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EFFECT OF IRREGULAR CONFIGURATIION ON SEISMIC PERFORMANCE OF BUILDING BY USING ETABS

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Abstract: This research paper studies the behaviour of different irregular plan buildings under seismic performance. The building plans, more severe damages which have eccentricity between center of mass and center of rigidity in compare to building plan which have no eccentricity between center of mass and center of rigidity. The buildings well during earthquake which have zero eccentricity. Most common shape of building plans as Square shape, 'C' shape, 'L' shape, 'O' shape, '+' shape, and 'Y' shape which are repeatedly used in urban areas nowadays, which conforms as per clause 7.1 of IS Code 1893 (part 1)2016, are modelled by using ETABS software. Different parameters as Story drift, Story displacement, Torsion (Ratio of max story drift to average story drift), Total Base shear and Natural Time period are studied for six models. After analysis Response spectrum method, comparison of seismic performance of different models was performed and most vulnerable building shape against earthquake forces was located in this study for zone III.

Keywords: Earthquake damage, ETABS software, Plan irregularity, Response spectrum analysis, Seismic excitation, Zone III.

I. INTRODUCTION

Earthquake is known as shaking of earth, due to which sudden release of energy in earth surface takes place so that there is a formation of earthquake waves. When earthquake waves travel through the building, the building undergoes deformation. The buildings which are symmetrical in plan and elevation perform much better than those which have irregularity either in plan or in elevation under seismic loading. The irregular buildings having no regular geometry, not uniformly distributed mass and stiffness in plan. Past earthquake occurrence demonstrates that the building with irregularity are prone to more earthquake damages. IS Code 1893:2016 (Part 1) has explained building configuration system for better performance of RC buildings during earthquake response. A building is regular when building configuration are almost symmetrical about the axis and it is said to be irregular when it lacks of symmetry and discontinuity in geometry, mass or load resisting elements. The damages of the building are directly proportional to the amount of energy released during seismic excitation. The main objective of this research paper is to understand the behaviour of different configuration buildings under seismic performance in seismic zone III. In this study a 17 storey RC framed multistory building of regular Square shape, 'C' shape, 'L' shape, 'O' shape, '+' shape, and 'Y' shape building in seismic zone III, was used for study. All six models are chosen in such a way that plot area is nearly same and building built up area is different. All models constructed at same location. All models are modelled and analyzed by ETABS software using Response spectrum analysis. The seismic performance of all models in terms of story drift, story displacement, ratio of max story drift to average story drift, Total Base shear and Natural time Period were studied. By comparing above parameters, the best model which perform well during seismic excitation was located.

II. STRUCTURAL MODELING

Four building shapes representing regular square shape and irregular 'C' shape, 'L' shape, 'O' shape, '+' shape, and 'Y' shape building are modelled using EATBS. For this study, structures of G+16 (17) story are chosen. These structures are modelled according to the Indian Standard Code IS 1893:2016(part 1). The details of structure which are used in analysis are as follows,

Table 1: Geometrical and Material Data

Building Location	Nashik	Size of Beam	200X600 mm
Building Type	Residential Building	Size of shear wall	200X1300mm
Area of plot	40m X 40m	Grade of concrete	M30
Number of Story	17 (G+16)	Grade of concrete	M30
Floor to floor height	3 m	Unit wt. of concrete	25 KN/m3
Bottom Story height	3 m	SDL	1.5KN/m2
Total height of building	51 m	Live Load	2KN/m2
Slab thickness	125 mm	Grade of Steel	HYSD 500

Table 2: Seismic Data

Zone Factor (Z)	III (0.16)
Importance factor (I)	1.5
Response reduction factor (R)	4
Soil type	II
Damping	5%
Code used for analysis	IS 1893-2016

III. LOADING COMIBINATION

The structure has been analyzed for load combinations considering all the previous loads in proper ratio. Combination of self-weight, dead load, live load and seismic load was taken into consideration according to IS-code 875(Part 5).

Table 3: Load Combinations

1.(0.9DL+1.5SPEC1)	14.(1.2DL+1.2LL-1.2WX)
2.(0.9DL-1.5SPEC1)	15.(1.2DL+1.2LL+1.2WY)
3.(0.9DL+1.5SPEC2)	16.(1.2DL+1.2LL-1.2WY)
4.(0.9DL-1.5SPEC2)	17.(1.5DL+1.5SPEC1)
5.(0.9DL+1.5WX)	18.(1.5DL-1.5SPEC1)
6.(0.9DL-1.5WX)	19.(1.5DL+1.5SPEC2)
7.(0.9DL+1.5WY)	20.(1.5DL-1.5SPEC2)
8.(0.9DL-1.5WY)	21.(1.5DL+1.5WX)
9.(1.2DL+1.2LL+1.2SPEC1)	22.(1.5DL-1.5WX)
10.(1.2DL+1.2LL-1.2SPEC1)	23.(1.5DL+1.5WY)
11.(1.2DL+1.2LL+1.2SPEC2)	24.(1.5DL-1.5WY)
12.(1.2DL+1.2LL-1.2SPEC2)	25.(1.5DL+1.5LL)
13.(1.2DL+1.2LL+1.2WX)	

IV. PLAN DETAIL OF BUILDINGS SHAPES

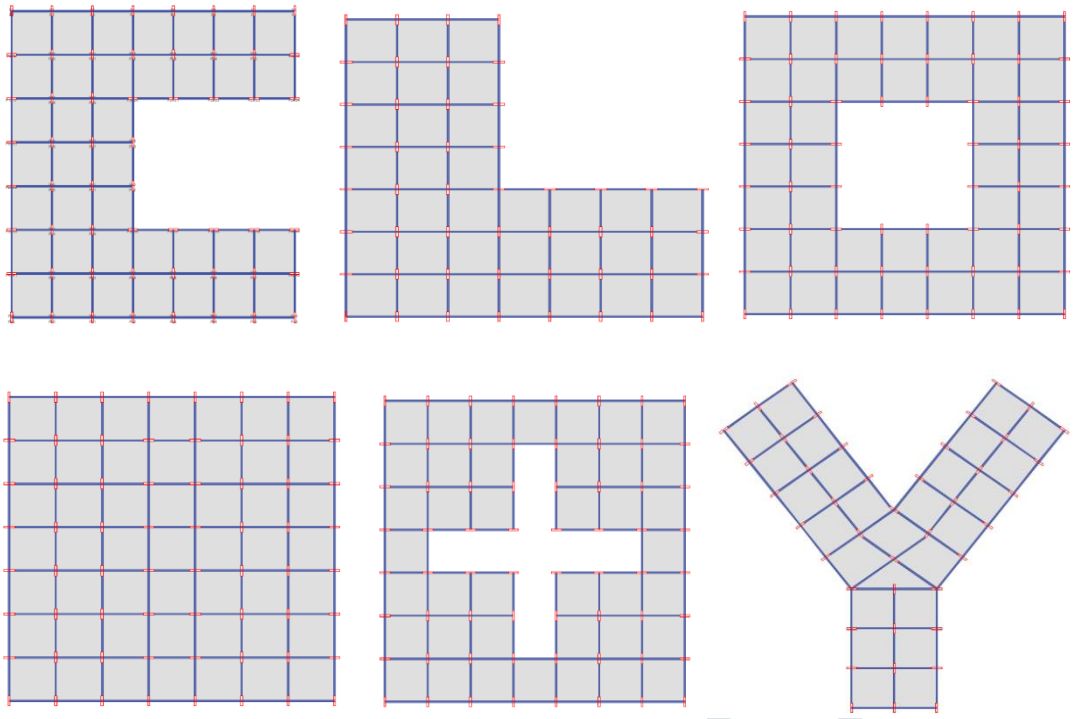

Fig 1 : Plan details of different models

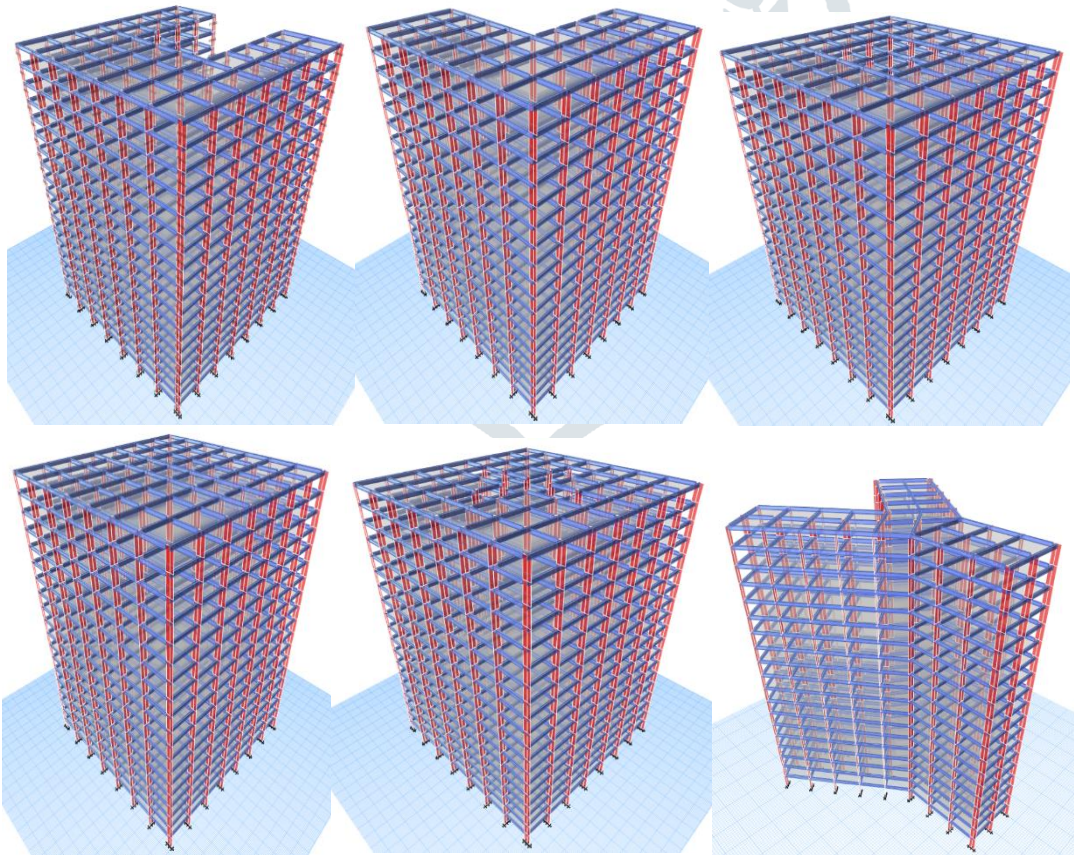

Fig 2: 3D View of different models

V. ANALYSIS OF THE STRUCTURES

In this study, response spectrum method is used since the structure is of irregular type therefore torsional irregularity is the major parameter to be considered for the study. In this analysis in both X and Y direction is used during earthquake analysis which leads to a better and quick assessment of the structure. The building site chosen for construction is Nashik in zone III. In seismic analysis, the behaviour of building is studied for story drift, story displacement and torsion.

Story Drift

Story Drift is the displacement of one-story level to another story level above or below. As per IS Code 1893:2016, the story drift in both X and Y direction should not be more than 0.004H, where H is the height of story. The limited value as per IS Code 1893-2016 story, 0.004x3000= 12 mm.

Table 4: Story drift in 'X' and 'Y' direction

Story	X Direction						Y Direction					
	C Shape	L Shape	O Shape	Square Shape	+ Shape	Y Shape	C Shape	L Shape	O Shape	Square Shape	+ Shape	Y Shape
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Terrace	1.699	1.977	2.314	2.304	2.456	2.093	1.81	1.449	1.815	1.532	2.175	1.54
Story17	2.169	2.507	2.604	2.832	2.868	2.582	2.281	1.831	2.132	1.991	2.553	1.972
Story16	2.729	3.106	3.227	3.49	3.468	3.145	2.758	2.247	2.579	2.505	3.042	2.475
Story15	3.294	3.707	3.868	4.156	4.06	3.713	3.219	2.657	3.013	3.015	3.524	2.961
Story14	3.815	4.268	4.463	4.775	4.608	4.249	3.639	3.034	3.411	3.484	3.966	3.41
Story13	4.275	4.768	4.997	5.327	5.094	4.73	4.009	3.366	3.762	3.9	4.355	3.806
Story12	4.674	5.201	5.461	5.804	5.511	5.15	4.327	3.652	4.064	4.26	4.687	4.151
Story11	5.013	5.568	5.854	6.207	5.858	5.508	4.59	3.891	4.315	4.565	4.962	4.443
Story10	5.292	5.872	6.18	6.54	6.139	5.803	4.802	4.085	4.518	4.816	5.182	4.683
Story9	5.517	6.113	6.441	6.804	6.358	6.036	4.966	4.239	4.674	5.017	5.349	4.876
Story8	5.69	6.298	6.642	7.003	6.516	6.211	5.081	4.352	4.786	5.173	5.465	5.02
Story7	5.814	6.425	6.783	7.141	6.617	6.326	5.15	4.427	4.855	5.282	5.533	5.118
Story6	5.89	6.496	6.865	7.216	6.659	6.377	5.173	4.463	4.881	5.347	5.551	5.168
Story5	5.911	6.501	6.875	7.218	6.637	6.351	5.141	4.457	4.858	5.362	5.513	5.163
Story4	5.858	6.414	6.787	7.123	6.526	6.218	5.038	4.39	4.77	5.308	5.401	5.084
Story3	5.681	6.176	6.537	6.861	6.271	5.913	4.82	4.225	4.571	5.134	5.164	4.887
Story2	5.242	5.644	5.968	6.275	5.724	5.307	4.378	3.865	4.166	4.724	4.69	4.468
Story1	4.221	4.479	4.705	4.981	4.546	4.115	3.453	3.072	3.311	3.783	3.689	3.554
Ground	1.798	1.952	1.959	2.134	1.9	1.711	1.467	1.327	1.307	1.614	1.548	1.563

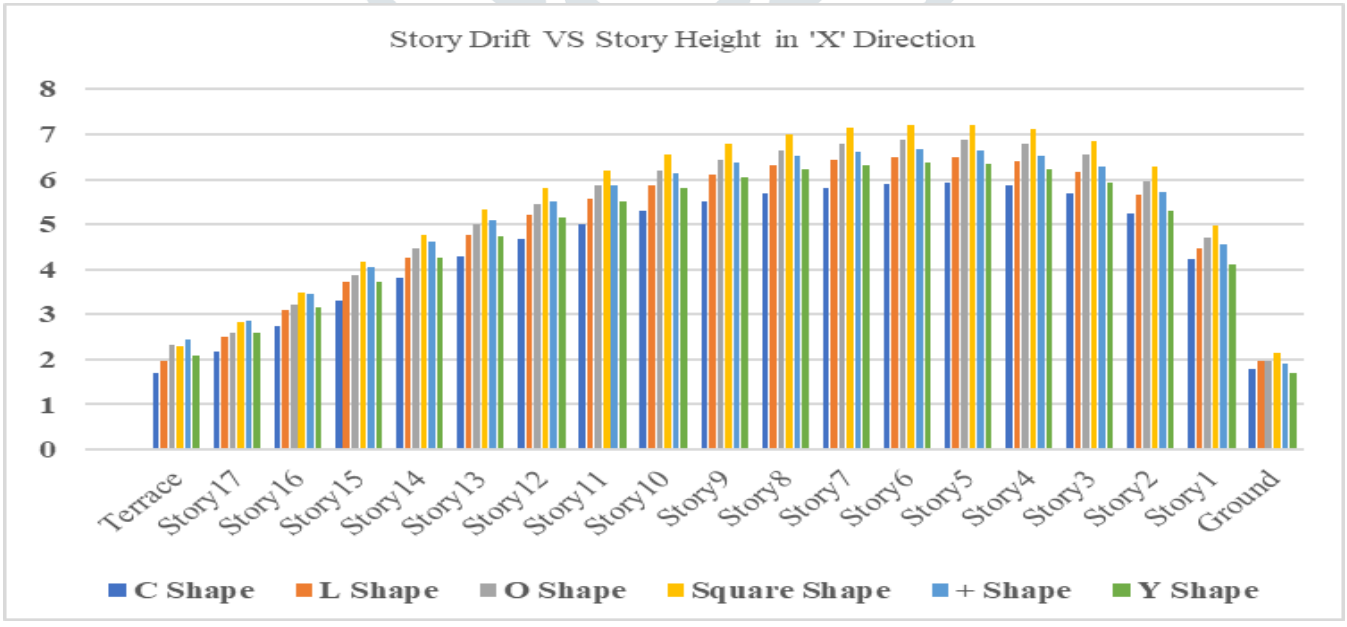

Fig 3: Graph of Story Drift VS Story Height in 'X' Direction

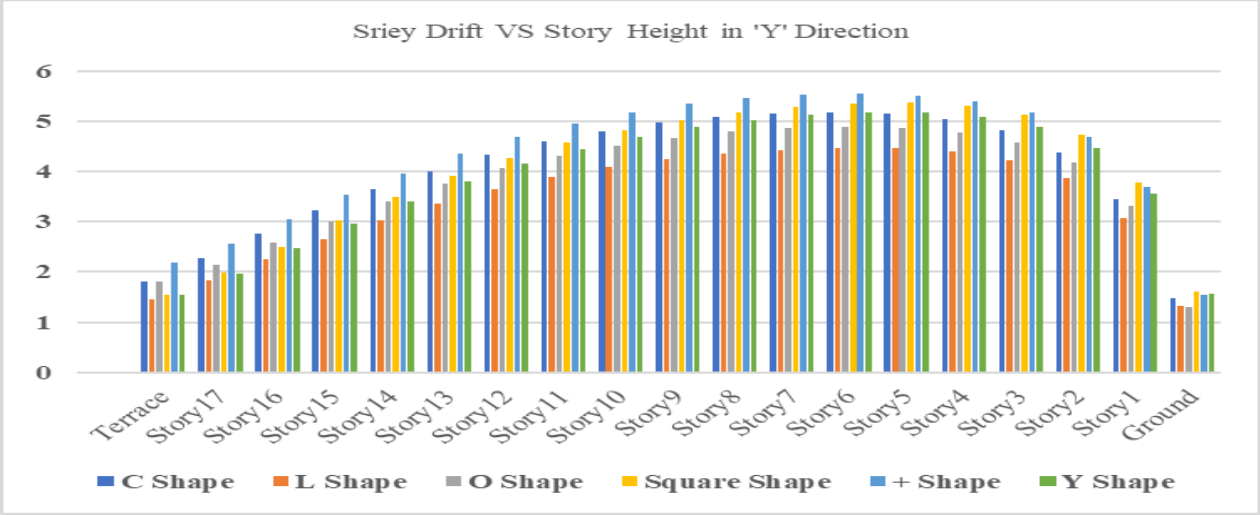

Fig 4: Graph of Story Drift VS Story Height in 'Y' Direction

Story displacement

According to IS Code 1893-2016, the maximum allowable deflection is calculated as h/250, where h is the height of story above the ground level.

Table 3: Max story displacement in 'X' and 'Y' direction

Story	X Direction						Y Direction					
	C Shape	L Shape	O Shape	Square Shape	+ Shape	Y Shape	C Shape	L Shape	O Shape	Square Shape	+ Shape	Y Shape
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Terrace	84.582	93.472	98.53	104.191	97.816	91.538	76.102	65.029	71.788	76.812	82.349	74.342
Story17	82.883	91.495	96.216	101.887	95.36	89.445	74.292	63.58	69.973	75.28	80.174	72.802
Story16	80.714	88.988	93.612	99.055	92.492	86.863	72.011	61.749	67.841	73.289	77.621	70.83
Story15	77.985	85.882	90.385	95.565	89.024	83.718	69.253	59.502	65.262	70.784	74.579	68.355
Story14	74.691	82.175	86.517	91.409	84.964	80.005	66.034	56.845	62.249	67.769	71.055	65.394
Story13	70.876	77.907	82.054	86.634	80.356	75.756	62.395	53.811	58.838	64.285	67.089	61.984
Story12	66.601	73.139	77.057	81.307	75.262	71.026	58.386	50.445	55.076	60.385	62.734	58.178
Story11	61.927	67.938	71.596	75.503	69.751	65.876	54.059	46.793	51.012	56.125	58.047	54.027
Story10	56.914	62.37	65.742	69.296	63.893	60.368	49.469	42.902	46.697	51.56	53.085	49.584
Story9	51.622	56.498	59.562	62.756	57.754	54.565	44.667	38.817	42.179	46.744	47.903	44.901
Story8	46.105	50.385	53.121	55.952	51.396	48.529	39.701	34.578	37.505	41.727	42.554	40.025
Story7	40.415	44.087	46.479	48.949	44.88	42.318	34.62	30.226	32.719	36.554	37.089	35.005
Story6	34.601	37.662	39.696	41.808	38.263	35.992	29.47	25.799	27.864	31.272	31.556	29.887
Story5	28.711	31.166	32.831	34.592	31.604	29.615	24.297	21.336	22.983	25.925	26.005	24.719
Story4	22.8	24.665	25.956	27.374	24.967	23.264	19.156	16.879	18.125	20.563	20.492	19.556
Story3	16.942	18.251	19.169	20.251	18.441	17.046	14.118	12.489	13.355	15.255	15.091	14.472
Story2	11.261	12.075	12.632	13.39	12.17	11.133	9.298	8.264	8.784	10.121	9.927	9.585
Story1	6.019	6.431	6.664	7.115	6.446	5.826	4.92	4.399	4.618	5.397	5.237	5.117
Ground	1.798	1.952	1.959	2.134	1.9	1.711	1.467	1.327	1.307	1.614	1.548	1.563

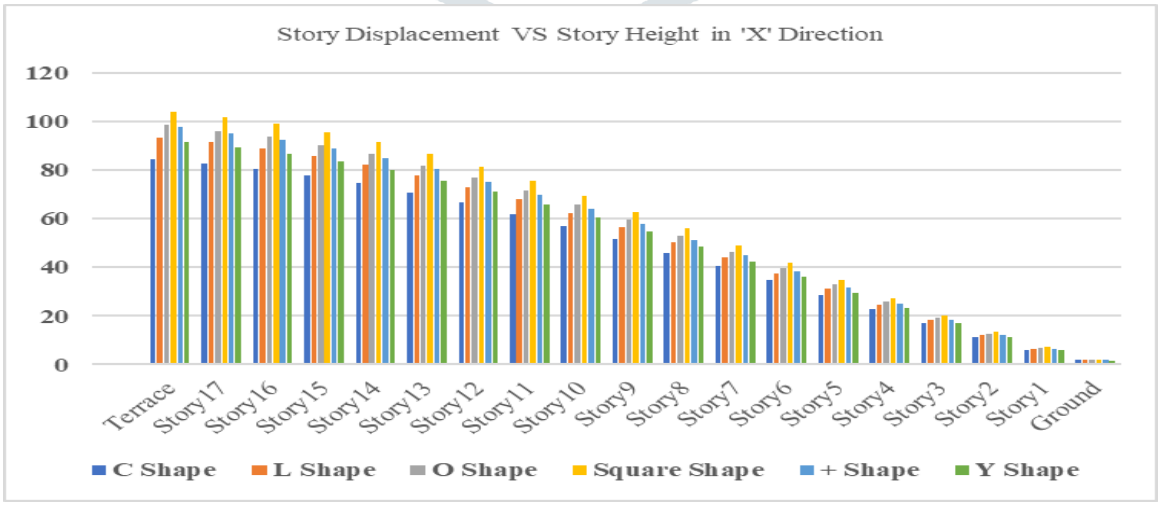

Fig 5: Graph of Story Displacement VS Story Height in 'X' Direction

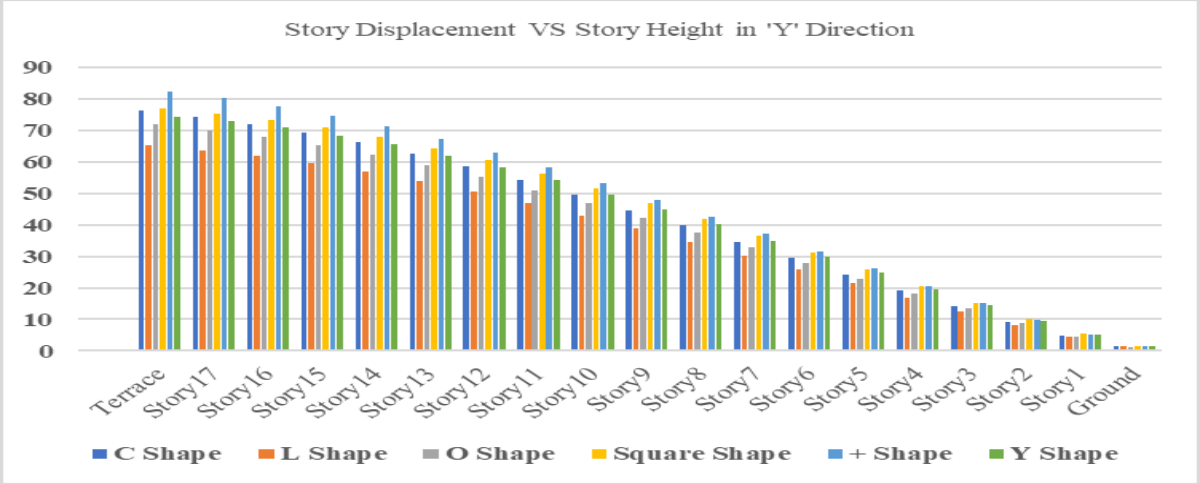

Fig 6: Graph of Story Displacement VS Story Height in 'Y' Direction

Max / Avg. Story Drift Ratio (Torsion):

As per IS 1893:2016 Code describe that the torsional irregularity will be occur when max story drift/ average story drift ratio is more than 1.2.

Table 4: Ratio of Max drift / Average drift in 'X' and 'Y' direction

Story	X Direction						Y Direction					
	C Shape	L Shape	O Shape	Square Shape	+ Shape	Y Shape	C Shape	L Shape	O Shape	Square Shape	+ Shape	Y Shape
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Terrace	4.7572	5.5356	6.4792	6.4512	6.8768	5.8604	5.068	4.0572	5.082	4.2896	6.09	4.312
Story17	6.0732	7.0196	7.2912	7.9296	8.0304	7.2296	6.3868	5.1268	5.9696	5.5748	7.1484	5.5216
Story16	7.6412	8.6968	9.0356	9.772	9.7104	8.806	7.7224	6.2916	7.2212	7.014	8.5176	6.93
Story15	9.2232	10.3796	10.8304	11.6368	11.368	10.3964	9.0132	7.4396	8.4364	8.442	9.8672	8.2908
Story14	10.682	11.9504	12.4964	13.37	12.9024	11.8972	10.1892	8.4952	9.5508	9.7552	11.1048	9.548
Story13	11.97	13.3504	13.9916	14.9156	14.2632	13.244	11.2252	9.4248	10.5336	10.92	12.194	10.6568
Story12	13.0872	14.5628	15.2908	16.2512	15.4308	14.42	12.1156	10.2256	11.3792	11.928	13.1236	11.6228
Story11	14.0364	15.5904	16.3912	17.3796	16.4024	15.4224	12.852	10.8948	12.082	12.782	13.8936	12.4404
Story10	14.8176	16.4416	17.304	18.312	17.1892	16.2484	13.4456	11.438	12.6504	13.4848	14.5096	13.1124
Story9	15.4476	17.1164	18.0348	19.0512	17.8024	16.9008	13.9048	11.8692	13.0872	14.0476	14.9772	13.6528
Story8	15.932	17.6344	18.5976	19.6084	18.2448	17.3908	14.2268	12.1856	13.4008	14.4844	15.302	14.056
Story7	16.2792	17.99	18.9924	19.9948	18.5276	17.7128	14.42	12.3956	13.594	14.7896	15.4924	14.3304
Story6	16.492	18.1888	19.222	20.2048	18.6452	17.8556	14.4844	12.4964	13.6668	14.9716	15.5428	14.4704
Story5	16.5508	18.2028	19.25	20.2104	18.5836	17.7828	14.3948	12.4796	13.6024	15.0136	15.4364	14.4564
Story4	16.4024	17.9592	19.0036	19.9444	18.2728	17.4104	14.1064	12.292	13.356	14.8624	15.1228	14.2352
Story3	15.9068	17.2928	18.3036	19.2108	17.5588	16.5564	13.496	11.83	12.7988	14.3752	14.4592	13.6836
Story2	14.6776	15.8032	16.7104	17.57	16.0272	14.8596	12.2584	10.822	11.6648	13.2272	13.132	12.5104
Story1	11.8188	12.5412	13.174	13.9468	12.7288	11.522	9.6684	8.6016	9.2708	10.5924	10.3292	9.9512
Ground	5.0344	5.4656	5.4852	5.9752	5.32	4.7908	4.1076	3.7156	3.6596	4.5192	4.3344	4.3764

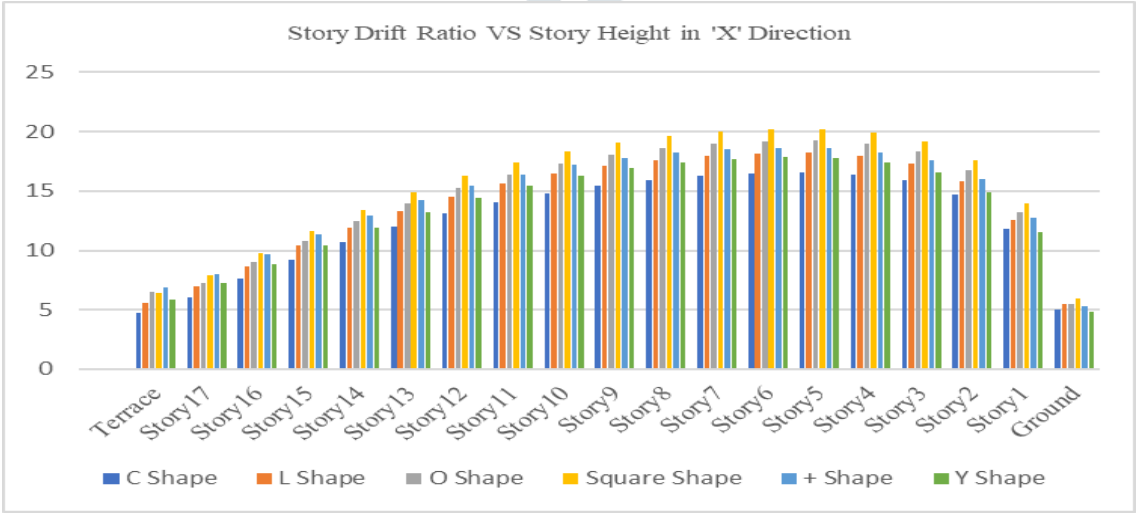

Fig 7: Graph of Story Drift Ratio VS Story Height in 'X' Direction

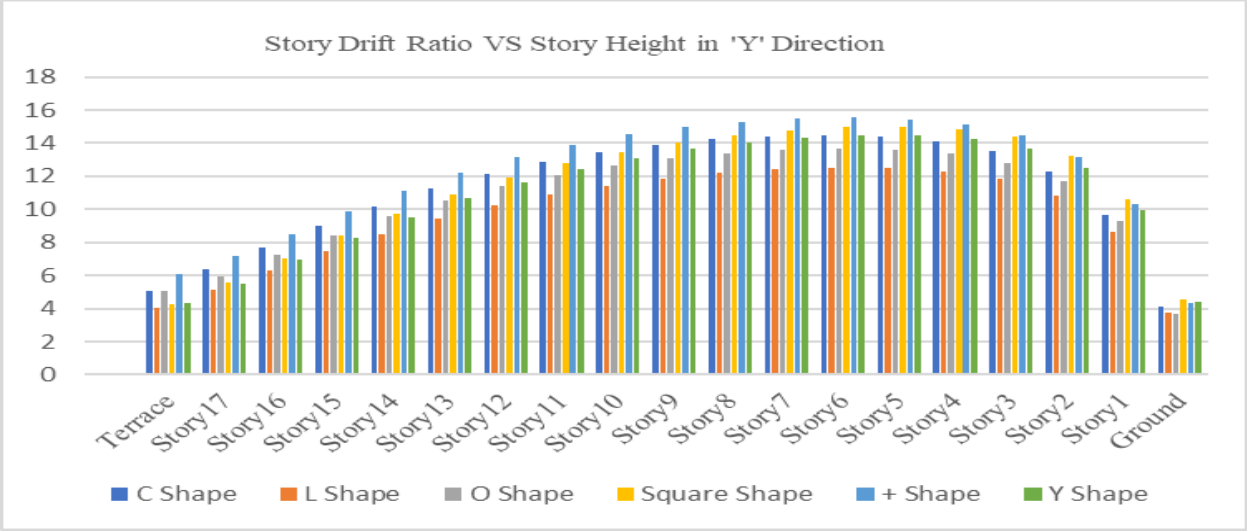

Fig 8: Graph of Story Drift Ratio VS Story Height in 'Y' Direction

Total Base Shear:

The shear value generated from the sum of design lateral forces at levels above the structure's storey consideration is known as the storey shear. The storey shear will be greatest at the bottom floors and lowest at the top stories. In the table below, the shear values for both models are listed.

Table 5: Total base Shear in 'X' and 'Y' Direction

Story	Base shear in X Direction	Base shear in Y Direction
C Shape	3633.19	5284.64
L Shape	3014.74	4242.97
O Shape	4201.22	5951.72
SQUARE Shape	5216.53	6738.02
+ Shape	4730.41	6110.11
Y Shape	2973.8	2779.86

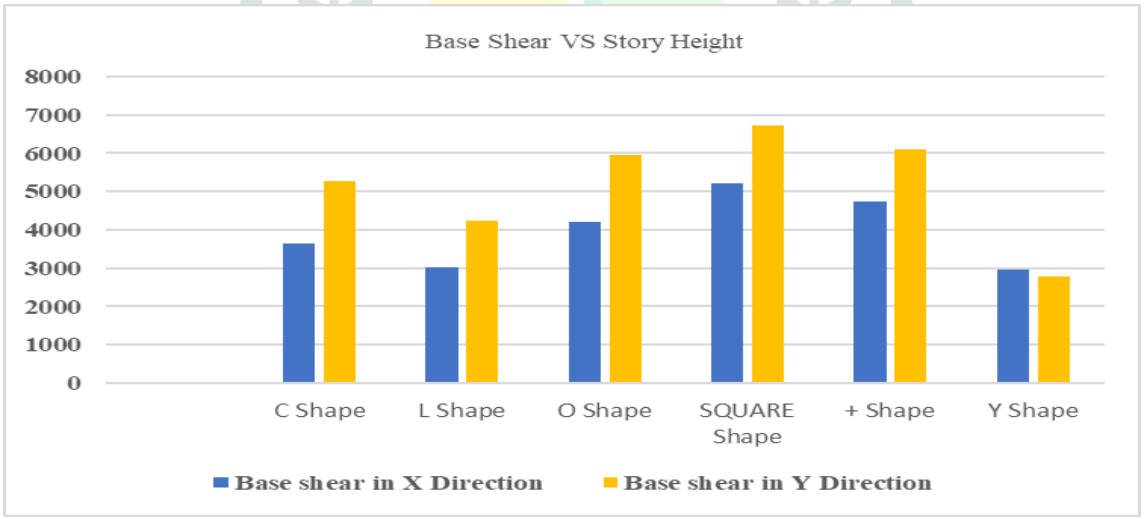

Fig 9: Graph of Story Base Shear VS Story Height

Fundamental Natural Period:

When the ground shakes, the base of a building moves with the ground, and the building swings back and forth motion. The time taken (in seconds) for each complete cycle of oscillation is Fundamental Natural Period of the building. The results obtained in analysis by using Etabs are shown below:

Table 6: Time Period in 'X' and 'Y' Direction

Story	Time Period of Structure (Sec)
C Shape	3.306
L Shape	3.531
O Shape	3.395
SQUARE Shape	3.331
+ Shape	3.38
Y Shape	3.376

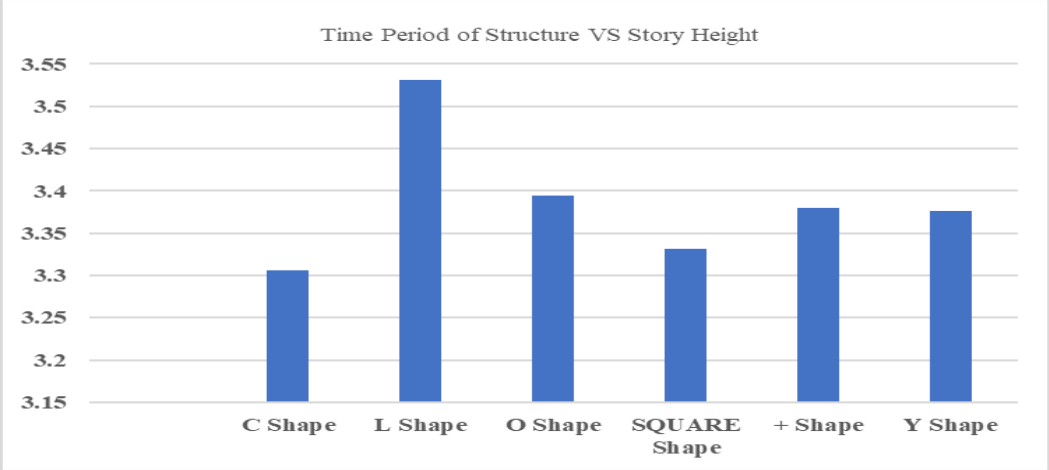

Fig 10: Graph of Time Period VS Story Height

Results of analysis are discussed in terms of parameters such as story drift, story displacement, story drift Ratio and natural period.

- Storey Drift gradually increases at the base then maximum at the middle of the storey & minimum at the top of the storey.
- Storey displacement is minimum near the base and 1st storey of structure and gradually increases to top of structure.
- For damping of 5%, natural period increases as the acceleration increases.
- The natural period is more in Irregular buildings as compare to regular building of square shape.
- The storey drift is more in Irregular buildings as compare to regular building structure.
- The storey displacement is more in irregular buildings as compare to regular building.

VI. RESULT AND CONCLUSION:

A Response Spectrum analysis was performed and results were found in terms of storey drift, storey displacement and max. drift/avg. drift ratio, base Shear and Natural period. From the results of analysis of the models following conclusions can be drawn,

a) The comparative study of story drift in X and Y direction for four models are represented in table 4, in figure 3 and figure 4. The story drift behaviour of Square shape, 'C' shape, 'L' shape, 'O' shape, '+' shape, and 'Y' shape building are increasing from 1st to 8th storey and then decreases thereafter. Maximum story drift for all models are within permissible limit according to IS code 1893:2016.

b) The comparative study of story displacement in X and Y direction for four models are represented in table 5, in figure 5 and figure 6. On comparing the story displacement of Square shape, 'C' shape, 'L' shape, 'O' shape, '+' shape, and 'Y' shape building story displacements is decreases at the bottom and increase at the top. Maximum story displacement for all models are within permissible limit according to IS code 1893:2016.

c) The comparative study of torsion in X and Y direction for four models are represented in table, in figure 7 and figure 8. The torsional behaviour of the structure depends upon the max drift/avg. drift ratio of the storey.

d) The results of fundamental natural periods have proved that; the code IS 1893:2016 doesn't consider the irregularity of buildings

e) Irregular structural configurations are affected severely during earthquakes especially in high seismic zones. The performance of model C and L was more vulnerable to earthquake than rest of the models for structures.

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REFERENCES

[1] Nilesh Sanjiv More Nikam P.A., Jadhav R. M.., "Structural Analysis of Multi-Storied Building for Different Plan Configuration for Different Types of Soil Considering Equivalent Strut Approach" ISSN: 2454-9150, 2018.

[2] Mr. Nimit Moza, Prof. Pravin Nikam, "Study of Lateral Load Resisting System for High Rise Building Analysis" ISSN: 2456-9976, 2021.

[3] Rahman, Shaikh Abdul Aijaj Abdul Salik, Ansari Ubaidurrahman, "Seismic analysis of vertically irregular buildings", p-ISSN 0976-6308, e-ISSN: 0976-6316 2016.
[4] Shelke, Ravindra N; Ansari U. "Seismic analysis of vertically irregular RC building frames" p-ISSN 0976-6308, e-ISSN: 0976-6316,2017.
[5] Raúl González Herrer, "Influence of Plan Irregularity of Buildings" The 14th world conference on earthquake engineering October 12-17,2008.
[6] Ravi Kumar C M, "Effect of Irregular Configurations on seismic Vulnerability of RC Buildings" Architecture Research 2012.
[7] Rucha S. Banginwar, M. R. Vyawahare, "Effect of Plans Configurations on the Seismic Behaviour of the Structure by Response Spectrum Method" IJERA ISSN: 2248-9622 vol 2 June 2012.
[8] Milind V. Mohod "Effect of Shape and Plan Configuration on Seismic Response of Structure" IJSTR VOLUME 4, ISSUE 09, SEPTEMBER 2015
[9] Komal R. Bele, and S.B.Borghate "Dynamic analysis of building with plan irregularity" JCEET ISSN 2349-879 volume 2, 2
[10] Atul Patane, Sachin Kadam "Effect of Horizontal Irregularity on Seismic Behavior of Building" IJESRT ISSN: 2277-9655 2015
[11] Veena S Ravi, Sreedevi Lekshmi "Effect of Shape and Plan Configuration on Seismic Response of Structure (ZONE II & V)" IJSR ISSN: 2319-7064 2015
[12] IS 1893 (Part 1): 2002 Code Indian Standard Criteria for Earthquake Resistant Design.
[13] IS 875 (Part 2): 1987 code Indian Standard Code of Practice for Design.