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Research Article

Response of Multistory Irregular L Shape Building under Basic Wind Speed of 39 m/s

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Abstract

Wind analysis in this era considered as a main criteria for modern tall buildings such that the tall buildings are considered as a cantilever structure which is fixed at its base and is free at other end. These multistory buildings are not same in plan and having different projections which is vulnerable to wind and its exposures. The main criteria in this research work is to present the position of these tall buildings having plan of L – shape 20 story building under a basic wind speed of 39 m/s. Using Staad pro software, a total of 4 cases has analyzed. Dimension of plan is different from both the projection on which wind is applied in all four directions. A comparison of result parameters like displacements, story drift, axial forces in column, shear in beam in both longitudinal and transverse direction are made for all the models and suggestions are made to choose which position is the best of all.

Keywords: *L shape building, Maximum displacement, Structural position, Staad pro, Story drift, Wind effects.*

1. Introduction

In this era, futuristic structures are taken into account for modern lifestyles people and their way of living. For this, construction leads to improvements in the development of high rise building by the fact that there is scarcity of land. Due to this requirement, modern analysis and design procedures have taken into account to construct new light and slender structures. These are susceptible to larger wind and seismic effects. Now we are solely depending on the previous historical data and it will unable to find in future that which kind of load is going to fail the structure. For that it is necessary to analyze the structure for each horizontal loading. Consider the storm effects which has considered as higher effects as compared to normal wind loading.

IS: 875 (part-3)-1987, provides the standard method to find out the design pressures by wind loads along with different factors such as risk coefficient, topography factor, terrain roughness and height factor taken from IS 875 Part III from different clauses. The pressure obtained for any height will be directly applied to effective area of structure. Since code remains inaudible about how the structure will behave on the same computed load when the structure is rotated along its vertical axis with plan regularity as well as irregularity.

Therefore, it is proposed to perform wind analysis longitudinally and transversely for different extruded plan extended to wide area such as irregular L shaped multistoried building. Hence the search will complete when the exact location is determined. Moreover search also extend when the applied wind strikes the structure and creates the effects to neighboring structures.

2. Objective

This study is solely based on the wind analysis and the parametric effects are determined by using different L shaped plan cases under wind speed of 39 m/s.

1. To determine similar and pairing patterns by analyzing L shape multistory building of Case A, Case B, Case C and Case D.
2. To find and check the reduction in all the parameters when structural projection part is more or less.
3. To analyze the structure graphically to obtain real values if no criterion of extra supports like bracings, shear wall etc. provided.
4. To obtain Maximum nodal displacements, story drift for all cases.
5. To obtain, compare and analyze axial forces in column at ground level, shear forces and moments in beam.

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3. Methodology in Wind Analysis

Method of analysis is solely depend on wind pressure in this work. The main criteria is to find the wind pressures at particular height above 10 m as per codal provisions of IS 875 part III and feed these values in Staad pro so that the software apply the manually calculated pressures of particular intensity to a particular nodal height.

Pressure of wind above ground level will be calculated as:

$$P_Z = 0.6\, V_Z^2 \quad \text{(Eq. 1)}$$

where

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

$$V_z = k_1\, k_2\, k_3 V_b \quad \text{(Eq. 2)}$$

Risk coefficients for different classes of structures in different wind speed zones taken from IS 875 Part III clause 5.3.1

k1 = probability factor (risk coefficient) (clause 5.3.1 IS 875 Part III),

$$k_1 = \frac{X_{N,P_N}}{X_{50,\,0.63}} = \frac{A - B\left[\ln\left\{-\frac{1}{N}\ln\left(1 - P_N\right)\right\}\right]}{A + 4B} \quad \text{(Eq 3)}$$

Where,

N = mean probable design life of the structure in years.
P_N = risk level in N consecutive years (probability that the design wind speed is exceeded at least once in N successive years), nominal value = 0.63.

$X_{N,P}$ = extreme wind speed for given value of N and P_N; and

$X_{50,0.63}$ = extreme wind speed for N = 50 years and P_N = 0.63

A and B are coefficients having the following values for different basic wind speed zones:

Table 1 Values for different basic wind speed zones

Zone	A	B
33 m/s	83.2	9.2
39 m/s	84.0	14
44 m/s	88.0	18
47 m/s	88.0	20.5
50 m/s	88.8	22.8
55 m/s	90.8	27.3

k_2 = terrain roughness and height factor taken from IS 875 Part III clause 5.3.2

k_3 = topography factor taken from IS 875 Part III clause 5.3.3

V_b = basic wind speed of any particular region taken from IS 875 Part III Appendix A.

4. Structure Modeling

The complete framed structure has been designed in Staad pro, analysis and design tool. The L shape multistory model descriptions according to its geometry, properties, loading, material and support are listed in Table 2. Details of dead and live loading are listed in Table 3. Wind loading which is applied for L shape plan of various cases model is shown in Table 4. Details of loading combinations as per I.S. recommendations are listed in Table 5 respectively. Figure 1 to 4 shows various detailed L shaped plans and 3D view is shown in Figure 5. Table 6 shows the details of L shape multistory building cases that are taken into account in this research work.

Table 2 Description of L-shape building

Building configuration	G + 19 (commercial)
Plan of building	Irregular - L shaped (CASE A, B, C, D)
Plinth area	700 m^2
Height of building above ground level	70 m
Floor height	3.5m
Depth of footing	1.5 m deep
Dimensions of building	50 m x 30 m
Each bay in X and Z direction	5m
Size of beam	300 mm x 450 mm
Size of column	350 mm x 500 mm
Slab Thickness	150 mm
Concrete and Steel Grade	M25 & Fe 415 grade
Support	Fixed

Table 3 Details of Dead and Live loading

Floor Finish load	3 KN/m^2
Wall load (External)	13.65 KN/m
Wall load (Internal)	7.66 KN/m
Wall load (Roof Parapet)	7.66 KN/m
Water proofing (including terrace finish)	3.2 KN/m^2
Live load for floor and roof	5 KN/ m^2 & 2 KN/ m^2

Table 4 Details of Wind loading

Basic wind speed	39 m/s
Exposure	85 %
Wind load in +X direction	As per intensity along height in +X direction
Wind load in -X direction	As per intensity along height in -X direction
Wind load in +Z direction	As per intensity along height in +Z direction
Wind load in -Z direction	As per intensity along height in -Z direction

Table 5 Details of loading combinations as per IS recommendations

S. No.	Load Combinations
1	1.5 (DL+LL)
2	1.5 (DL+WLX)
3	1.5 (DL-WLX)
4	1.5 (DL+WLZ)
5	1.5 (DL-WLZ)
6	1.2 (DL+LL+WLX)
7	1.2 (DL+LL-WLX)
8	1.2 (DL+LL+WLZ)
9	1.2 (DL+LL-WLZ)
10	0.9 DL+1.5WLX)
11	0.9 DL-1.5WLX)
12	0.9 DL+1.5WLZ)
13	0.9 DL-1.5WLZ)

Table 6 Details of L shape multistory building cases

CASE A	30 m in +X direction with 50 m in –Z direction
CASE B	30 m in -X direction with 50 m in –Z direction
CASE C	30 m in +X direction with 50 m in +Z direction
CASE D	30 m in -X direction with 50 m in +Z direction

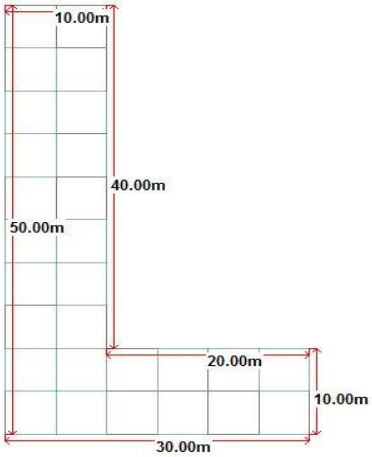


Fig.1 L shape building CASE A

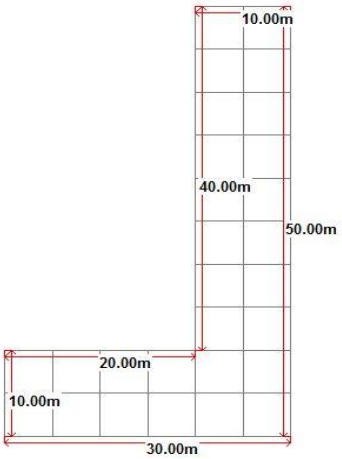


Fig. 2 L shape building CASE B

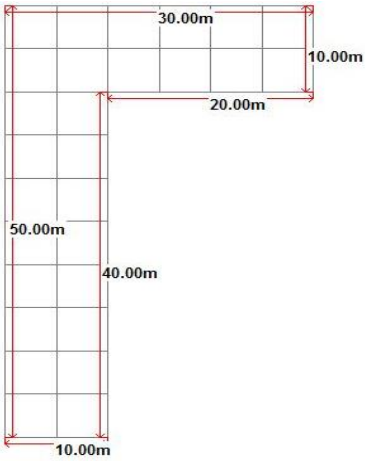


Fig. 3 L shape building CASE C

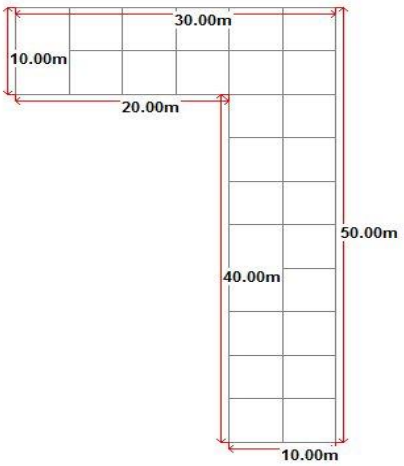


Fig. 4 L shape building CASE D

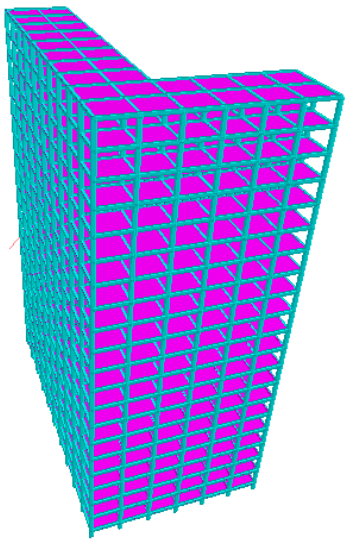


Fig. 5 3D view of L shape Multi-story building

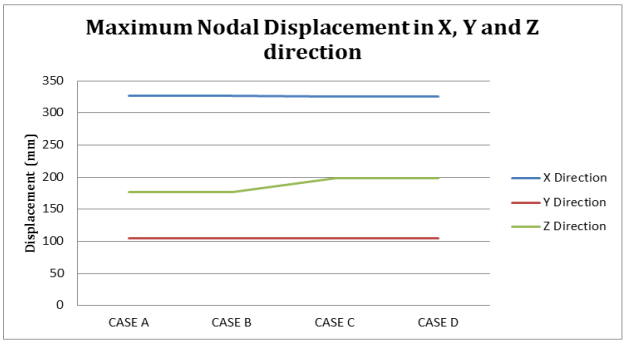
5. Results and Discussions

After the applications of wind pressure along the height of L shape multistory building, analytic results

for medium soil condition for different cases due to wind effects at a speed of 39 m/s are as follows:-

Table 7 Maximum nodal displacement in X, Y and Z direction for all 4 cases under wind speed of 39 m/s

L SHAPED BUILDING CASES	Maximum Displacement		
	X direction (mm)	Y direction (mm)	Z direction (mm)
CASE A	326.896	104.491	176.305
CASE B	326.896	104.491	176.305
CASE C	325.373	104.491	198.524
CASE D	325.373	104.491	198.524



Graph 1 Graphical representation of maximum nodal displacement in X, Y and Z direction for all 4 Cases under wind speed of 39 m/s.

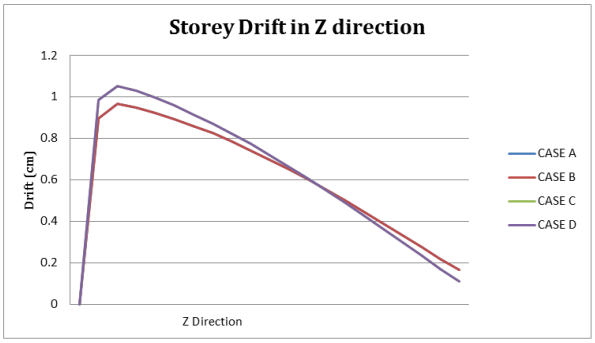
Table 8 Story drift in X direction for all 4 Cases under wind speed of 39 m/s

Height (m)	Story Drift For X Direction (cm)			
	CASE A	CASE B	CASE C	CASE D
0	0	0	0	0
3.5	1.0821	1.0754	1.1179	1.0754
7	1.2626	1.2491	1.3035	1.2491
10.5	1.2791	1.2591	1.3198	1.2591
14	1.271	1.2448	1.3108	1.2448
17.5	1.253	1.2209	1.2917	1.2209
21	1.2278	1.1900	1.2651	1.1900
24.5	1.1962	1.1530	1.2320	1.1530
28	1.1587	1.1105	1.1929	1.1105
31.5	1.116	1.0631	1.1484	1.0631
35	1.0686	1.0114	1.0991	1.0114
38.5	1.017	0.9558	1.0456	0.9558
42	0.9614	0.8966	0.9879	0.8966
45.5	0.9021	0.8340	0.9263	0.8340
49	0.8393	0.7684	0.8613	0.7684
52.5	0.7735	0.7001	0.7932	0.7001
56	0.7053	0.6299	0.7226	0.6299
59.5	0.6351	0.5580	0.6500	0.5580
63	0.5632	0.4849	0.5757	0.4849
66.5	0.4908	0.4117	0.5008	0.4117
70	0.4259	0.3461	0.4337	0.3461

Table 9 Story drift in Z direction for all 4 Cases under wind speed of 39 m/s

Height (m)	Story Drift For Z Direction (cm)			
	CASE A	CASE B	CASE C	CASE D
0	0	0	0	0
3.5	0.8995	0.8995	0.9861	0.9861
7	0.9673	0.9673	1.0549	1.0549
10.5	0.9501	0.9501	1.0302	1.0302
14	0.9252	0.9252	0.9972	0.9972
17.5	0.8958	0.8958	0.9595	0.9595
21	0.8625	0.8625	0.9178	0.9178
24.5	0.8259	0.8259	0.8727	0.8727
28	0.7863	0.7863	0.8246	0.8246
31.5	0.744	0.744	0.7738	0.7738
35	0.6993	0.6993	0.7207	0.7207
38.5	0.6527	0.6527	0.6658	0.6658
42	0.604	0.604	0.6089	0.6089
45.5	0.5533	0.5533	0.5501	0.5501
49	0.5009	0.5009	0.4898	0.4898
52.5	0.4468	0.4468	0.4280	0.4280
56	0.3916	0.3916	0.3652	0.3652
59.5	0.3353	0.3353	0.3016	0.3016
63	0.278	0.278	0.2374	0.2374
66.5	0.2199	0.2199	0.1728	0.1728
70	0.1663	0.1663	0.1133	0.1133

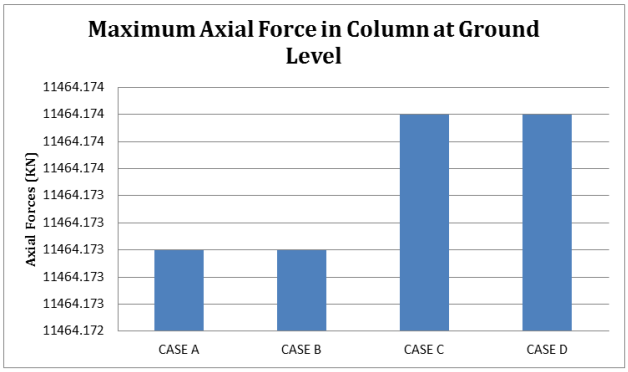
Graph 2 Graphical representation of story drift in X direction for all 4 Cases under wind speed of 39 m/s



Graph 3 Graphical representation of story drift in Z direction for all 4 Cases under wind speed of 39 m/s

Table 10 Maximum axial forces in column at ground level for all 4 cases under wind speed of 39 m/s

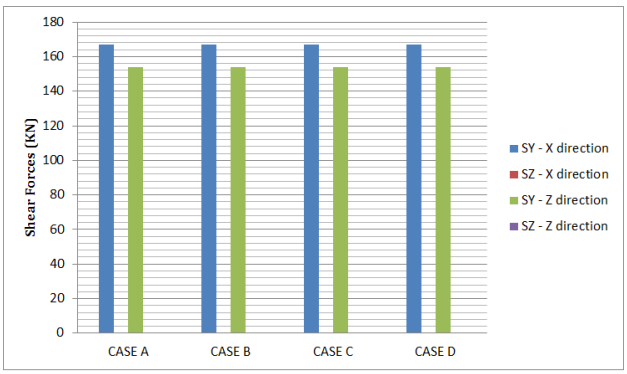
L SHAPED BUILDING CASES	Maximum Axial Forces in Column (KN)
CASE A	11464.173
CASE B	11464.173
CASE C	11464.174
CASE D	11464.174



Graph 4 Graphical representation of maximum axial forces in column at ground level for all 4 cases under wind speed of 39 m/s

Table 11 Maximum shear forces in beam in X & Z direction for all 4 cases under wind speed of 39 m/s

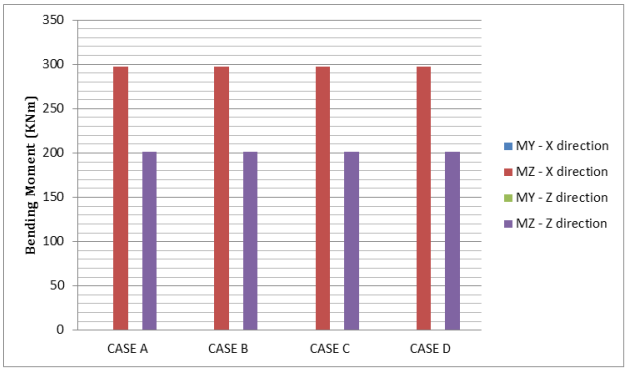
L SHAPED BUILDING CASES	Maximum Shear Forces in Beam			
	X direction (KN)		Z direction (KN)	
	SY	SZ	SY	SZ
CASE A	166.911	0.302	154.088	0.424
CASE B	166.911	0.302	154.088	0.424
CASE C	166.806	0.320	154.088	0.424
CASE D	166.806	0.320	154.088	0.424



Graph 5 Graphical representation of maximum shear forces in beam in X and Z direction for all 4 cases under wind speed of 39 m/s.

Table 12 Maximum bending moment in beam in X & Z direction for all 4 cases under wind speed of 39 m/s

L SHAPED BUILDING CASES	Maximum Bending Moment in Beam			
	X direction (KNm)		Z direction (KNm)	
	MY	MZ	MY	MZ
CASE A	0.805	297.378	1.114	201.180
CASE B	0.805	297.378	1.114	201.180
CASE C	0.871	296.988	1.114	201.180
CASE D	0.871	296.988	1.114	201.180



Graph 6 Graphical representation of maximum moments in beam in X and Z direction for all 4 cases under wind speed of 39 m/s.

Conclusions

It has been concluded from the above study that wind forces effects are less in 39 m/s wind speed but during detailed analysis, all considered cases shows different values in all parameters.

1. Case A and Case B in almost all parameters show a same value pattern since these two cases are identical and make a pair. Same values are shown in Case C and Case D. It has also been concluded that when structural projection part is more, then there will definitely be a reduction in all the parameters.
2. Parametric results obtained show the real values, since there is no criterion of extra supports like bracings, shear wall etc. required.
3. Maximum nodal displacements has seen maximum in X direction for all cases. This is due to stiffness along X direction is less because wind projecting acting area is more.
4. Story drift seems to be maximum at 10.5 m for X direction and 7 m for Z direction. From this maximum values, due to wind effects, the drift values are again lowering down.
5. Axial forces seems to be same for all cases, shear forces and bending in X direction beams shows different values between identical pairs. No change in maximum shear forces and bending in beam in Z direction.

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