STUDY OF COMPARISON BETWEEN STATIC AND DYNAMIC ANALYSIS SUBJECTED TO WIND AND EARTHQUAKE LOAD

RABI AKHTAR[1], SHREE PRAKASH[2], MIRZA AAMIR BAIG[3]

[1]*M.TECH (STRUCTURAL & FOUNDATION ENGINEERING)*
[2,3] *Assistant Professor*
Department of Civil Engineering AL-FALAH UNIVERSITY, Faridabad INDIA

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Abstract -High-rise buildings are exposed to both static and dynamic loads. Depending on the method used and how the structure is modeled in finite element software the results can vary. Some of the issues and modeling techniques, introduced below, are investigated in this Master's thesis. Dynamic effects such as resonance frequencies, Gust factors and accelerations are considered. The variation in static results from reaction forces, overturning moments, deflections, and force distributions between concrete cores are investigated with different models. The models are evaluated by different elements and methods, such as construction stage analysis, to study the impact these have on the results. Simplified calculations by hand according to IS (875-partIII), Explanatory handbook of IS(875-partIII)-SP64, Draft code of IS (875-partIII), Thesis references from IIT. The 3D-finite element software used for the analyses is STAAD Pro. V8i(Series-4). From the results it can be observed, when modeling a high-rise building in finite element software, that one model is often not sufficient to cover all different aspects. To see the global behavior, one model can be used, and when studying the detailed results another model with a fine mesh, that have converged, is often needed. The same principle applies when evaluating horizontal and vertical loads, different models or methods are usually needed.

***KeyWords*: High-rise buildings, resonance frequencies, accelerations, Gust factor, displacements, finite element, overturning moments.**

1.INTRODUCTION

Buildings are defined as structures that are utilized by the people as a shelter for living, working or storage. Vertical tall building structures are most commonly used because of shortage of land and facilitated by increasing population, there are many tall buildings have been constructed in India to provide the services and give the shelters to increasing population, tall buildings are complex structures and it should be designed carefully because there are many internal and external stresses that are introduced while applying the wind and earthquake load whichever is dominant.

Tall buildings are designed either for wind or earthquake because it can apply both phenomenon so the building would be designed uneconomical.
Tall buildings are critically affected by wind loads in following two ways:

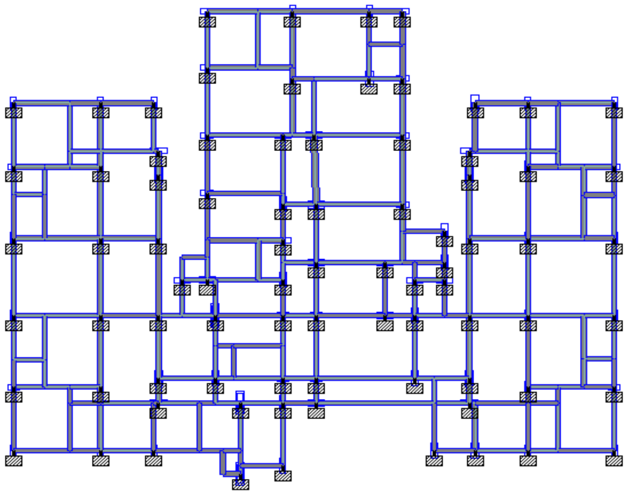
- Firstly it exerts forces and moments on the structure and its cladding.
- Secondly it distributes the air in and around the building mainly termed as Wind Pressure.

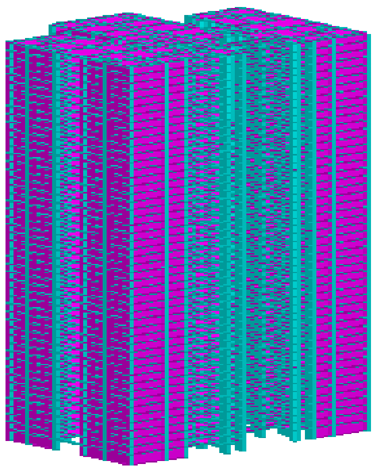
There are two types of analysis have been done in this paper. The first one is linear static analysis and second is linear dynamic analysis. In the static analysis we can calculate the pressure and forces and statically distribute the forces on the structure according the computational program and getting the values of deflection, B.M and Shear forces. In dynamic analysis the behaves in different manner in comparison to static analysis due to vortex and gustiness effect of the wind. Sometimes because of unpredictable nature of wind which is dangerous for tall building structures, these building can collapse due to improper designing and we should be careful while designing tall building and use the best possible structural elements that can take the maximum effect of irregular wind pressure such as, shear wall , bracing system. Pressure have been increase when going to the upper floors of the structures because of the increasing of terrain category.The forces usually decreases in the dynamic due to the dropping of the hourly mean wind speed but the torsion, time period and modes of the building is quite different in comparison to static analysis. Tall building can free to move at high wind speeds in all the three global directions which is (x,y and z). the external and internal pressure coefficient are given in the codes and the codes do not expected the maximum wind speed for the life of the building and does not consider the high local suctions which cause the first damage to the trusses.Due to all these facts the Wind Load estimation for Tall Buildings are very much important.

2.Objective

1. Analytical determination of wind loads and earthquake loads as per IS-875 Part -3 and IS 1893-2002.

2. To determine the height beyond which wind loads combinations are critical as compared to seismic load combinations.
3. To Study the behavior of tall structures when subjected to along wind loads.
4. To study the effect of shape of the structure.
5. To study the contribution of shear wall and Bracing frames to check the lateral displacement of the structure with respect to the columns.
6. To determine the effect of wind load on various parameters like fundamental, time period, storey drifts, lateral joint displacements, bending moments and shear force in columns and beams etc.





2.1. MODEL CONFIGURATION

Table.no.1

	R.C.C BUILDING
HEIGHT	150m
AREA	1100 sqm.
Each Story	3.15m
height	
COLUMN	0.350Mm*0.750Mm (1st to 50^{th} floor)
BEAM	250mm*550mm
SLAB	150mm
GRADE OF CONCRETE	25M (SLAB)
GRADE OF CONCRETE	25M (BEAM)
GRADE OF CONCRETE	30M(COLUMN)
GRADE OF STEEL	FE500 (Rebar)
ZONE	IV
REGION	DELHI
LIVE LOAD	2- 3KN/sqm

3.METHODOLOGY

3.1 DESIGN WIND LOAD

Designed wind load is defined as it can be designed with parameters of wind which are given in Indian standard codes IS(875-partIII) and in high rise structures there are gust factors and wind tunnel effects have been used to determine the actual behavior of wind on structures and the designed wind pressure should be applied on the model. Wind load have been applied on that structures which are applicable for wind analysis such as tall buildings, chimneys, trusses etc.. There are various figures and phenomenon is used in explanatory handbook to apply wind forces on different type of structures and the pressure could not be steady, but highly fluctuating, partly as a result of the gustiness of the wind, but also because of local vortex shedding at the edges of the structures themselves. Sometimes the fluctuating pressure can causes the critical damage to the structure. If the structure is dynamically wind sensitive then the pressure cannot be uniformly distributed over the structure and some irregular behavior can be observed while using dynamical effect on the structure. Thereare various shapes of the structures have been discussed in the Indian standard and we have to apply the wind according to the shapes of the building because wind can be varied if the shapes of the building are different.

3.1.1 Type of Wind Design

Typically for wind sensitive structures three basic wind effects need to be considered.

a). Environmental wind studies
b). Wind loads for façade
c). Wind loads for structure

3.2 DESIGN CRITERIA

In terms of designing a structure for lateral wind loads the following basic design criteria need to be satisfied.

Stabilityshould be checked against overturning, uplift and/or sliding of the structure as a whole. Or if we are failing to achieve proper stability then we have to give the proper alignment and directions of the inertial forces to avoid the exceeding drift displacement and overturning of a whole structure. There are some limiting checks have been given in Indian standards and the stability cannot be exceed against the limiting values.

Strength of the structural components of the building is required to be sufficient to withstand imposed loading without failure during the life of the structure. We must provide the adequate stiffness to the structure to avoid the collapse of the structure. We are using computational program to calculate the strength of the structure and we are giving the collapse combination in the software to check the whole strength of the structure.

Serviceability-For buildings, where inter-story and overall deflections are expected to remain within acceptable limits. Control of deflection and drift is imperative for tall buildings with the view to limiting damage and cracking of non structural members such as the facade, internal partitions and ceilings.

3.3 ALONG AND ACROSS WIND LOADING:

Along wind and Across wind loading is applied when wind is blowing normal to the structure and perpendicular to the structure. We are taking the wind in both the directions in isolation. So, Along wind direction is taken when the wind is applying normal to the structure and Across wind direction is taken when the wind is applying transverse to the normal direction which is 90^0 Along wind and Across wind can be applied in tall buildings, chimneys, O.H.T.. The torsional effect is also noticed while applying the along and across wind loading on the structure.building tends to vibrate in rectilinear and torsional modes. The amplitude of such oscillations is dependent on the nature of the aerodynamic forces and the dynamic characteristics of the building.

3.3.1 Along-Wind Loading

The along-wind loading is applied normal to the wind direction on the structure we can take the angle of wind along-wind load is 0^0. Wind can be assumedto consist of a mean componentdue to the action of the mean wind speed (eg, the mean-hourly wind speed) and a fluctuating component due to wind speed variations from the mean.

3.3.2 Across-Wind Loading

Across-wind loading is applied perpendicular to the direction of wind we can take the wind directions independently in both the directions and when we applied the wind in along-wind loading at 0^0 so we have to apply Across-wind loading at angle of 90^0 which is perpendicular to the along-wind loading. We have many examples of slender structures that are to be designed dynamically across-wind loading.Tall chimneys, street lighting standards, towers.
The excitation of modern tall buildings and structures can be divided into three mechanisms and their higher time derivatives, which are described as follows:

(a) Vortex Shedding.
(b) The incident turbulence mechanism.
(c) Higher derivatives of crosswind displacement.

3.4 CODAL CRITERIA FOR THE BUILDINGS TO BE EXAMINED FOR DYNAMIC EFFECTS OF WINDS

Building can be examined as per the clauses of the Indian standard codes. The code is used for wind analysis is IS(875-partIII). Building should beaslender structures and structural elements should also be investigated. The importance of wind induced oscillations or excitations along and across the direction of wind.In general, the following guidelines may be used for examining the problems of wind induced oscillations:

a) Buildings and closed structures with a height to minimum lateral dimension ratio of more than about 5.0, and

b) Buildings and closed structures whose natural frequency in the first mode is less than1.0 Hz. Any building or structure which satisfy either of theabove two criteria shall be examined for dynamic effects of wind.

1) The fundamental time period (T) may either be established by experimental observation on similar building or calculated by rational method of analysis in the absence of such data, T may be determined as follow for multi stories building.
a) For moment resisting frames without bracing or shear walls for resisting the lateral loads.
T = 0.1 n
b) For all others
T = 0.09 $H/\sqrt{d}$

3.5 HOURLY MEAN WIND SPEED (VZ)

The basic wind speed is in Gust Factor to be used as a hourly mean wind speed and it depends upon the k2' factor in IS(875-partIII) refer table 33:
a) Risk level;
b) Terrain roughness, height and size of structure; and

c) Local topography.

Vz = Vb k1.k2.k3
Vz = hourly mean wind speed in m/s, at height z
Vb = regional basic wind speed in m/s
k1 = probability factor (risk coefficient) (Table 3.1)
k2 = Terrain and height factor (Table 3.2)
k3 = topography factor

Design wind speed up to 10 m height from mean ground level shall be considered constant.
We have been used the tables and graphs in IS(875-partIII) to calculate the design wind speed and design wind pressure.

3.6 DESIGN WIND PRESSURE (pz):

The design wind pressure can be obtained at any height above mean ground level shall be calculated by the following relationship between wind pressure and wind velocity
Pz = 0.6 Vz^2

3.7 FORCE COEFFICIENT

The value of force coefficientshave been calculated according to the Indian standards and it will apply to a whole structure, we are using a graph in IS(875-partIII) to calculate the values of Cf (force coefficient) with respect to the length, width and height of the building and value of Cf is multiplied by the effective frontal area Ae of the building or structure and by design wind pressure, pa gives the total wind load on that particular building or structure.
F = Cf*Ae*pa
Where F is the force acting in a direction specified in the respective tables and Cf is the force coefficient for the building.
Refer Fig. 3.4 for the value of Cf with respect the value of a=length of building), b=(width of building), h=(height of the building).

3.8 GUST FACTOR METHOD

Application Only the method of calculating load along wind or drag load by using gust factor method is given in the code since methods for calculating load across –wind or other components are not fully matured for all types of structures. However, it is permissible for a designer to use gust factor method to calculate all components of load on a structure using any available theory. However, such a theory must take into account the random nature of atmospheric wind speed.

3.8.1 Hourly mean wind

Use of the existing theories of gust factor method require a knowledge of maximum wind speeds averaged over one hour at a particular location .hourly mean wind speeds at different heights in different terrains is given in Table 3.2. IS 875 3

3.8.2 Along wind Load

Along wind load on a structure on a strip area (Ae) at any height (z) is given by:
Fz = Cf.Ae.pz.G
G =Gust Factor = (peak load/ mean load) and is given by:

$$G = 1 + g_f r \sqrt{[(1 + \emptyset^2)] + \frac{SE}{\beta}}$$

gf = peak factor defined as the ratio of the expected peak value to the root mean value of a fluctuating load,
r = roughness factor which is dependent on the size of the structure in relation to the ground roughness.
B = background factor indicating a measure of slowly varying component of fluctuating wind load.
SE/β= measure of the resonant component of the fluctuating wind load.
S = size reduction factor.
E = measure of available energy in the wind stream at the natural frequency of the structure.
Β = damping coefficient (as a fraction of critical damping) of the structure.

$$\emptyset = \frac{g_f r}{4}\sqrt{B}$$

and is to be accounted only for buildings less than 75 m high in terrain Category 4
and for buildings .less than 25 m high in terrain Category 3, and is to be taken as zero in all other categories.

$$\lambda = \frac{b.c_y}{h.c_z} \text{ and } F_0 = \frac{h.C_z.f_0}{V_h}$$

Cy = lateral correlation constant which may be taken as 10 in the absence of more precise load data,
Cz = longitudinal correlation constant which may be taken as 12 in the absence of more precise load data,
b= breadth of a structure normal to the wind stream,
h = height of a structure,
Vh = Vz = hourly mean wind speed at height z
F_o = natural frequency of the structure, and
L(h) = a measure of turbulence length scale

4. LIMIT STATE OF SERVICEABILITY.

Limit state of serviceability is given in IS-456 and it states that the services of the structures can be calculated according to the clause 35.3 in IS-456, There are 4 combination can make with the earthquake and wind load and deflection have been calculated according to these combinations are given below.

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1) DL+0.8LL+0.8WLX/EQX
2) DL+0.8LL-0.8WLX/EQX
3) DL+0.8LL+0.8WLZ/EQZ
4) DL+0.8LL-0.8WLZ/EQZ

5. DISPLACEMENT IN X-DIR. AND Z-DIR.

Limiting deflection of (H/500) = 300mm for the combinations of limit state of serviceability

MAX. DISPLACEMENT DUE WIND AT 150 METRES HEIGHT				
COMB. OF SERV.	WITHOUT SHEARWALL(MM)		WITH SHEARWALL	
	X-DIR	Z-DIR	X-DIR	Z-DIR
D+0.8L+0.8WLX	880	327	224	89
D+0.8L-0.8WLX	901	335	231	89
D+0.8L+0.8WLZ	38	700	14	251
D+0.8L-0.8WLZ	82	835	16	277

Table-1

It has been observed that after applying earthquake load the displacement increases listed given below:

COMPARISON OF DISPL. B/W EQ AND WL				
COMB. OF SERV.	EARTHQUAKE		WIND LOAD	
	X-DIR	Z-DIR	X-DIR	Z-DIR
D+0.8L+0.8WL/EQX	749	208	224	89
D+0.8L+0.8WL/EQX	767	38	231	89
D+0.8L-0.8WL/EQZ	80	718	14	251
D+0.8L-0.8WL/EQZ	55	548	16	277

Table-2

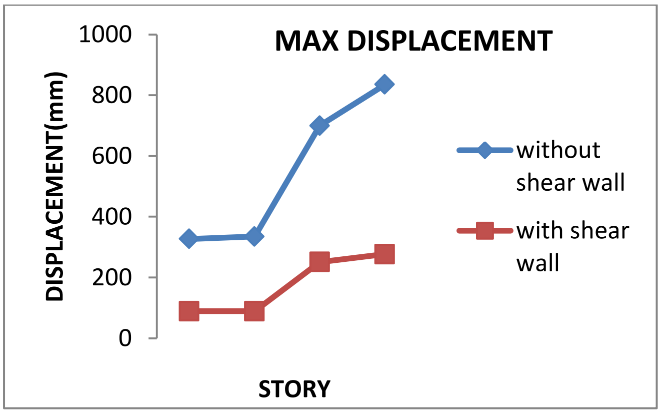

Chart.no.1

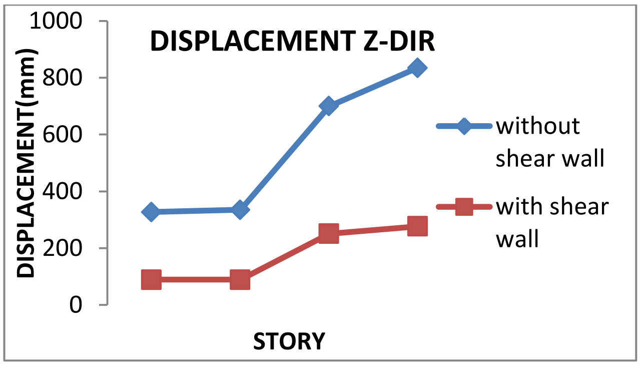

Chart.no.2

6. MAXIMUM DRIFT

Permissible drift as per IS(1893-2002) Earthquake resistant and design is 0.004*H.
So, according to that the allowable drift as per code is (0.004*3.15=0.0126m) and 12.6mm between floor to floor.

7. CONCLUSIONS & RESULTS

1) Shear wall system to be used to control the deflection over the moment resisting frame.

2) Variation of deflection between two system is about 25% observed.

3) The forces Fx and Fz in dynamic analysis is less in comparison to static analysis due to reduction of k2 factor.

4) The variation of the forces between static and dynamic analysis should be around 8-10% .

5) Earthquake forces have been applied and noticed that the earthquake forces governs and majorly affect the structure as given in table 2.

6)Displacement in earthquake forces increases in comparison to wind forces.

7) Finally, there are more shear walls needed to control the deflection of the structure.

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BIOGRAPHY:

(RABI AKHTAR)
M.Tech (Structural & Foundation Engineering)
Department of Civil Engineering
AL-FALAH University, Faridabad
INDIA

SHREE PRAKASH
(Assistant Professor)
Department of Civil Engineering
AL-FALAH University, Faridabad
INDIA

MIRZA AAMIR BAIG
(Assistant Professor)
Department of Civil Engineering
AL-FALAH University,Faridabad
INDIA