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Study of Seismic and Wind Effect on Multi-Storey R.C.C. Building using ETABS

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Abstract - *Nowadays, there are wide range of complicated and irregular structures that are analyzed and designed to resist the earthquake and wind load. This structures can be analyzed and designed by varied softwares like ETABS, STAAD Pro, TEKLA etc. Structural analysis is a branch that involves in determination of behavior of structures so as to predict the responses of various structural parts due to loading. Each structure is subjected to either one or combination of loads like gravity load, earthquake load and wind load. ETABS stands for Extended 3 Dimensional Analysis of Building System. ETABS software could be used for analysis of static, dynamic, linear and non-linear, etc. responses of structure and design of structures. In the present paper, effect of height of building on base shear, lateral force generated due to earthquake and wind load is evaluated using ETABS software. The study includes modelling and analysis of building by using ETABS software, and comparing wind load and earthquake load at different storeys. From the analysis, the minimum height of building at that the wind load dominates over earthquake load is discerned.*

Key Words: **ETABS, STAAD Pro, TEKLA, Gravity load, Structural analysis, Base shear, Lateral force**

1.INTRODUCTION

All building structures have various structural components like slabs, beams, columns and foundation. All these components are analyzed for different combination of loads and are designed to resists these loads without failure for its intended life. There are mainly two types of loads coming on structure are vertical load and horizontal/lateral load. Vertical load consists of dead load and live load whereas lateral load consist of wind and earthquake load. Both wind and earthquake loads are dynamically applied loads. Earthquake/ seismic load are the acceleration produced in structure during earthquakes. There are various methods of computing earthquake forces like seismic co-efficient method, time-history method, etc. Other type of lateral force is wind load. Wind is a mass of air that moves in a horizontal direction from an area of high pressure to an area of low pressure. High winds generate great pressure against the surface of structure and can be destructive. This intensity of pressure is wind load. Structures which comes under seismic zones or are subjected to wind pressure are analysed for this loads also along with normal dead load and live load and shear force and bending moment on each component is evaluated. Nowadays, structures are analysed and designed by using various software Like ETABS, STAAD PRO, TEKLA, etc. due to its advantages like accuracy, time saving etc. and thus proves to be economical.

ETABS is the abbreviation of "Extended 3D Analysis of building System. ETABS is a product of Computer and structures, Inc. and is globally used for structural analysis and design of various types of structures. ETABS enables 3D object modelling, visualization tools, linear and non-linear analysis, static and dynamic analysis, sophisticated design for various types of materials. Thus ETABS is an integrated software package for design which ranges from simple 2D frames to modern high rise buildings. In this report, an irregular building is analyzed at different storeys. In these effects of building on base shear, lateral forces generated due to earthquake load and wind load is evaluated using ETABS software. This study includes modelling of building using ETABS software. Then building is analyzed by considering following loads:

1) Dead load 2) Live load 3) Earthquake load 4) Wind load

By considering different load combination the base shear, shear forces and bending moment coming on the structure are evaluated at various storeys. Results of wind load and earthquake load are compared at various heights. The minimum height of building at which the wind load dominates over earthquake load is found out.

1.1 Objectives

1. The main objective of this study is to analyse a residential building for earthquake and wind loads by using ETABS software.
2. Comparison of wind and earthquake load which are obtained from ETABS software at various storeys.
3. Determination of the minimum height at which wind load becomes dominant over earthquake load.

2. LITERATURE REVIEW

1. **Baldev Prajapati et.al (2013) -** "Study of Seismic and Wind Effect on Multi-storey R.C.C, Steel and Composite Building." In this paper, analysis and design of symmetric high rise (G+30) of RCC, steel and composite building under the effect of wind and earthquake load is analysed and designed using the

ETABS software. In all buildings shear wall is provided to resist the lateral forces. They concluded that the steel-concrete composite building is better option.

2. **Abhay Guleria (2014) -** "Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations." In this paper, structural behaviour of a 15-storey R.C.C framed building with different structural configuration is analysed using ETABS software. Different plan configuration considered are rectangular, C, L and I-shape. The analysis showed that the storey overturning moment varies inversely with storey height. Moreover, L-shape, I-shape type buildings gave similar response against overturning moment.
3. **Rajeshwari Patil et.al (2017) -** "Analysis and Design of Residential Building by using SAP-2000". In this paper, analysis of and RCC framed 3 storey building is done using SAP2000 software. By using the analysis data by SAP2000, the structural components are then designed manually using IS 456 and SP-16 charts.
4. **Chandrashekar et.al (2015)** – "Analysis and Design of Multi-Storied Building by Using ETABS Software." In this paper, analysis and design G+5 storey building under the lateral loading effect of wind and earthquake is done by using ETABS. They have also taken in consideration the occurrence of spread of fire and importance of use of fire-proof material.
5. **D. Ramya et.al (2015) -** "Comparative Study on Design and Analysis of Multi-storeyed Building (G+10) by STAAD.PRO and ETABS software." In this paper, design of multi-storeyed (G+10) building is done by using ETABS and STAAD-Pro. Comparative study is done of both design and finally economical section is found out for G+10 multi-storeyed building.

3. PROBLEM STATEMENT

A multi-storey irregular structure is considered for the study. Modelling and analysis of structure is done on ETABS software at each storey, so as to determine the minimum height at which wind load becomes dominant over earthquake load in both 'X' and 'Y' direction.

3.1 Preliminary Data

a) Location – Mumbai b) Beam – 230mm x 600mm

c) Column – 230mm x 600mm

d) Slab thickness: (1) Slab – 100mm (2) Staircase slab - 125mm

e) Thickness of external wall – 150 mm f) Thickness of internal wall – 100 mm g) Grade of concrete - M25

h) Grade of steel – HYSD 500 i) Use of aerated block with density 7.5 KN/m3

Load acting on structure are;

a) Dead load b) Live load

c) Wind load in 'X' and 'Y' direction d) Earthquake load in 'X' and 'Y' direction

- Live load consideration – 2 KN/m

a) Zone factor (Z) = 0.16 b) Soil type = III

c) Response reduction factor (R) = 5.0

d) Importance factor = 1.0

e) Wind Speed = 44 m/s

f) Terrain category = 1.0

g) Structure Class = B

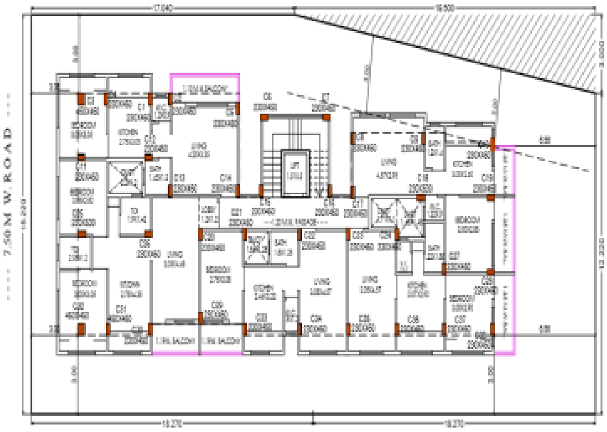

Fig- 1: Plan of building

4. METHODOLOGY

Following are the various steps used to solve the above problem;

A) Modelling

B) Defining of properties

C) Calculation of various load

D) Defining and assigning of various load (DL, LL, EL, WL) and load combinations

E) Check model and run analysis

F) Result analysis and comparison of WL and EL

G) Conclusion

5. CALCULATIONS

5.1 Calculation of force co-efficient for 11th, 10th, 9th, 8th, 7th, 6th, 5th storey

- Width of Building (w) = 10.720 + 8.870/2
  = 9.795m
- Length of Building (l) = 29.680m

Table-1: Building Height Ratio

Sr.no.	Storey No.	Height (m)	h/w ratio
1.	11th	33	33 / 9.795 = 3.369
2.	10th	30	30 / 9.795 = 3.062
3.	9th	27	27 / 9.795= 2.7 2.756
4.	8th	24	24 / 9.795 = 2.45
5.	7th	21	21 / 9.795 = 2.143
6.	6th	18	18 / 9.795 = 1.837
7.	5th	15	15 / 9.795 = 1.53

- From table 4 IS 875(part 3)-1987 for all above storey, building height ratio lies in between, (3/2) < (h/w) < 6.
- Building plan ratio l/w = 29.680/9.795
  = 3.03
- From table 4 IS 875(part 3)-1987 building plan ratio lies between (3/2) < (l/w) <4.
- Therefore, the external force co-efficient for above all above storey is taken for building height ratio (3/2) < (h/w) < 6 and building plan ratio (3/2) < (l/w) < 4 from IS 875 (part 3) – 1987.

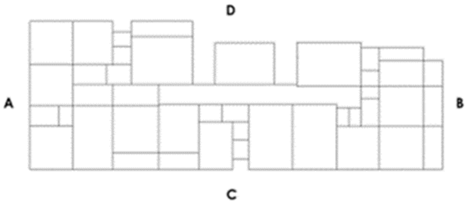

Fig- 2: Faces of plan considered

Table-2: External pressure coefficients (C_{pe}) for walls of rectangular clad building

Wind Angle	C_{pe} for surface			
ɵ	A	B	C	D
0°	+0.7	-0.4	-0.7	-0.7
90°	-0.5	-0.5	+0.8	-0.1

- **Internal pressure coefficient (C_{pi})** = ±0.5
  (From Cl.6.2.3.2 IS 875 (part 3)-1987)

Table-3: Force coefficient for 11th, 10th, 9th, 8th, 7th, 6th, 5th storey

Wind Angle	C_f for surface			
ɵ	A	B	C	D
0°	1.2	0.9	1.2	1.2
90°	1.0	1.0	1.3	0.6

- Now, this above force co-efficient are assigned on surface walls with their respective direction.

5.2 Base Shear (KN) results for 11th, 10th, 9th, 8th, 7th, 6th, 5th storey

Table-4: Base shear results (KN) for 11th, 10th, 9th, 8th, 7th, 6th and 5th storey

Load Combination	**11 th storey**	**10 th storey**	**9th storey**	**8th storey**
1.5DL	-	-	-	-
1.5(DL+IL)	-	-	-	-
1.2(DL+IL+W_X)	1042	932.23	824.42	718.33
1.2(DL+IL-W_X)	1041	932.23	824.42	718.33
1.2(DL+IL+W_Y)	2733	2446	2163	1885
1.2(DL+IL-W_Y)	2732.7	2445.7	2162.8	1884.5
1.2(DL+IL+$W_{(-X)}$)	1013	907.91	802.92	699.59
1.2(DL+IL-$W_{(-X)}$)	1013.2	907.91	802.92	699.59
1.2(DL+IL+$W_{(-Y)}$)	2732.4	2445.4	2162.6	1884.3
1.2(DL+IL-$W_{(-Y)}$)	2732	2445	2163	1884
1.5(DL+W_X)	1302	1165	1031	897.91
1.5(DL-W_X)	1302.03	1165.29	**1030.53**	897.91
1.5(DL+W_Y)	3416	3057	2704	2356
1.5(DL-W_Y)	3415.8	3057	2703.5	2355.6
1.5(DL+$W_{(-X)}$)	1267	1134.8	1003.6	874.49
1.5(DL-$W_{(-X)}$)	1266.5	1135	1004	874.49
1.5(DL+$W_{(-Y)}$)	3415.5	3056.7	2703.2	2355.3
1.5(DL-$W_{(-Y)}$)	3416	3057	2703	2355
(0.9DL+1.5W_X)	1302	1165	1031	897.91
(0.9DL-1.5W_X)	1302.0	1165.2	1030.5	897.91
(0.9DL+1.5W_Y)	3416	3057	2704	2356
(0.9DL-1.5W_Y)	3415.8	3057.1	2703.5	2355.6
(0.9DL+1.5$W_{(-X)}$)	1267	1134.8	1003.6	874.49
(0.9DL-1.5$W_{(-X)}$)	1266.5	1135	1004	874.49
(0.9DL+1.5$W_{(-Y)}$)	3415.5	3056.7	2703.2	2355.3
(0.9DL-1.5$W_{(-Y)}$)	3416	3057	2703	2355
1.2(DL+IL+E_X)	762.71	768.62	773.52	777.29
1.2(DL+IL-E_X)	762.71	768.62	773.52	777.29
1.2(DL+IL+E_Y)	863.41	881.56	899.29	918.3
1.2(DL+IL-E_Y)	863.41	881.56	899.29	918.3
1.5(DL+E_X)	953.39	960.78	**966.9**	971.61
1.5(DL-E_X)	953.39	960.78	966.91	971.61

1.5(DL+E_Y)	1079	1102	1124	1148
1.5(DL-E_Y)	1079.2	1101.9	1124.1	1147.8
(0.9DL+1.5E_X)	953.39	960.78	966.91	971.61
(0.9DL-1.5E_X)	953.39	960.78	966.91	971.61
(0.9DL+1.5E_Y)	1079	1102	1124	1148
(0.9DL-1.5E_Y)	1079.2	1101.9	1124.1	1147.8

5.3 Result - The minimum height at which wind load becomes dominant over earthquake load in 'X' direction (Wx > Ex), is at 27 m i.e. at **9th storey.**

5.4 Calculation of force co-efficient for 4th, 3rd, 2nd storey

Table-5: Building Height Ratio

Sr.no.	Storey No.	Height (m)	h/w ratio
1.	4th	12	12 / 9.795 =1.2251
2.	3rd	9	9 / 9.795 = 0.918
3.	2nd	6	6 / 9.795 = 0.612

From table 4 IS 875(part 3)-1987 for all above storey, building height ratio lies in between, (1/2) < (h/w) < (3/2).

Table -6: Force coefficient for 11th, 10th,9th, 8th, 7th, 6th, 5th storey

Wind Angle	C_f for surface			
ɵ	A	B	C	D
0°	1.2	0.8	1.2	1.2
90°	1.0	1.0	1.2	0.6

- Now, this above force co-efficient are assigned on surface walls with their respective direction.

5.5 Base Shear (KN) results for 4th, 3rd, 2nd and 1st storey

Table -6: Force coefficient for 11th, 10th, 9th, 8th, 7th, 6th, 5th storey

Load combination	BASE SHEAR (KN)			
	4th storey	3rd storey	2nd storey	1st storey
1.5 D. L	-	-	-	-
1.5 (D.L+L.L)	-	-	-	-
1.2 (D.L+L.L+W_X)	303.95	216.14	129.68	42.27
1.2(D.L+L.L-W_X)	303.95	216.14	129.68	42.27
1.2(D.L+L.L+W_Y)	788.94	561.01	336.61	112.20
1.2(D.L+L.L-W_Y)	788.94	561.01	336.61	112.20
1.2(D.L+L.L+$W_{(X)}$)	292.78	208.20	124.92	40.474
1.2 (D. L+L.L-$W_{(-X)}$)	292.787	208.20	124.92	40.474
1.2 (D.L +L.L+$W_{(Y)}$)	788.84	560.95	336.57	112.19
1.2 (D. L+L.L-$W_{(-Y)}$)	788.847	560.95	336.57	112.19
1.5(D.L+W_X)	379.94	270.17	162.10	52.84
1.5 (D. L-W_X)	379.94	270.17	162.10	52.84
1.5 (D. L+W_Y)	986.17	701.27	**420.7**	140.25
1.5 (D. L-W_Y)	986.17	701.27	420.76	140.25
1.5 (D.L+$W_{(-X)}$)	365.98	260.25	156.15	50.593
1.5 (D. L-$W_{(-X)}$)	365.98	260.25	156.15	50.593
1.5 (D. L+$W_{(-Y)}$)	986.05	701.19	420.71	140.23
1.5 (D. L-$W_{(-Y)}$)	986.05	701.19	420.71	140.23
(0.9 D. L+1.5 W_X)	379.94	270.17	162.10	52.84
(0.9 D. L-1.5 W_X)	379.94	270.17	162.10	52.84
(0.9 D. L+1.5 W_Y)	986.17	701.27	420.76	140.25
(0.9 D. L-1.5 W_Y)	986.17	701.27	420.76	140.25
(0.9 D. L+1.5 $W_{(-X)}$)	365.98	260.25	156.15	50.593
(0.9 D. L-1.5 $W_{(-X)}$)	365.98	260.25	156.15	50.593
(0.9 D. L+1.5 $W_{(-Y)}$)	986.05	701.19	420.71	140.238
(0.9 D. L-1.5 $W_{(-Y)}$)	986.05	701.19	420.71	140.238
1.2 (D. L+L.L+E_X)	630.83	445.38	259.93	137.56
1.2 (D. L+L.L-E_X)	630.83	445.38	259.93	137.56
1.2 (D. L+L.L+E_Y)	630.83	445.38	259.93	137.56
1.2 (D. L+L.L-E_Y)	630.83	445.38	259.93	137.56
1.5 (D. L+E_X)	788.54	556.72	324.91	171.95
1.5 (D. L-E_X)	788.54	556.72	324.91	171.95
1.5 (D. L+E_Y)	788.54	556.72	**324.9**	171.95
1.5 (D. L-E_Y)	788.54	556.72	324.91	171.95
(0.9 D. L+1.5 E_X)	788.54	556.72	324.91	171.95
(0.9 D. L-1.5 E_X)	788.54	556.72	324.91	171.95
(0.9 D. L+1.5 E_Y)	788.54	556.72	324.91	171.95
(0.9 D. L-1.5 E_Y)	788.54	556.72	324.91	171.95

5.6 Result - The minimum height at which wind load becomes dominant over earthquake load in 'Y' direction (Wy > Ey), is at 6 m i.e. at **2nd storey.**

6. CONCLUSIONS

1. The minimum height at which wind load becomes dominant over earthquake load in 'X' direction (Wx > Ex), is 27m i.e.at 9th storey.
2. The minimum height at which wind load becomes dominant over earthquake load in 'Y' direction (Wy > Ey), is 6m i.e. at 2nd storey.
3. From the above results, we can see that in 'X' direction wind load becomes dominant over earthquake load comparatively higher (i.e.27m), than in 'Y' direction (i.e.6m). This is because surface area of our plan in 'Y' direction was comparatively

more than in 'X' direction. As we know wind load is directly proportional to surface area upon which it is applied. As the surface area was more in 'Y' direction therefore wind load became dominant over earthquake load (i.e. W. L > E.L) at a lesser height.

4. As the surface area was less in 'X' direction the wind load became dominant over earthquake load (i.e. W.L > E.L) at a comparatively higher height.
5. Moreover, other factor which influenced was location, as our building was situated in Mumbai, and as Mumbai comes in coastal region, wind speed was relatively more as compared to non-coastal regions. Thus, we can conclude that in our case wind load became dominant over earthquake load in both 'X' and 'Y' direction at a comparatively lesser height because of its location and surface area.

Other factors which influence is geometry of plan, its locality etc. Results may vary for various buildings having different aspect ratio, shapes like oval, circular etc. different locality, wind speeds, seismic zones. Thus, various buildings can further be studied to determine the minimum height at which wind load would become dominant over earthquake load.

7. REFERENCES

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