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EFFECT OF WIND LOAD ON LOW, MEDIUM, HIGH RISE BUILDINGS IN DIFFERENT TERRAIN CATEGORY

B.Shobha1, Dr.H.SudarsanaRao2 ,Dr.Vaishali.G.Ghorpade3

[1]*M. Tech (Computer aided structural Engineering), Department of Civil Engineering, J.N.T.U.A College of Engineering, Ananthapuramu. 515002, Andhra Pradesh, India*

[2]*Professor of Civil Engineering and Director(I.C.S), J.N.T.University Anantapur,Ananthapuramu,515002, Andhra Pradesh, India.*

[3]*Professor of Civil Engineering , JNTUA College of Engineering ,Anantapur,Ananthapuramu. 515002, Andhra Pradesh, India.*

ABSTRACT: Any Tall building can vibrate in both the directions of "along wind" and "across wind" caused by the flow of wind. Modern Tall buildings designed to satisfy lateral drift requirements, still may oscillate excessively during wind storm. These oscillations can cause some threats to the Tall building as buildings with more and more height becomes more vulnerable to oscillate at high speed winds. Sometimes these oscillations may even cause discomfort to the occupants even if it is not in a threatening position for the structural damage. So an accurate assessment of building motion is an essential prerequisite for serviceability. There are few approaches to find out the Response of the Tall buildings to the Wind loads.

Wind is a perceptible natural motion of air relative to earth surface,especially in the form of air current blowing in a particular direction. The major harmful aspect which concern to civil engineering structures is that, it will load any and every object that comes in its way. Wind blows with less speed in rough terrain and higher speed in smooth terrain. This paper presents story drift, storey shear, and support reactions that occur in different storey Buildings (Low Rise Buildings, Medium Rise Buildings, and High Rise Buildings) due to wind in different terrain category. Totally12 models for G+5, G+10 and G+15 are analyzed using ETABSv9.7.4 package. Present work provides a good source of information about variation in drift, shear with change in height of model, percentage change in drift, shear of same model in different terrain category.

KEY WORDS*: *Tall Buildings, drift, storey shear, ETABSv9.7.4, different terrain category

INTRODUCTION

1.1.GENERAL

Wind has two aspects. The first beneficial one is that its energy can be utilized to generate power, sail boats and cool down the temperature on a hot day.The other a parasitic one is that it loads any and every object that comes in its way. The latter is the aspect an engineer is concerned with, since the load caused has to be sustained by a structure with the specified safety. All civil and industrial structures above ground have thus to be designed to resist wind loads. This introductory note is concerning the aspect of wind engineering dealing with civil engineering structures.

1.2.ESTIMATION OF WIND LOAD ON BUILDINGS:

Wind load on a Tall building can be determined by:

1. Analytical Method given in the code IS 875: part 3-1987 which is given by A.G.Davenport(1967). The analytical method is usually acceptable for a building with regular shape and size and is almost based on the geometric properties of the building and without incorporating the effects of the nearby buildings.
2. Secondly the Estimation of Wind Load through Wind tunnel testing with as called building model used. In Wind Tunnel Testing for the structural design the Dynamic analysis of the scaled model building is done with Balendra'sapproach(1997)and for the cladding design the Surface Pressure Measurement analysis with Pressure Measurement system is done. Also the effects of the nearby buildings have been taken into consideration as the Interference effects on the buildings in a same procedure being used for an isolated building model.

1.3. TERRAIN

Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of wind under consideration. Wherever sufficient meteorological information is available about the wind direction, the orientation of any building or structure may be suitably planned.

Terrain in which a specific structure stands shall be assessed as being one of the following terrain categories:

A. TERRAIN CATEGORY 1

Exposed open terrain with few or no obstructions and in which the average height of any object surrounding the structure is less than 1.5 m

Open terrain, open country or open ground is terrain which is mostly flat and free of obstructions such as trees and buildings. Examples include farmland, grassland and specially cleared areas such as an airport.

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Fig1 OPEN GROUNDFig2.OPEN AREA

B. TERRAIN CATEGORY 2

Open terrain with well scattered obstructions having heights generally between 1.5 to 10 m

Forest terrain can be divided into three categories: sparse, medium, and dense. An immense forest could have all three categories within its borders, with more sparse terrain at the outer edge of the forest and dense forest at its heart. The Table below describes in general terms how likely it is that a given square has a terrain element in it.

Table1:Types of trees &undergrowth differences in sparse ,medium, dense

	Sparse	Medium	Dense
Typical trees	50%	70%	80%
Massive trees	-	10%	20%
Light undergrowth	50%	70%	50%
Heavy undergrowth	-	20%	50%

Fig3.Terrain category 2

TERRAIN CATEGORY 3

Terrain with numerous closely spaced obstructions having the size of building-structures up to 10 m in height with or without a few isolated tall structures.

Fig4. Terrain category3

TERRAIN CATEGORY 4

Terrain with numerous large high closely spaced obstructions.

Fig5. Terrain category 4

1.4.OBJECTIVES OF THE STUDY

Following are the main objectives of the work:

1. The main objective of the present work is to study the effect and variation of wind pressure for three categories of buildings Low Rise Buildings, Medium Rise Buildings, and High Rise Buildings for different terrain categories.
2. In the present study the variations of the wind pressure on typical multi-storied Buildings will be obtained by dynamic analysis method as given by the draft code IS-875 part 3
3. In the present work, multistory buildings of 6storey, 11storey and 16storey will be modeled for different Terrain categories i.e. Terrain categories 1, Terrain categories 2, Terrain categories 3, Terrain categories 4.
4. The analysis of the building will be carried out using ETABSV9.7.4. Using the dynamic analysis method.
5. The results from the models (story drift, story shear) are compared in different types of story buildings (low, medium, high rise buildings) for different terrain categories.

2 .LITERATURE REVIEW

Holmes and Lewis (1986, 1987 and 1989) Performed extensive experimental work onthe fluctuating pressure measurements using a small diameter connecting tube totransmit the pressure from the connecting point, or tap, to the pressure transducer. Theirauthentic work has provided sufficient guidelines to develop a range near optimumsystems for the measurement of fluctuating pressure on models of the buildings in windtunnels. In the present study the choice of tubing system for pressure measurements islargely based on the work of Holmes and Lewis (1987).

Whitbread (1963) Presented an account of various flow parameters required to bematched in the wind tunnels and concluded that Jensen's (1958) model law providedsatisfactory answers using floor roughening devices.

Fujimoto et al. (1975) Tested a 1:400 scaled aero elastic mod el of rectangular tallbuilding (1:1.2:3.75) in smooth flow and two boundary layer flows. Values of alongwind and across wind response are presented versus reduced velocity and a relationshipis established. Experimental gust factors are compared with Davenport (1967). A four mass model was also tested in natural wind, and contribution of higher modes isreported to be negligible on displacements and about 10% on accelerations

Peter A. Irwin (2010) Studied the procedure for determining wind pressures on the exteriorcladding of tall buildings. The methods used in a pressure model study are reviewedincluding measurement system frequency response, the determination of peak pressurecoefficients, combining wind tunnel and meteorological data and evaluating internalpressures. In addition, an assessment is made of the uncertainties involved in windtunnel testing as compared with using building code methods.

Holmes and Lewis (1989) Performed extensive experimental work onthe fluctuating pressure measurements using a small diameter connecting tube totransmit the pressure from the connecting point, or tap, to the pressure transducer. Theirauthentic work has provided sufficient guidelines to develop a range near optimumsystems for the measurement of fluctuating pressure on models of the buildings in windtunnels. In the present study the choice of tubing system for pressure measurements islargely based on the work of Holmes and Lewis (1987).

3.EFFECT OF WIND LOAD ON BUILDINGS AND STRUCTURES

3.1. NATURE OF WIND IN ATMOSPHERE

In general, wind speed in the atmospheric boundary layer increases with height from zero at ground level to a maximum at a height called the gradient height. There is usually a slight change in direction (Ekman effect) but this is ignored in the Code. The variation with height depends primarily on the terrain conditions. However, the wind speed at any height never remains constant and it has been found convenient to resolve its instantaneous magnitude into an average or mean value and a fluctuating component around this average value. The average value depends on the averaging time employed in analyzing the meteorological data and this averaging time can be taken to be from a few seconds to several minutes. The magnitude of fluctuating component of the wind speed, which represents the gustiness of wind, depends on the averaging time. Smaller the averaging interval, greater is the magnitude of the wind speed.

3.2. BASIC WIND SPEED:

Figure6 gives basic wind speed map of India, as applicable at 10 m height above mean ground level for different zones of the country. Basic wind speed is based on peak gust speed averaged over a short time interval of about 3 seconds and corresponds to 10m height above the mean ground level in an open terrain (Category 2). Basic wind speeds presented in Fig.6.have been worked out for a 50-year return period.

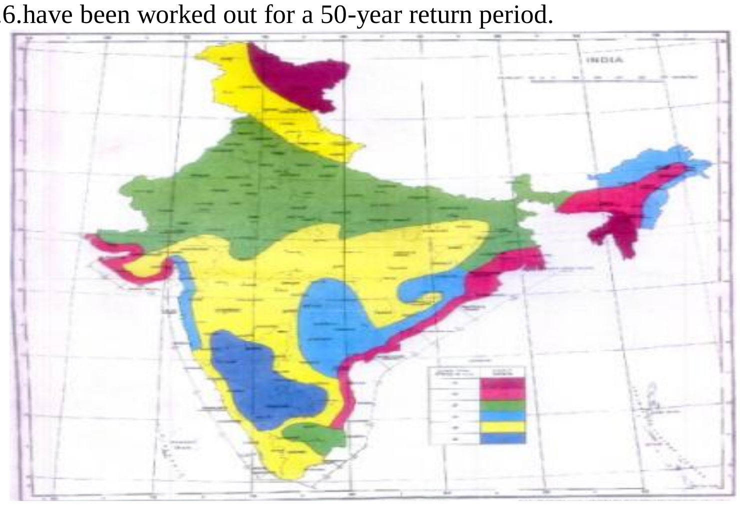


Fig 6.Basic wind speed in m/s (based on 50 year return period)

3.3. Design Wind Speed (Vz)

The basic wind speed for any site shall be obtained from Fig. 1 and shall be modified to include the following effects to get design wind speed, Vz at any height, Z for the chosen structure: (a) Risk level, (b) Terrain roughness and height of structure, (c) Local topography, and (d) Importance factor for the cyclonic region. It can be mathematically expressed as follows:

$$Vz = V_bK_1K_2K_3K_4$$

Where Vz = design wind speed at any height z in m/s,

K1=probability factor (risk coefficient)

K2=terrain roughness and height factor

K3=topography factor

K4=importance factor for the cyclone region

4. DESIGN CONSIDERATIONS AND MODELING OF BUILDING IN ETABS

The design details of low , medium, high rise buildings are presented in Table 2a,2b,2c.And the models are depicted in fig 7,8,9 respectively

Table2. Design details of Low Rise Buildings

G+5 Design	Details
Type of structure	RCC frame structure
Number of stories(G+5)	6 stories
Story to story height	3m
Ground story height	3.5m
Grade of concrete	M30 for columns and slab M25 for Beams
Thickness of slab	0.12m
Thickness of wall	0.23m
Beams size	0.3mx0.4m
Column size	0.4mx0.6m
Density	For concrete 24KN/m^3 For brickwall 19KN/m^3

Table 3. Design details of Medium rise buildings

G+10 Design	Details
Type of structure	RCC frame structure
Number of stories(G+5)	11 stories
Story to story height	3m
Ground story height	3.5m
Grade of concrete	M30 for columns and slab M25 for Beams
Thickness of slab	0.12m
Thickness of wall	0.23m
Beams size	0.3mx0.4m
Column size	0.4mx0.6m
Density	For concrete 24KN/m^3 For brickwall 19KN/m^3

Table4.Design details of High rise buildings

G+15 Design	Details
Type of structure	RCC frame structure
Number of stories(G+5)	16 stories
Story to story height	3m
Ground story height	3.5m
Grade of concrete	M30 for columns and slab M25 for Beams
Thickness of slab	0.12m
Thickness of wall	0.23m
Beams size	0.3mx0.4m
Column size	0.4mx0.6m
Density	For concrete 24KN/m^3 For brickwall 19KN/m^3

MODELS IN ETABS

a.Low Rise Building (G+5)

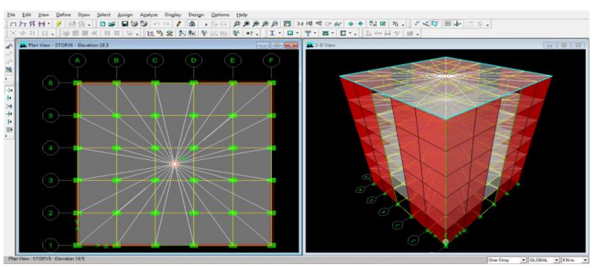


Fig 7. Model 1

b. Medium Rise Building (G+10)

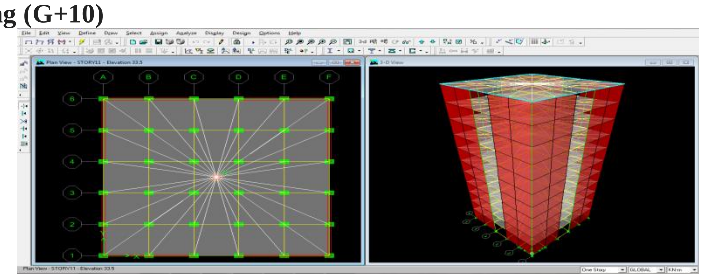


Fig 8. Model 2

c. High Rise Building (G+15)

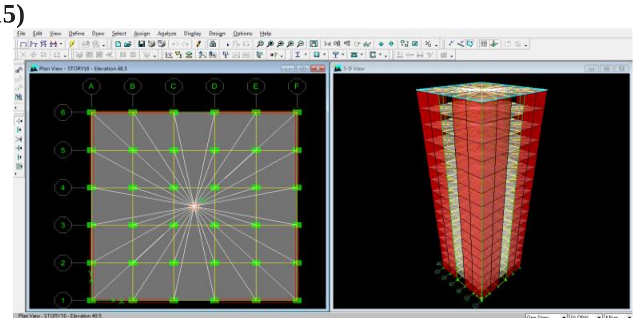


Fig9.Model 3

5.RESULTS AND DISUSSIONS

5.1STOREY DRIFT

Drift is defined as the lateral displacement. Storey drift is the drift of a multistory building relative to the level below. Inter storey drift is the difference between the roof and floor displacements of any given storey as the buildings ways during the earthquake, normalized by the storey height. For example, for a 10 foot high storey, an inter storey drift of 0.10 indicates that the roof is displaced one foot in relation to the floor below.

a.G+5

Table 5. Drift Values (meters)in terrain categories

Story	Drift in tc 1	Drift in tc 2	Drift in tc 3	Drift in tc 4
STOREY6	0.000002	0.000002	0.000002	0.000001
STOREY5	0.000002	0.000002	0.000002	0.000001
STOREY4	0.000002	0.000002	0.000002	0.000001
STOREY3	0.000002	0.000002	0.000002	0.000001
STOREY2	0.000002	0.000002	0.000002	0.000001
STOREY1	0.000001	0.000001	0.000001	0.000001

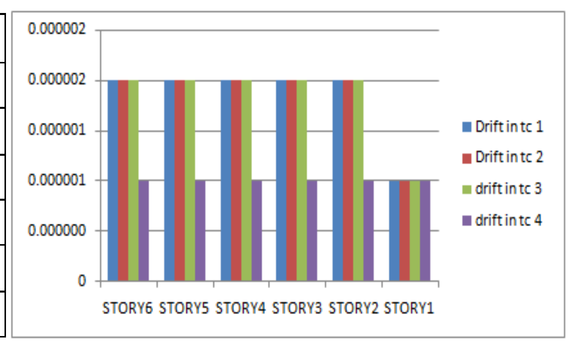


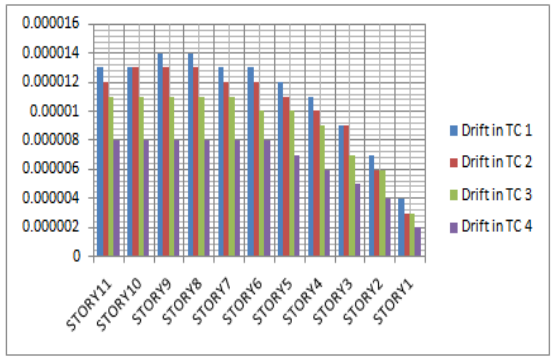
fig 10..Drift values(meters)in terrain categories

From the above graph it was concluded that the storey drift (lateral displacement) has less values in terrain category 4. So the effect of wind load is less for the building in terrain category 4 for low rise buildings. Thepercentage reduction of drift in low rise buildings are comparison between terrain category 1 and terrain category 4 various is 50% ,50%in terrain category 2 and terrain category 4, and 50% in terrain category 3 and terrain category 4.

b. G+10

Table 6. Drift Values(maters) in terrain categories

Story	Item	Load	Drift in TC 1	Drift in TC 2	Drift in TC 3	Drift in TC 4
STOREY11	Max Drift X	WIND	0.000013	0.000012	0.000011	0.000008
STOREY10	Max Drift X	WIND	0.000013	0.000013	0.000011	0.000008
STOREY9	Max Drift X	WIND	0.000014	0.000013	0.000011	0.000008
STOREY8	Max Drift X	WIND	0.000014	0.000013	0.000011	0.000008
STOREY7	Max Drift X	WIND	0.000013	0.000012	0.000011	0.000008
STOREY6	Max Drift X	WIND	0.000013	0.000012	0.00001	0.000008
STOREY5	Max Drift X	WIND	0.000012	0.000011	0.00001	0.000007
STOREY4	Max Drift X	WIND	0.000011	0.00001	0.000009	0.000006
STOREY3	Max Drift X	WIND	0.000009	0.000009	0.000007	0.000005
STOREY2	Max Drift X	WIND	0.000007	0.000006	0.000006	0.000004
STOREY1	Max Drift X	WIND	0.000004	0.000003	0.000003	0.000002



In the same way of the low rise buildings (G+5).

The value of storey drift (lateral displacement) has less value for Terrain category 4 compared to other terrain categories (Terrain category 1, Terrain category 2 and Terrain category 3). It was also concluded that the storey drift values are decreases from the top storey to bottom storey in each Terrain category. Thepercentage reduction of drift in medium rise buildings are comparison between terrain category 1 and terrain category 4 various is 38.46%,33.33%in terrain category 2 and terrain category 4, and 27.27% in terrain category 3 and terrain category 4.

c. G+15

Table7. Drift Values(maters) in terrain categories

Story	Load	Drift in tc 1	Drift in tc 2	Drift in tc 3	Drift in tc 4
STOREY16	WINDX	0.000037	0.000035	0.000031	0.000026
STOREY15	WINDX	0.000038	0.000035	0.000031	0.000026
STOREY14	WINDX	0.000038	0.000036	0.000032	0.000027
STOREY13	WINDX	0.000038	0.000036	0.000032	0.000027
STOREY12	WINDX	0.000038	0.000036	0.000032	0.000027
STOREY11	WINDX	0.000038	0.000036	0.000032	0.000027
STOREY10	WINDX	0.000037	0.000035	0.000031	0.000026
STOREY9	WINDX	0.000036	0.000034	0.00003	0.000025
STOREY8	WINDX	0.000035	0.000033	0.000029	0.000024
STOREY7	WINDX	0.000033	0.000031	0.000028	0.000023
STOREY6	WINDX	0.000031	0.000029	0.000026	0.000021
STOREY5	WINDX	0.000024	0.000026	0.000023	0.000019
STOREY4	WINDX	0.00002	0.000023	0.00002	0.000016
STOREY3	WINDX	0.000014	0.000018	0.000016	0.000013
STOREY2	WINDX	0.000004	0.000013	0.000012	0.000009
STOREY1	WINDX	0.000007	0.000006	0.000005	0.000004

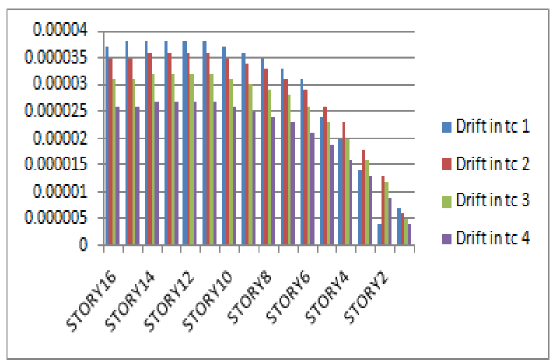


Fig12. Drift Values(meters) in terrain categories

The values of storey drift (lateral displacement values) have higher values in the high rise buildings than low rise buildings and medium rise buildings. And the value of storey drift (lateraldisplacement) has less value for Terrain category 4 compared to other terrain categories (Terrain category 1, Terrain category 2 and Terrain category 3). Thepercentage reduction of drift in high rise buildings are comparison between terrain category 1 and terrain category 4 various is 29.73%, 25.71%in terrain category 2 and terrain category 4, and 16.12% in terrain category 3 and terrain category 4.

2.STOREY SHEARS AND OVER TURNING MOMENTS

BUILDING TORQUE (T)

Torque is a twisting or turning force that tends to cause rotation around an axis, which might be a center of mass or a fixed point

a. G+5

Table 8:BuildingTorque(t)in terrain categories

Storey	building torque in tc 1	building torque in tc 2	building torque in tc 3	building torque in tc 4
STOREY6	247.924	225.601	194.092	121.643
STOREY5	732.369	665.928	568.574	364.928
STOREY4	1196.794	1087.18	917.474	608.213
STOREY3	1645.665	1493.622	1246.249	851.498
STOREY2	2092.516	1898.143	1572.426	1094.783
STOREY1	2576.605	2336.373	1925.785	1358.342

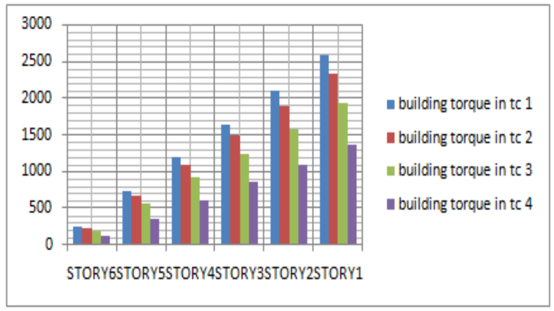


Fig13. Building torque(t)in terrain categories

For the low rise buildings the value of building torque T has less value for the Terrain category 4 than other terrain categories (Terrain category 1, Terrain category 2, and Terrain category 3). And also it was concluded that building torque has less values for the story 6 and maximum values for the story 1.Thepercentage reduction of drift in low rise buildings are comparison between terrain category 1 and terrain category 4 various is 50.93%, 46.08%in terrain category 2 and terrain category 4, and 37.32% in terrain category 3 and terrain category 4.

b.G+10

.Table9.BuildingTorque(t)in terrain categories

Storey	Load	Building torque T in TC 1	Building torque T in TC 2	Building torque T in TC 3	Building torque T in TC 4
STOREY11	WIND	271.897	257.729	226.69	188.072
STOREY10	WIND	810.785	767.876	674.35	552.288
STOREY9	WIND	1341.504	1266.021	1110.432	884.211
STOREY8	WIND	1863.748	1750.525	1533.757	1179.122
STOREY7	WIND	2377.41	2221.516	1944.354	1439.867
STOREY6	WIND	2878.604	2677.93	2338.912	1683.841
STOREY5	WIND	3363.049	3118.257	2713.394	1927.127
STOREY4	WIND	3827.474	3539.509	3062.295	2170.412
STOREY3	WIND	4276.345	3945.952	3391.07	2413.697
STOREY2	WIND	4723.196	4350.472	3717.247	2656.982
STOREY1	WIND	5207.285	4788.703	4070.606	2920.541

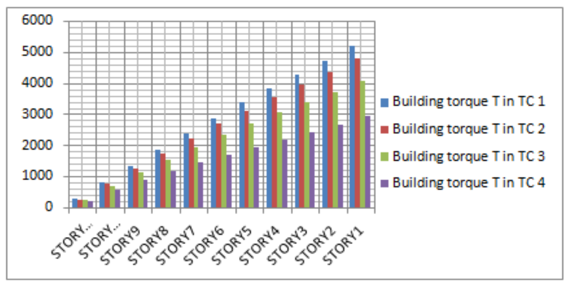


Fig14. Building torque(t)in terrain categories

In the case of medium rise buildings (G+10) the maximum value of building torque (T) was obtained at terrain category 1 and minimum value of building torque was obtained at terrain category 4. The building twist value is increases from top story to bottom story.Thepercentage reduction of drift in medium rise buildings are comparison between terrain category 1 and terrain category 4 various is 30.82%, 27.02%in terrain category 2 and terrain category 4, and 17.03% in terrain category 3 and terrain category 4.

c.G+15

.Table9. BuildingTorque(t)in terrain categories

STOREY	Load	Building torque in tc1	Building torque in tc2	Building torquein tc3	building torque in tc4
STOREY16	WINDX	290.14	275.499	246.782	225.601
STOREY15	WINDX	865.494	821.694	734.896	666.421
STOREY14	WINDX	1433.487	1360.719	1214.883	1091.867
STOREY13	WINDX	1994.166	1892.62	1686.81	1502.209
STOREY12	WINDX	2547.58	2417.445	2150.747	1897.722
STOREY11	WINDX	3093.776	2935.242	2606.761	2278.679
STOREY10	WINDX	3632.663	3445.389	3054.42	2642.895
STOREY9	WINDX	4163.383	3943.534	3490.503	2974.819
STOREY8	WINDX	4685.627	4428.038	3913.827	3269.729
STOREY7	WINDX	5199.289	4899.029	4324.424	3530.474
STOREY6	WINDX	5700.483	5355.442	4718.982	3774.449
STOREY5	WINDX	6184.928	5795.77	5093.465	4017.734
STOREY4	WINDX	6649.353	6217.022	5442.365	4261.019
STOREY3	WINDX	7098.224	6623.464	5771.14	4504.304
STOREY2	WINDX	7545.075	7027.984	6097.317	4747.589
STOREY1	WINDX	8029.163	7466.215	6450.676	5011.148

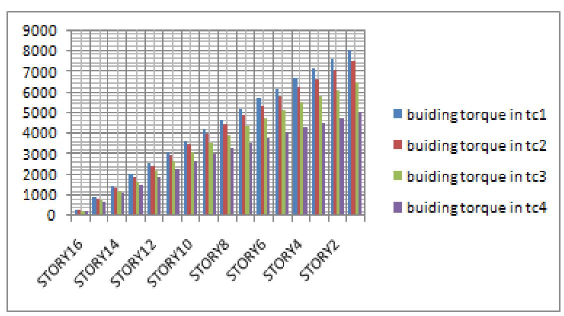


Fig15. Building torque(t)in terrain categories

The value of building torque (T) also has less value for the terrain category 4 than other terrain categories (i.e, terrain category 1, terrain category 2, and terrain category 3) in all the cases.Thepercentage reduction of drift in high rise buildings are comparison between terrain category 1 and terrain category 4 various is 22.24%, 18.11%in terrain category 2 and terrain category 4, and 8.58% in terrain category 3 and terrain category 4.

3.SHEAR FORCE (V)

The shear force at the cross section of the beam may be defined as the un balanced vertical force to the right or left of the section.

a.G+5

Table11. Shear force (v)in terrain categories

Storey	Shear force v in tc 1	Shear force v in tc 2	Shear force v in tc3	Shear force v in tc 4
STOREY6	-33.06	-30.08	-25.88	-16.22
STOREY5	-97.65	-88.79	-75.81	-48.66
STOREY4	-159.57	-144.96	-122.33	-81.1
STOREY3	-219.42	-199.15	-166.17	0
STOREY2	-279	-253.09	-209.66	-145.97
STOREY1	-343.55	-311.52	-256.77	-181.11

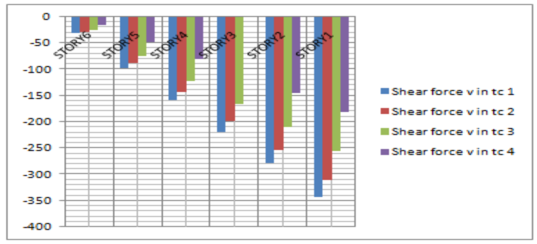


Fig16. Shear force (v)in terrain categories

From the above table and graph it was observed that the maximum value of shear force was obtained for terrain category 1 and minimum value is obtained for terrain category 4. The shear force value increases from 6th story to 1st story in low rise buildings.Thepercentage reduction of drift in low rise buildings are comparison between terrain category 1 and terrain category 4 various is 50.93%, 46.07%in terrain category 2 and terrain category 4, and 37.32% in terrain category 3 and terrain category 4.

b.G+10

Table12. Shear force (v)in terrain categories

Story	Load	Shear Force V in TC 1	Shear Force V in TC 2	Shear Force V in TC 3	Shear Force V in TC 4
STORY11	WIND	-36.25	-34.36	-30.23	-25.08
STORY10	WIND	-108.1	-102.38	-89.91	-73.64
STORY9	WIND	-178.87	-168.8	-148.06	-117.89
STORY8	WIND	-248.5	-233.4	-204.5	-157.22
STORY7	WIND	-316.99	-296.2	-259.25	-191.98
STORY6	WIND	-383.81	-357.06	-311.85	-224.51
STORY5	WIND	-448.41	-415.77	-361.79	-256.95
STORY4	WIND	-510.33	-471.93	-408.31	-289.39
STORY3	WIND	-570.18	-526.13	-452.14	-321.83
STORY2	WIND	-629.76	-580.06	-495.63	-354.26
STORY1	WIND	-694.3	-638.49	-542.75	-389.41

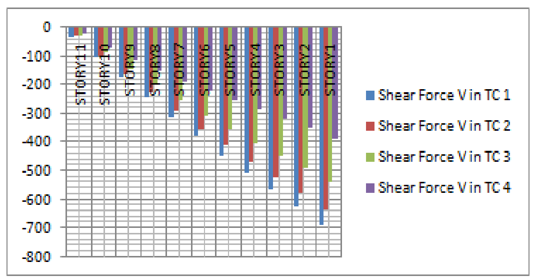


Fig17. Shear force (v)in terrain categories

For the medium rise buildings also the shear force is minimum for terrain category 4 and maximum for the terrain category 1.Thepercentage reduction of drift in medium rise buildings are comparison between terrain category 1 and terrain category 4 various is 30.81%, 27%in terrain category 2 and terrain category 4, and 17.03% in terrain category 3 and terrain category 4.

c.G+15

Table13. Shear force (v)in terrain categories

Stoery	Load	Shear force v in tc 1	Shear force v in tc2	Shear force v in tc3	Shear force v in tc4
STOREY16	WINDX	-38.69	-36.73	-32.9	-30.08
STOREY15	WINDX	-115.4	-109.56	-97.99	-88.86
STOREY14	WINDX	-191.13	-181.43	-161.98	-145.58
STOREY13	WINDX	-265.89	-252.35	-224.91	-200.29
STOREY12	WINDX	-339.68	-322.33	-286.77	-253.03
STOREY11	WINDX	-412.5	-391.37	-347.57	-303.82
STOREY10	WINDX	-484.36	-459.39	-407.26	-352.39
STOREY9	WINDX	-555.12	-525.8	-465.4	-396.64
STOREY8	WINDX	-624.75	-590.41	-521.84	-435.96
STOREY7	WINDX	-693.24	-653.2	-576.59	-470.73
STOREY6	WINDX	-760.06	-714.06	-629.2	-503.26
STOREY5	WINDX	-824.66	-772.77	-679.13	-535.7
STOREY4	WINDX	-886.58	-828.94	-725.65	-568.14
STOREY3	WINDX	-946.43	-883.13	-769.49	-600.57
STOREY2	WINDX	-1006.01	-937.06	-812.98	-633.01
STOREY1	WINDX	-1070.56	-995.5	-860.09	-668.15

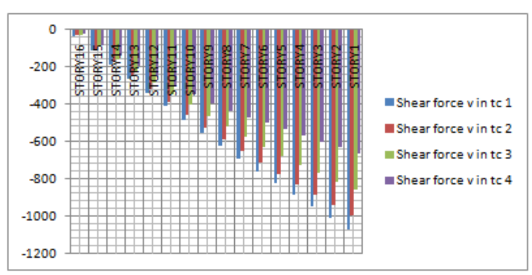


Fig18. Shear force (v)in terrain categories

From the above tables and graphs the maximum value of shear force was obtained at terrain category 1 and minimum value of shear force was obtained at terrain category 4 in all cases. For the low rise buildings have less shear force values than medium rise and high rise buildings. The less values of shear force will results in less deflection values.Thepercentage reduction of drift in high rise buildings are comparison between terrain category 1 and terrain category 4 various is 22.25%, 18.10%in terrain category 2 and terrain category 4, and 8.57% in terrain category 3 and terrain category 4..

3.BENDING MOMENT (M)

The bending moment at the cross section of the beam may be defined as the algebraic sum 0f the moments of the forces, to the right or left of the section

a. G+5

Table14. Bending moment M in terrain categories

storey	Bending Moment M in tc 1	Bending Moment M in tc 2	Bending Moment M in tc 3	Bending Moment M in tc 4
STOREY6	-99.17	-90.24	-77.637	-48.657
STOREY5	-392.117	-356.611	-305.066	-194.628
STOREY4	-870.835	-791.483	-672.056	-437.913
STOREY3	-1529.1	-1388.93	-1170.56	-778.512
STOREY2	-2366.11	-2148.19	-1799.53	-1216.43
STOREY1	-3568.52	-3238.5	-2698.23	-1850.32

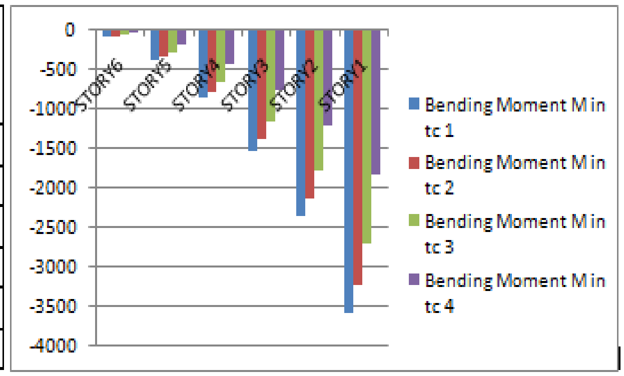


Fig19.Bending moment M in terrain categories

From the above table and graph it was observed that the maximum value of bending moment was obtained for terrain category 1 and minimum value is obtained for terrain category 4. The Bending moment value increases from 6th story to 1st story in low rise buildings. Thepercentage reduction of drift in low rise buildings are comparison between terrain category 1 and terrain category 4 various is 50.93%, 46.085%in terrain category 2 and terrain category 4, and 37.32% in terrain category 3 and terrain category 4..

b.G+10

Table15. Bending moment M in terrain categories

Storey	Load	Bending Moment M in TC 1	Bending Moment M in TC 2	Bending Moment M in TC 3	Bending Moment M in TC 4
STOREY11	WIND	-108.759	-103.092	-90.676	-75.229
STOREY10	WIND	-433.073	-410.242	-360.416	-296.144
STOREY9	WIND	-969.674	-916.651	-804.589	-649.829
STOREY8	WIND	-1715.17	-1616.86	-1418.09	-1121.48
STOREY7	WIND	-2666.14	-2505.47	-2195.83	-1697.42
STOREY6	WIND	-3817.58	-3576.64	-3131.4	-2370.96
STOREY5	WIND	-5162.8	-4823.94	-4216.76	-3141.81
STOREY4	WIND	-6693.79	-6239.75	-5441.67	-4009.98
STOREY3	WIND	-8404.33	-7818.13	-6798.1	-4975.46
STOREY2	WIND	-10293.6	-9558.32	-8285	-6038.25
STOREY1	WIND	-12723.7	-11793	-10184.6	-7401.17

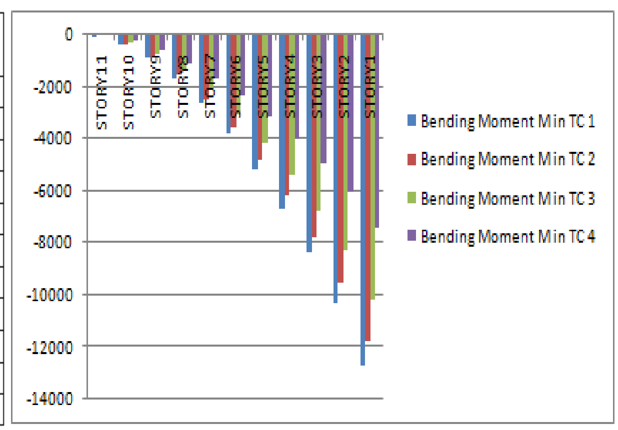


Fig19: Bending moment M in terrain categories

For the medium rise buildings also the Bending moment is minimum for terrain category 4 and maximum for the terrain category 1in all stories. Thepercentage reduction of drift in medium rise buildings are comparison between terrain category 1 and terrain category 4 various is 30.82%, 27.02%in terrain category 2 and terrain category 4, and 17.035% in terrain category 3 and terrain category 4. .

c.G+15

Table 16. Bending moment M in terrain categories

Storey	Load	Bending moment M in tc 1	Bending moment M in tc2	Bending moment M in tc3	Bending moment M in tc4
STOREY16	WINDX	-116.056	-110.199	-98.713	-90.24
STOREY15	WINDX	-462.254	-438.877	-392.671	-356.809
STOREY14	WINDX	-1035.65	-983.165	-878.624	-793.555
STOREY13	WINDX	-1833.32	-1740.21	-1553.35	-1394.44
STOREY12	WINDX	-2852.35	-2707.19	-2413.65	-2153.53
STOREY11	WINDX	-4089.86	-3881.29	-2413.65	-3065
STOREY10	WINDX	-5542.92	-5259.44	-4678.12	-4122.16
STOREY9	WINDX	-7208.28	-6836.86	-6074.32	-5312.09
STOREY8	WINDX	-9082.53	-8608.07	-6074.32	-6619.98
STOREY7	WINDX	-11162.2	-10567.7	-9369.62	-8032.17
STOREY6	WINDX	-13442.4	-12709.9	-11257.2	-9541.95
STOREY5	WINDX	-15916.4	-15028.2	-13294.6	-11149
STOREY4	WINDX	-18576.1	-17515	-15471.5	-12853.4
STOREY3	WINDX	-21415.4	-20164.4	-17780	-14655.2
STOREY2	WINDX	-24433.5	-22975.6	-20218.9	-16554.2
STOREY1	WINDX	-28180.4	-26459.8	-23229.2	-18892.7

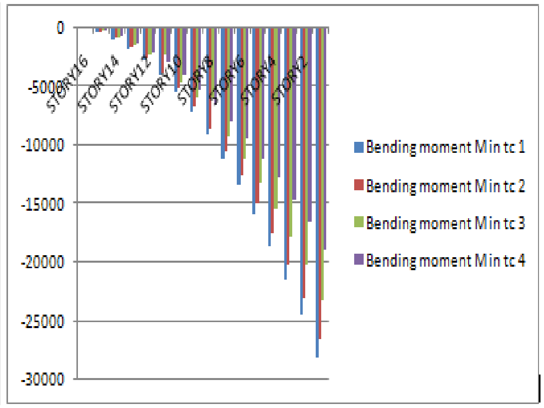


Fig21. Bending moment M in terrain categories

The same conclusion was made for the high rise buildings as we discussed for the low rise as well as medium rise buildings from the above graphs and tables. From the above tables and graphs the maximum value of bending moment was obtained at terrain category 1 and minimum value of shear force was obtained at terrain category 4 in all cases. For the low rise buildings have less Bending moment values than medium rise and high rise buildings. The less values of shear force will results in less deflection values.Thepercentage reduction of drift in high rise buildings are comparison between terrain category 1 and terrain category 4 various is 22.22%, 18.11%in terrain category 2 and terrain category 4, and 8.58% in terrain category 3 and terrain category 4.

CONCLUSIONS

From the above study the following conclusions are made

1. The values of storey drifts are constant in G+5 building model in all terrain categories up to 2nd storey and it decreases to 1st storey this indicates there is less effect of wind in the low rise buildings
2. In case of medium rise and high rise buildings value of storey drift decreases from top storey to bottom storey (11th to 1st in medium rise buildings and 16th to 1st in High rise buildings). The Higher drift values are obtained in terrain category 1 and lower drift values are obtained at terrain category 4.
3. The maximum values of building torque (T) was obtained in terrain category 1 than remaining terrains. The value of building twist decreases from 6th storey to 1st storey due to fixed supports present in bottom of the building.
4. The maximum values of Shear forces and Bending moments are obtained at terrain category 1. The forces and moments decrease from top story to bottom storey (6th to 1st in case of low rise buildings,11th to 1st in medium rise buildings and 16th to 1st in High rise buildings)
5. For the above conclusions the maximum values are obtained at terrain category 1 in all cases and minimum values are obtained in terrain category 4.From this it was concluded that there is no wind effect on buildings which are in terrain category 4 whencompredtoother terrain categories.

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