Research Paper Engineering

Seismic Performance Evaluation of Multi-Storeyed Building – An Approach to Symmetric and Asymmetric Building

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ABSTRACT

In present scenario, most of the buildings are often constructed with irregularities such as torsional irregularities, unsymmetrical layouts and plan irregularities etc. Reinforced concrete multi storeyed building are subjected to most dangerous earthquakes it was found that main reason for failure of RC building is irregularity in its plan dimensions and its lateral forces resisting system. In this research, linear static and linear dynamic analysis has been used to evaluate the seismic performance of 2 buildings with similarity in its area, height but differs in plan. Analysis is done by taking (g+20) storey buildings by linear static and response spectrum method using ETABS and is code 1893 -2002 part 1. The analysed model is in zone II and their soil condition is medium.

KEYWORDS : Symmetric and Asymmetric structures; Dynamic analysis, Storey displacement, Base Shear, Torsion.

Introduction: Buildings having simple regular geometry in plan as well as in elevation, suffer much less damage than the irregular configuration. A building shall be considered as irregular as per IS 1893-2002, if it lacks symmetry and has discontinuity in geometry, mass or load resisting elements. These irregularities may cause problem in continuity of force flow and stress concentrations. The structural analysis of G+20 storey reinforced concrete symmetrical and asymmetrical frame building is done with the help of Etabs software.

Asymmetric-plan buildings, namely buildings with in-plan asymmetric mass and strength distributions, are systems characterized by a coupled torsional-translational seismic response [6]. Plan and also elevation irregularities in Indian standard code (IS 1893): The irregularity of the structure might will classify in 2 sorts i.e. Plan and vertical, these are often characterized by 5 differing types like torsional, re-entrant corners, for plan irregularity[5]. An ideal multistory building designed to resist lateral loads due to earthquake would consist of only symmetric distribution of mass and stiffness in plan at every storey and a uniform distribution along height of the building. Such a building would respond only laterally and is considered as torsionally balanced (TB) building[2]

Concept of regular and irregular configuration

To perform well in an earth quake a building should possess four main attributes namely simple and regular configuration and adequate lateral Strength, stiffness and ductility. Current earthquake codes define structural configuration as either regular or irregular in terms of size and shape of the building, arrangement of the structural and non-structural elements within the structure, distribution of mass in the building etc. A building shall be considered as irregular for the purposes of this standard, if at least one of the conditions is applicable as per IS 1893(part1):2002

Asymmetric or plan irregular structures are those in which seismic response is not only translational but also torsional, and is a result of stiffness and/or mass eccentricity in the structure. Asymmetry may in fact exist in a nominally symmetric structure because of uncertainty in the evaluation of center of mass and stiffness, inaccuracy in the measurement of the dimensions of structural elements.

Case Study Details:

Dimension of beam	700mmx900mm
Dimension of column	700mmx1400mm
Thickness of Slab	150mm
Thickness of outside wall	230mm
Thickness of inner wall	150mm
Height of	3.5m
No of storey	G+20
Live Load	3kN/m2
Floor Finish	1kN/m2
Grade of reinforcing steel	Fe415
Grade of concrete	M 25
Density of concrete	25 kN/m3
Density of infill	20kN/m3
Seismic Zone	II
Importance factor	1
Zone factor	0.16
Damping ratio	5%

1. Base shear : It is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. It can be seen from results given in table that base shear depends upon seismic zone, terrain nature, base condition, and building height and shape. When a regular rectangular building is compared with a + shaped building, the base shear in the +shaped building is seems to be more than that of rectangular building in the lower storeys and gets reduces as the building height is increased. Plot of building height vs base shear for zone II are shown in figure.

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Table No -1

	Base Shear in X Direction		Base Shear in Y Direction	
Storey level	+ Shape Building	Rect Shape Building	+ Shape Building	Rect Shape Building
20	228.52	227.3	199.57	195.65
19	534.96	520.79	473.91	451.16
18	794.38	761.44	711.8	661.58
17	991.02	947.39	897.45	824.45
16	1133.43	1085.52	1038.33	946.71
15	1235.52	1186.96	1147.42	1039.79
14	1309.87	1261.96	1235.77	1113.5
13	1365.22	1318.09	1309.4	1173.56
12	1409.13	1362.57	1372.01	1224.01
11	1451.47	1404.79	1429.03	1270.49
10	1503.34	1455.03	1487.55	1319.96
9	1572.03	1520.13	1552.57	1377.22
8	1658.04	1600.89	1624.57	1442.78
7	1757.62	1694.09	1701.89	1514.87
6	1867.05	1795.95	1784.29	1592.65
5	1982.51	1902.21	1872.37	1675.76
4	2095.85	2005.08	1962.36	1760.09
3	2192.31	2091.54	2042.5	1834.84
2	2254.92	2147.21	2096.58	1885.44
1	2275.3	2165.37	2114.64	1902.64

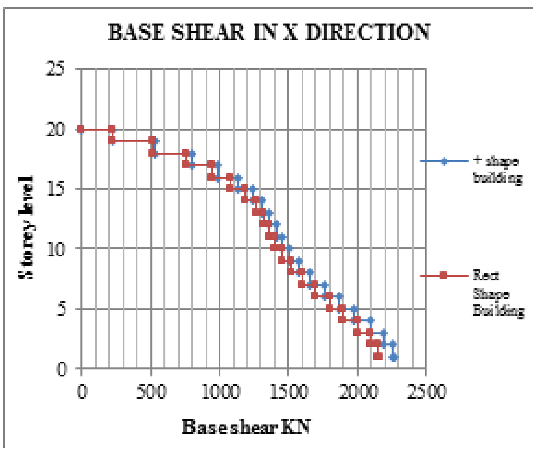

Chart No – 1(a)

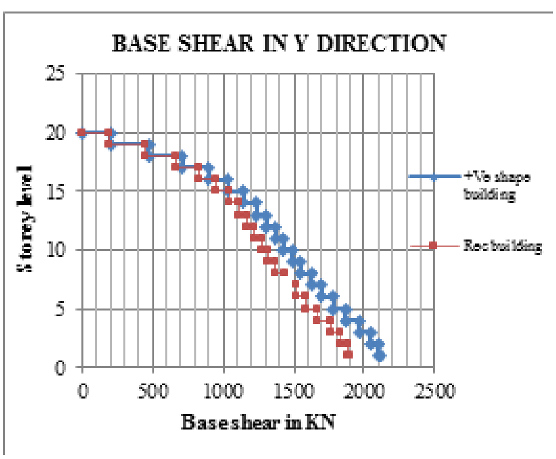

Chart No – 1(b)

2 .Storey displacement: It can be seen from the results that the displacement increases with increase in floor level of building. It can also be seen that the storey displacement is more in + shaped building as compare to rectangular building.

Table No -2

	Storey Displacement in X Direction		Storey Displacement in Y Direction	
Storey level	+ Shape Building	Rect Shape Building	+ Shape Building	Rect Shape Building
20	0.017333	0.015385	17.23301	17.3317
19	0.016642	0.014806	16.75284	16.78395
18	0.015899	0.014178	16.20308	16.16774
17	0.015102	0.013499	15.57777	15.48173
16	0.014259	0.012774	14.88399	14.73497
15	0.013379	0.012014	14.13113	13.93749
14	0.012472	0.011226	13.328	13.09841
13	0.011546	0.010417	12.4821	12.22541
12	0.010607	0.009594	11.59949	11.32461
11	0.009659	0.008759	10.68469	10.40045
10	0.008706	0.007915	9.740697	9.455756
9	0.007749	0.007063	8.769283	8.492009
8	0.006788	0.006204	7.771598	7.509987
7	0.005824	0.005337	6.748679	6.510291
6	0.004858	0.004463	5.701761	5.493707
5	0.003892	0.003586	4.632726	4.461628
4	0.002932	0.002708	3.545587	3.417284
3	0.001989	0.001842	2.450636	2.368879
2	0.001093	0.001013	1.377235	1.340373
1	0.000331	0.000305	0.426374	0.4199

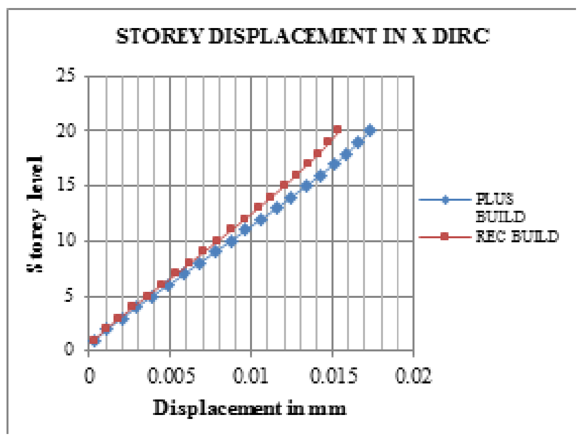

Chart No – 2(a)

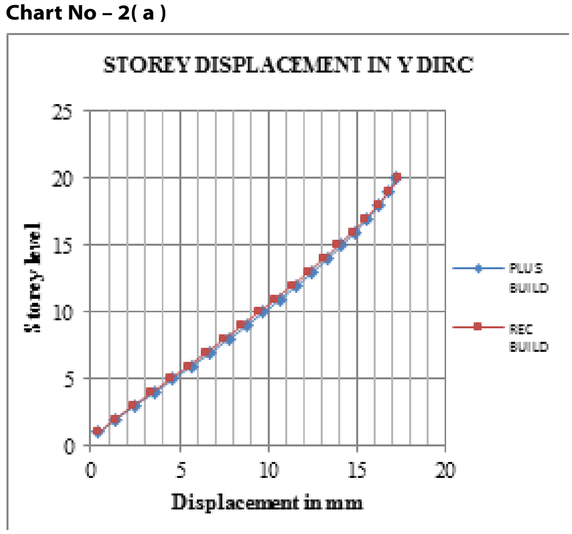

Chart No – 2 (b)

3 .Inter-storey Drift: Inter storey drift is the difference between the roof and floor displacement of any given storey as building sways during the earthquake, normalized by the storey height. The greater the drift, the greater likelihood of damage

Table No -2

	Storey Drift in X Direction		Storey Drift in Y Direction	
Storey level	+ Shape Building	Rect Shape Building	+ Shape Building	Rect Shape Building
20	0.000208	0.000175	0.000147	0.000166
19	0.000229	0.000194	0.000175	0.000194
18	0.000251	0.000216	0.000206	0.000222
17	0.000271	0.000234	0.000232	0.000246
16	0.000285	0.000248	0.000253	0.000265
15	0.000296	0.000258	0.000269	0.000279
14	0.000302	0.000265	0.000282	0.000289
13	0.000305	0.000268	0.000291	0.000296
12	0.000305	0.000269	0.000297	0.0003
11	0.000303	0.000268	0.000301	0.000302
10	0.0003	0.000266	0.000304	0.000302
9	0.000296	0.000264	0.000307	0.000303
8	0.000292	0.000262	0.000309	0.000303
7	0.000288	0.000259	0.000311	0.000303
6	0.000283	0.000257	0.000313	0.000303
5	0.000278	0.000254	0.000315	0.000303
4	0.000271	0.000249	0.000314	0.000301
3	0.000256	0.000237	0.000307	0.000294
2	0.000218	0.000202	0.000272	0.000263
1	0.00011	0.000102	0.000142	0.00014

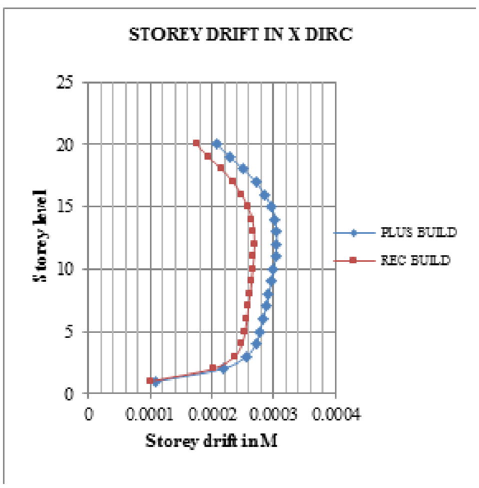

Chart No – 3(a)

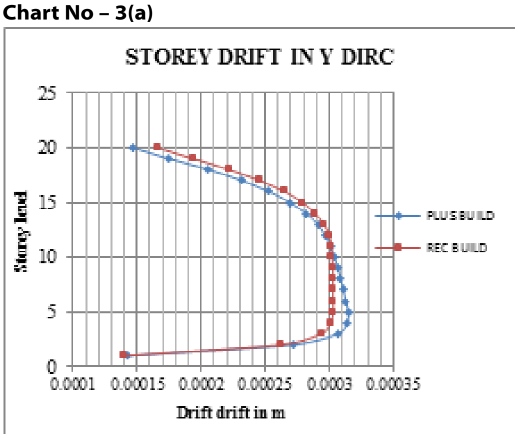

Chart No – 3(b)

4.Time period: It can be seen from the results that the time period depends upon the terrain nature, building height and does not depend upon seismic zone. I t can also be seen that time period for normal ground is more than sloping for their respective mode. This increase in time period decreases lateral inertia force developed in the building due to earthquake significantly.

Table No -4

No of Modes	Time Period (Sec)	
	+ Shape Building	Rect Shape Building
1	2.258	2.248
2	2.184	1.982
3	1.658	1.503

Chart No –5

5. Torsion: Torsion in buildings during earthquake shaking may be caused from a variety of reasons, the most common of which are non-symmetric distributions of mass and stiffness. The lateral-torsional coupling due to eccentricity between centre of mass (CM) and centre of rigidity (CR) in asymmetric building structures generates torsional vibration even under purely translational ground shaking. During seismic shaking of the structural systems, inertia force acts through the centre of mass while the resistive force acts through the centre of rigidity.

Table No -5

Building Torsion					
Storey level	+ Shape Building	Rect Shape Building	Storey level	+ Shape Building	Rect Shape Building
20	2285.244	1704.985	10	15033.36	10912.77
19	5349.593	3906.053	9	15720.32	11401.04
18	7943.799	5710.888	8	16580.39	12006.79
17	9910.228	7105.64	7	17576.24	12705.91
16	11334.32	8141.525	6	18670.52	13469.89
15	12355.16	8902.348	5	19825.06	14266.94
14	13098.66	9464.781	4	20958.48	15038.4
13	13652.16	9885.749	3	21923.08	15686.8
12	14091.33	10219.38	2	22549.24	16104.07
11	14514.73	10536.01	1	22753.01	16239.92

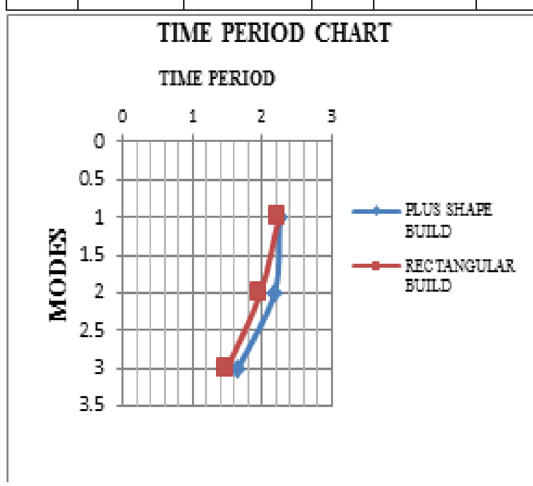

Chart No –5

CONCLUSIONS :

The plan configurations of structure has significant impact on the seismic response of structure in terms of displacement, story drift, story shear

Large displacement was observed in the + shape building. It indicates that building with severe irregularity shows maximum displacement and storey drift.

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