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# COMPARATIVE STUDY OF RCC BUILDING WITH AND WITHOUT GUST FACTOR METHOD

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## ABSTRACT

As there is an economic growth there is an increasing demand for infrastructure in order to fulfill the requirement. As this will lead to high demand for all structures with multiple housing units that are not only spacious but also visually appealing. This leads to various kinds of abnormalities and these various abnormalities forces the building to deviate from their expected behavior. The aim of this thesis is to review the previous works on the abnormalities of structure and the various indexes that can be helpful to the standardization of the behavior the structure because of wind effects. In reference to Indian codes ( IS 456:2000 and IS 875(part 3):2015) Static and dynamic methods are discussed on different heights of building. The aim of this thesis is to review the along and across wind effects on buildings and suggest how dynamic method is helpful in getting the critical wind values experienced by tall storey buildings .The main parameters are Static and Dynamic methods. With help of above mentioned two methods, some values are suggested where our tall structure will experience critical dynamic moments. Further the aspects ratios were varied and the most suitable and low experiencing gust effect ratio suggested.

**Keywords :** Gust Factor, Peak Wind Approach – Static Method, Dynamic Response Method, Along wind direction, Across wind direction

## I. INTRODUCTION

Every structure carries its own and objects weight which in simple terms we call as load. Load is something which is carried normally a heavy object. There are different types of loads acting on a structure briefly classified as vertical loads and horizontal loads. The vertical loads are dead load, live load, and impact load. The horizontal loads are wind loads and earthquake loads. Different types of loads are as follows:

1. Dead load – It is a first vertical load. These are permanent or stationary loads which acts on a building throughout their life span. Dead loads are produced due to the self-weight of the structural members, fixed equipment's, partition or outer walls. In a building self-weight is generated by their structural members like beam, column, and roof.

2. Live load – It is a second vertical load in a structure. These are movable loads without any impact. These loads are considered to be temporary loads which keeps on changing time to time. This load depends on the occupancy or the use of building.

3. Earthquake load – These forces comprise of both horizontal and vertical forces on building. This is basically a vibrational force which is resolve in 3 mutually perpendicular directions. Vertical direction movement does not affect much to superstructure but the horizontal direction forces play important role in building designs.

4. Snow loads – This comprises under vertical loads. These type of loads are considered in snow fall areas. The IS 875 part 4 covers snow load clauses.

5. Wind loads – Wind load is a horizontal loads caused by the air movement. This type of loads is considered in designing high rise buildings. Four to Five stories building is called as low rise building and wind loads are not dominant on for such heights because the columns and the walls are strong enough to

accommodate the effects. IS 875 part 3 2015 covers the full details about this load. Wind loads are of two types (a) static loads (b) Dynamic loads.

1. Static :- These loads are independent of time, structures dead load can be taken as static load. Here the load remains constant with time or changes gradually and also in this type of loading has one response i.e. displacement and this response can be calculated by the equilibrium principle of force and static.

2. Dynamic :- These loads are time dependent and can be accelerating or deaccelerating. Here the load changes with time very rapidly. For example live load, earthquake load, snow load. These are time dependent because loading and responses may vary with time. These are having 3 types of response i.e. displacement, velocity and acceleration. In structural dynamic problem, inertia force is the most important distinguishing characteristics.

**Effects of wind on structure:-**

- Structure gets affected in several ways such as galloping, vortex shedding and buffeting.
- When unsteady wind flow from the surface of building, swirling vortices are created and when vortices shed they result in a wind pressure reduction at regular intervals. These pressure variations can result in lateral force generation at right angles which leads to sway.
- There is a possibility that the frequency of the tall building structure matches with the wind frequency which can produce large displacements and critical effects on the frame.
- Due to wind effects building can lead to translational vibrations and these vibrations can lead to human discomfort as humans are sensitive to vibrations.
- Cracking and damage of the ceilings, façade, partitions, may occur.

**The following criteria should be fulfilled in wind load analysis:-**

- Stability against uplift, sliding of building and counter toppling.
- Structural components should be strong to wear excess load during the life cycle of building.
- Despite of normal wind deflections serviceability of building should be fulfilled in terms of human comfort.

## II. METHODOLOGY

### 2.2 Method of analysis

**2.2.1 Peak Wind Approach- Static Method (PWA-SM)** (From Clause 6.3 IS 875 part 3 2015)

**For Case H= 100m B= 20m D= 12m**

Basic wind speed, Vb= 33 m/s

$$V_z = V_b\, k_1\, \bar{k}_2\, k_3 \text{ (At height z design wind speed in m/s )}$$

Here,

$k_1 = 1$ (From Clause 6.3.1 IS 875 part 3 2015)

$k_3 = 1$ (From Clause 6.3.3 IS 875 part 3 2015)

$\bar{k}_2 = 0.8$ (From Clause 6.3.2.2 IS 875 part 3 2015)

Therefore,

$V_z = 33 \times 0.8$

$= 26.4 m/s$

Design Wind Pessure

$p_z = 0.6\, Vz\text{^}2$ (From Clause 7.2 IS 875 part 3 2015)

$= 0.6 \times 26.4^2$

$= 418.176\ N/m^2$

Design wind load at any height = $p_z C_p A$ (From Clause 7.3.1 IS 875 part 3 2015)

$= 1.4 \times 418.176 \times 4$

$= 2341.78\ N/m^2$

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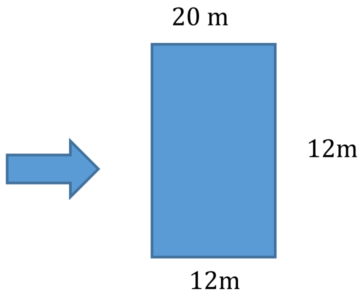
Therefore,

$$M = 23.41\ KN/m^2$$

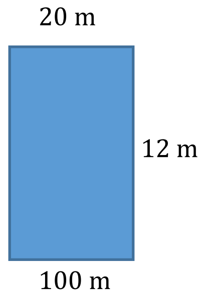
**4.2.2 Dynamic Wind Response Method**

Consider a building of height 100m as shown in figure and comparing the base moments and shear by the above described methods and comparing the results.

(a) Along wind Response :- (From Clause 10.2 IS 875 part 3 2015)




PLAN




ELEVATION

Here we Know,

$Z = 10m$, $h = 100m$, $s = 5m$, $V_b = 33m/s$

$a/b = 30/18 = 1.66$ $h/b = 100/18 = 5.66$

Drag coefficient $C_{f,z} = 1.4$

Effective frontal area $A_z = 1 \times 6 = 6m^2$

Design hourly wind pressure $P_d = 0.6\ V_{zd}^2 (N/m^2)$

Design hourly wind speed $V_{zd} = K_{2,I} \times V_b$

Where,

$K_{2,I} = 0.1423\ [\ln(Z/Z_{0,i})]*(Z_{0,i})^{0.0706}$ (From Clause 6.4 IS 875 part 3 2015)

$= 0.1423*[\ln(10/2)]*(2)^{0.0706}$

$K_{2,I} = 0.24$

$Vz_d = V_b\ k_1 \bar{k}_2\ k_3$

$V_{zd} = 0.24 \times 33 = 7.94\ m/s$

$P_d = 37.79\ N/m^2$

Roughness factor $r = 2 \times I_{z,4}$

$I_{z,4} = 0.466 - 0.1358 \log_{10}(Z/Z_{0,4})$

$I_{z,4} = 0.372$

$r = 2 \times 0.372 = 0.74$

Peak factor for upwind velocity $g_v = 4$ (for terrain category 4)

Background Factor Bs =

$$= \frac{1}{\left[1 + \frac{\sqrt{0.26(h-s)^2 + 0.46 b_{sh}^2}}{L_h}\right]}$$

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$b_{sh}$ = 20m $L_h = 70 \times (h/10)^{0.25} = 70 \times (100/10)^{0.25} = 125$m

Bs = 0.7

Turbulence Intensity $g = g_v * I_{b,I} * \sqrt{Bs}/2$

$g = 4*0.23*\sqrt{0.7}/2 = 0.38$

Size reduction factor $S = \frac{1}{\left[1+\frac{3.5fh}{V}\right]*\left[1+\frac{4fb}{V}\right]}$

Time period $T = 0.09H/\sqrt{d} = 0.09*100/\sqrt{30} = 1.67$

$f_a = 1/T = 0.59$

$V_{h,d} = K_{2,I} * V_b$

$K_{2,I} = 0.1423\,[\,\ln(Z/Z_{0,i})]*(Z_{0,i})^{0.0706}$

$= 0.1423*[\ln(100/2)]*(2)^{0.0706}$

$K_{2,I} = 0.58$

$V_{h,d} = 0.58 \times 33 = 19.38$ m/s

Therefore,

S = 0.018

Spectrum of turbulence $E = \frac{\pi N}{(1+70.8N^2)^5/6}$

E = 0.036

$g_r = \sqrt{2ln}(3600fa) = 3.9$

Damping Coefficient β = 0.020

Gust Factor $G = 1+r\sqrt{\left[gB(1+g)^2 + Hs.g.S.\frac{E}{\beta}\right]}$

G = 3.14

Along Wind load $Fz = C_{f,z}.A_z.P_d.G$

Fz = 1.4 x 6 x 37.79 x 3.14

Fz = 996.75 KN

Therefore,

Base bending moment Mz = 9.96 Knm

(b) Across Wind Response :- (From Clause 10.3 IS 875 part 3 2015)


$$M_c = 0.5 g_h p_h b h^2 (1.06 - 0.06\,k)\sqrt{\left(\frac{\pi C_{fs}}{\beta}\right)}$$

Where,

Peak Factor $g_h = \sqrt{2ln}(3600fc) = 3.74$

Hourly mean wind pressure $P_h = 223.34$

Breadth b = 12m

Mode shape factor k = 1

c = 0.0025

β = 0.02

Therefore,

$$M_c = 0.5*3.74*12*100^2*(1.06-0.06*1)*\frac{\sqrt{\pi*0.0025}}{0.02}$$

$M_c = 31386080.8$

Across wind load $F_{z,c} = (3*31386080.8/100^2)*(10/100) = 941.582$ KN

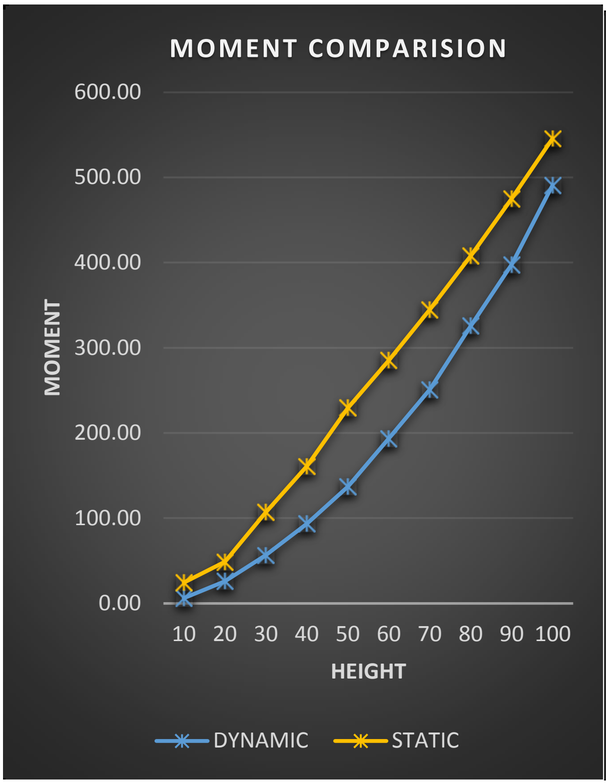
Base bending moment Mz = 9.41 Knm

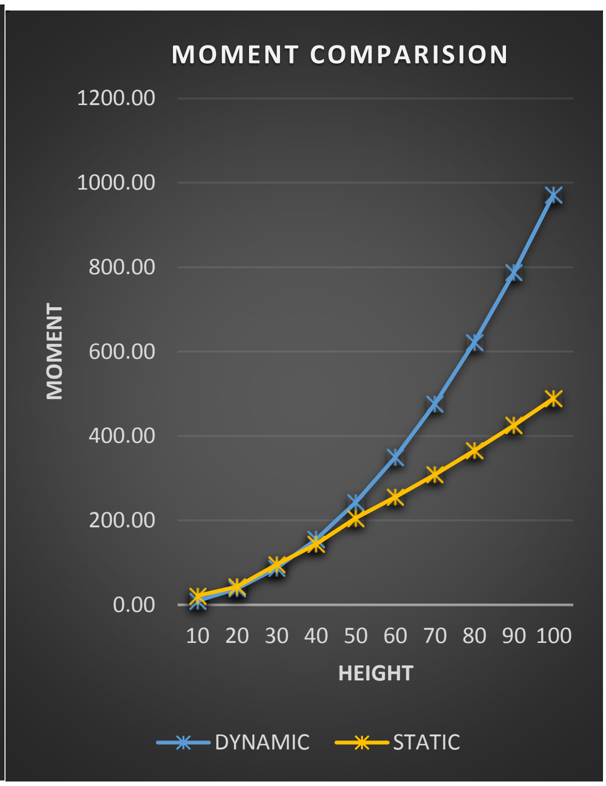
## III. RESULTS AND DISCUSSION

**Case 1 - FOR H=100m,D=20m,B=8m**

| Along Direction | | |
|---|---|---|
| Z | Dynamic moments | Static moments |
| 10 | 6.02 | 24.25 |
| 20 | 25.82 | 48.51 |
| 30 | 56.46 | 106.97 |
| 40 | 93.44 | 160.82 |
| 50 | 136.91 | 229.28 |
| 60 | 193.57 | 285.23 |
| 70 | 250.94 | 344.76 |
| 80 | 325.80 | 407.96 |
| 90 | 397.27 | 474.91 |
| 100 | 490.92 | 545.72 |

| Across Direction | | |
|---|---|---|
| Z | Dynamic moments | Static moments |
| 10 | 9.72 | 21.75 |
| 20 | 38.90 | 43.49 |
| 30 | 87.52 | 95.91 |
| 40 | 155.59 | 144.18 |
| 50 | 243.12 | 205.56 |
| 60 | 350.09 | 255.72 |
| 70 | 476.51 | 309.09 |
| 80 | 622.38 | 365.75 |
| 90 | 787.69 | 425.78 |
| 100 | 972.46 | 489.27 |




**Case 2 - FOR H=80m,D=20m,B=8m**

| Along Direction | | | Across Direction | | |
|---|---|---|---|---|---|
| Z | Dynamic moments | Static moments | Z | Dynamic moments | Static moments |
| 10 | 6.38 | 23.42 | 10 | 8.04 | 22.582 |
| 20 | 27.50 | 46.84 | 20 | 32.15 | 45.163 |
| 30 | 60.09 | 103.28 | 30 | 72.34 | 99.595 |
| 40 | 101.09 | 155.28 | 40 | 128.61 | 149.729 |
| 50 | 146.33 | 221.37 | 50 | 200.96 | 213.466 |
| 60 | 209.68 | 275.39 | 60 | 289.38 | 265.558 |
| 70 | 279.45 | 338.74 | 70 | 393.87 | 326.638 |

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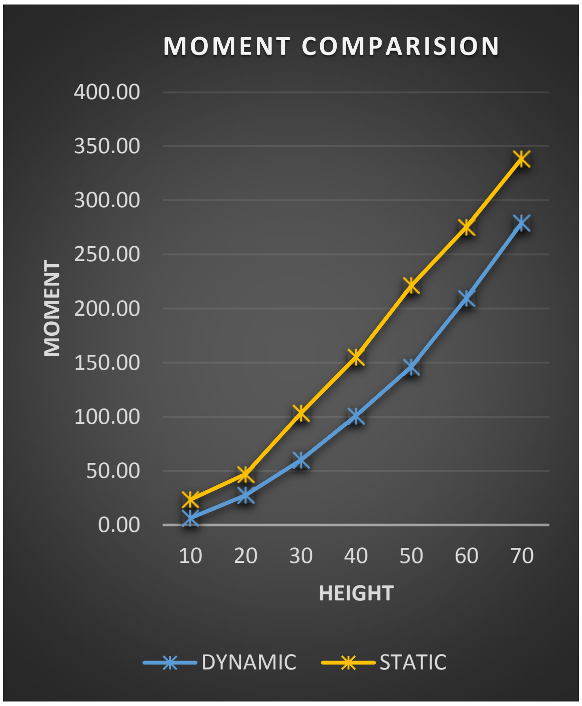
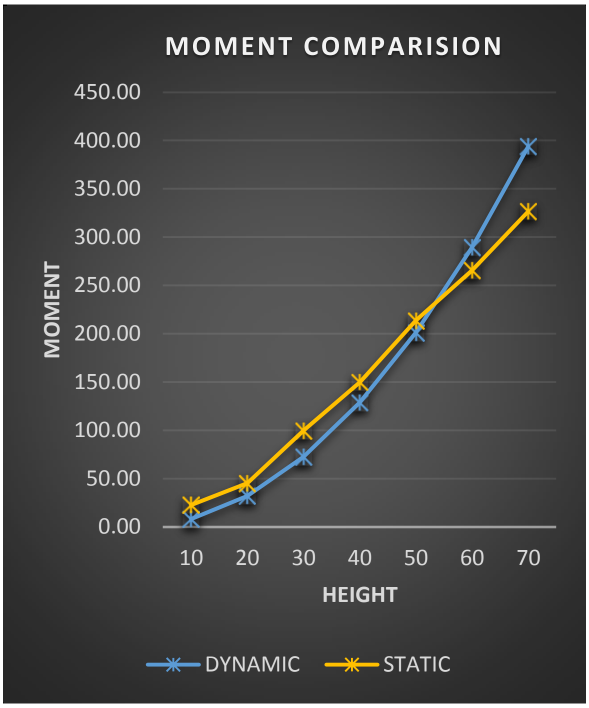
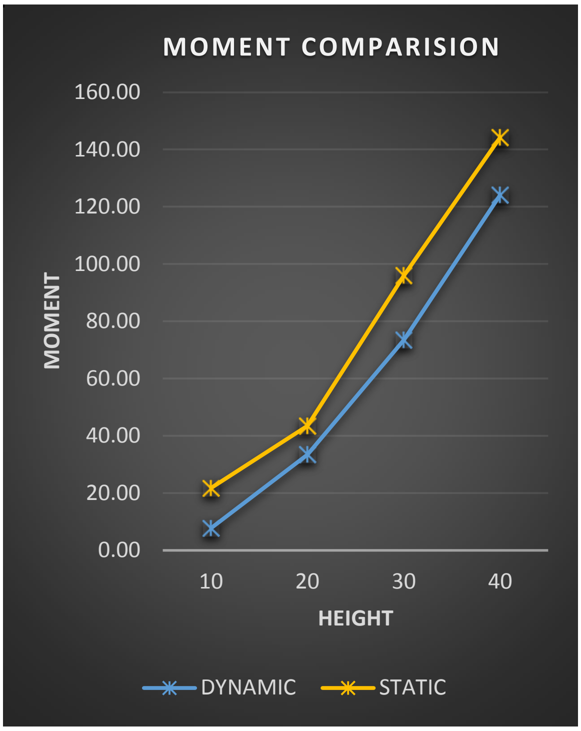


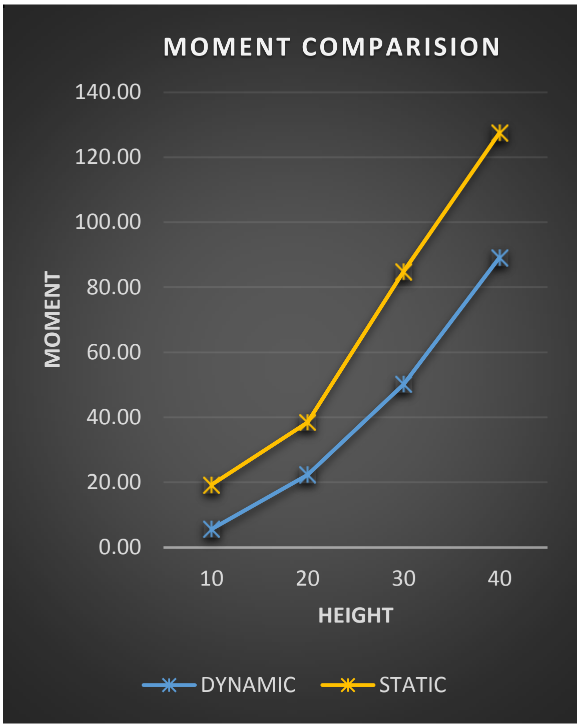




**Case 3 - FOR H=40m,D=20m,B=8m**

| Along Direction | | |
|---|---|---|
| Z | Dynamic moments | Static moments |
| 10 | 7.72 | 21.75 |
| 20 | 33.39 | 43.49 |
| 30 | 73.45 | 95.91 |
| 40 | 124.07 | 144.18 |

| Across Direction | | |
|---|---|---|
| Z | Dynamic moments | Static moments |
| 10 | 5.57 | 19.236 |
| 20 | 22.30 | 38.472 |
| 30 | 50.17 | 84.840 |
| 40 | 89.18 | 127.547 |




## IV. CONCLUSIONS

The following conclusions are obtained from the study and summarized report of the above literature reviews which are as follows:

- As the height of building increases, both the static and dynamic base moments and forces increases in both along and across wind directions.
- With change in Aspect ratio the sudden increment is seen in dynamic moments.
- In along direction, the Static moments are more as compared to dynamic moments.
- In Across direction, initially the static moments are greater but sudden increment is observed after 0.6H - 0.8H in dynamic moments.
- For square building gust factor is maximum and decreases slightly with the height of building.
- For Square building along wind forces decreases rapidly and increases linearly with increase in height. For square building across wind loading is maximum and also increases with height of building. For high rise structures across wind loading is more than along wind loading.
- As the number of stories of a multi storied structure increases the slenderness of frame also increases. With height the building frame becomes more and more flexible.
- There is need to consider the wind effects in the case of tall frames having more than 20 storey particularly in severe wind climate to get the critical values for design.
- The energy content in the fluctuating component increases as the height of frame increases.

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