

Structural Performance of High Rise Building with RC Structural Wall.

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Abstract-Now RC Structural wall construction in metropolitan cities is widely used. Due to the growing population in India, the new construction technique should be adopted for the faster construction process. Aluform technology in this technique beam and column are replaced by reinforced concrete wall system and whole building is design with RC structural wall i.e. shear wall. It is specially design to allow rapid design of high rise building G+ 24 storey with RC structural wall and its advantages as a structural point of view. For this thesis design software ETABS is used for design and analysis. Analysis is carried out considering the various static and dynamic seismic and wind loads are used. For validation of work we will go for part manual calculation to check correctness of analysis. Then design of system is carried out. Concluding remark will be given with respective high structural performance.

Keywords – High rise building, Aluform Technique, Analysis and Design, ETABS V18.0, Wind load and Seismic load.

1. INTRODUCTION

Population of India is growing fast in urban area or in metro cities. This is the basic reason for increasing land cost in cities. With increasing land cost, it is not surprising that the number of stories in building in urban area across the country is increasing rapidly. Therefore the construction of tall structures such as high rise building, sky scrapers or sky towers is an important indicator of country or city economic and technological strength with the continued development and progress of the economy, technology and material in recent years. In beam column system of buildings reinforced concrete frames are provided in both principal directions to resist vertical loads and the vertical loads are transmitted to vertical framing system i.e. columns and foundations. This type of systems is effective in resisting both vertical & horizontal loads. The lateral load resisting system provided in multi storey building is moment resisting frame, with beams being eliminated in years in majority of the building to simplify and accommodate the use of more economical framework. In recent years R.C. tube structure and R.C. structural wall have been introduced to provide the required stiffness.

1.1 NEED OF RESEARCH

The variation between the supply and the demand mass housing is tremendous. Rapid Urbanization has resulted in a geometric increase in the housing demand, which cannot be fulfilled by conventional column beam method of construction. The traditional or conventional method of construction for affordable housing is comparatively a slow process and limited quality control, particularly when a large size project is involved It is therefore obligatory to work out

A method or scheme where the speed and quality of construction are controlled but a systematic approach. Structures with Structural walls are more earthquake resistant .Therefore aluminum formwork system identified to be suitable for Indian conditions for mass housing. To achieve the value added construction projects without compromising the quality at any cost as the concept of value engineering represented.

Therefore, structural performance of high rise building with structural walls needs to be investigated.

1.2 AIM AND OBJECTIVE OF STUDY

Within the scope of this study, the main objectives of study is to investigate the possibility.

To find parameters like storey displacements, base shear, and relative storey drifts and irregularities of structure under static and dynamic wind and seismic loads. The aim of this study is achieved through the following objectives:

To analyze the structure under dynamic wind and seismic loading and to understand the behavior of structure subjected to lateral loading with the help of time period, frequency, modal mass participating ratio.

1.3. LIMITATION.

Wind and earthquake forces are the most predominant loads that demand lateral design of structures. Large Therefore, buildings should be designed with the earthquake-resistance, comfort and convenience in mind.

2. LITERATURE REVIEW

Rahul b. Mojidral, et.al [12] [2017]: Focused on the Seismic design of buildings, reinforced concrete structural walls, or shear walls, act as major earthquake resisting members. Concrete walls are provided for the additional gravity force resistant. The properties of these seismic shear walls here fore, it is important to evaluate the seismic response of the walls appropriately. In these papers conventional, monolithic with external walls structural systems and monolithic with internal wall system for G+ 20, G+ 25, G+ 30 stories was studied with the help of ETABS V 15 analysis and design. Additional parameters like Lateral displacement, story drift are calculated for both the structures. We concluded that there is drastic improvement in the monolithic structure as compared to conventional structure in term of strength as well as cost.

Ashish Sath, et.al [2018][1] this study the behavior of high rise building against the wind force in wind zone 2nd, L shape is studied and analyzed for specific heights. Also direction of wind plays very vital role in behavior of structure.

M. A. Hube et.al [8][2014] have done analysis of seismic Behavior of RC slender structural wall. Researcher had Mentioned effect of Chile Earthquake on RC structural walls and its damage analysis in year 2010. The objectives of this research is to understand observed damaged in slender walls i.e. crushing of concrete ,buckling and fracture of reinforcement . Recommendations had provided to avoid the lateral displacement and effective stiffness to slender walls.

P. P. Chandurkar [11][2013] had presented study of G + 9 building having three meters height foe each storey. The whole building design had carried out according to IS code for seismic resistant design and the building had considered fixed at base. Structural element for design had assumed as square or rectangular in section .they had done modeling of building using ETAB software in that four different models were different positioning of shear walls.

M.G Rajendran[2][2013] presents the study of comparison of the difference between the wind behavior of building with and without shear wall using Staad Pro. In this paper the Staad model of 15 storey building considered to carry out study with and without shear wall using and also 20 storeys building will model same as it. Displacement of 15 storey building and 20 storey building ith shear wall is 20.18% and 14.60% less than the building without

shear wall. They concluded that building with shear wall will resist wind load effectively.

3. METHODOLOGY AND INVESTIGATION

3.1 Introduction

Study of this work is based on analysis of high rise residential building G+24 storey with RC structural wall by using Etab18.1.0. located in Pune Modeling is done in ETAB18.1.0. Run analysis, results are concluded. Manual Calculation are done to verify the software result.

3.2. Description of the Building

Table 1.1- Description of the Building

Number of storey	G+24 Storey
Floor Height	2.9m
Floor to Floor height	71 .6m
Soil bearing capacity	As per soil report, SBC at a depth of 2m to 7.5m is 40 t/m ² considered
Depth of foundation	2m
Slab thickness	0.125m
Sunk slab thickness	0.1m
Wall thickness	0.2m
Concrete Grade	M40
Steel Grade	FE500

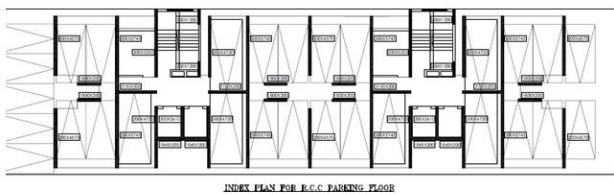
Table 1.2 Seismic, Wind, Dead, Live Loading Parameters

Sr.No.	Parameter	Value
1	Seismic coefficient as per IS:1893-2016	
	Type of Structure	SMRF
	Seismic Zone	III
	Response Reduction Factor	4
	Importance Factor	1

2	Wind Coefficient as per IS:875	
	Design wind speed	39.0 m/s
	Terrain category	3
3	Dead Load	
	Floor Finish (Floors)	1.2KN/m ²
	Floor Finish (Staircase)	3KN/ m ²
	Sunk Slab	9KN/ m ²
4	Live Load	2KN/ m ²
	Floors	2KN/m ²
	Staircase	3KN/ m ²



TYPICAL FLOOR PLAN
Figure.1.1- Typical Floor Plan



INDEX PLAN FOR R.C.C. PARKING FLOOR
Figure 1.2 Structural Layout with RC Structural wall

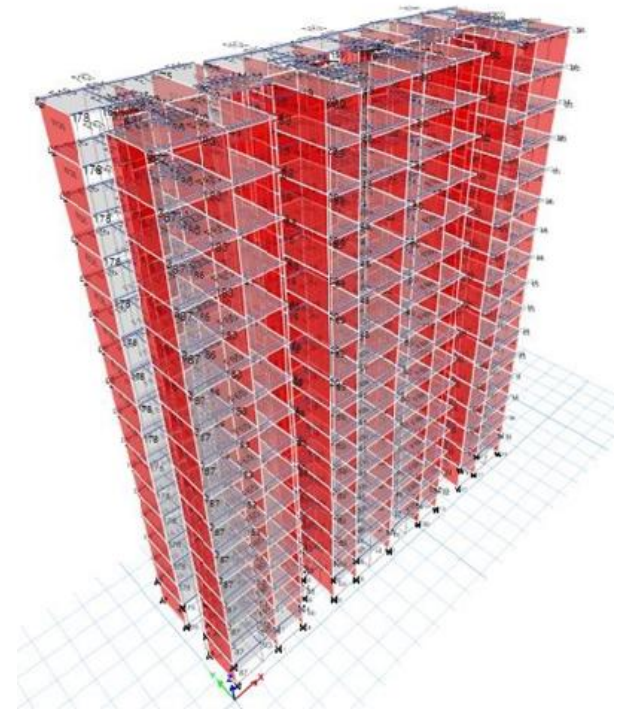


Figure 1.3 – ETAB model with Structural Wall

3.3 Seismic Load

3.3.1. Time Period

Time period will be calculated based on following equation as per IS 1893- 2016 clause no- 7.6.2 i).Time period T is given by following equation, as per IS1893:2016 Clause No.

$$T_a = \frac{0.09h}{\sqrt{d}}$$

Where,

H = height of building and D base dimension of building in meter

ii) Time period for shear wall is calculated by following formula,

$$T = \frac{0.075h^{0.75}}{\sqrt{Aw}}$$

3.3.2 Seismic Weight

W is the seismic weight of the building.

For the purpose of estimating the seismic weight of the building, full dead load and part live load are to be included.

The proportion of live load to be considered is given by IS: 1893 (Part 1) as per Table 10; live load need not be considered on the roofs of buildings in the calculation of design earthquake force.

Since the live load is 2Kn/sqm only 50% of the live load is lumped at the floors.

Hence, the total seismic weight on the floors and the roof is:

$$\text{Floors: } W_1 = W_2 = W_3$$

2.3. Force Distribution with Building Height:

Storey level	Wi (Kn)	hi(m)	Wi*hi*1000	Wihi2/Wihi2	Lateral Force at Level EL in Direction (KN)

3.3.3 Design Base Shear (Vb)

(Vb) = Ah x W.....IS1893:2016 Clause No.7.6.1

Where,

Ah = Design horizontal acceleration

W = Seismic Weight

3.3.4. Design horizontal acceleration (Ah)

Design horizontal acceleration (Ah) or design horizontal base shear coefficient (Ah) of a building is a function of its translational natural periods in the considered direction of design lateral force.

The design horizontal acceleration will be calculated based on following equation as per IS1893-2016 clause no.6.4.2

$$A_h = \frac{\left(\frac{Z}{2}\right) \left(\frac{S_a}{g}\right)}{\left(\frac{R}{I}\right)}$$

Where,

Z = Seismic Zone factor

I = Importance factor I

R = Response reduction factor R

Sa/g = design acceleration coefficient

For different soil type

3.4. Wind Load

High-rise buildings are strongly sensitive to wind loads and wind forces are applied to exposed surfaces of the building

3.4.1. Design wind pressure (Pz)

Wind speed in the atmospheric boundary layer increases with height from at ground level to maximum at a height called the gradient height. The basic wind speed (Vb) shall be modified to include risk level, terrain roughness, height of the structure and local topography to get the design wind velocity Vz. Design wind pressure (Pz) shall be calculated as per the clauses of IS: 875 (Part 3):2015

$$P_z = 0.6 \times V_z^2$$

Where, Vz = Basic wind Velocity

Vb = 39 m/s Basic wind speed for Pune.

$$V_z = K_1 \times K_2 \times K_3 \times K_4 \times V_b$$

Coefficients considered for computing pz

k1 = probability factor = 1

k2 = terrain, height and structure size

Factor >calculated as per the provisions of Clause 6.3.2.2 and Table 2.

k3 = Topography factor = 1.0

k4 = Importance factor = 1.0

Table 1.3- The 'k2' Values for terrain category "3"

Height (m)	K2 Factor
10	0.91
15	0.97
20	1.01
30	1.06
50	1.12
100	1.20
150	1.24
200	1.27

3.4.2. Dynamic Wind Load

Static wind effect primarily causes elastic bending and twisting of structure. For tall, long span and slender structures dynamic analysis of the structure is essential, Wind gusts causes fluctuating forces on the structure which induce large dynamic motions, including oscillations, several failures of structures have occurred in India due to wind. As high-rise being flexible and when subjected to randomly varying wind will it experience wind forces which acts in the direction of wind known as along wind component which results buffeting effects caused by turbulence. As per IS875:2015 clause no. 7.1 Dynamic analysis need to be done, if the aspect ratio i.e. height

to minimum lateral dimension ratio is more than 5 or the natural frequency in the first mode is less than 1.0.Hz. For Calculation of Time Period

3.4.3. Along wind load -

As per IS875:2015 clause no.8.3 and figure 8, figure 9, figure 10, figure 11 We can calculate Gust Factor and dynamic wind. Along wind load on a structure on a strip area (a) at any height (z) is given by,

$$F_z = C_f * A_e * P_z * G$$

Where,

Fz = along wind load on the structure at any height z corresponding to strip area

Cf = force coefficient for the building

Ae = effective frontal area considered for the structure at height z,

Pz = Design pressure at height z due to hourly mean wind obtained as 0.6Vz² (N/m²)

G= Gust factor given by,

$$G = 1 + g_r \sqrt{B(1+\phi)^2 + \frac{SE}{\beta}}$$

3.4.4. Gust Factor

It is the ratio between the peak wind gust of a specific duration to the mean wind speed for a period of time.

Table.1. 4- Gust Wind Load Coefficient

H	=	Total height of main structure of the building in meters above Ground level
B	=	Breadth of a structure in the horizontal plane normal to wind direction
D	=	Maximum base dimension of building in meters In a direction parallel to the applied wind force.
Tx	=	Time period of building /structure in along wind direction (corresponding displaced Mode)
fx	=	1/T
gR	=	Peak factor for resonant

		response
		$\sqrt{[2\ln(3600Xfa)]}$
β	=	Damping Coefficient
k1	=	Probability factor(risk coefficient)
K2	=	Terrain roughness and height factor
K3		Topography factor
k4	=	Importance factor for cyclonic region
Vb	=	Regional wind basic speed.
Vhd	=	Design Hourly mean wind speed at height z
	=	$Vhd = Vb k1 k2 k3 k4$
Pz	=	Wind pressure at height z
	=	$0.60 Vhd^2$
Pd	=	Design Wind Pressure
	=	$Kd Ka Kc pz$
Lh	=	Measure of effective turbulence length scale at height h
N	=	Effective reduced frequency
E	=	Spectrum of turbulence in the approaching wind stream
b0h	=	Average breadth of building between 0 to h
S	=	Size reduction factor $S = \frac{1}{\left[1 + \frac{3.5f_a h}{V_{h,d}}\right] \left[1 + \frac{4f_a b_{0h}}{V_{h,d}}\right]}$
Hs	=	Height Factor for resonance response $H_s = 1 + \left(\frac{z}{h}\right)^2$
gv	=	Peak factor for upwind velocity fluctuation

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.
Ih,i	=	Turbulence intensity at height h in terrain category i
r	=	roughness factor which is twice the longitudinal turbulence intensity (Ih) = 2In
Bs	=	Background Factor indicates the measure of slowly s varying component of fluctuating wind load caused by lower frequency wind speed variations.
ϕ	=	factor to account for second order turbulence intensity $\phi = \frac{g_v I_{hi} \sqrt{B_s}}{2}$
Gx	=	Gust Factor $G = 1 + g_t r \sqrt{\left[B (1+\phi)^2 + \frac{SE}{\rho} \right]}$

Table .1.5 -Hourly mean wind speed factor different heights

Height(m)	K2 factor
Up to 10	0.5
15	0.55
20	0.59
30	0.64
50	0.7

100	0.79
150	0.84
200	0.88
250	0.91
300	0.93
350	0.95
400	0.97
450	0.98
500	0.99

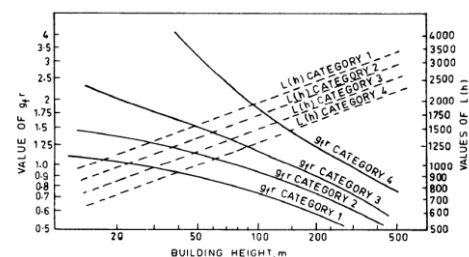


Fig. 8 VALUES OF gfr AND L (h)

Figure..1.4: Value of gfr and L(h)

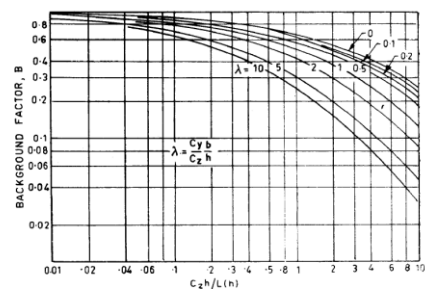


Fig. 9 BACKGROUND FACTOR B

Figure.1.5: Value of background factor

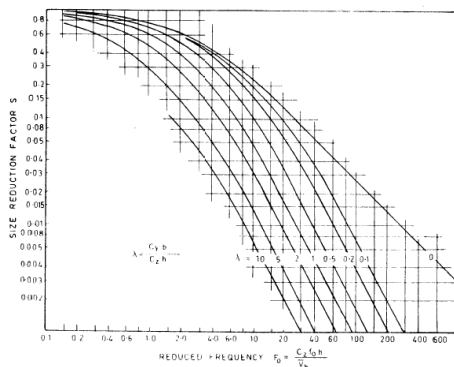


FIG. 10 SIZE REDUCTION FACTOR, S

Figure.1.6: Size reduction factor

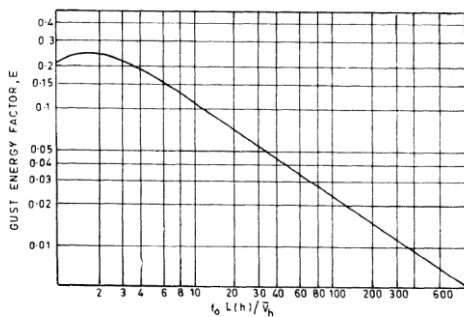


FIG. 11 GUST ENERGY FACTOR, E

Figure. 1.7: Gust Energy Factor

Table .1.6 Gust Factor – X direction

H	Total height of main structure of the building in meters above Ground level	71.60	m
B	Breadth of a structure in the horizontal plane normal to wind direction	3 9 4 8	m
D	Maximum base dimension of building in meters in a direction parallel to the applied wind force.	12.75	m
Tx	0.09 h/sq39.48	1.03	Sec
f0x	1/T	0.97	Sec
L(h)	For H =	1300.00	
g f r	For H =	1.30	
Cy	Lateral correlation const which may be taken as in the absence of m precise load data	10.00	
Cz	Longitudinal correlation	12.00	

	constant which may be taken as 12 in the absence of more precise load data		
LAM DA(X)	Cyb / (Cz H)	0.46	
Czh/L(h)		0.66	
BX	Background factor indicating a measure of slow varying compound of fluctuating wind load & is obtained from fig.9	0.70	
Category	For H =		
Vb	Regional wind basic speed, for Pune	39.00	m/s
k1	Probability factor, for 50 year return period	1.00	
k2	Hourly mean wind speed factor (see table 33)	0.74	
k3	Topography factor, for flat terrain	1.20	
V1h	Hourly mean wind speed at height z		
	V1z = Vb k1 k2 k3	34.63	m/s
pz1	Design pressure at height z due to hourly mean wind		
	0.60 Vz2	719.63	N/m ²
F0	Czf0h/V1h	24.09	
SX	Size reduction factor fig 10	0.12	
f0L(h)/V1h		36.44	
E	Measure of available energy in the wind stream at the natural frequency of the structure (fig 11)	0.01	
Beta	Damping coefficient – for RC structures	0.016	
f	(g f r B0.5)/4		
	0.00 for building higher than 25m in category – 3	0.00	
GX	guest factor		
	1 + g f r [B(1+f)2 + SE/b]0.5	2.14	

Table.1.7. Gust Factor – Y direction

H	Total height of main structure of the building in meters above Ground level	71.60	m
B	Breadth of a structure in the horizontal plane normal to wind direction	12.75	m
D	Maximum base dimension of building in meters in a direction parallel to the applied wind force.	39.45	m
Ty	0.09		
f0y	$h/\sqrt{12.75}$	1.80	Sec
L(h)	For H =71.6m value is obtained from fig. 8	1300.00	
gfr	For H =71.6m value is obtained from fig. 8	1.30	
Cy	Lateral correlation constant which may be taken as 10 in the absence of more precise load data	10.00	
Cz	Longitudinal correlation constant which may be taken as 12 in the absence of more precise load data	12.00	

LAMDA(X)	Cyb / (Cz H)	0.15	
Czh/L(h)		0.66	
BX	Background factor indicating a measure of slow varying compound of fluctuating wind load & is obtained from fig.9	0.01	
Category	For H = 71.6m	3	
Vb	Regional wind basic speed, for pune	39.00	m/s
k1	Probability factor, for 50 year return period	1.00	
k2	Hourly mean wind speed factor (see table 33)	0.74	
k3	Topography factor, for flat terrain	1.20	
V1h	Hourly mean wind speed at height z		
	$V1z = Vb k1 k2 k3$	34.63	m/s
pz1	Design pressure at height z due to hourly mean wind		
	$0.60 Vz^2$	719.63	N/m ²
F0	$Czf0h/V1h$	13.75	
SX	Size reduction factor fig 10	0.13	
f0L(h)/V1h		20.80	
E	Measure of available energy in the wind stream at the natural frequency of the structure (fig 11)	0.12	
Beta Bd	Damping	0.016	

	coefficient - for RC structures		
f	$(g f r B 0.5) / 4$		
	0.00 for building higher than 25m in category - 3	0.00	
GY	guest factor		
	$1 + g f r$ $[B(1+f)2 +$ $SE/b]0.5$	2.29	

Table.1.8: Dynamic wind load calculation

S t o r e y	He i g h t	Cum.H t	K2	Gx	Gy	Pz	Fx	Fy
24	2.9	71.6	0.744	2.55	2.51	505.293	67.542	207.270
23	2.9	68.7	0.739	2.53	2.51	498.228	67.542	204.352
22	2.9	65.8	0.743	2.53	2.51	491.213	66.591	201.454
21	2.9	62.9	0.728	2.53	2.51	484.288	65.647	198.578
20	2.9	60.0	0.723	2.53	2.51	477.333	64.709	195.721
19	2.9	57.1	0.718	2.53	2.51	470.467	63.779	195.721
18	2.9	54.2	0.713	2.53	2.49	463.651	62.855	192.886
17	2.9	51.3	0.708	2.53	2.49	456.885	61.937	188.679
16	2.9	48.4	0.702	2.51	2.49	450.169	61.027	185.906
15	2.9	45.5	0.695	2.51	2.49	441.062	59.398	182.145
14	2.9	42.6	0.687	2.51	2.49	430.092	57.921	177.615
13	2.9	39.7	0.678	2.51	2.09	419.260	56.462	173.141
12	2.9	36.8	0.669	2.51	2.09	408.566	55.022	141.601
11	2.9	33.9	0.660	2.5	2.09	398.011	53.600	137.942
10	2.9	31	0.652	2.5	2.09	387.593	51.847	134.332
9	2.9	28.1	0.643	2.5	2.09	377.314	50.472	130.769
8	2.9	25.2	0.631	2.48	2.09	362.786	48.529	125.734
7	2.9	22.3	0.616	2.48	2.09	346.292	46.006	120.017
6	2.9	19.4	0.602	2.46	2.09	330.181	43.865	114.434
5	2.9	16.5	0.585	2.09	2.09	312.528	41.231	108.316
4	2.9	13.6	0.562	2.09	2.09	288.874	32.262	99.898
3	2.9	10.7	0.539	2.09	2.09	264.933	29.563	91.280
2	2.9	7.8	0.553	2.09	2.09	278.879	25.253	79.072
1	2.9	4.9	0.5	2.09	2.09	288.150	21.574	66.802
G	2.0	2	0.5	2.09	2.09	288.150	8.806	27.266