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

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***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, story shear, and support reactions accour in different storey Buildings (Low Rise Buildings, Medium Rise Buildings, and High Rise Buildings) due to wind in different terrain category. Totally 12 models for G+5, G+10, G+15 are analyzed using ETABSv9.7.4 package. Present works provides a good source of information about variation in drift, shear are compared as height of model changes and percentage change in drift, shear of same model in different terrain category.***

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

## I.INTRODUCTION

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.

## IMPORTANCE OF WIND LOADS ON TALL BUILDINGS

Buildings are defined as structures utilized by the people as shelter for living, working or storage. As now a days there is shortage of land for building more buildings at a faster growth in both residential and industrial areas the vertical construction is given due importance because of which Tall Buildings are being build on a large scale.

Wind in general has two main effects on the Tall buildings:

- Firstly it exerts forces and moments on the structure and its cladding
- Secondly it distributes the air in and around the building mainly termed as *Wind Pressure*

Sometimes because of unpredictable nature of wind it takes so devastating form during some Wind Storms that it can upset the internal ventilation system when it passes into the building. For these reasons the study of air -flow is becoming integral with the planning a building and its environment

Wind forces are studied on four main groups of building structures:

1. Tall Buildings
2. Low Buildings
3. Equal-Sided Block Buildings
4. Roofs and Cladding

## 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. 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 a scaled building model used. In Wind Tunnel Testing for the structural design the Dynamic analysis of the scaled model building is done with Balendra's approach and for the cladding design the Surface Pressure Measurement analysis with Pressure Measurement system is done.

## DYNAMIC ANALYSIS OF WIND FORCES ON TALL BUILDINGS:

This thesis is an attempt to study behavior of the tall buildings under simulated atmospheric boundary layer and to evaluate various experimental and analytical techniques to compute dynamic response and present a detailed comparison. Researchers have laid down several analytical procedures during last few decades. Even though there are several grey areas which need to be addressed to achieve a better prediction of the response, i.e., a designer is interested in storey wise horizontal forces for dynamic analysis and design of structural frames. Hence, emphasize is given to compute the story wise lateral forces on building by analytical procedure and through base forces obtained by Wind tunnel testing on scaled model of building and surrounding terrain.

## TYPES OF BUILDINGS

The following 3 buildings are generally considered for the design

**Low rise buildings** (1 to 6 stories)

Design principles:

- Low rise housing typically involves residential townhouse/terrace housing or small scale residential apartment buildings
- Low rise housing will be located typically around the outer edges (beyond 400 metres) of the town centers
- The typical height for low rise housing is 2-4 storeys

**Medium rise buildings** (7 to 12 stories)

Design principles:

- Medium rise housing involves residential apartment buildings, sometimes with cafes or small shops at the ground level

- Smaller town centers such as Hurlstone Park, Dulwich Hill will have medium rise housing immediately surrounding the main street area
- Medium rise housing will range from 5-7 storey's
- Medium rise housing will be limited to 5 storey's in sensitive locations such as interface areas

**High rise buildings** (13 stories and above)

Design principles:

- High rise housing comprises both standalone apartment buildings and mixed use buildings that incorporate retail shops and / or commercial uses on the lower levels
- High rise housing starts from 9 storey's and extends to 25 storey's
- The lower end of this range will accommodated mainly within the smaller town centres such as Marrickville, Belmore and Lakemba
- High rise housing will be located close to the rail station – typically within 200-400m from the station

**OBJECTIVES**

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 was done by dynamic analysis method is given by the draft code IS-875 part 3 – is studied
3. In the present work, multistory buildings of 6 storey, 11 storey and 16 storey were 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 has been carried out using ETABSV9.7.4. And 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.

**SCOPE OF WORK**

The scope of the present work includes the study of the Wind load estimation on Tall buildings

1. Based on project, study was undertaken with a view to determine the extent of possible changes in the wind behavior of RC Building Models.
2. RC framed buildings are firstly designed for gravity loads and wind loads.
3. The study has been carried out by introducing symmetrical bare frame building models on different wind terrain categories using dynamic analysis method.
4. The study highlights the effect of wind load in different terrains i.e, Terrain 1, Terrain 2, Terrain 3, and Terrain 4 which are considered in the wind evaluation of buildings.
5. The study emphasis and discusses the effect of wind load for 6 storey, 11 storey, 16 storey Buildings are considered.
6. The entire process of modeling, analysis and design of all the primary elements for all the models are carried by using ETABS 9.7.4 version software.

**SUMMARY**

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.

## II.LITERATURE REVIEW

**Ning Lina, Chris Letchforda, Yukio Tamurab, Bo Liangc and Osamu Nakamurad**

These papers studied nine models with different rectangular cross -sections and were tested in a wind tunnel to study the characteristics of wind forces on tall buildings. The data was briefly reported (Local wind forces acting on rectangular prisms. Proceedings of 14th National Symposium on Wind Engineering, 4–6 December 1996, Japan Association for Wind Engineering, Tokyo, pp. 263–268.). In the present paper, local wind forces on tall buildings are investigated in terms of mean and RMS force coefficients, power spectral density, and span wise correlation and coherence. The effects of three parameters, elevation, aspect ratio, and side ratio, on bluff -body flow and thereby on the local wind forces are discussed. The overall loads and base moments are obtained by integration of local wind forces. Comparisons are made with results obtained from high –frequency force balances in two wind tunnels.

**Holmes and Lewis (1986, 1987 and 1989)**

They performed extensive experimental work on the fluctuating pressure measurements using a small dia meter connecting tube to transmit the pressure from the connecting point, or tap, to the pressure transducer. Their authentic work has provided sufficient guidelines to develop a range near optimum systems for the measurement of fluctuating pressure on models of the buildings in wind tunnels. In the present study the choice of tubing system for pressure measurements is largely based on the work of Holmes and Lewis (1987).

## III.EFFECT OF WIND LOAD ON BUILDINGS AND STRUCTURES

### BASIC WIND SPEED:

Figure 1 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. 1 have been worked out for a 50-year return period. The basic wind speed for some important cities/towns is also given in Appendix A.

### Wind load calculations as per the code is 875 : 1987

**Design Wind Speed (Vz)**

The 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:

$$V_z = V_b K_1 K_2 K_3 K_4$$

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

k1 = probability factor (risk coefficient)

k2 = terrain roughness and height factor

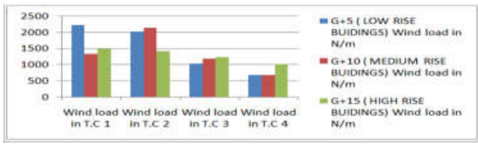
k3 = topography factor

k4 = importance factor for the cyclonic region

Design wind pressure ; **$P_z = 0.6\, V_Z^2$**

### COMPARASION OF WIND LOADS AS PER THE IS 875:2015

| S.NO | Terrain category | G+5 ( LOW RISE BUIDINGS) Wind load in N/m | G+10 ( MEDIUM RISE BUIDINGS) Wind load in N/m | G+15 ( HIGH RISE BUIDINGS) Wind load in N/m |
|---|---|---|---|---|
| 1 | Wind load in T.C 1 | 2216.525 | 1329.92 | 1483.248 |
| 2 | Wind load in T.C 2 | 2014.214 | 2134.44 | 1405.536 |
| 3 | Wind load in T.C 3 | 1026.389 | 1180.685 | 1232.342 |
| 4 | Wind load in T.C 4 | 670.94 | 670.94 | 1004.667 |




### WIND LOAD CALUCATIONS AS PER THE CODE IS 875:2015

**Design of wind speed as per the 2015 code**

$V_z = V_b k_1 k_2 k_3 k_4$ (AS PER 875 (PART-3) :2015)

Vz = design wind speed at height *z,* in m/s;

*k1* = probability factor (risk coefficient)

k2 = terrain roughness and height factor

k3 = topography factor ; and

k4 = importance factor for the cyclonic region .

$P_z = 0.6\, V_z^2$

$p_z$ = wind pressure at height *z,* in Is N/m$^2$, and
$V_z$ = design wind speed at height *z,* in m/s.
based on the modified code the wind pressure can be also obtained

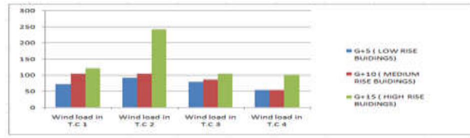
The design wind pressure $p_d$ can be obtained as,
$P_d = K_d K_a K_c P_z$

Kd = wind directionality factor,

$K_a$ = area averaging factor, and
$K_a$ = combination factor.

### COMPARASION OF WIND LOADS AS PER THE IS 875:2015

| S.NO | Terrain category | G+5 ( LOW RISE BUIDINGS) | G+10 ( MEDIUM RISE BUIDINGS) | G+15 ( HIGH RISE BUIDINGS) |
|---|---|---|---|---|
| 1 | Wind load in T.C 1 | 72.334 | 104.92 | 120.44 |
| 2 | Wind load in T.C 2 | 92.204 | 104.92 | 241.704 |
| 3 | Wind load in T.C 3 | 78.6924 | 85.3134 | 104.214 |
| 4 | Wind load in T.C 4 | 53.54 | 53.53 | 101.199 |

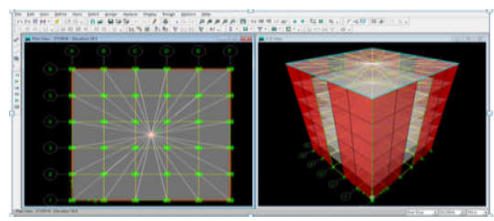



## IV.DESIGN CONSIDERATIONS AND MODELING OF BUILDING IN ETABS

### LOW RISE BUILDING

| 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<br>M25 for Beams |
| Thickness of slab | 0.12m |
| Thickness of wall | 0.23m |
| Beam size | 0.3mX0.4m |
| Column size | 0.4mX0.6m |
| Density | For concrete 24kN/m$^3$<br>For brick wall 19kN/m$^3$ |

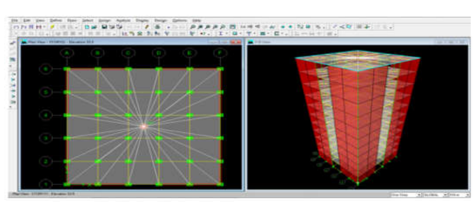
**Low Rise Building ((G+5) 4 models**



### MEDIUM RISE BUILDINGS

| G+10 Design details | |
|---|---|
| Type of structure | RCC frame structure |
| Number of stories (G+5) | 11Stories |
| Story to story height | 3m |
| Ground story height | 3.5m |
| Grade of concrete | M30 for columns and slab<br>M25 for Beams |
| Thickness of slab | 0.12m |
| Thickness of wall | 0.23m |
| Beam size | 0.3mX0.4m |
| Column size | 0.4mX0.6m |
| Density | For concrete 24kN/m$^3$<br>For brick wall 19kN/m$^3$ |

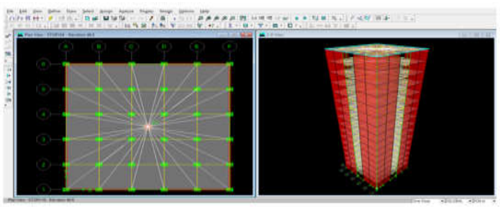
**Medium Rise Building ((G+10) 4 models)**



## HIGH RISE BUILDING

| G+15Design details | |
|---|---|
| Type of structure | RCC frame structure |
| Number of stories (G+5) | 16Stories |
| Story to story height | 3m |
| Ground story height | 3.5m |
| Grade of concrete | M30 for columns and slab<br>M25 for Beams |
| Thickness of slab | 0.12m |
| Thickness of wall | 0.23m |
| Beam size | 0.3mX0.4m |
| Column size | 0.4mX0.6m |
| Density | For concrete 24kN/m$^3$<br>For brick wall 19kN/m$^3$ |

### High Rise Building ((G+15) 4 models)

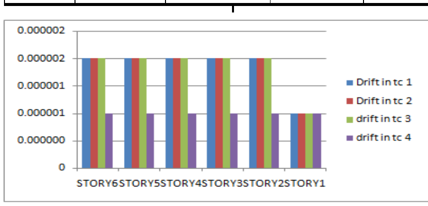


## V.RESULTS AND ANALYSIS

### STORY DRIFT

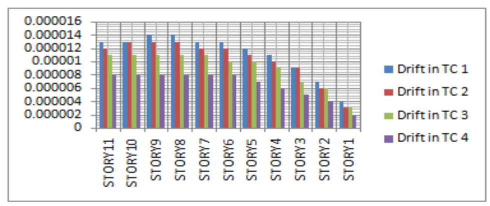
G+5

| Story | Drift in TC 1 | Drift in TC 2 | Drift in TC 3 | Drift in TC 4 |
|---|---|---|---|---|
| STORY6 | 0.000002 | 0.000002 | 0.000002 | 0.000001 |
| STORY5 | 0.000002 | 0.000002 | 0.000002 | 0.000001 |
| STORY4 | 0.000002 | 0.000002 | 0.000002 | 0.000001 |
| STORY3 | 0.000002 | 0.000002 | 0.000002 | 0.000001 |
| STORY2 | 0.000002 | 0.000002 | 0.000002 | 0.000001 |
| STORY1 | 0.000001 | 0.000001 | 0.000001 | 0.000001 |



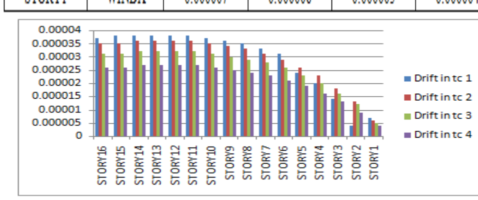

G+10

| Story | Item | Load | Drift in TC 1 | Drift in TC 2 | Drift in TC 3 | Drift in TC 4 |
|---|---|---|---|---|---|---|
| STORY11 | Max Drift X | WIND | 0.000013 | 0.000012 | 0.000011 | 0.000008 |
| STORY10 | Max Drift X | WIND | 0.000013 | 0.000013 | 0.000011 | 0.000008 |
| STORY9 | Max Drift X | WIND | 0.000014 | 0.000013 | 0.000011 | 0.000008 |
| STORY8 | Max Drift X | WIND | 0.000014 | 0.000013 | 0.000011 | 0.000008 |
| STORY7 | Max Drift X | WIND | 0.000013 | 0.000012 | 0.000011 | 0.000008 |
| STORY6 | Max Drift X | WIND | 0.000013 | 0.000012 | 0.00001 | 0.000008 |
| STORY5 | Max Drift X | WIND | 0.000012 | 0.000011 | 0.00001 | 0.000007 |
| STORY4 | Max Drift X | WIND | 0.000011 | 0.00001 | 0.000009 | 0.000006 |
| STORY3 | Max Drift X | WIND | 0.000009 | 0.000009 | 0.000007 | 0.000005 |
| STORY2 | Max Drift X | WIND | 0.000007 | 0.000006 | 0.000006 | 0.000004 |
| STORY1 | Max Drift X | WIND | 0.000004 | 0.000003 | 0.000003 | 0.000002 |




G+15

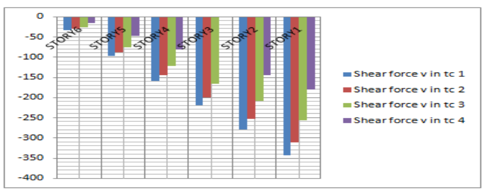
| Story | Load | Drift in tc 1 | Drift in tc 2 | Drift in tc 3 | Drift in tc 4 |
|---|---|---|---|---|---|
| STORY16 | WINDX | 0.000037 | 0.000035 | 0.000031 | 0.000026 |
| STORY15 | WINDX | 0.000038 | 0.000035 | 0.000031 | 0.000026 |
| STORY14 | WINDX | 0.000038 | 0.000036 | 0.000032 | 0.000027 |
| STORY13 | WINDX | 0.000038 | 0.000036 | 0.000032 | 0.000027 |
| STORY12 | WINDX | 0.000038 | 0.000036 | 0.000032 | 0.000027 |
| STORY11 | WINDX | 0.000038 | 0.000036 | 0.000032 | 0.000027 |
| STORY10 | WINDX | 0.000037 | 0.000035 | 0.000031 | 0.000026 |
| STORY9 | WINDX | 0.000036 | 0.000034 | 0.00003 | 0.000025 |
| STORY8 | WINDX | 0.000035 | 0.000033 | 0.000029 | 0.000024 |
| STORY7 | WINDX | 0.000033 | 0.000031 | 0.000028 | 0.000023 |
| STORY6 | WINDX | 0.000031 | 0.000029 | 0.000026 | 0.000021 |
| STORY5 | WINDX | 0.000024 | 0.000026 | 0.000023 | 0.000019 |
| STORY4 | WINDX | 0.00002 | 0.000023 | 0.00002 | 0.000016 |
| STORY3 | WINDX | 0.000014 | 0.000018 | 0.000016 | 0.000013 |
| STORY2 | WINDX | 0.000004 | 0.000013 | 0.000012 | 0.000009 |
| STORY1 | WINDX | 0.000007 | 0.000006 | 0.000005 | 0.000004 |



## SHEAR FORCE (V)

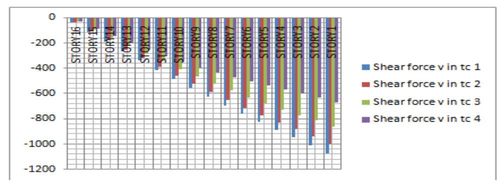
### G+5

| Story | Shear force v in tc 1 | Shear force v in tc 2 | Shear force v in tc3 | Shear force v in tc 4 |
|---|---|---|---|---|
| STORY6 | -33.06 | -30.08 | -25.88 | -16.22 |
| STORY5 | -97.65 | -88.79 | -75.81 | -48.66 |
| STORY4 | -159.57 | -144.96 | -122.33 | -81.1 |
| STORY3 | -219.42 | -199.15 | -166.17 | 0 |
| STORY2 | -279 | -253.09 | -209.66 | -145.97 |
| STORY1 | -343.55 | -311.52 | -256.77 | -181.11 |



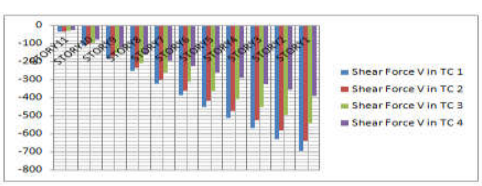

### G+15

| 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 |
|---|---|---|---|---|---|
| STORY16 | WINDX | -38.69 | -36.73 | -32.9 | -30.08 |
| STORY15 | WINDX | -115.4 | -109.56 | -97.99 | -88.86 |
| STORY14 | WINDX | -191.13 | -181.43 | -161.98 | -145.58 |
| STORY13 | WINDX | -265.89 | -252.35 | -224.91 | -200.29 |
| STORY12 | WINDX | -339.68 | -322.33 | -286.77 | -253.03 |
| STORY11 | WINDX | -412.5 | -391.37 | -347.57 | -303.82 |
| STORY10 | WINDX | -484.36 | -459.39 | -407.26 | -352.39 |
| STORY9 | WINDX | -555.12 | -525.8 | -465.4 | -396.64 |
| STORY8 | WINDX | -624.75 | -590.41 | -521.84 | -435.96 |
| STORY7 | WINDX | -693.24 | -653.2 | -576.59 | -470.73 |
| STORY6 | WINDX | -760.06 | -714.06 | -629.2 | -503.26 |
| STORY5 | WINDX | -824.66 | -772.77 | -679.13 | -535.7 |
| STORY4 | WINDX | -886.58 | -828.94 | -725.65 | -568.14 |
| STORY3 | WINDX | -946.43 | -883.13 | -769.49 | -600.57 |
| STORY2 | WINDX | -1006.01 | -937.06 | -812.98 | -633.01 |
| STORY1 | WINDX | -1070.56 | -995.5 | -860.09 | -668.15 |




### G+10

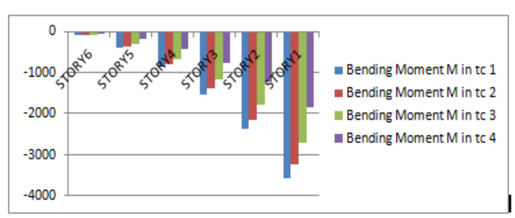
| Story | Load | Shear Force V in TC 1 | Shear Force V in TC 2 | Shear Force V in TC 3 | Shear Force V in TC 4 |
|---|---|---|---|---|---|
| STORY11 | WIND | -36.25 | -34.36 | -30.23 | -25.08 |
| STORY10 | WIND | -108.1 | -102.38 | -89.91 | -73.64 |
| STORY9 | WIND | -178.87 | -168.8 | -148.06 | -117.89 |
| 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 |




## BENDING MOMENT (M)

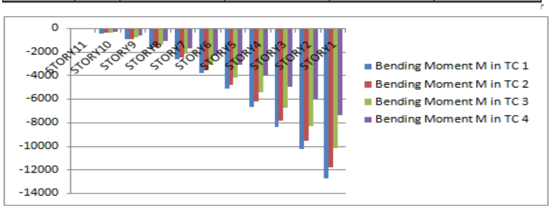
### G+5

| story | Bending Moment M in tc 1 | Bending Moment M in tc 2 | Bending Moment M in tc 3 | Bending Moment M in tc 4 |
|---|---|---|---|---|
| STORY6 | -99.17 | -90.24 | -77.637 | -48.657 |
| STORY5 | -392.117 | -356.611 | -305.066 | -194.628 |
| STORY4 | -870.835 | -791.483 | -672.056 | -437.913 |
| STORY3 | -1529.1 | -1388.93 | -1170.56 | -778.512 |
| STORY2 | -2366.11 | -2148.19 | -1799.53 | -1216.43 |
| STORY1 | -3568.52 | -3238.5 | -2698.23 | -1850.32 |



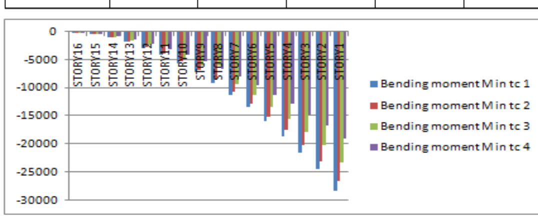
**G+10**

| Story | 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 |
|---|---|---|---|---|---|
| STORY11 | WIND | -108.759 | -103.092 | -90.676 | -75.229 |
| STORY10 | WIND | -433.073 | -410.242 | -360.416 | -296.144 |
| STORY9 | WIND | -969.674 | -916.651 | -804.589 | -649.829 |
| STORY8 | WIND | -1715.17 | -1616.86 | -1418.09 | -1121.48 |
| STORY7 | WIND | -2666.14 | -2505.47 | -2195.83 | -1697.42 |
| STORY6 | WIND | -3817.58 | -3576.64 | -3131.4 | -2370.96 |
| STORY5 | WIND | -5162.8 | -4823.94 | -4216.76 | -3141.81 |
| STORY4 | WIND | -6693.79 | -6239.75 | -5441.67 | -4009.98 |
| STORY3 | WIND | -8404.33 | -7818.13 | -6798.1 | -4975.46 |
| STORY2 | WIND | -10293.6 | -9558.32 | -8285 | -6038.25 |
| STORY1 | WIND | -12723.7 | -11793 | -10184.6 | -7401.17 |




**G+15**

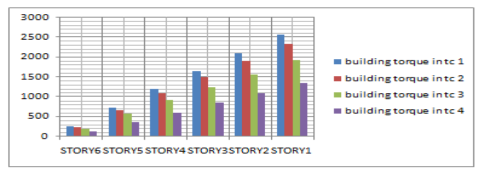
| Story | Load | Bending moment M in tc 1 | Bending moment M in tc 2 | Bending moment M in tc 3 | Bending moment M in tc 4 |
|---|---|---|---|---|---|
| STORY16 | WINDX | -116.056 | -110.199 | -98.713 | -90.24 |
| STORY15 | WINDX | -462.254 | -438.877 | -392.671 | -356.809 |
| STORY14 | WINDX | -1035.65 | -983.165 | -878.624 | -793.555 |
| STORY13 | WINDX | -1833.32 | -1740.21 | -1553.35 | -1394.44 |
| STORY12 | WINDX | -2852.35 | -2707.19 | -2413.65 | -2153.53 |
| STORY11 | WINDX | -4089.86 | -3881.29 | -2413.65 | -3065 |
| STORY10 | WINDX | -5542.92 | -5259.44 | -4678.12 | -4122.16 |
| STORY9 | WINDX | -7208.28 | -6836.86 | -6074.32 | -5312.09 |
| STORY8 | WINDX | -9082.53 | -8608.07 | -6074.32 | -6619.98 |
| STORY7 | WINDX | -11162.2 | -10567.7 | -9369.62 | -8032.17 |
| STORY6 | WINDX | -13442.4 | -12709.9 | -11257.2 | -9541.95 |
| STORY5 | WINDX | -15916.4 | -15028.2 | -13294.6 | -11149 |
| STORY4 | WINDX | -18576.1 | -17515 | -15471.5 | -12853.4 |
| STORY3 | WINDX | -21415.4 | -20164.4 | -17780 | -14655.2 |
| STORY2 | WINDX | -24433.5 | -22975.6 | -20218.9 | -16554.2 |
| STORY1 | WINDX | -28180.4 | -26459.8 | -23229.2 | -18892.7 |




**BUILDIND TORQUE (T):**

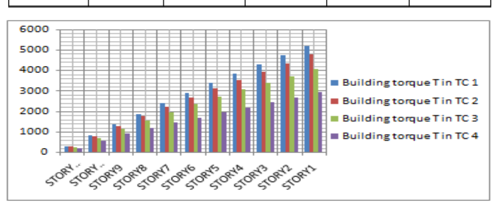
**G+5**

| Story | building torque in tc 1 | building torque in tc 2 | building torque in tc 3 | building torque in tc 4 |
|---|---|---|---|---|
| STORY6 | 247.924 | 225.601 | 194.092 | 121.643 |
| STORY5 | 732.369 | 665.928 | 568.574 | 364.928 |
| STORY4 | 1196.794 | 1087.18 | 917.474 | 608.213 |
| STORY3 | 1645.665 | 1493.622 | 1246.249 | 851.498 |
| STORY2 | 2092.516 | 1898.143 | 1572.426 | 1094.783 |
| STORY1 | 2576.605 | 2336.373 | 1925.785 | 1358.342 |



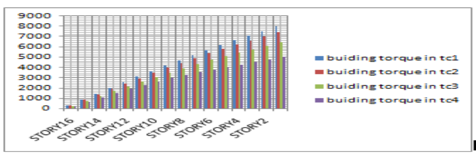

**a. G+10**

| Story | 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 |
|---|---|---|---|---|---|
| STORY11 | WIND | 271.897 | 257.729 | 226.69 | 188.072 |
| STORY10 | WIND | 810.785 | 767.876 | 674.35 | 552.288 |
| STORY9 | WIND | 1341.504 | 1266.021 | 1110.432 | 884.211 |
| STORY8 | WIND | 1863.748 | 1750.525 | 1533.757 | 1179.122 |
| STORY7 | WIND | 2377.41 | 2221.516 | 1944.354 | 1439.867 |
| STORY6 | WIND | 2878.604 | 2677.93 | 2338.912 | 1683.841 |
| STORY5 | WIND | 3363.049 | 3118.257 | 2713.394 | 1927.127 |
| STORY4 | WIND | 3827.474 | 3539.509 | 3062.295 | 2170.412 |
| STORY3 | WIND | 4276.345 | 3945.952 | 3391.07 | 2413.697 |
| STORY2 | WIND | 4723.196 | 4350.472 | 3717.247 | 2656.982 |
| STORY1 | WIND | 5207.285 | 4788.703 | 4070.606 | 2920.541 |



**G+15**

| Story | Load | Building torque in tc1 | Building torque in tc2 | Building torque in tc3 | building torque in tc4 |
|---|---|---|---|---|---|
| STORY16 | WINDX | 290.14 | 275.499 | 246.782 | 225.601 |
| STORY15 | WINDX | 865.494 | 821.694 | 734.896 | 666.421 |
| STORY14 | WINDX | 1433.487 | 1360.719 | 1214.883 | 1091.867 |
| STORY13 | WINDX | 1994.166 | 1892.62 | 1686.81 | 1502.209 |
| STORY12 | WINDX | 2547.58 | 2417.445 | 2150.747 | 1897.722 |
| STORY11 | WINDX | 3093.776 | 2935.242 | 2606.761 | 2278.679 |
| STORY10 | WINDX | 3632.663 | 3445.389 | 3054.42 | 2642.895 |
| STORY9 | WINDX | 4163.383 | 3943.534 | 3490.503 | 2974.819 |
| STORY8 | WINDX | 4685.627 | 4428.038 | 3913.827 | 3269.729 |
| STORY7 | WINDX | 5199.289 | 4899.029 | 4324.424 | 3530.474 |
| STORY6 | WINDX | 5700.483 | 5355.442 | 4718.982 | 3774.449 |
| STORY5 | WINDX | 6184.928 | 5795.77 | 5093.465 | 4017.734 |
| STORY4 | WINDX | 6649.353 | 6217.022 | 5442.365 | 4261.019 |
| STORY3 | WINDX | 7098.224 | 6623.464 | 5771.14 | 4504.304 |
| STORY2 | WINDX | 7545.075 | 7027.984 | 6097.317 | 4747.589 |
| STORY1 | WINDX | 8029.163 | 7466.215 | 6450.676 | 5011.148 |




## V.CONCLUSIONS

From the above study the following conclusions were made

1. The values of storey drifts are constant in G+5 building design in all terrain categories up to 2nd storey and is 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 story drift is decreases from top story to bottom story (11th to 1st in medium rise buildings and 16th to 1st in High rise buildings). And 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 terrain category 1 than remaining terrains. The value of building twist decreases from 6th storey to 1st story.
4. The maximum values of Shear forces and Bending moments are obtained at terrain category 1. The forces and moments are decreases 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 than other terrain categories.

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