads for G+15



Maximum storey drift in Zone-IV under earthquake loads for G+15

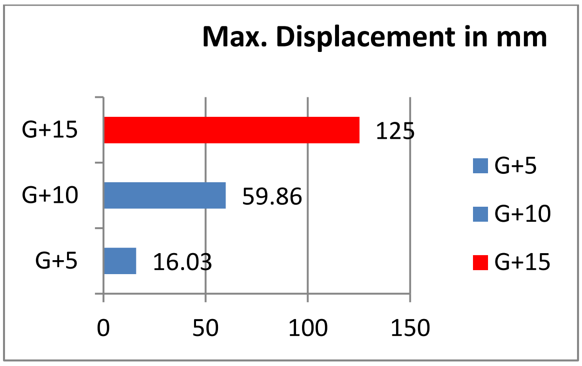


Maximum storey drift in Zone-V under earthquake loads for G+15



MAXIMUM DISPLACEMENT DUE TO WIND LOADS ALONG LENGTH (X-DIRECTION)

As per IS: 456:2000, clause (20.5), Maximum lateral sway at the top should not exceed (H/500) for wind loads, where H is the height of the building.
Maximum Displacement For G+5 = (20000)/ (500) = 40mm.
Maximum Displacement For G+10 = (35000)/ (500) = 70mm
Maximum Displacement For G+15 = (50000)/ (500) = 100mm



CONCLUSIONS

As per IS: 456:2000, clause (20.5), Maximum lateral sway at the top should not exceed (H/500) for wind loads, where H is the Height of the building. Maximum Displacement For G+5 = 40mm, G+10 = 70mm, G+15 = 100mm. As per IS: 1893(part 1):2002 Clause 7.11.1, The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times of the storey height(h=3000mm).Maximum Storey Drift = 0.004x3000 =12mm.

1) Maximum Wind Displacement is in Limits for G+5 (16.03mm) ,G+10 (59.86mm).But It exceeds its limits for G+15 (125mm) .
2) The Lateral Drift for G+5 is in limits for Zones II, III & IV. But it exceeds its limits for Zone V.
3) The Lateral Drift for G+10 is in limits for Zones II, III. But it exceeds its limits for Zone IV &V.
4) The Lateral Drift for G+15 is in limits for Zones II, III. But it exceeds its limits for Zone IV &V.
5) The Maximum Drift for G+5 (15.83mm) Occurs at Storey – 3 in Seismic Zone –V.
6) The Maximum Drift for G+10 (20.85mm) Occurs at Storey – 4 in Seismic Zone –V.
7) The Maximum Drift for G+15 (23.66mm) Occurs at Storey – 5 in Seismic Zone –V.
8) For Axial Forces and Support Reactions , Considering G+5(103.45 kN),G+10 (218.92kN), G+15 (342.12kN) Seismic Zone –II as reference the values for Zone –III , IV, V Increases by 1.6 ,2.4 ,3.6 times of reference structures respectively.
9) Structure Height doesnot influence in Axial forces and Support Reactions for different Structures in Various Zones.
10) Governing Load case for structure G+5 , G+10 ,G+15 Zone –V is **1.5D.L+1.5E.L.**

From all the conclusions it is concluded that Seismic Force is more predominant than wind Force.

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