“Analysis and Design of Multi-Storieyed Irregular RC Building Under Influence of Wind Load"

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Abstract- *In this paper a detailed study on the behavior of structural irregularities in high rise building is given. Now a days, In the designing of the multi-storied buildings the irregularities in structures are inevitable due to functional requirements of the building. It is very essential to consider the effect of lateral loads induced from wind pressure. The present study describes the effect of wind speed 55 m/s on three types of buildings of G+20 multi storied frame structure for different irregularities. The three structures considered as regular building, stiffness irregular and vertical irregular. The results are tabulated by performing analysis using STAAD Pro in the form of Bending Moment, Shear Force and Axial Force in the irregular buildings.*

Keywords- Lateral Load, Wind pressure, STAAD Pro, Bending Moment, Shear Force, Axial Force.

I. INTRODUCTION

In modern world the new materials and construction techniques are used in structures. There are different kinds of structures that are being used such as high rise structures like towers, chimney, buildings etc. In case height of structure is greater than 6m the intensity of wind load will be acting on the structure. Due to this load the swaying effects are there on the structure. When the height of structure is more than 12m the intensity of the wind load will be even more. In recent scenario the population in cities is increasing. Therefore, we need tall buildings to fulfill requirement of living of people. As the height of the building increases, the building becomes more flexible, low in damping and light in weight. Such structure influences more under the wind pressure. Wind forms the predominant source of load in free standing tall structures. The structure experiences aerodynamic forces due to wind on tall structure are divided into two categories as shown in the Fig 1.

1. Along-wind effect: The drag force acting in the direction of the mean wind.
2. Across-wind effect: The lift force acting perpendicular to the direction.

The wind load is the most crucial factor that determined design of all building over 5 storey. The building taller than 5 storey generally requires additional steel and lateral systems. The action of natural wind, gusts and other aerodynamic forces will be affecting a tall building continuously. The structure deflects from a mean position and oscillate continuously.

Buildings should have following two types of structures according their use.

1. **Regular Structure**: It has load, mass, and stiffness distributed equally along column, beam and slab. The chances of collapse of regular building are less.

2. **Irregular Structure**: The multi storey building having some structural irregularities like horizontal, vertical, stiffness and mass. The chances of collapse are more than regular building.

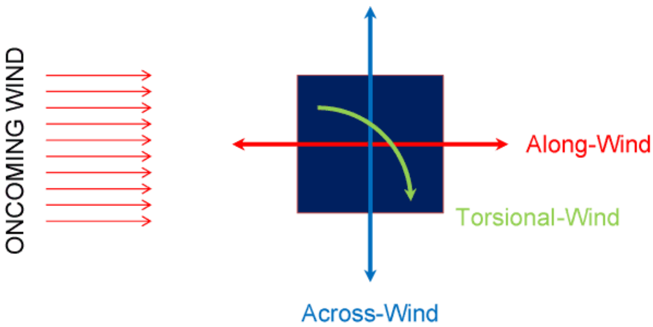

Fig. 1. Along & Across wind effect

II. METHOD OF ANALYSIS

Code-based procedure for wind analysis:

Basic wind speed can be obtained by IS 875 (Part III): 2015 ANNEX A (Clause 6.2) & should be modified by including the effect of following factors to get design wind velocity at any height for the given structure:

a) Risk level

b) Terrain roughness & height of structure
c) Local topography

Wind Speed = $V_z = V_b \times K_1 \times K_2 \times K_3$
Wind Pressure = $P_z = 0.6\ V_z$
Where;
V = Design wind speed at any height z in m/s
K_1 = Probability Factor (Risk Coefficient)
K_2 = terrain, height & structure size factor
K_3 = Topography factor
P_z = Design wind speed in N/m^2 at any height z
NOTE: Constant design wind speed is considered up to 10m height from mean ground level.

III. MODELLING AND ANALYSIS

An RCC framed structure is basically an assembly of slabs, beams, columns and foundation inter-connected to each other as a unit. The load transfer mechanism in these structures is from slabs to beams, from beams to columns and then ultimately from columns to the foundation, which passes the load to the soil. In this analysis we adopted 3 cases by considering different irregularities for the same structure, as explained below.

1. Regular
2. Mass Irregularity
2. Stiffness Irregularity
3. Vertical Irregularity

Design characteristic: The following design characteristic are considered for the analysis of multi-storied RC frames.

Table 1. Design Data

S. N.	PARTICULARS	DIMENSIONS/SIZE
1	Model	G+20
2	Wind Speed	55 m/s
3	Floor Height	3 m
4	Plan Size	30 X 30 m
5	Size of Column	0.5 X 0.23 m
6	Size of Beams	0.45 X 0.23 m
7	Wall	1. External wall = 0.23 m 2. Internal wall = 0.15 m
8	Thickness of Slab	150 mm
9	Material used	M 20 & Fe 415
10	Place	Darbhanga
11	Software used	STAAD pro

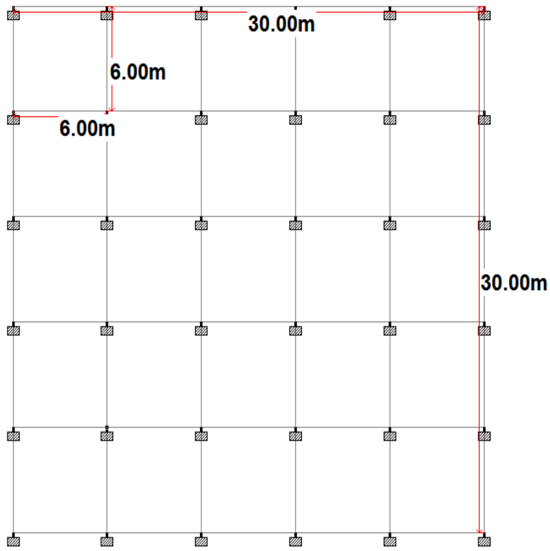

Fig. 2. Model Plan

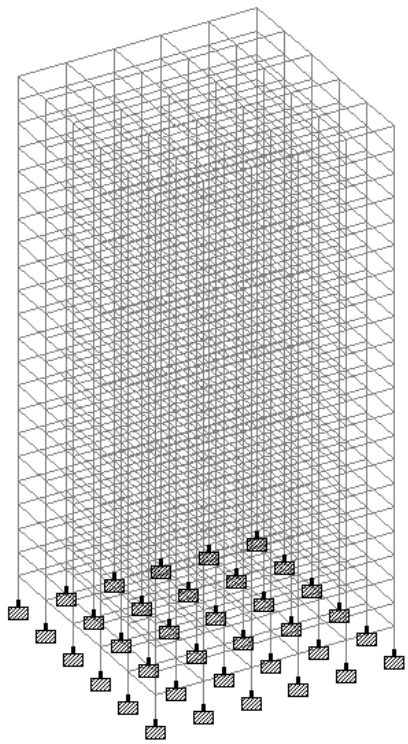

Fig. 3. Regular Building

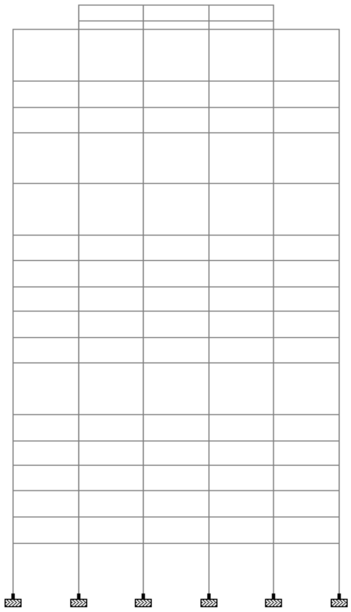

Fig. 4. Mass Irregular Building

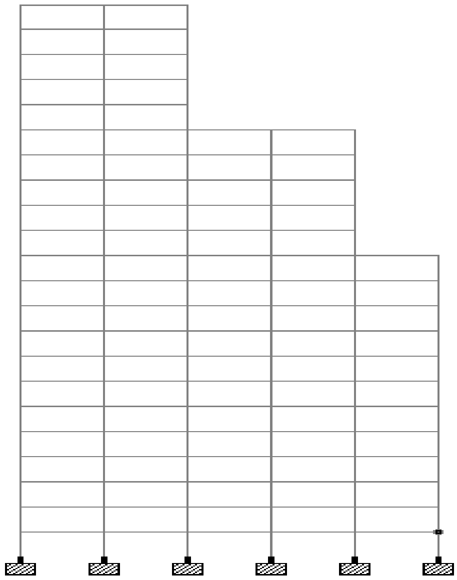

Fig. 6. Vertical Irregular Building

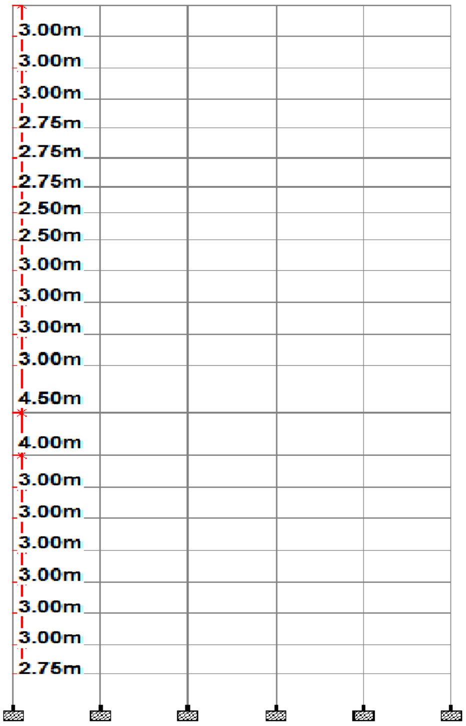

Fig. 5. Stiffness Irregular Building

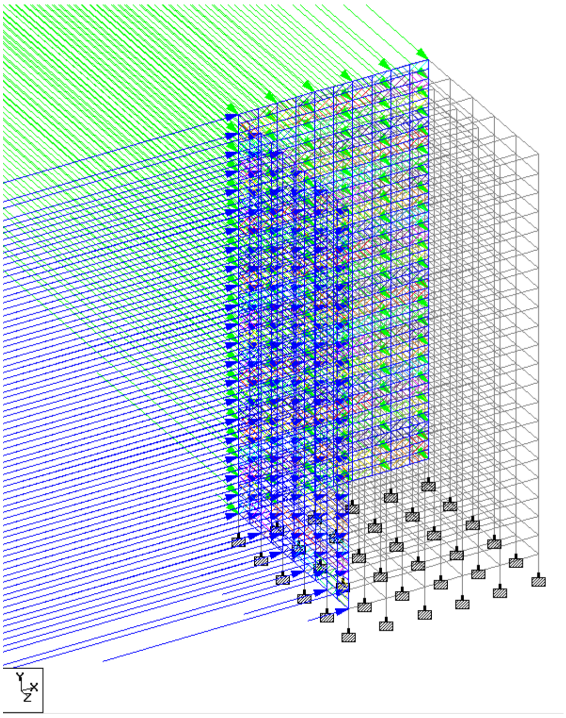

Fig. 7. General arrangement of Wind Load

IV. RESULT

	Regular Structure	Mass Irregular Structure	Stiffness Irregular structure	Vertical Irregular Structure
C1	6360	5814	6443	5800
C2	8808	9456	8898	9006
C3	11281	12760	11300	10678

Table 2. Highest Reaction (KN) from Columns

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
C1	7125	6375	7500	6750
C2	9750	10500	9750	9750
C3	12375	15000	12375	12000

Table 3. Required steel (Sq. mm) in Column

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
C1	9098.15	8116.9	8116.9	7135.65
C2	10079.4	11559.91	10079.4	10079.4
C3	13023.15	16715.79	13272.78	13772.04

Table 4. Provided steel (Sq. mm) in Column

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
G	133	202	118	129
1	83	150	70	97
5	46	77	39	83
10	68	213	79	101
15	162	340	188	187
20	250	471	250	242

Table 5. Bending Moment (KN-m) windward direction in X-Direction

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
G	133	202	118	129
1	83	150	70	97
5	46	77	39	83
10	155	95	159	201
15	246	205	260	250
20	323	322	322	225

Table 6. Bending Moment (KN-m) windward direction in Z-Direction

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
1	32	73	28	35
5	116	229	111	122
10	203	390	234	205
15	263	499	287	266
20	294	551	313	335

Table 7. Deflection (mm) in X-Direction

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
1	73	32	63	46
5	230	115	219	142
10	391	301	467	219
15	500	261	559	313
20	552	292	603	421

Table 8. Deflection (mm) in Z-Direction

	M_U	M_L	M_R	SF
G	0	178	297	118
5	147	40	279	219
10	140	90	404	216
15	130	61	372	206
20	122	23	250	190

Table 9. Bending Moment (KN-m) and Shear Force (KN) of Regular Building

	M_U	M_L	M_R	SF
G	107	107	209	120
5	153	114	435	227
10	158	123	441	230
15	155	115	431	227
20	147	99	414	242

Table 10. Bending Moment (KN-m) and Shear Force (KN) of Mass Irregular Building

	M_U	M_L	M_R	SF
G	0	163	271	108
5	150	47	287	220
10	141	91	404	216
15	126	54	359	200
20	121	250	24	189

Table 11. Bending Moment (KN-m) and Shear Force (KN) of Stiffness Irregular Building

	M_U	M_L	M_R	SF
G	81	80	181	116
5	155	120	438	227
10	153	121	438	226
15	142	53	408	217
20	112	8	294	181

Table 12. Bending Moment (KN-m) and Shear Force (KN) of Vertical Irregular Building

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vert Irreg Struc
G	0	400.76	0	301
5	555.33	579.24	567.38	587.
10	527.98	599.07	531.91	584.
15	488.83	587.17	473.23	535.
20	457.67	555.53	453.79	481

Table 13. Required steel (Sq. mm) in Bottom of Beam

	Regualr Structure	Mass Irregular Structure	Stiffness Ireegular Structure	Vertical Irregular Structure
G	608.99	400.78	620.75	297.35
5	146.64	426.61	172.63	449.91
10	334.54	461.56	338.36	446.03
15	224.92	430.54	198.72	345.99
20	83.93	368.94	975.72	29.8

Table 14. Required steel (Sq. mm) in Top (Extra Left) of Beam

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
G	1181.42	807.37	1168.41	693.11
5	1099.51	1816.75	1134.13	1831.64
10	1666.47	1846.47	1666.47	1831.64
15	1515.65	1796.2	1455.57	1685.63
20	975.72	1714.51	87.81	1164.59

Table 15. Required steel (Sq. mm) in Top (Extra Right) of Beam

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
G	401.92	628	401.92	514.96
5	628	828.96	628	828.96
10	628	828.96	628	828.96
15	628	828.96	628	628
20	628	628	628	628

Table 16. Provided steel (Sq. mm) in Bottom of Beam

	Regular Structure	Mass Irregular Structure	Stiffness Irregular Structure	Vertical Irregular Structure
G	1482.02	1168.08	1168.08	854.08
5	1168.08	2188.58	1207.33	2188.58
10	1810.96	2188.58	2188.58	2188.58
15	1697.96	2188.58	1697.96	2188.58
20	1168.08	2188.58	1207.33	1207.33

Table 15. Required steel (Sq. mm) in Top (Extra Left and Right) of Beam

V, CONCLUSION

1. Regular structure and stiffness irregular structure having almost same reaction at the base of column. In case of mass irregular structure is having a maximum reaction at the base of column whereas, in case of vertical irregular structure having less reaction at the base of column.
2. Maximum steel required in mass irregular structure as compare to other structure.
3. Maximum bending moment in windward direction in mass irregular structure as compare to other structure.
4. Regular, stiffness irregular and vertical irregular structure having a maximum deflection at X-direction as compare to Z-direction but, in case of mass irregular structure vice-versa.
5. The height of structure increases the bending moment decreases.
6. The height of structure increases the shear force decreases.

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