

Dynamic Wind Analysis of Tall Building Provided with Steel Bracing as Per Proposed Draft for Indian Wind Code and Effect of Soft Storey

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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.

Key words: 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 (V_z) is given by

$$V_z = V_b \cdot K_1 \cdot K_2 \cdot K_3$$

The design wind pressure (Pa) is given by

$$P_z = 0.6V_z^2$$

Where V_b = basic wind speed as per IS 875: PART -3, V_z is design wind pressure at height z in m/s, k_1 is the probability factor given in IS 875 part 3 table 1, k_2 is the terrain roughness and height factor given in table 2, k_3 is topographical factor and k_4 is cyclonic factor.

A. Dynamic Response Factor:

According dynamic response factor as per proposed wind code method the following equations are used.

Where P_z = 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

$$C_{dyn} = \frac{1+2 \cdot I_h [g v^2 + b s + \frac{H s g r^2 s E}{\beta}]^{0.5}}{(1+2 g v I_h)}$$

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

B_s 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.

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

S is size reduction factor given by expression presented below

$$S = \frac{1}{[1 + \frac{4f_0 h (1+g v I_h)}{V_h}] [1 + \frac{4f_0 b_0 h (1+g v I_h)}{V_h}]}$$

E is $(\pi/4)$ 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

$$N = \frac{f_0 L_h [1+(g v I_h)]}{V_h}$$

Where V_h = 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 same 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	27.386X106 KN/m ²
E of brick masonry	3500X103 KN/m ²
Density of brick masonry	20 KN/m ³
Density of reinforced concrete	25 KN/m ³
Grade of concrete	M30

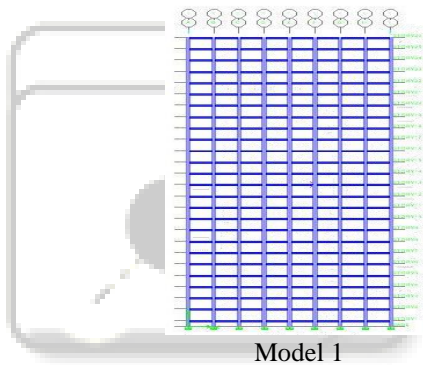
Loads	
Floor finishes	1 KN/m ²
Imposed load	3 KN/m ²
Slab thickness	0.15m
Column size	0.23mX0.7m
Beam size	0.23mX0.45m
Thickness of wall	0.23m

Table 1: Description of structural model

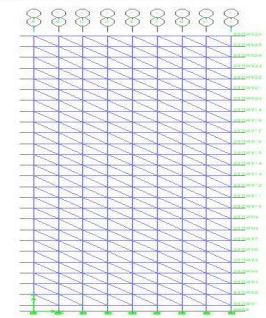
IV. MODELS FOR ANALYSIS

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

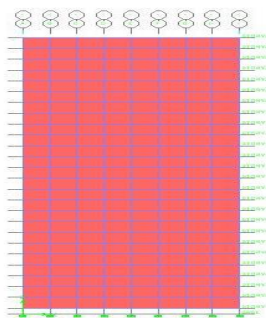
- Model 1: Bare frame model without bracings, however masses of infill walls are included in the model.
- Model 2: Bare frame model with diagonal bracings.
- Model 3: Full Infill model without bracings.
- Model 4: Full Infill model with diagonal bracings.
- Model 5: building has one full brick Infill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



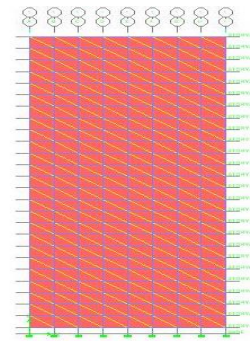
Model 1



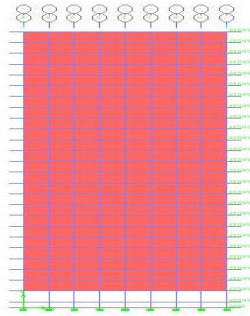
Model 2



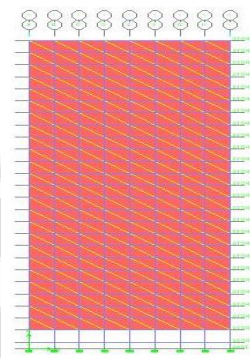
Model 3



Model 4



Model 5



Model 6

V. RESULT AND DISCUSSION

Lateral Displacement and storey drift for bare frame without diagonal bracing for wind zone 47 m/s for model 1.

Storey No	Disp X	Disp Y	Storey No	Drift X(m)	Drift Y (m)
26	214	219	26	0.0004	0.0004
25	212	217	25	0.0005	0.0005
24	211	215	24	0.0007	0.0007
23	208	212	23	0.0008	0.0009
22	205	209	22	0.0011	0.0011
21	201	205	21	0.0013	0.0013
20	196	200	20	0.0015	0.0015
19	191	194	19	0.0017	0.0018
18	185	188	18	0.0019	0.0020
17	178	181	17	0.0021	0.0022
16	171	173	16	0.0023	0.0024
15	162	165	15	0.0025	0.0026
14	153	156	14	0.0027	0.0028
13	144	146	13	0.0029	0.0030
12	133	135	12	0.0031	0.0031
11	122	124	11	0.0033	0.0033
10	111	112	10	0.0034	0.0035

09	99	100	09	0.0036	0.0036
08	86	87	08	0.0037	0.0038
07	73	74	07	0.0038	0.0039
06	59	60	06	0.0039	0.0039
05	46	46	05	0.0038	0.0039
04	32	32	04	0.0036	0.0036
03	19	20	03	0.0031	0.0031
02	08	08	02	0.0021	0.0021
01	1.3	1.40	01	0.0006	0.0007

Table 2:

Lateral displacement and storey drift for bare frame with diagonal bracing for wind zone 47 m/s for model 2.

Storey No	Disp-x (mm)	Disp-y (mm)	Storey No	Drift x (m)	Drift y (m)
26	95	96	26	0.0002	0.0002
25	94	95	25	0.0002	0.0002
24	93	94	24	0.0003	0.0003
23	91	92	23	0.0004	0.0004
22	90	91	22	0.0005	0.0005
21	88	89	21	0.0006	0.0006
20	86	87	20	0.0007	0.0007
19	83	84	19	0.0007	0.0007
18	81	82	18	0.0008	0.0008
17	78	78	17	0.0009	0.0009
16	74	75	16	0.0010	0.0010
15	71	71	15	0.0011	0.0011
14	67	68	14	0.0011	0.0011
13	63	63	13	0.0012	0.0012
12	58	59	12	0.0013	0.0013
11	54	54	11	0.0013	0.0013
10	49	49	10	0.0014	0.0014
09	44	44	09	0.0015	0.0015
08	38	39	08	0.0015	0.0015
07	33	33	07	0.0016	0.0016
06	27	28	06	0.0016	0.0016
05	22	22	05	0.0016	0.0017
04	16	16	04	0.0016	0.0016
03	10	10	03	0.0015	0.0015
02	04	05	02	0.0110	0.0011
01	1.104	0.92	01	0.0005	0.0004

Table 3:

A. Storey Displacements:

Following Fig 1, 2, 3, 4, 5 and 6 represents the variation of displacements over the height of building for model 1, model 2, model 3, model 4, model 5 and model 6 respectively.

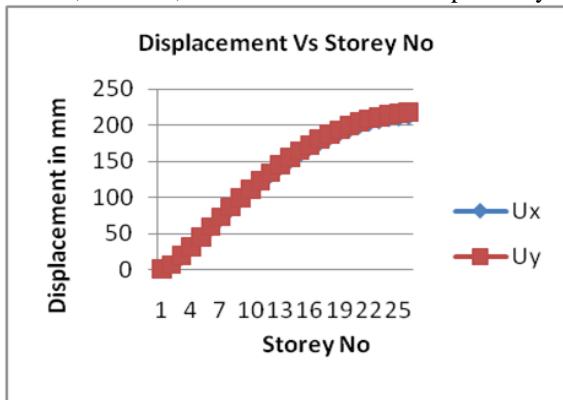


Fig. 2: displacement Vs storey No

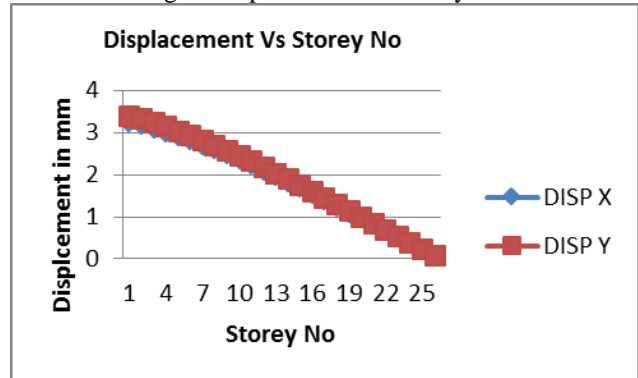


Fig. 3: displacement Vs storey No

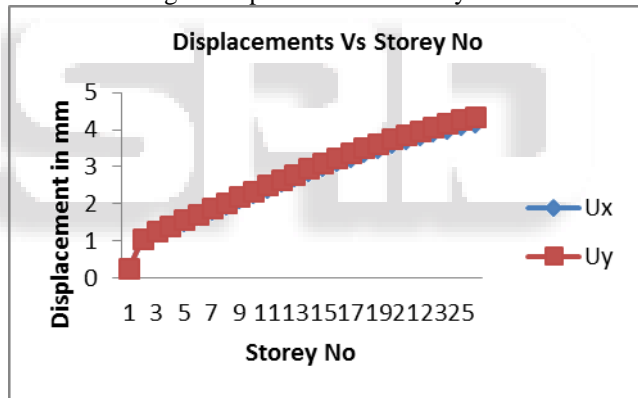


Fig. 4: displacements Vs storey No



Fig. 5: displacement Vs storey No

B. Storey Drifts:

The following fig 1, 2, 3, 4, 5 and 6 represents variations of drifts over the height of building for Model 1, Model 2, Model 3, Model 4, Model 5, and Model 6 respectively.

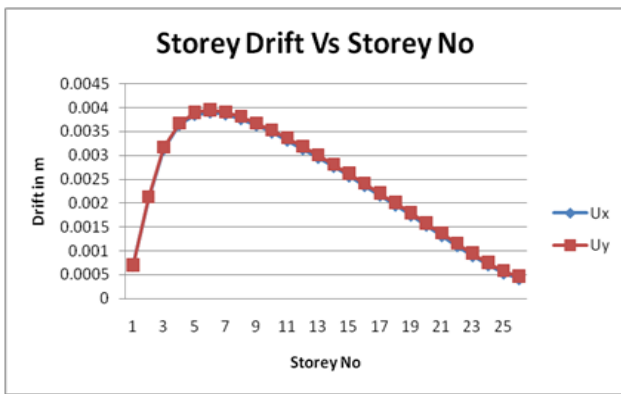


Fig. 6: storey Drift Vs storey No

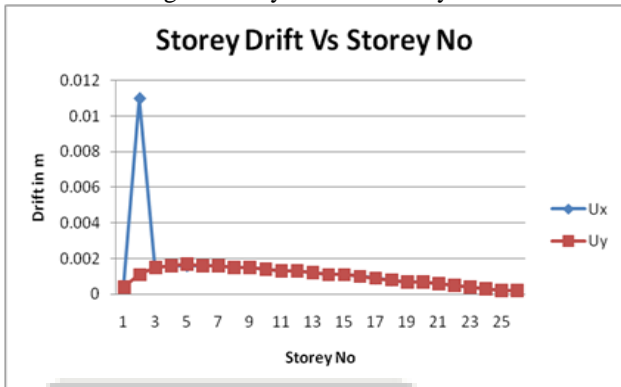


Fig. 7: storey Drift Vs storey No

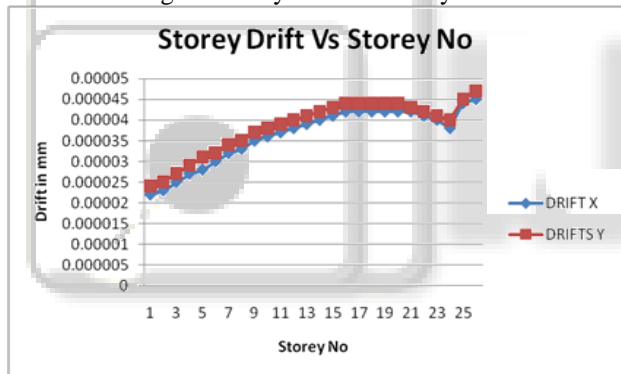


Fig. 8: storey Drift Vs storey No

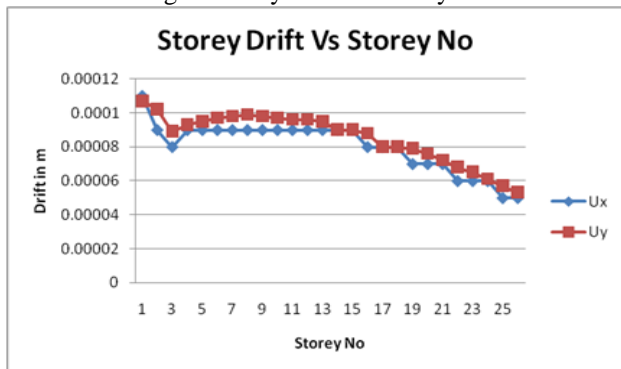


Fig. 9: storey Drift Vs storey No

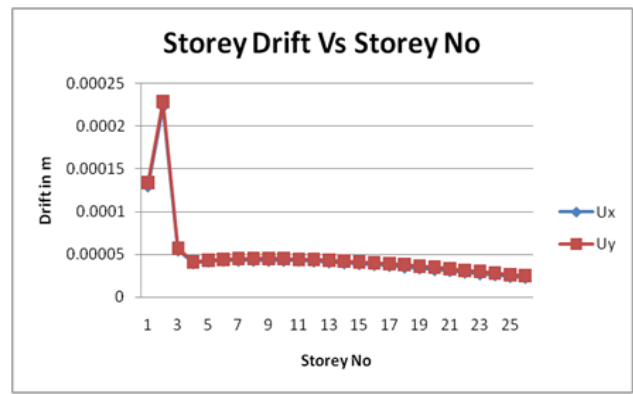


Fig. 10: storey Drift Vs storey No

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] Infilled 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.

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