# DYNAMIC WIND ANALYSIS OF TALL BUILDING PROVIDED WITH STEEL BRACING AS PER PROPOSED DRAFT FOR INDIAN WIND CODE AND EFFECT OF SOFT STOREY (PART 2)

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***ABSTRACT-*** *For preliminary design including the proportioning of a structure, the variation of wind force on a structure with variation of site parameters and structural parameters should be known. The present study is an effort to achieve the same, primarily based on proposed draft for Indian wind code considering two different wind speed zones. RC framed buildings are generally designed without considering the structural action of masonry infill walls present. These walls are widely used as partitions and considered as non-structure elements. But they affect both structural and non-structural performance of the RC buildings with lateral loads*.

***KEYWORDS***: proposed draft code, Indian wind code, Soft storey, Equivalent diagonal strut, Dynamic coefficient factor, Displacement, drift.

## I. INTRODUCTION

### *A. General*

Codes and standards are the mainstream of information to the designers of civil engineering structure. The wind loading codes are primarily based on comprehensive data on wind speeds collected by the meteorological departments, and the results of the results of the research carried out understand wind characteristics and its effect on structure, based on these data and experiments made in wind tunnel.

As wind is a randomly varying dynamic phenomenon, it has significant dynamic effects on buildings and structures especially on high rise flexible structures. Codes and standards utilize the ''gust loading factor' (GLF) approach for estimating dynamic effect on high-rise structures. The concept of GLF was first introduced by davenport in 1967. Wind is air in motion relative to the surface of earth. The effect of wind on the structure as a whole is determined by the combined action of external & internal pressures acting upon it. Wind velocity consists of a mean plus a fluctuating component, momentary deviation of the fluctuating component from the mean value is responsible for creation of gust. Both the components of wind velocity vary with height & depend upon the approach terrain & topography.

## II. METHODOLOGY

The design wind velocity (Vz) is given by

$$Vz = Vb.\ K_1.\ K_{2.}\ K_3$$

The design wind pressure (Pa) is given by

$$Pz = 0.6Vz2$$

Where Vb = basic wind speed as per IS 875: PART -3, Vz is design wind pressure at height z in m/s, k1 is the probability factor given in IS 875 part 3 table 1 , k2 is the terrain roughness and height factor given in table 2, k3 is topographical factor and k4 is cyclonic factor.

***DYNAMIC RESPONSE FACTOR:*** According dynamic response factor as per proposed wind code method the following equations are used.

Where Pz = Design wind pressure at height z in N/m$^2$ given by

$C_{dyn}$ i

s dynamic response factor (total load / mean load) and is given by

$$C_{dyn} = \frac{1+2*Ih[gv^2*bs+\frac{Hsgr^2SE]^{0.5}}{\beta}}{(1+2gvIh)}$$

Where $I_h$ = turbulence intensity, obtained from table 31 of IS: 875 (part 3): proposed draft and commentary; gv = peak factor for the up wind velocity fluctuations, which shall be taken as

Bs is back ground factor, which is a measure of the slowly varying background component of the fluctuating response, caused by the low frequency wind speed variations given as follows.

$$Bs = \frac{1}{1+\frac{[36(h-s)^2+64b^2sh]^{0.5}}{2Lh}}$$

S is size reduction factor given by expression presented below

$$S = \frac{1}{\left[1+\frac{4foh(1+gvIh)}{Vh}\right]\left[1+\frac{4foboh(1+gvIh)}{Vh}\right]}$$

E is $\left(\frac{\pi}{4}\right)$ times the spectrum of turbulence in the approaching wind stream given by

$$E = \pi N/(1+70N^2)^{5/6}$$

And N = reduced frequency, and is given by

$$N = \frac{fo\ Lh\ [1+(gv*Ih)]}{Vh}$$

Where Vh = design wind speed at height h.

## III. DESCRIPTION OF STRUCTURAL MODEL

Twenty five storey building is considered having 8 bays in X and Y directions with plan dimension 40x40m and storey height 3.5m each in all the floors and spacing is 5m.the building is kept symmetric in both mutually perpendicular directions in plan to avoid torsional effects. The orientation and size of column is kept some throughout the height of the structure. The building is considered for wind speed zones 47 m/s and the response obtained. The building is considered as general building located in terrain category three i.e. has obstruction up to 10m height of building and surface is plain.

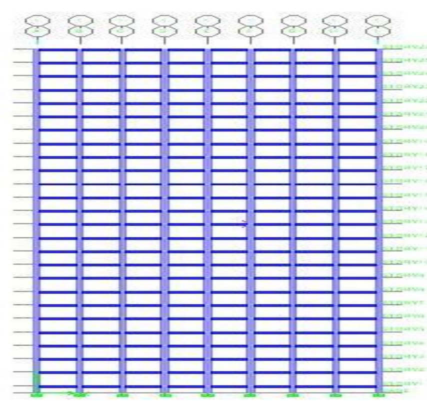
| **Data** | **Values** |
|---|---|
| Basic wind speed $V_b$ | 47 m/s |
| E for M30 concrete | 27.386X10$^6$ KN/m$^2$ |
| E of brick masonry | 3500X10$^3$ KN/m$^2$ |
| Density of brick masonry | 20 KN/m$^3$ |
| Density of reinforced concrete | 25 KN/m$^3$ |
| **Grade of concrete** | M30 |
| **Loads** | |
| Floor finishes | 1 KN/m$^2$ |
| Imposed load | 3 KN/m$^2$ |
| **Slab thickness** | 0.15m |
| **Column size** | 0.23mX0.7m |
| **Beam size** | 0.23mX0.45m |
| Thickness of wall | 0.23m |

Table 1: Description of structural model

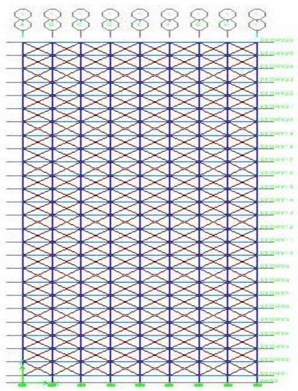
## IV. MODELS FOR ANALYSIS

Following six models are analyzed as special moment resisting frame using equivalent static analysis and dynamic response spectrum analysis.

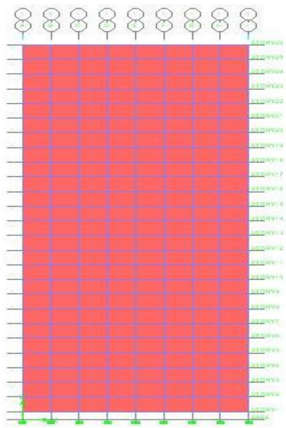
- Model 1: Bare frame model without bracings, however masses of infill walls are included in the model.
- Model 2: Bare frame model with X bracings.
- Model 3: Full Infill model without bracings.
- Model 4: Full Infill model with X bracings.
- Model 5: building has one full brick Infill masonry wall in all storeys without bracing with ground soft storey.
- Model 6: building has one full brick Infill masonry wall in all storeys with X bracing with ground soft storey.



Model 1



Model 2



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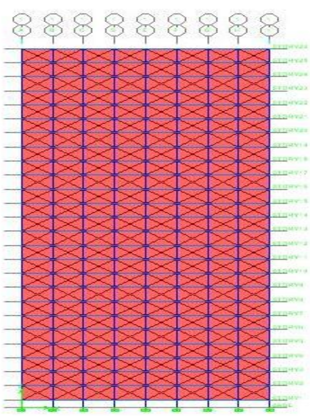
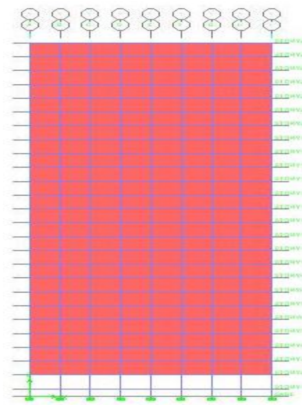


Model 4



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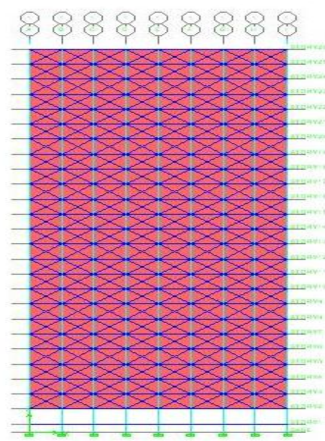

Model 6

V. *RESULT AND DISSCSSION*

Table 2: Lateral displacement and storey drifts for bare frame model for X bracing for wind speed zones 47 m/s.

| STOREY NO | DISP X | DISP Y | DRIFT X | DRIFT Y |
|---|---|---|---|---|
| 26 | 28.916 | 28.917 | 0.000082 | 0.000082 |
| 25 | 28.627 | 28.628 | 0.000101 | 0.000101 |
| 24 | 28.274 | 28.275 | 0.000125 | 0.000125 |
| 23 | 27.838 | 27.839 | 0.000149 | 0.000149 |
| 22 | 27.316 | 27.316 | 0.000174 | 0.000174 |

| | | | | |
|---|---|---|---|---|
| 21 | 26.707 | 26.704 | 0.000199 | 0.000199 |
| 20 | 26.012 | 26.012 | 0.000223 | 0.000223 |
| 19 | 25.232 | 25.233 | 0.000246 | 0.000246 |
| 18 | 24.370 | 24.370 | 0.000270 | 0.000270 |
| 17 | 23.426 | 23.427 | 0.000292 | 0.000292 |
| 16 | 22.404 | 22.404 | 0.000314 | 0.000314 |
| 15 | 21.304 | 21.304 | 0.000336 | 0.000336 |
| 14 | 20.129 | 20.130 | 0.000356 | 0.000356 |
| 13 | 18.883 | 18.883 | 0.000376 | 0.000376 |
| 12 | 17.568 | 17.568 | 0.000394 | 0.000394 |
| 11 | 16.188 | 16.188 | 0.000412 | 0.000412 |
| 10 | 14.745 | 14.746 | 0.000429 | 0.000429 |
| 09 | 13.245 | 13.245 | 0.000444 | 0.000444 |
| 08 | 11.690 | 11.690 | 0.000458 | 0.000458 |
| 07 | 10.086 | 10.086 | 0.000471 | 0.000471 |
| 06 | 8.4386 | 8.4387 | 0.000481 | 0.000481 |
| 05 | 6.7541 | 6.7543 | 0.000489 | 0.000489 |
| 04 | 5.0438 | 5.0439 | 0.000490 | 0.000490 |
| 03 | 3.3301 | 3.3302 | 0.000472 | 0.000472 |
| 02 | 1.6765 | 1.6765 | 0.000364 | 0.000364 |
| 01 | 0.4026 | 0.4027 | 0.000201 | 0.000201 |

Table 3: Lateral displacement and storey drifts for infilled frame model for X bracing for wind speed zone 47 m/s.

| STOREY NO | DISP X | DISP Y | DRIFT X | DRIFT Y |
|---|---|---|---|---|
| 26 | 3.3121 | 3.3121 | 0.000023 | 0.000023 |
| 25 | 3.2299 | 3.2299 | 0.000025 | 0.000025 |
| 24 | 3.1422 | 3.1422 | 0.000027 | 0.000027 |
| 23 | 3.0487 | 3.0487 | 0.000028 | 0.000028 |
| 22 | 2.9494 | 2.9494 | 0.000030 | 0.000030 |
| 21 | 2.8445 | 2.8445 | 0.000032 | 0.000032 |
| 20 | 2.7341 | 2.7341 | 0.000033 | 0.000033 |
| 19 | 2.6185 | 2.6185 | 0.000034 | 0.000034 |
| 18 | 2.4978 | 2.4978 | 0.000036 | 0.000036 |
| 17 | 2.3725 | 2.3725 | 0.000037 | 0.000037 |
| 16 | 2.2427 | 2.2427 | 0.000038 | 0.000038 |
| 15 | 2.1089 | 2.1089 | 0.000039 | 0.000039 |
| 14 | 1.9713 | 1.9713 | 0.000040 | 0.000040 |
| 13 | 1.8306 | 1.8306 | 0.000041 | 0.000041 |
| 12 | 1.6872 | 1.6872 | 0.000042 | 0.000042 |
| 11 | 1.5416 | 1.5416 | 0.000042 | 0.000042 |
| 10 | 1.3944 | 1.3944 | 0.000042 | 0.000042 |
| 09 | 1.2462 | 1.2462 | 0.000042 | 0.000042 |
| 08 | 1.0976 | 1.0976 | 0.000042 | 0.000042 |
| 07 | 0.9493 | 0.9493 | 0.000042 | 0.000042 |
| 06 | 0.8022 | 0.8022 | 0.000041 | 0.000041 |
| 05 | 0.6571 | 0.6571 | 0.000041 | 0.000041 |
| 04 | 0.5150 | 0.5150 | 0.000039 | 0.000039 |
| 03 | 0.3769 | 0.3769 | 0.000038 | 0.000038 |
| 02 | 0.2446 | 0.2446 | 0.000042 | 0.000042 |
| 01 | 0.0986 | 0.0986 | 0.000049 | 0.000049 |

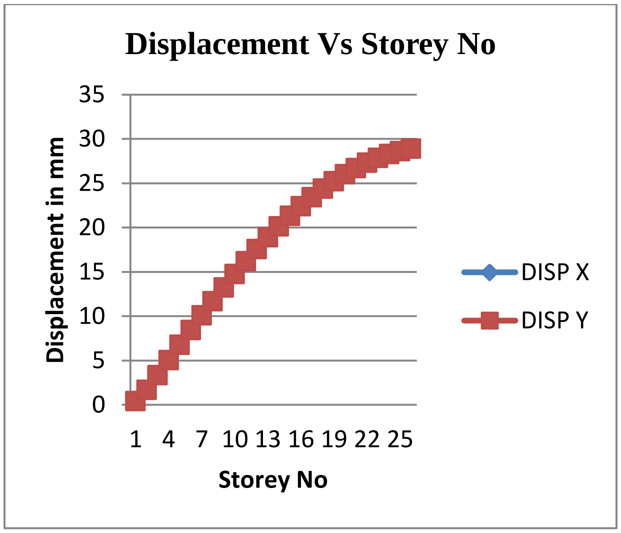


Fig 1: Comparison of Lateral displacement Vs Storey No for bare frame model for wind speed zone 47m/s.

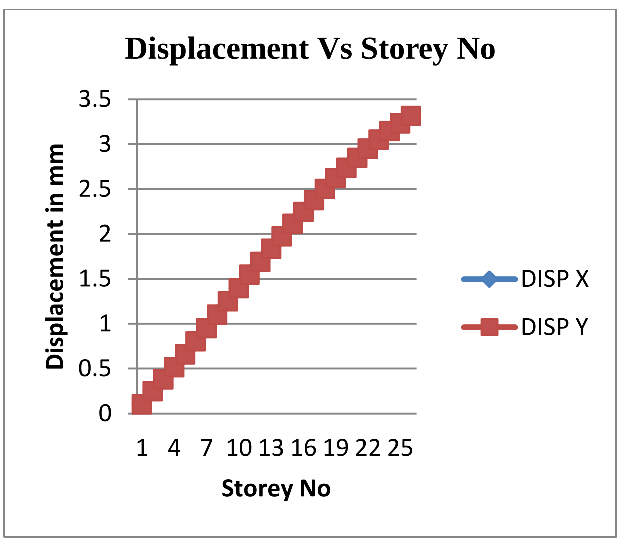


Fig 2: Comparison of Lateral displacement Vs Storey No for infilled frame model for wind speed zone 47m/s.

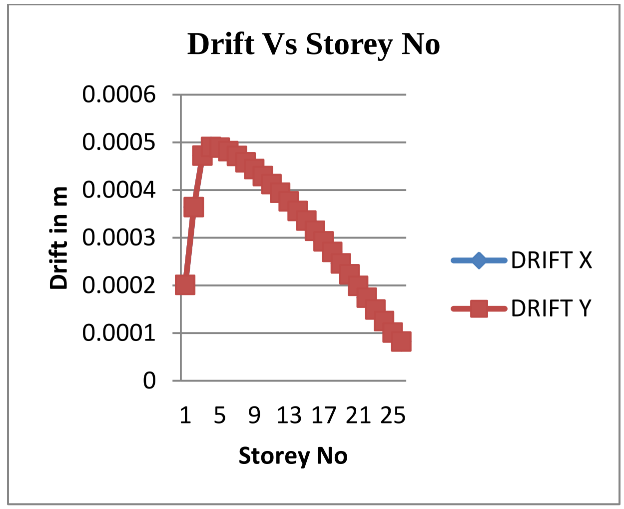


Fig 3: Comparison of Drift Vs Storey No for bare frame model for wind speed zone 47m/s.

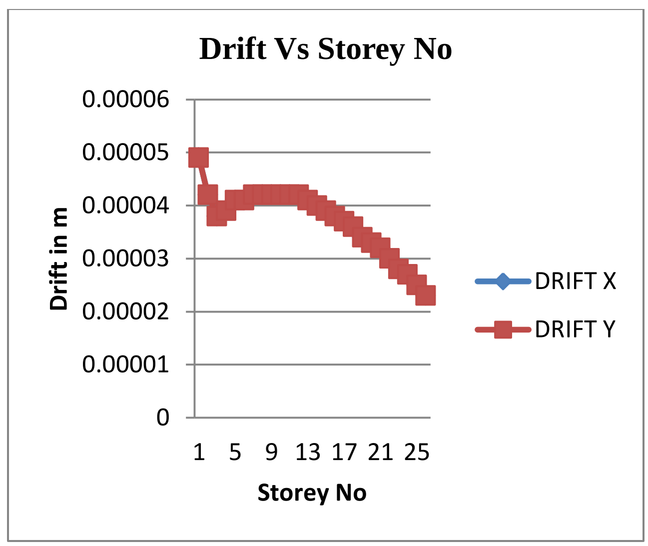


Fig 4: Comparison of Drift Vs Storey No for infilled frame model for wind speed zone 47m/s.

## VI. CONCLUSIONS

1) Dynamic coefficient factor not only varies with the height of the structure but is also influenced by wind speed zones.
2) Dynamic wind load increases with increase in height of structure
3) Dimension of the column should be increased to increase the lateral resistance.

4) Infill model effectively braces the RC frame structure and increases the lateral resistance to wind loads. Hence the effect of infill has to taken in consideration during the design of structure.
5) Wind forces remains constant up to 3 stories and increases linearly over the height of the building for wind speed zones 47m/s
6) Effect of soft storey increases with increase in position of soft storey as the lateral resistance goes on decreases.
7) Displacements limits are exceeding wind speed zones for bare framed model. Though practically such system do not exit it is very vulnerable.
8) Maximum displacements are within the limits for wind speed zones for infilled model and displacement decreased by 77.84% compared with displacements of bare frame model indicates the huge increase in lateral resisting system by considering the effect of infill.
9) Maximum displacement exceeded limits for model1 3, model 1 4, model 15 in Y direction for 47 m/s wind speed zones maximum displacement in either direction were within limits. This clearly suggests that the influence of soft stories is predominant in 47 m/s wind speed zone and hence the lateral stiffness has to be increased.
10) .Maximum storey drift is found a ground stories for model 1 3, model 1 4, model 1 5and abrupt increase in drifts were found for soft stories indicating large decrease in stiffness. So the stiffness has to be increased by provision of infill, increasing dimension of column or by some other lateral resisting system to increase the lateral resistance against wind loads and reduce soft storey effects.
11) Soft storey exhibits very poor performance in case of 47 m/s wind speed zones.

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