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Comparative Study of RC Building with and without Vertical Irregularity Subjected to Earthquake and Wind Loading

Dr. A. R. Gupta [1], Vicky P. Dhawale[2]
[1]*Guide & M.E Coordinator, Department of Structural Engineering C.O.E.T. Akola, S.G.B.A.U. Amravati (India)*
[2]*PG Student, Department of Structural Engineering C.O.E.T. Akola, S.G.B.A.U. Amravati (India)*

Abstract: Vertical irregular structures constitute a large portion of the modern urban infrastructure. The group of people involved in constructing the building facilities, including owner, architect, structural engineer, contractor and local authorities, contribute to the overall planning, selection of structural system, and to its configuration. This may lead to building structures with irregular distributions in their mass, stiffness and strength along the height of building. When such structures are located in a high wind zone and seismic zone, the safety of the structure becomes more challenging. So to acquire safety against additional deformations there is need to study of detailed considerations to design earthquake resistance structures as well as wind resistance structure. The work done over here is to find out the effect of vertical irregularity for the structure subjected to seismic and wind loads. Further the comparison is done for various models analyzed and on basis of observation remark are drawn. While considering the effect of seismic or wind force on high rise structure, study reveals that the effect of seismic forces are more vulnerable in terms of Displacement , Drift values , Member end forces and Moments developed.
Keywords: Irregular Structure, Wind Analysis, Seismic Analysis, Vertical Irregularity, High Rise Building, etc.

I. INTRODUCTION

From last few decades, The number of tall structures and skyscrapers around the world has increased drastically which is serving many purpose like residential, offices etc. and many other commercial requirements. Beautiful aesthetic appearance and eye catching shapes and projections of the structures has increased the demand of tall structure. In the perspective of structural engineer designing such eye catching shapes and the projections in a high rise structures is a challenging job to study the behaviour of structure. In vertically irregular structure, failure of structure starts at a point of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular Structure. So, The effect of vertical irregularities in the seismic and the wind load performance of a structure becomes really important. Height wise changes in stiffness and mass render the dynamic characteristics of these buildings different from regular building.

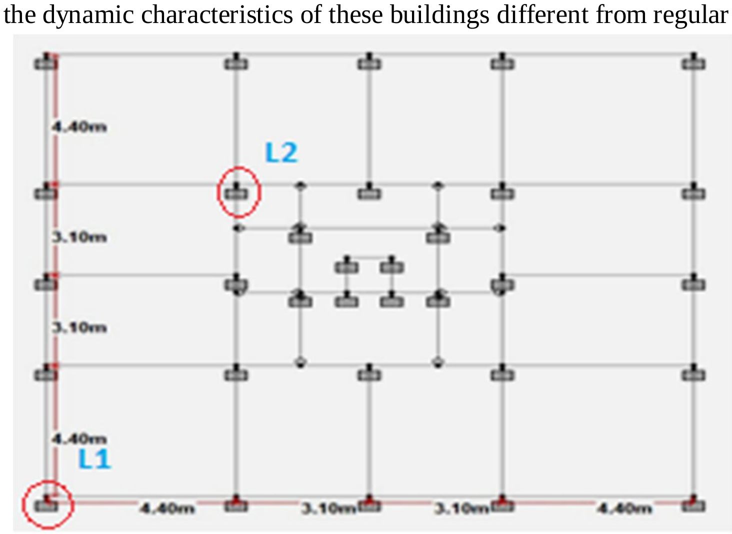

Figure 1. Plan of structure

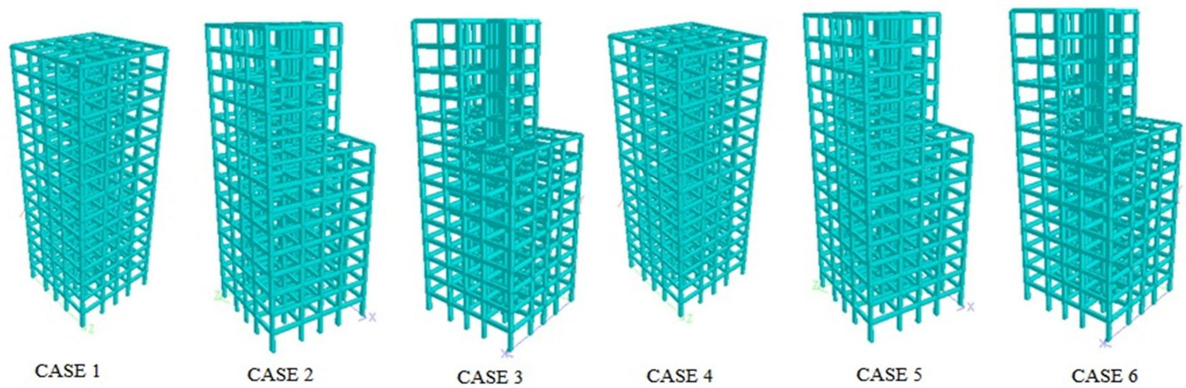

Figure 2. 3d model elevation

II. MODELLING AND ANALYSIS

The study in this thesis is based on an investigation on effect of vertical irregularity in high rise structure subjected to wind and seismic forces. In this thesis total six models are analyzed. All the models with and without vertical irregularity are analyzed by static analysis method in STAAD. Pro software. All the selected buildings are designed as per Indian Standards. The STAAD. Pro Software is used to develop 3D model and to carry out analysis. The seismic loads and wind loads to be applied on the structure are based on Indian Standards. The analysis is performed for seismic zone IV and basic wind speed 47 m/s as per IS 1893(Part 1) : 2002 and IS 875(Part 3) : 1987. A thirteen storey reinforced concrete structure with and without vertical irregularity is analyzed with seismic and wind forces. To study the effect of seismic forces and wind forces with vertical irregularity, six cases are modelled and analyzed in which Case 1, Case 2 and Case3 are subjected to seismic forces and Case 4, Case 5 and Case 6 are subjected to wind forces for the same location. Case 1 and Case 4 are the structures with no vertical irregularity and maintained symmetry. Case 2 and Case 5 are the structures with removed quarter portion above 8th storey and case 3 and Case 6 are structures with removed half portion above 8th storey.

Definition for L1 and L2 :

L1 – First location for the comparison of result data.

L2 – Second location for the comparison of result data.

TABLE 1
specifications of plan

Total Area	225 sq. m
Plan	15 x 15 Sq. m
Structure Height	39 m (3 m each storey)
Bays	4 bays in X and Z direction.
Support Type	Fixed Support
Column	
a. column	0.6 x 0.38 m (From GF to 8th floor)
b. column	0.45 x 0.38 m (From 9th to 13th floor)
c. column	0.38 x 0.30 m (Lift column)
Beam	
a. Beam	0.6 x 0.30 m (GF to 8th floor)
b. Beam	0.45 x 0.30 m (9th to 13th floor)
c. Beam	0.45 x 0.30 m (All secondary beams)
d. Beam	0.38 x 0.30 m (Lift beam)

TABLE 2
structural data

Type of structure	OMRF
No. of stories	G+12
Storey height	3m
Grade of concrete	M25
Grade of steel	Fe 415
Thickness of slab	150mm
Seismic zone	IV
Location	Delhi
Wind speed	47 m/s
Soil type	Medium

III. RESULT AND DISCUSSION

From the values of Table 3, Table 4, Table 5, Table 6, Table 7, Table 8, Table 9 and Table 10 when the comparison is made for all the 6 cases, it can be observed that the values are more for the structure subjected to seismic forces as compared to the structure subjected to wind forces.

TABLE 3
max. displacement(mm) (for location 1)

Node	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
371	176.48	182.02	176.52	24.45	27.39	32.57
366	170.17	175.46	168.00	23.91	26.70	31.28
361	160.00	165.29	155.62	22.98	25.56	29.45
356	147.70	152.11	139.96	21.75	24.03	27.18
351	132.61	136.44	108.84	20.19	22.22	24.49
346	115.72	118.93	103.13	18.35	20.06	21.60
341	99.80	102.44	89.71	16.45	17.87	19.00
336	87.15	89.38	78.61	14.83	16.00	16.82
331	74.17	76.00	66.95	13.03	13.99	14.51
326	60.96	62.42	54.99	11.08	11.82	12.11
321	47.72	48.82	42.96	8.98	9.52	9.65
316	34.60	35.38	31.06	6.76	7.12	7.14
311	21.75	22.23	19.47	4.42	4.46	4.60
306	9.37	9.57	8.37	2.00	2.12	2.08
301	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 4
max. displacement(mm) (for location 2)

Node	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
147	180.86	182.62	180.35	25.82	28.92	32.80
142	173.30	174.69	170.80	25.08	27.89	31.16
137	162.76	163.60	157.94	24.08	26.57	29.21
132	150.00	150.80	142.45	22.79	24.94	26.96
127	134.32	134.13	125.01	21.21	23.03	24.43
122	117.55	117.20	107.31	19.37	20.86	21.82
117	118.00	100.42	92.23	17.39	18.57	19.17
112	87.40	86.55	79.40	15.55	16.46	16.78
107	73.95	73.00	66.99	13.63	14.31	14.39
102	60.37	59.57	54.48	11.56	12.08	11.97
97	46.88	46.10	42.12	9.36	9.68	9.50
92	33.64	33.10	30.09	7.00	7.22	6.99
87	20.88	20.52	18.57	4.61	4.70	4.48
82	8.95	8.73	7.85	2.15	2.16	2.00
77	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 5
beam end forces (for location 1)

Node	Max.Shear Force(KN)					
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
371	39.08	39.56	41.16	24.04	24.28	24.62
366	43.15	90.77	94.51	-1.97	27.17	55.57
361	93.52	146.30	152.31	1.83	57.70	88.56
356	147.95	205.49	214.25	1.64	88.47	118.03
351	206.02	209.56	218.33	1.62	119.62	149.70
346	266.96	271.44	282.40	1.49	151.03	181.34
341	329.43	334.54	343.61	4.58	182.63	218.72
336	406.97	412.45	415.98	1.58	220.89	257.36
331	484.95	490.43	490.02	1.63	293.70	295.29
326	562.66	567.79	564.08	1.63	330.79	332.27
321	639.69	644.17	637.61	1.62	367.17	368.44
316	715.57	719.13	710.02	1.56	402.57	403.55
311	789.84	792.23	780.83	1.39	436.83	437.45
306	862.03	863.07	849.54	-2.25	469.34	469.56
301	930.32	930.09	914.47	0.00	0.00	0.00

TABLE 6
beam end forces (for location 2)

Node	Max.Shear Force(KN)					
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
147	54.17	53.00	24.29	35.77	35.01	13.54
142	109.29	105.75	63.20	73.60	71.26	31.98
137	168.70	164.00	110.55	113.10	109.20	51.11
132	231.70	225.20	164.52	152.90	147.63	70.93
127	297.68	229.30	223.50	193.20	186.40	91.07
122	364.99	293.20	292.70	234.20	226.30	133.80
117	416.62	358.90	333.40	273.90	264.80	170.50
112	473.30	410.60	381.80	312.02	301.50	209.41
107	537.23	465.40	435.60	351.50	339.70	249.60
102	604.18	524.48	493.60	392.50	379.60	291.30
97	674.19	586.32	555.70	435.50	421.90	334.65
92	747.67	651.30	622.04	480.90	466.50	379.91
87	825.09	792.27	693.00	528.66	513.70	427.40
82	905.90	871.60	768.70	579.50	564.36	478.16
77	911.42	877.04	774.20	0.00	0.00	0.00

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TABLE 7
beam end forces (for location 1)

Node	Bending Moment (KN.m)					
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
371	977	1002	1005	445	454	446
366	-554	1003	1013	606	-318	291
361	-725	1199	1211	616	-297	325
356	-929	1327	1343	642	-317	333
351	-1101	-1142	-1154	664	-331	346
346	-1290	-1340	-1356	684	-348	348
341	-1775	-1851	-1874	990	-416	595
336	-1783	-1852	-1872	1033	-535	515
331	-1786	-1859	-1885	1012	534	512
326	-1793	-1868	-1902	993	522	502
321	-1787	-1862	-1904	969	505	488
316	-1763	-1838	-1887	936	483	469
311	-1736	-1809	-1866	889	448	436
306	-1781	-1858	-1926	778	327	320
301	-2794	-2933	-3067	0	0	0

TABLE 8
beam end forces (for location 2)

Node	Bending Moment (KN.m)					
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
147	-960	-1011	720	-190	-200	182
142	-1201	-1276	950	-156	-183	172
137	-1538	-1640	1162	-202	-247	204
132	-1791	-1905	1289	-232	-290	223
127	-1986	1802	1455	-265	-324	232
122	-1976	2046	-1642	-270	-222	-256
117	-2350	1784	-2049	-334	-273	-277
112	-2573	2219	-2201	-391	-363	-338
107	-2639	2274	-2288	-420	-409	-376
102	-2663	2382	-2325	-450	-448	-414
97	-2651	2451	-2328	-477	-484	-448
92	-2062	2483	-2292	-498	-513	-477
87	-2515	-2265	-2220	-515	-528	-499
82	-2055	-1571	-1811	-423	-386	-414
77	2504	2601	2217	0	0	0

TABLE 9
reaction values

Node	Shear Force(kN)					
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
1	3958	3883	2576	1935	1929	1233
2	4450	4218	3087	2233	2129	1538
3	4423	3916	3062	2191	1918	1497
4	4450	3474	3087	2233	1704	1538
5	3958	2662	2576	1935	1246	1233
76	4423	4359	3321	2339	2346	1752
77	4054	3901	3444	2595	2528	2144
78	3663	3348	2906	2416	2231	1976
79	4054	3614	3444	2595	2259	2144
80	4423	3422	3321	2334	1772	1752
151	4342	4317	3816	2276	2299	1983
152	3586	3539	3219	2403	2375	2179
154	3586	3289	3219	2403	2224	2179
155	4342	3854	3816	2276	1989	1983
226	4475	4483	4305	2373	2408	2285
227	4228	4212	4090	2706	2713	2650
228	3743	3706	3666	2530	2505	2478
229	4228	4097	4090	2706	2645	2650
230	4475	4293	4305	2373	2272	2285
301	4138	4137	4068	2056	2105	2106
302	4038	4022	3992	2130	2160	2175
303	4069	4041	4019	2120	2140	2165
304	4038	4003	3992	2130	2140	2175
305	4138	4060	4068	2056	2051	2106
377	3332	3259	3098	1426	1433	1386
378	3419	3318	3318	1504	1503	1556
379	3332	3187	3098	1426	1383	1386
381	3419	3424	3318	1504	1553	1556
390	1938	2025	2153	399	399	399
391	1938	2025	2153	399	399	399
392	1418	1484	1581	271	271	271
393	1418	1484	1581	271	271	271

TABLE 10
reaction values

Node	Bending Moment(kN.m)					
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
1	254	252	223	48	46	48
2	248	239	219	51	49	50
3	233	220	-190	48	48	48
4	248	229	219	51	52	50
5	353	227	223	48	50	48
76	-294	-300	-260	-55	-57	-55
77	-283	-278	-250	-55	-56	-55
78	-234	-223	-210	-49	-50	-50
79	-283	-258	-250	-54	-53	-55
80	-294	-256	-260	-55	-52	-55
151	-293	-299	-257	-53	-56	-53
152	-282	-276	-248	-52	-54	-52
154	-282	258	-248	-52	52	-52
155	-293	257	-257	-53	52	-53
226	288	-294	252	51	-53	-51
227	280	270	246	54	52	53
228	234	220	205	50	49	49
229	280	258	246	54	55	53
230	288	257	252	51	54	-51
301	-259	-265	-230	-52	-54	-52
302	-141	-139	-126	-30	-31	-30
303	-135	-129	-121	-29	-29	-29
304	-141	-129	-126	-30	-19	-30
305	-260	-226	-230	-52	-50	-52
377	240	229	210	46	-45	45
378	-240	-222	-212	-46	-46	-46
379	240	223	210	46	46	45
381	-239	-231	207	-46	-47	-46
390	-48	-51	-56	-1	0	-1
391	-48	-51	-56	-1	0	-1
392	50	53	58	3	3	3
393	50	53	58	3	3	3

IV. CONCLUSION

When the comparison is done for Nodal displacement values, Beam end forces and Reaction values between structure subjected to seismic forces and wind forces with and without vertical irregularities, the values are more for the structure subjected to seismic forces. As per the clause of IS 1893 (Part 1):2002 either one of the force should be considered i.e. seismic or wind. From the above study it can be concluded that even if the structure is having vertical irregularity the analysis and design considering seismic forces will make structure safe against wind load also.

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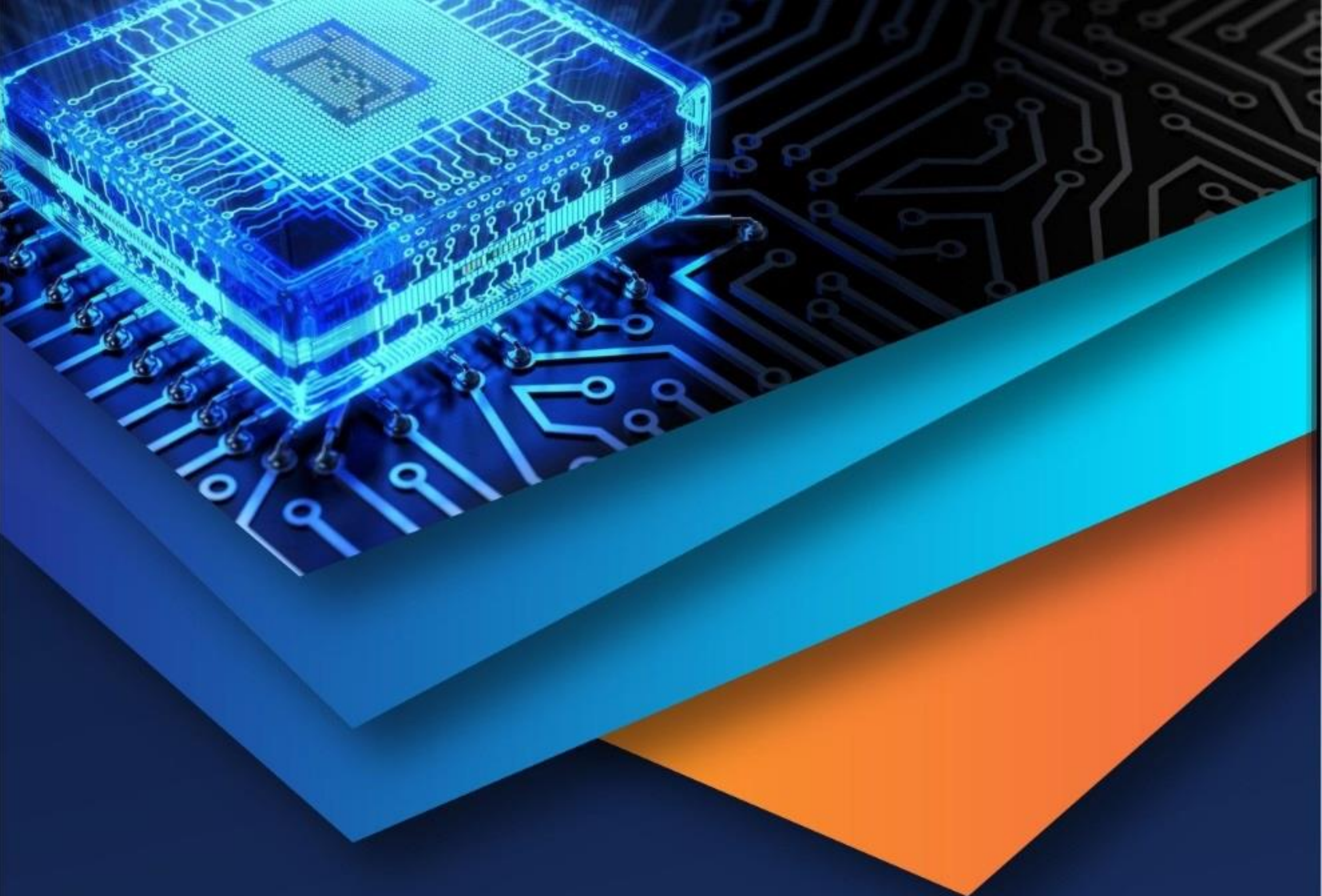

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