Analysis and comparison of wind and seismic load for multi-storey RCC building (G+20)

(For Gopalpur, Odisha Location)

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Abstract: All Residential, Commercial and Plant RCC and STEEL buildings designed as per the load applied at the buildings. Dead and live loads are the load which are continuously works at the buildings but Wind and Seismic loads are the load that comes all of sudden and sudden works at buildings it may be safe and may be damaged due to the wind and seismic load. Here we will analysis the REINFORCED CONCRETE STRUCUTRE (G+20) Building with effects of wind load and seismic loads including Dead and live loads and we will compare the Wind and seismic load for Building frame, that which load is critical Wind or Seismic. For analysis and comparison we will use STAAD PRO, software and manual calculations as per the India standards.

***Keywords*: RCC building analysis, Wind load, Seismic load, Load comparison.**

I. INTRODUCTION

This document covers the analysis and comparison of wind and seismic load for multistorey RCC Building. This document covers the analysis and comparison of wind and seismic load for multi-storey RCC Building. The RCC multi-storey building is G+20 story building with 24.76m (c/c) length and 10.49m width (c/c) total height of building is 84.00m and floor to floor distance is 4.00m. The building is designed using the structural analysis software package STAAD.Pro V8i and in-house MS-Excel Sheets. The analysis is performed for self-weight of structural members, other Dead Load on the members, Live Load, Wind load & Seismic Loads. Various possible load combinations of the above loads are listed in accordance with IS-456:2000.

II. MATERIAL PROPERTIES AND LOCATION

Material	Property	Value	Units
Concrete, M30	Density	25	kN/cum
	Characteristic Strength	30	N/sq mm
	Modulus of Elasticity	25000	N/sq mm
	Specification	IS 456	
High Strength Reinforcing Steel (TMT)	Density	78.5	kN/cum
	Characteristic Strength	500	N/sq.mm
	Modulus of Elasticity	200000	N/sq.mm
	Specification	IS 1786	

Location of building : Gopalpur, Odisha.
Basic wind speed : 50.0 m/s (180 km/h). (As per IS 875-Part 3 - 2015)
Seismic Zone : Zone II

III. EASE OF USE DISCRIPTION OF STRUCUTRE AND GEOMETRY

The Rcc multistorey building is G+20 story building with 24.807m (c/c) length and 11.96m width (c/c) total height of building is 84.00m and floor to floor (c/c) distance is 4.00m. Columns are used RCC type columns and RCC type beams with sections as below:-

Columns = 800X1000mm
Beams = 450X700mm

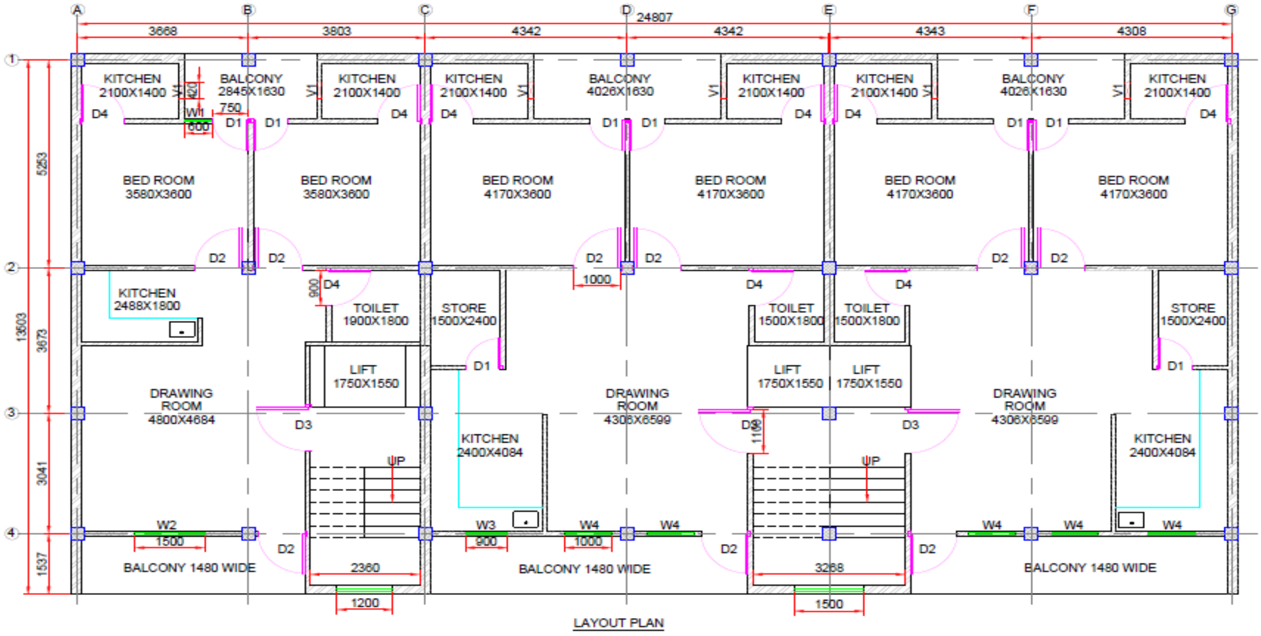

Fig. : Layout plan of building

IV. DESIGN PHILOSPHY

The Building is designed using the structural analysis software package STAAD. Pro V8i and in-house MS-Excel Sheets. The analysis is performed for self-weight of structural members, other Dead Load on the members, Live Load & Seismic Loads. Various possible load combinations of the above loads are listed in accordance with IS-456:2000.

V. BASIC LOADS

DEAD LOAD

Self-Weight:
Self-weight of Beams, Columns be calculated by STAAD.Pro inbuilt command.
Wall Loads:
On plinth beams for 230mm thick Brick wall = 3.75 * 0.23 * 18 = 15.525 kN/m
On plinth beams for 115mm thick Brick wall = 3.75 * 0.115 * 18 = 7.763 kN/m
Roof Loads:
Load has been considered as per the specification
Floor load (Slab Load) = 0.125*25+1.2 = 4.325 KN/sqm
Load due to Parapet Wall =0.5*0.115*18 =1.035 KN/m
Water Tank = 20.0kN Point Load.

LIVE LOAD

Live Load on full accessible Roof = 3 kN/m2 (Reference Code – IS 875-Part2)

i) RESIDENTIAL BUILDINS	
a) Dwelling houses:	
1) All rooms and kitchens	2·0
2) Toilet and bath rooms	2·0
3) Corridors, passages, staircases including fire escapes and store rooms	3·0
4) Balconies	3.0
b) Dwelling units planned and executed in accordance with IS : 8888-1979* only:	
1) Habitable rooms, kitchens, toilet and bathrooms	1·5
2) Corridors, passages and staircases including fire escapes	1·5
3) Balconies	3·0

IS 875-Part2 (Live Load)

SEISMIC LOAD

Seismic Load on structure is calculated as per IS 1893-Part 1 in staad pro.
Seismic zone = II

Response Reduction Factor, R = 5.0
Structure Type = RC Frame Building
Damping Ratio = 5%
Seismic load in STAAD is defined by using in-built Seismic Definition function.

6.4.2 The design horizontal seismic coefficient A_h for a structure shall be determined by the following expression:

$$A_h = \frac{Z\, I\, S_a}{2\, R\, g}$$

Provided that for any structure with $T \leq 0.1$ s, the value of A_h will not be taken less than $Z/2$ whatever be the value of I/R

where

Z = Zone factor given in Table 2, is for the Maximum Considered Earthquake (MCE) and service life of structure in a zone. The factor 2 in the denominator of Z is used so as to reduce the Maximum Considered Earthquake (MCE) zone factor to the factor for Design Basis Earthquake (DBE).

I = Importance factor, depending upon the functional use of the structures, characterised by hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance (Table 6).

R = Response reduction factor, depending on the perceived seismic damage performance of the structure, characterised by ductile or brittle deformations. However, the ratio (I/R) shall not be greater than 1.0 (Table 7). The values of R for buildings are given in Table 7.

S_a/g = Average response acceleration coefficient

Horizontal Seismic coefficient

7.5.3 *Design Seismic Base Shear*

The total design lateral force or design seismic base shear (V_B) along any principal direction shall be determined by the following expression:

$$V_B = A_h W$$

where

A_h = Design horizontal acceleration spectrum value as per 6.4.2, using the fundamental natural period T_a as per 7.6 in the considered direction of vibration; and

W = Seismic weight of the building as per 7.4.2.

Base Shear

WIND LOAD

Wind Load on structure is calculated as per IS: 875 (Part-III)-2015.

Table: - Wind load calculation

Wind Pressure Calculation					
Basic Wind Speed	=	180.00	kmph		
Basic Wind Speed	=	50	m/sec		
Design Period	=	100	years		
Terrain Category	=	1			
Class		4			
Total Height of building	=	84	m		
		Length	Width	Nos	
Building Dimension	=	24807	13503	1	
Risk Co-efficient,k1	=	1.08	**(As per Table-1, IS-875,part-3)**		
Terrian Factor, k2	=	1.26	**For Terrain Category 1**		
Topography factor,k3	=	1.00	**(As per Table-2 of IS: 875 Part 3- 1987)**		
Importance factor,k4	=	1.30	**(Refer IS-875,part-3 clause-6.3.4)**		
Design Wind Speed, Vz=k1*k2*k3*k4=	=	88.45	**m/sec**		
Design Wind pressure, Pz =0.6*(Vz)^2=	=	4694.25	**N/sqm**		
As per Latest code IS : 875 (Part-3-2015)					
The design wind pressure pd can be obtained as as per clause 4.5.2(pd = Kd. Ka. Kc .Pz)					
Where,					
Wind directionality factor,kd	=	1.00	**(Refer clause-7.2.1, In IS-875-part-3)**		
Area of Building	=	334.97	**≥100**		
Area averaging factor, ka	=	0.8	**(if this area is >= 25 than Ka = 0.9)**		
Combination factor,kc	=	1	**(Refer clause-7.3.3.13, In IS-875-part-3)**		
Design pressure shall be, pd = Kd. Ka. Kc . Pz=	=	3755.40	**N/sqm**		

Table 1 Risk Coefficients for Different Classes of Structures in Different Wind Speed Zones
(*Clause* 6.3.1)

Sl No.	Class of Structure	Mean Probable Design Life of Structure in Years	k_1 Factor for Basic Wind Speed m/s					
			33	39	44	47	50	55
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	All general buildings and structures	50	1.0	1.0	1.0	1.0	1.0	1.0
ii)	Temporary sheds, structures such as those used during construction operations (for example, formwork and false work), structures during construction stages and boundary walls	5	0.82	0.76	0.73	0.71	0.70	0.67
iii)	Buildings and structures presenting a low degree of hazard to life and property in the event of failure, such as isolated towers in wooded areas, farm buildings other than residential buildings	25	0.94	0.92	0.91	0.90	0.90	0.89
iv)	Important buildings and structures such as hospitals communication buildings/towers, power plant structures	100	1.05	1.06	1.07	1.07	1.08	1.08

7.2 Design Wind Pressure

The wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind speed:

$$p_z = 0.6\ V_z^2$$

where

p_z = wind pressure at height z, in N/m²; and

V_z = design wind speed at height z, in m/s.

The design wind pressure p_d can be obtained as,

$$p_d = K_d\ K_a\ K_c\ p_z$$

where

K_d = wind directionality factor,

K_a = area averaging factor, and

K_c = combination factor (*see* **7.3.3.13**).

The value of p_d, however shall not be taken as less than 0.70 p_z.

VI. LOAD CASES AND COMBINATIONS

LOAD CASES:-

Load Case -1: Seismic Load in X-dir (X-DIR)
Load Case -2: Seismic Load in Z-dir (Z-DIR)
Load Case -3: Dead Load (DL)
Load Case -4: Live Load (LL)

Load Case -5: Wind Load in +X-dir
Load Case -6: Wind Load in -X-dir
Load Case -7: Wind Load in +Z-dir
Load Case -8: Wind Load in -Z-dir

LOAD COMBINATIONS:-

Limit State of serviceability:-
LOAD COMB 101 1*DL+1*LL
LOAD COMB 102 1*DL+1*SX
LOAD COMB 103 1*DL+(-1)*SX
LOAD COMB 104 1*SZ+1*DL
LOAD COMB 105 -1*SZ+1*DL
LOAD COMB 106 0.8*SX+1*DL+0.8*LL
LOAD COMB 107 -0.8*SX+1*DL+0.8*LL
LOAD COMB 108 0.8*SZ+1*DL+0.8*LL
LOAD COMB 109 -0.8*SZ+1*DL+0.8*LL
LOAD COMB 110 1*DL+1*WX
LOAD COMB 111 1*DL+1*-WX
LOAD COMB 112 1*WZ+1*DL
LOAD COMB 113 1*-WZ+1*DL
LOAD COMB 114 0.8*WX+1*DL+0.8*LL
LOAD COMB 115 0.8*-WX+1*DL+0.8*LL
LOAD COMB 118 0.8*WZ+1*DL+0.8*LL
LOAD COMB 119 0.8*-WZ+1*DL+0.8*LL

Limit State of collapse/Strength:-
LOAD COMB 201 1.5*DL+1.5*LL
LOAD COMB 202 1.5*SX+1.5*DL
LOAD COMB 203 -1.5*SX+1.5*DL
LOAD COMB 204 1.5*SZ+1.5*DL
LOAD COMB 205 -1.5*SZ+1.5*DL
LOAD COMB 206 1.5*SX+0.9*DL
LOAD COMB 207 -1.5*SX+0.9*DL
LOAD COMB 208 1.5*SZ+0.9*DL
LOAD COMB 209 -1.5*SZ+0.9*DL
LOAD COMB 210 1.2*SX+1.2*DL+1.2*LL
LOAD COMB 211 -1.2*SX+1.2*DL+1.2*LL
LOAD COMB 212 1.2*SZ+1.2*DL+1.2*LL
LOAD COMB 213 -1.2*SZ+1.2*DL+1.2*LL
LOAD COMB 214 1.5*WX+1.5*DL
LOAD COMB 215 1.5*-WX+1.5*DL
LOAD COMB 216 1.5*WZ+1.5*DL
LOAD COMB 217 1.5*-WZ+1.5*DL
LOAD COMB 218 1.5*WX+0.9*DL
LOAD COMB 219 1.5*-WX+0.9*DL
LOAD COMB 220 1.5*WZ+0.9*DL
LOAD COMB 221 1.5*-WZ+0.9*DL
LOAD COMB 222 1.2*WX+1.2*DL+1.2*LL
LOAD COMB 223 1.2*-WX+1.2*DL+1.2*LL
LOAD COMB 224 1.2*WZ+1.2*DL+1.2*LL
LOAD COMB 225 1.2*-WZ+1.2*DL+1.2*LL

VII. ANALYSIS RESULT

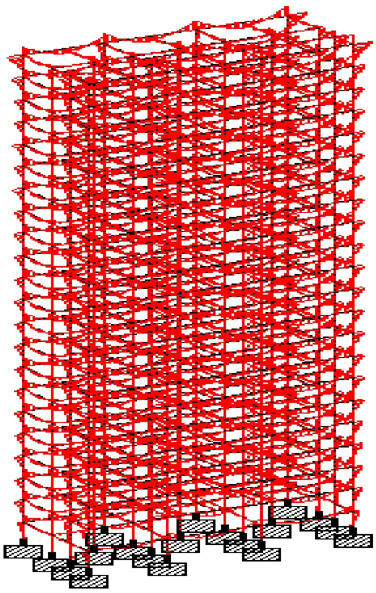

Fig: Beam Forces of Building Frame

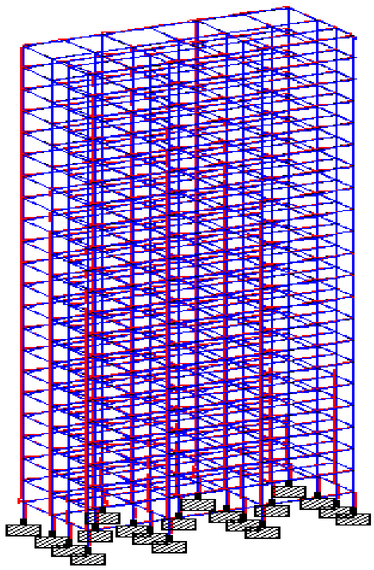

Fig: Beam Stresses of Building Frame

Table: - Analysis results summary for column and beams

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	23	204 1.5*SZ+1.5*DL	23	18421	-5.173	-457.2	2.498	1793.858	-13.757
Min Fx	25	209 -1.5*SZ+0.9*DL	50	-5420	23.343	441.8	-5.914	-471.716	-33.797
Max Fy	189	217 1.5*-WZ+1.5*DL	95	66.971	907.18	5.042	0.841	-6.211	1274.759
Min Fy	189	216 1.5*WZ+1.5*DL	101	31.959	-948.4	-4.523	-0.969	-8.292	1413.348
Max Fz	148	221 1.5*-WZ+0.9*DL	67	4196	4.372	748.82	-8.054	-1652.22	9.669
Min Fz	148	216 1.5*WZ+1.5*DL	67	9683.2	-1.539	-768.5	7.962	1682.717	-2.646
Max Mx	377	204 1.5*SZ+1.5*DL	177	-2.364	118.97	-1.367	146.222	5.016	204.293
Min Mx	411	204 1.5*SZ+1.5*DL	190	-1.959	31.73	-0.578	-141.52	0	0
Max My	17	216 1.5*WZ+1.5*DL	17	10141	-1.576	-662.4	5.865	2040.864	-8.304
Min My	17	221 1.5*-WZ+0.9*DL	17	4947.4	3.002	655.94	-5.862	-2048.021	14.558
Max Mz	400	205 -1.5*SZ+1.5*DL	174	-16.15	883.2	1.542	0.84	-3.243	1524.222
Min Mz	20	203 -1.5*SX+1.5*DL	20	9909.6	-575.3	-34.05	1.824	14.56	-1497.37

VIII. ECCENTRICITY AND DEFLECTION CHEKCS

Eccentricity check of column –

25.4 Minimum Eccentricity

All columns shall be designed for minimum eccentricity, equal to the unsupported length of column/ 500 plus lateral dimensions/30, subject to a minimum of 20 mm. Where bi-axial bending is considered, it is sufficient to ensure that eccentricity exceeds the minimum about one axis at a time.

As per definition:-

For depth = L/500 + d/30 = 4000/500 + 800/30 = 8+ 26.6 = 34.6 > 20 Hence OK
For width = L/500 + b/30 = 4000/500 + 1000/30 = 8+ 33.3 = 41.3 > 20 Hence OK

Deflection check in beam –

23.2.1 The vertical deflection limits may generally be assumed to be satisfied provided that the span to depth ratios are not greater than the values obtained as below:

a) Basic values of span to effective depth ratios for spans up to 10 m:

Cantilever	7
Simply supported	20
Continuous	26

Beam depth = 700mm, Beam width = 450mm, Length of beam = 5250mm
So, span to depth ratio = 5250/450 = 11.66 < 26 Hence OK

IX. COMPARISON AND RESULT

Wind and seismic loads are main loads which effects the structure most and as per the IS code and general practice we cannot take both load cases in single load combination. These both loads have hazardous with the structure so here as per our design we will compare the both loads effect at the RCC frame and for that we will compare the forces and reactions of the frame for wind and seismic load combinations.

Table: - Max and Min reactions for wind and seismic load combinations

Combinations	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Wind loads	MAX	198.94	10720	435.60	1365.199	9.495	512.462
	MIN	-197.71	56.70	-441.57	-1360.57	-9.887	-507.64

Combinations	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Seismic Loads	MAX	383.5	12280.8	395.5	1289.1	6.3	991.2
	MIN	-376.5	-1626.8	-403.5	-1291.4	-6.0	-998.2

Table: - Wind and Seismic load effectiveness result

		Siesmic load reactions	=	Wind load reactions
Fx kN	MAX	383.562	>	198.945
	MIN	-376.541	>	-197.715
Fy kN	MAX	12280.859	>	10720.354
	MIN	-1626.885	>	56.701
Fz kN	MAX	395.535	<	435.603
	MIN	-403.596	<	-441.573
Mx kN-m	MAX	1289.105	<	1365.199
	MIN	-1291.406	<	-1360.576
My kN-m	MAX	6.358	<	9.495
	MIN	-6.033	<	-9.887
Mz kN-m	MAX	991.224	>	512.462
	MIN	-998.248	>	-507.649

X. CONCLUSION

1. The Effective parameters for wind load affecting any building are subjected to the area to wind as well as pressure of wind defined by the code according to its location.

2. The Effective parameters for seismic load affecting any building are subjected to the zone factor according to its location, importance of building, the kind of structural frame, the period coefficients according to the dimension of the building frame, type of soil and weight of the structure.

3. The results shows in this thesis shows that compression and tension are higher for earthquake then the wind load, Horizontal forces in long span higher for the seismic load and horizontal forces in short span higher for the wind load.

4. The ductile detailing recommended for the effect of seismic load and bracing or extra members required for the effect of seismic load.
5. The building systems consists of shear walls and structural frames, shear walls dominate the calculation of lateral forces especially when the shear wall comes in the direction of horizontal forces are suitable. So it is noted that the shear wall take care of the horizontal forces and columns can be neglected.

6. Wind load is more effective than earthquake for the buildings when wind zone is higher than the seismic zone, Seismic load is more effective than wind load for the building when seismic zone is higher and then the wind zone.

7. The effect of the wind and loads increases according the height of the building increases.

8. The structural frame building shall be design independently for the both directions with the critical forces of wind load and seismic loads separately.

9. For ductile detailing we should prefer IS 13920-2016 (Ductile design and detailing of reinforced concrete structures subjected to seismic forces – code of practice)

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