Analysis of Tall Structural Systems using ETABs

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Abstract— Due to heavy urbanisation and population growth, vertical growth has become challenging thing in the building industry. This challenge is handled by using material of high strength and light weight. In addition to imposition of advanced efficient structural forms for gravity and lateral loads, there is continuous development to control structural distortion, in this regard bracing system have the responsibility of controlling lateral response because as we know at the height there is a large amount of wind forces which is more effective over there so we have to control the lateral effect. The present investigation involves the study and comparison of structural system and conclude which system is more efficient regarding different factor with help of ETABs.
Key words: Etabs-2016, Outrigger, Frame Tube, Storey Drift

I. Introduction

Tallness is relative matter and also tall building can't be defining in specific term like height and number of floors, a tall structure may be defining as one that, because of its height, is affected by lateral forces due to wind or earthquake action and also they play important role in structural design that's why consider these action from the very beginning of the design process.

Tall buildings and tower have fascinated mankind from the beginning of civilization. Construction of tall tower being initially for defence and later ecclesiastical purpose. Tall building emerged in late nineteenth century in the united states of America. Many tall building are being built worldwide especially in Asian countries such as china, Korea, japan and Malaysia till 1980.Traditionally the function of tall building has been as a commercial building and other usage such as residential, hotel tower and mixed use.Tall commercial buildings are frequently developing in city centre as prestige symbol for corporate organization. Further the tourist and business community, with its increasing mobility, has fuelled a need for more frequently high rise and city centre hotel accommodations.Due to heavy urbanisation and population growth, the cost of land is increasing rapidly and the land availability has become a constraint for developers and builders, and this creates a picture of vertical growth as natural process. Control the lateral response of tall building is main problem with tall structure because the increased wind pressure due to the large exposed area of the building, high intensity of the wind at higher elevation and the earthquake load add to the bulk of structural forces. prevent those effect we provide different systems to structure

II. Analysis and Design

In this chapter analysis and design of 100 storey building of various structural system is presented. Analysis, design and modelling of structure perform in ETABS software. All member design using IS 456:2000, foe seismic analysis using IS 1893(Part 1):2002 and perform wind analysis using IS:875(part 3)-1987. Perform the analysis result in term of Storey drift, Story displacement and storey shear. In this research perform analysis of various model which is based on different type of structural system which is mentioned in previous.

The 100 storey building is having grid of 54 m X 54 m square. Grid and side view of building as shown in fig provide the spacing between the column is 4m.

A. Design Data

No of storey = 100 nos.
Total height of building = 300 m
Plan area of building = 60 m X 60 m
Floor height = 3 m
Size of Column = 1.5 x 1.5 m(up to 30)
1.2 x 1.2 m(31 to 60)
0.8 x 0.8 m(61 to 90)
0.5 x 0.5 m(91 to 100
Size of Beam =800 x 600 mm (upto 30)
700 x 500 mm (31 to 60)
550 x 450 mm (61 to 90)
450 x 350 mm (91 to 100)
Dimension of Slab = 6 m x 6 m
Thickness of slab = 180 mm
Size of Shear wall = 300 mm
Type of Bracing section = ISMB350
Grade of Concrete = M50
Grade of Steel = HYSD415
Size of Outrigger: 0.8 X 0.6 m

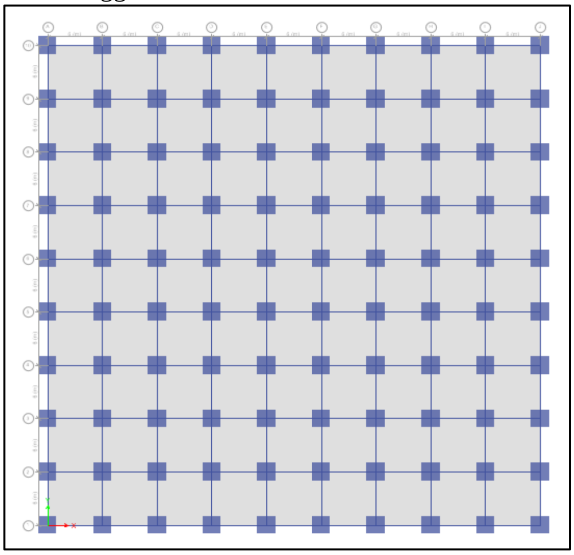

Fig. 1: Story floor plan

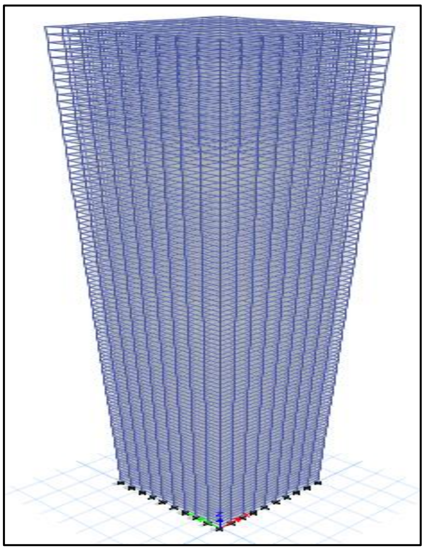

Fig. 2: side view of building

Loading data:
Live load = 2 KN/m^2
Dead load = consider only self-weight
Wind load = speed: 44 m/s
Terrain category: 3
Structure class: C
Risk coefficient(K_1): 1.07
Topography Factor(K_3): 1
Seismic load = Zone(Z): 0.16 (Zone 3)
Site type = II
Importance Factor(I) = 1.5
Time period(T) = Programme Calculated

B. Load Combination

No.	COMBINATION
1	1.5 (D.L)
2	1.5 (D.L + L.L)
3	1.2 (D.L + L.L + Wind)
4	1.2 (D.L + L.L - Wind)
5	1.5 (D.L + Wind)
6	1.5 (D.L - Wind)
7	0.9 D.L + 1.5 L.L
8	0.9 D.L – 1.5 L.L
9	1.2 (D.L + L.L + E_x)
10	1.2 (D.L + L.L - E_x)
11	1.2 (D.L + L.L + E_Y)
12	1.2 (D.L + L.L – E_Y)
13	1.5 (D.L + E_x)
14	1.5 (D.L - E_x)
15	1.5 (D.L + E_Y)
16	1.5 (D.L – E_Y)
17	0.9 D.L + 1.5 E_x
18	0.9 D.L - 1.5 E_x
19	0.9 D.L + 1.5 E_Y
20	0.9 D.L - 1.5 E_Y

Table 1:

III. Result and Discussion

Following are the few types of Structural systems which is analysis with the Help of ETABS. Each system has a different type of configuration because of their working or behaviour properties and in analysis two type of analysis performed namely wind analysis and seismic analysis through static linear analysis. In result data consider only Storey Displacement, Storey Drift and Storey Shear. Result data shown in following tables of various systems.

A. Outrigger System

Outrigger system has a bracing at different height. In this system bracings are tied to outer core to inner core. Inverted V shape bracings are using at different height. no of 3 Outrigger use in outer core at 1^{st},50^{th} and 100^{th} floor and same way at inner core in L Shape. Plan of outrigger system has shown in fig. Size of section is ISMB350 which is used in outriggers.

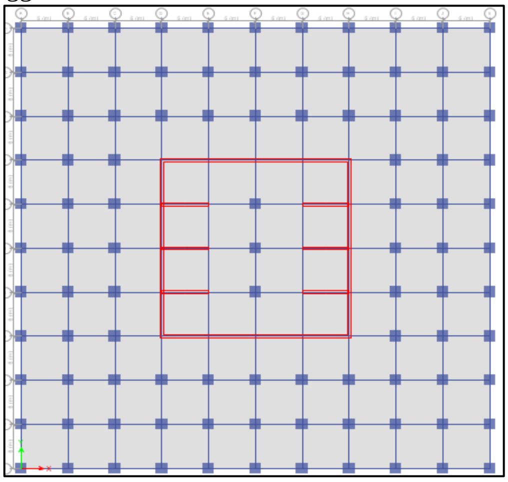

Fig. 3: plan of Outrigger systems

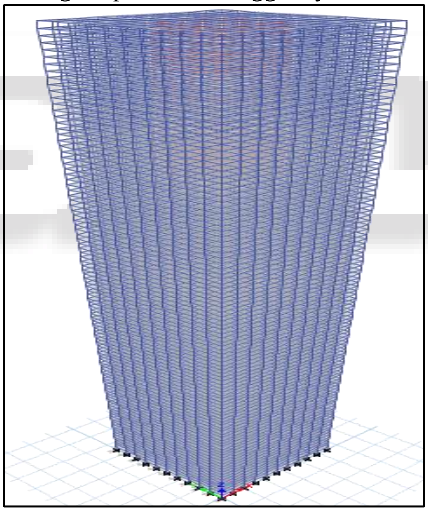

Fig. 4: 3-D view of O-T

STORY	displacement(mm)		story drift		story shear(KN)	
	x	y	x	y	x	y
Story100	124	132	1.6	1.7	575.3182	575.3182
Story90	108	115	1.6	1.7	6629.603	6629.603
Story80	92	97	1.7	1.8	12215.7	12215.7
Story70	75	80	1.7	1.8	16559.32	16559.32
Story60	59	63	1.4	1.4	19903.82	19903.82
Story50	47	50	1.2	1.2	23387.31	23387.31
Story40	35	37	1.2	1.3	25651.22	25651.22

Story30	23	25	1.1	1.2	27015.72	27015.72
Story20	13	14	0.9	1.0	27708.5	27708.5
Story10	5	5	2.439	2.297	47649.88	47649.877

Table 2: Seismic analytical result of Outrigger

STORY	displacement(mm)		story drift		story shear(KN)	
	x	y	x	y	x	y
Story100	295	315	3.4	3.6	575.0257	575.0257
Story90	261	278	3.4	3.7	11964.46	11964.46
Story80	226	241	3.6	3.8	23140.24	23140.24
Story70	190	202	3.6	3.9	34104.41	34104.41
Story60	154	164	3.1	3.3	44832.24	44832.24
Story50	125	134	2.8	3.0	55253.88	55253.88
Story40	96	103	3.0	3.1	65314.55	65314.55
Story30	67	72	2.9	3.1	74954.08	74954.08
Story20	39	42	2.6	2.8	83969.84	83969.84
Story10	15	16	2.0	2.2	92143.56	92143.56

Table 3: Wind analytical result of Outrigger

B. Graph of analytical result of Outrigger

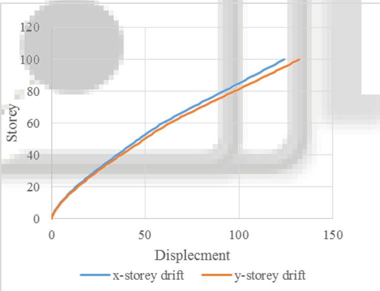

Fig. 5: Displecment of O-T System due to E_X&E_Y

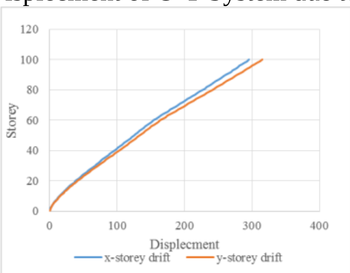

Fig. 6: Displecmentof O-T System due to wind

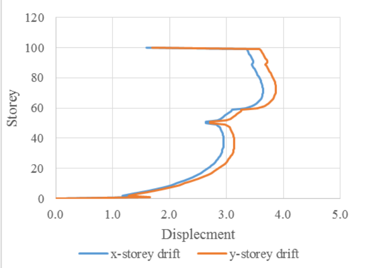

Fig. 7: Storey Drift of O-T due to E_X&E_Y

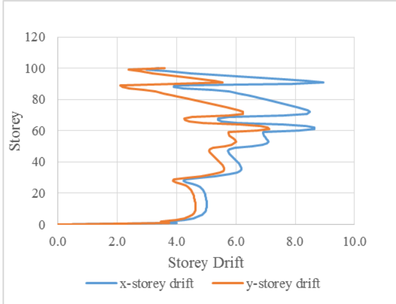

Fig. 8: Storey Drift of O-T due to Wind

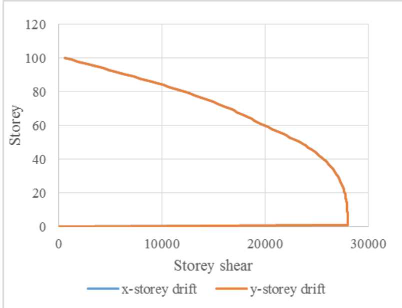

Fig. 9: Storey shear of O-T sys.due to E_X&E_Y

Fig. 10: Storey shear of O-T sys. due to wind

C. Frame Tube Structure

According to specification of this system, system has provided close spaced column where the spacing between two columns is 4 m. Plan of this system show in fig7.1. this system also known as stiff moment resisting frame, because it's prevent lateral load by stiffness. And gravity load transfers between tube and interior column.

STORY	displacement(mm)		story drift		story shear(KN)	
	x	y	x	y	x	y
Story100	238	238	1.3	1.3	531.3987	531.3987
Story90	214	214	2.2	2.2	5604.671	5604.671
Story80	188	188	3.1	3.1	10604.55	10604.55
Story70	153	153	3.9	3.9	14492.33	14492.33
Story60	114	114	2.5	2.5	17458.04	17458.04
Story50	90	90	2.5	2.5	20216.08	20216.08
Story40	65	65	2.5	2.5	22057.4	22057.4
Story30	41	41	1.7	1.7	23180.86	23180.86
Story20	25	25	1.5	1.5	23890.51	23890.51
Story10	11	11	1.4	1.4	24145.33	24145.33

Table 3: Seismic analytical result of Frame Tube Structure

STORY	displacement(mm)		story drift		story shear(KN)	
	x	y	x	y	x	y
Story100	643	643	2.8	2.8	575.0257	575.0257
Story90	589	589	5.0	5.0	11964.46	11964.46
Story80	530	530	7.1	7.1	23140.24	23140.24
Story70	449	449	9.3	9.3	34104.41	34104.41
Story60	351	351	6.4	6.4	44832.24	44832.24
Story50	286	286	6.7	6.7	55253.88	55253.88
Story40	216	216	7.4	7.4	65314.55	65314.55
Story30	144	144	5.4	5.4	74954.08	74954.08
Story20	92	92	5.381	5.381	66684.3222	66684.3222
Story10	41	41	5.237	5.237	72876.5867	72876.5867

Table 5: Wind analytical result of Frame Tube Structure

D. Graph of analytical result of Frame Tube Structure

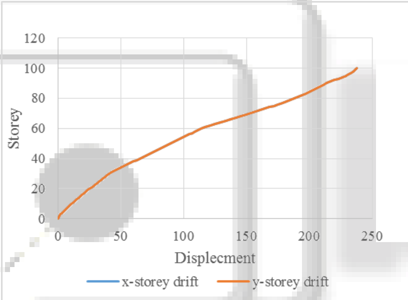

Fig. 11: Displecment of F-T System due to E_X&E_Y

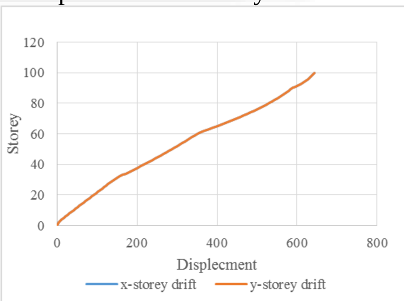

Fig. 12: Displecment of F-T System due to wind

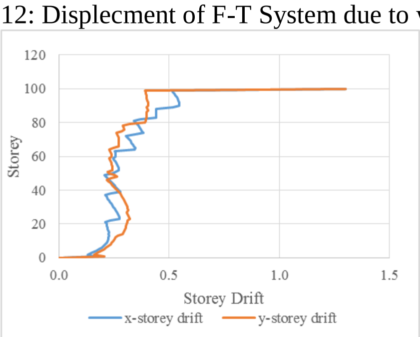

Fig. 13: Storey Drift of F-T due to E_X&E_Y

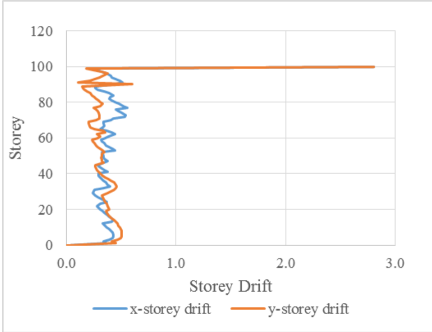

Fig. 14: Storey Drift of F-T due to Wind

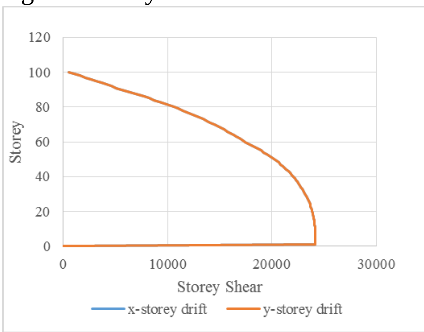

Fig. 15: Storey shear of F-T sys. due to E_X&E_Y

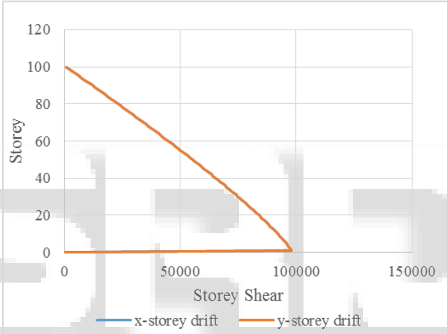

Fig. 16: Storey shear of F-T sys. due to wind

E. Total Cost of Structures

Here, following table shows the Cost in which all the cost are included such as Total Cost of Concrete, steel , labour, water , crane, HVAC and Foundation. All factor has their own certain percentage of total cost of Concrete and Steel respectively 20, 1, 20, 10, and 40 %. Also adding the Plumbing and Electric Work and which is 20%.

Sr.No	Type	Total Cost
1	Outrigger	325 cr
2	FRM	306 cr

Table 6: Cost of Structure

F. Efficiency Factor

It is depend on the top drift of structure and cost of structure, it shows that how efficient the structure are and result of these factor are following

Type	Outrigger	Bundle-tube	FRM
Efficiency Factor	0.24	0.33	0.30

Table 7: Efficiency Factor

G. Mass Participation Factor

In mass participation factor only 12 mode of building were consider and it is as per following,

Mode	Outrigger	Bundle Tube	FRM
12	0.6403	0.6329	0.6094
11	0.6403	0.6367	0.6094
10	0.6403	0.7434	0.617
9	0.8261	0.8037	0.7991
8	0.8261	0.8122	0.7991
7	0.8261	0.8664	0.8133
6	0.8943	0.8676	0.8627
5	0.8943	0.872	0.8627
4	0.8943	0.8913	0.8779
3	0.9211	0.8914	0.8996
2	0.9211	0.8917	0.8996
1	0.9211	0.9065	0.9079

Table 8: Mass Participation Factor

IV. CONCLUSION

In the present study an attempt was made to compare the different Structural systems with same structural configuration. The following conclusion has been derived based on Stability and cost effectiveness.

Stability check from displacement result. According to analytical result outrigger system shows minimum result in term of displacement, storey drift and shear force compare to another syatem.so on stability base the outrigeer system has more stability than frame tube structure.

According to cost the outrigger system is costly than frame tube structure. So in term of cost effectiveness outrigger shows negative result.

REFERENCES

[1] Ali Ruzi Özuygur, Department of Structural Engineering, YPU — Yapı Proje Uygulama Co.Istanbul, Turkey, October 2015, "Performance-based Seismic Design of an Irregular Tall Building -A Case Study".
[2] Azzam KATKHODA, Rana KNAA, Department of Structural Engineering, 2012 "Optimization in the Selection of Structural Systems for the Design of Reinforced Concrete High-rise Buildings in Resisting Seismic Forces".
[3] Dhanaraj M. Patil , Keshav K. Sangle, Structural Engineering Department, VJTI, Mumbai 400019, India, July 2016," Seismic Behaviour of Outrigger Braced Systems in High Rise 2-DSteel Buildings".
[4] Dhanaraj M. Patil , Keshav K. Sangle, Structural Engineering Department, VJTI, Mumbai 400019, India, June 2015 "Seismic Behaviour of Different Bracing Systems in High Rise 2-D Steel Buildings".
[5] Taranath S. D., Mahantesh. N.B., M.B.Patil, Journal of Civil Engineering and Environmental Technology, August 2014," Comparative Study of Pentagrid and Hexagrid Structural System for Tall Building".
[6] Yi Li , Qiu-Sheng Li, Department of Architecture and Civil Engineering, City University of Hong Kong, Kowloon, Hong Kong, June 2016," Wind-induced response based optimal design of irregular shaped tall buildings".
[7] IS: 1893-2002. Criteria for earthquake resistant design of structures: part–1 general provisions and buildings. New Delhi: Bureau of Indian Standards; 2002.
[8] IS: 875 (Part 2)-1987. Code of practice for design loads (other than earthquake) for buildings and structures: part 2 imposed loads. New Delhi: Bureau of Indian Standards;1987.
[9] Bryan Stafford Smith, Alex Coull, "Tall Building Structires: Analysis And Design", John Willey & Sons, Inc., Usa,1991.