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Effect of Irregular Configurations on Seismic Behaviour of Rc Buildings

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***Abstract:*-- This research paper studies the behaviour of different irregular plan buildings during seismic excitation. The building plans, which have eccentricity between center of mass and center of rigidity are subjected to more severe damages in compare to building plan which have no eccentricity between center of mass and center of rigidity. The buildings which have zero eccentricity perform well during earthquake. Most common shape of building plans as Square shape, 'L' shape, 'C' shape, and 'T' shape, which are repeatedly used in urban areas nowadays, which conforms as per clause 7.1 of IS Code 1893 (part 1)2002, are modelled by using ETABS software. Different parameters as Story drift, Story displacement and Torsion (Ratio of max story drift to average story drift) are studied for four models. After analysis using Linear Time history method, comparison of seismic performance of different models was performed and most vulnerable building shape against earthquake forces was located in this study.**

key words: Seismic excitation, Plan irregularity, earthquake damage, ETABS software, etc.

I. INTRODUCTION

Earthquake is known as tremors or 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 travels through the building, the building undergoes deformation.

The buildings which are regular in plan and elevation perform much better than those which have irregularity either in plan or in elevation under seismic loading. The building having no regular geometry, not uniformly distributed mass and stiffness in plan are called irregular buildings. Past earthquake occurrence demonstrate that the building with irregularity are prone to more earthquake damages.

IS Code 1893:2002 (Part 1) has explained building configuration system for better performance of RC buildings during earthquake response. A building is said to be 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 is 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 irregular shape buildings during seismic excitation in seismic zone IV. In this study a 15 storey RC framed multistory building of regular square shape and irregular 'L' shape, 'C' shape, 'T' shape building in seismic zone IV , was used for study. All four models are choosen in such a way that plot area is same and building built up area is different. All models constructed at same location. All models are modelled and analyzed by ETABS software using Linear Time history analysis. The seismic performance of all models in terms of story drift, story displacement and ratio of max story drift to average story drift were studied. By comparing above parameters the best model which perform well during seismic excitation was located.

2. STRUCTURAL MODELING

Four building shapes representing regular square shape and irregular 'L' shape, 'C' shape, 'T' shaped building are modelled using EATBS. For this study, structures of G+14 (15) story are chosen. These structures are modelled according to the Indian Standard Code IS 1893:2002(part 1). The details of structure which are used in analysis are as follows

Table 1: Geometric and Material Data

Building Type	Office Building
Area of plot	28m X 28m
Number of Story	15 (G+14)
Floor to floor height	3 m
Bottom Storey height	3.5 m
Total height of building	45.5 m
Slab thickness	180 mm
Size of Beam	300x550 mm 300x450 mm

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Size of Column	600x600 mm 450x450 mm
Grade of concrete (Beam, Slab)	M30
Grade of concrete (Column)	M30
Unit wt. of concrete	25 KN/m^3
Live Load	4.0 KN/m^2
Grade of Steel	HYSD 415

Table 2: Seismic Data

Zone Factor (z)	IV(0.24)
Importance factor (I)	1.5
Response reduction factor (R)	5
Soil type	II
Damping	5%
Code used for analysis	IS 1893-2002
Time history data used	Delhi University, New Delhi (DLU).

2.1 Plan Detail of buildings shapes

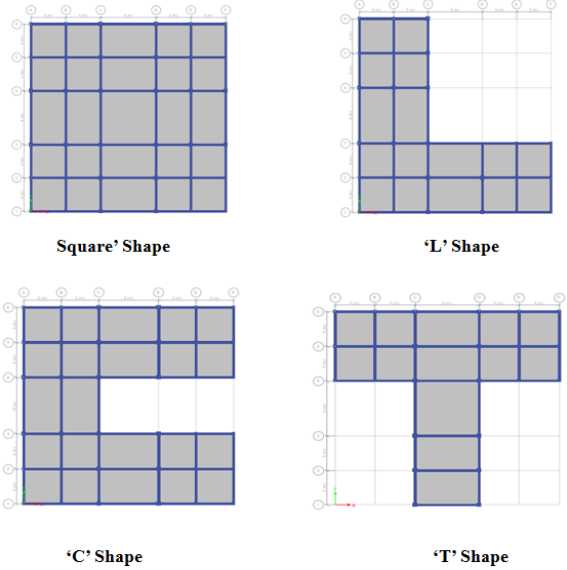

Fig 1: Plan details of different models.

2.2 3D view of different models

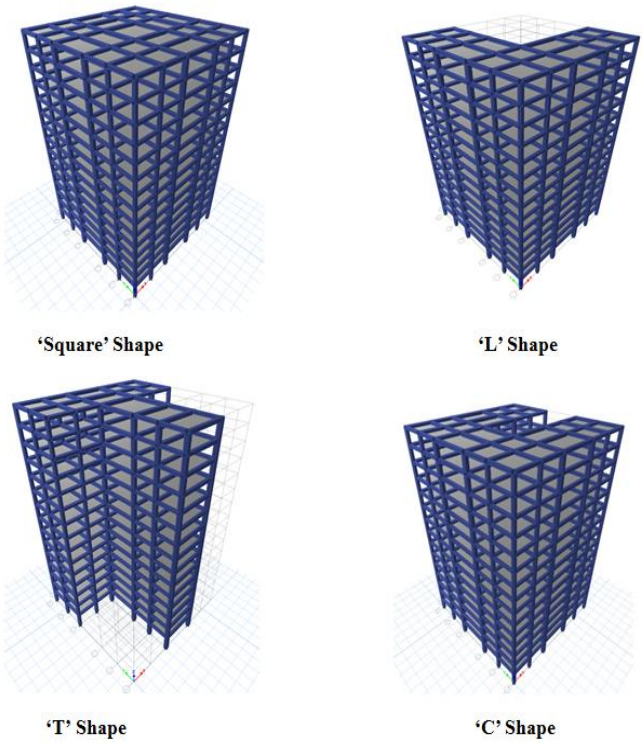

Fig 2: 3D View of different models.

3. ANALYSIS OF THE STRUCTURES

In this study, linear time history method is used since the structure is of irregular type therefore torsional irregularity is the major parameter to be considered for the study, also time history method gives better result in case of irregular and high rise building. In time history analysis actual ground acceleration data in both X and Y direction is used during earthquake analysis which leads to a more better and quick assessment of the structure. The building site chosen for construction is Delhi University, Delhi in zone IV. Necessary time history data is provided by IMD. In seismic analysis, the behaviour of building is studied for story drift, story displacement and torsion.

3.1. Story Drift

Story Drift is the displacement of one story level to other story level above or below. As per IS Code 1893:2002, the story drift in both X and Y direction should not be more than 0.004H, where H is the height of story.

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The limited value as per IS Code 1893-2002 story drift in 1st story, 0.004x3500 = 14 mm.
The limited value as per IS Code 1893-2002 story drift in 2nd to 12th story, 0.004x3000= 12 mm.

Table 3: Story drift in 'X' and 'Y' direction

Story	'X' Direction				'Y' Direction			
	Square Shape	'L' Shape	'C' Shape	'T' Shape	Square Shape	'L' Shape	'C' Shape	'T' Shape
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Story15	1.827	3.535	2.303	1.797	1.827	4.072	2.818	2.196
Story14	2.77	4.393	2.972	2.52	2.77	4.961	3.454	3.115
Story13	3.697	5.278	3.562	3.358	3.697	5.877	4.014	4.03
Story12	4.512	6.048	4.057	4.09	4.512	6.667	4.478	4.837
Story11	5.2	6.685	4.46	4.706	5.2	7.316	4.85	5.517
Story10	5.767	7.189	4.776	5.213	5.767	7.825	5.131	6.073
Story9	6.222	7.568	5.008	5.619	6.222	8.205	5.327	6.514
Story8	6.575	7.831	5.164	5.933	6.575	8.463	5.441	6.849
Story7	6.837	7.988	5.247	6.164	6.837	8.611	5.479	7.088
Story6	7.017	8.047	5.263	6.322	7.017	8.656	5.446	7.241
Story5	7.123	8.016	5.219	6.414	7.123	8.608	5.346	7.313
Story4	7.152	7.887	5.121	6.441	7.152	8.463	5.186	7.299
Story3	7.057	7.6	4.973	6.37	7.057	8.172	4.972	7.14
Story2	6.607	6.906	4.817	6.018	6.607	7.499	4.745	6.584
Story1	4.907	4.844	4.779	4.612	4.907	5.438	4.814	4.73

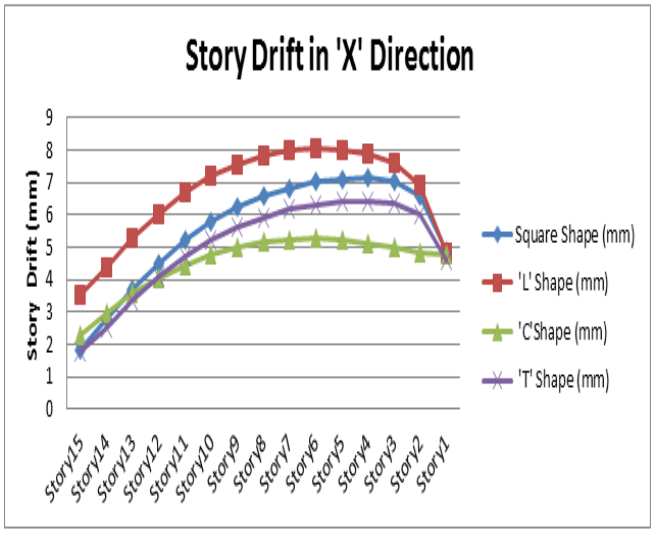

Fig 3: Comparison of Story drift in 'X' direction.

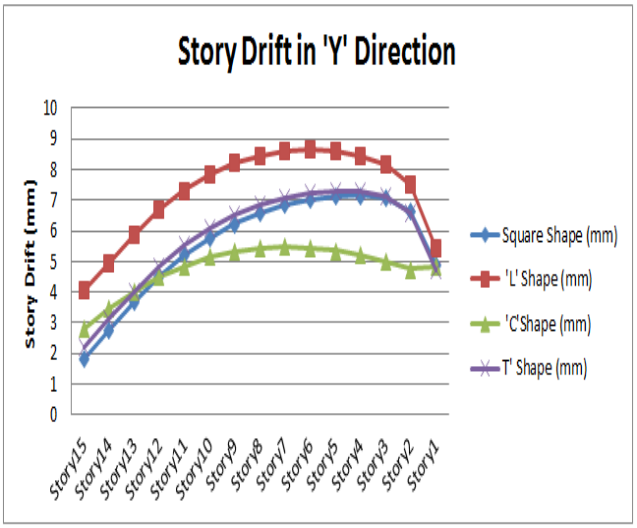

Fig 4: Comparison of Story drift in 'Y' direction.

3.2 Story displacement

According to IS Code 1893-2002, the maximum allowable deflection is calculated as h/250, where h is the height of story above the ground level.

Table 4: Max story displacement in 'X' and 'Y' direction

Story	'X' Direction				'Y' Direction				IS Code Value
	Square Shape	'L' Shape	'C' Shape	'T' Shape	Square Shape	'L' Shape	'C' Shape	'T' Shape	
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Story15	83.27	99.815	67.728	75.433	83.27	108.83	71.501	86.381	182
Story14	81.443	96.28	65.428	73.779	81.443	104.76	68.683	84.201	170
Story13	78.673	91.887	62.456	71.259	78.673	99.8	65.229	81.101	158
Story12	74.976	86.609	58.894	67.901	74.976	93.923	61.215	77.085	146
Story11	70.464	80.561	54.837	63.812	70.464	87.256	56.737	72.262	134
Story10	65.264	73.876	50.377	59.105	65.264	79.941	51.888	66.758	122
Story9	59.497	66.687	45.601	53.892	59.497	72.115	46.756	60.697	110
Story8	53.275	59.119	40.592	48.273	53.275	63.91	41.429	54.195	98
Story7	46.699	51.288	35.429	42.34	46.699	55.447	35.988	47.356	86
Story6	39.863	43.3	30.182	36.176	39.863	46.837	30.509	40.277	74
Story5	32.846	35.253	24.919	29.854	32.846	38.18	25.063	33.045	62
Story4	25.723	27.237	19.7	23.44	25.723	29.572	19.717	25.739	50
Story3	18.572	19.351	14.58	16.999	18.572	21.109	14.531	18.445	38
Story2	11.515	11.75	9.607	10.629	11.515	12.937	9.559	11.31	26
Story1	4.907	4.844	4.79	4.612	4.907	5.438	4.814	4.729	14

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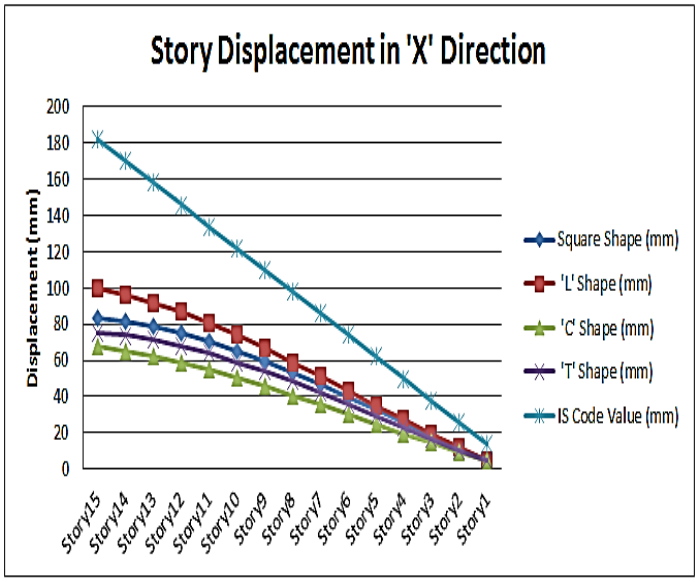

Fig 5: Comparison of Max Story displacement in 'X' direction

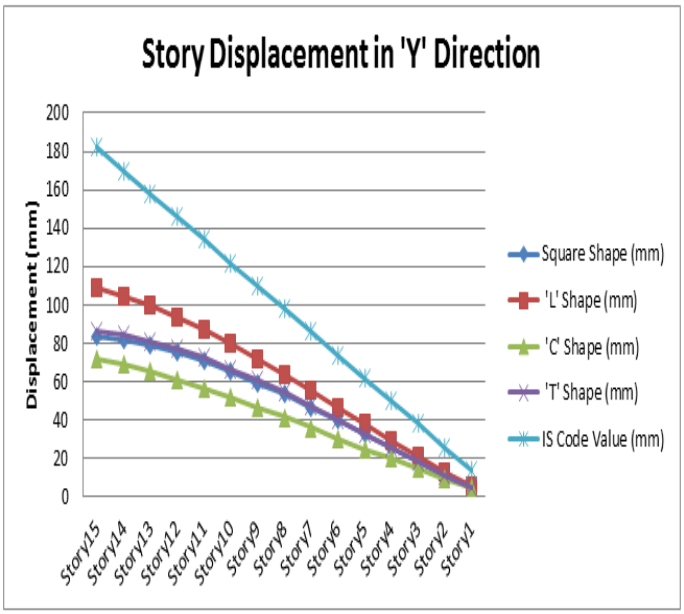

Fig 6: Comparison of Max Story displacement in 'Y' direction

3.3. Max / Avg. Story Drift Ratio (Torsion):

As per IS 1893:2002 Code describe that the torsional irregularity will be occur when max story drift/ average story drift ratio is more than 1.2.

Table 5: Ratio of Max drift / Average drift in 'X' and 'Y' direction

Storey	Ratio in 'X' Direction				Ratio in 'Y' Direction				IS Code Value
	Square Shape	'L' Shape	'C' Shape	'T' Shape	Square Shape	'L' Shape	'C' Shape	'T' Shape	
Story15	1.088	3.605	2.845	1.042	1.088	2.297	1.217	1.138	1.2
Story14	1.096	3.576	2.592	1.008	1.096	2.349	1.194	1.139	1.2
Story13	1.1	3.643	2.78	1.025	1.1	2.414	1.181	1.14	1.2
Story12	1.102	3.707	1.112	1.031	1.102	2.473	1.172	1.141	1.2
Story11	1.103	3.77	1.112	1.034	1.103	2.524	1.166	1.142	1.2
Story10	1.104	3.833	1.112	1.036	1.104	2.568	1.161	1.142	1.2
Story9	1.105	3.9	1.112	1.037	1.105	2.607	1.157	1.143	1.2
Story8	1.105	3.491	1.112	1.039	1.105	2.642	1.153	1.143	1.2
Story7	1.106	3.578	1.112	1.04	1.106	2.676	1.149	1.143	1.2
Story6	1.106	3.702	1.112	1.041	1.106	2.709	1.145	1.144	1.2
Story5	1.107	3.889	1.112	1.044	1.107	2.743	1.141	1.144	1.2
Story4	1.108	4.196	1.113	1.049	1.108	2.78	1.137	1.144	1.2
Story3	1.109	4.752	1.113	1.06	1.109	2.818	1.132	1.144	1.2
Story2	1.111	6.034	1.113	1.089	1.111	2.562	1.127	1.143	1.2
Story1	1.115	7.828	1.113	1.168	1.115	1.212	1.149	1.142	1.2

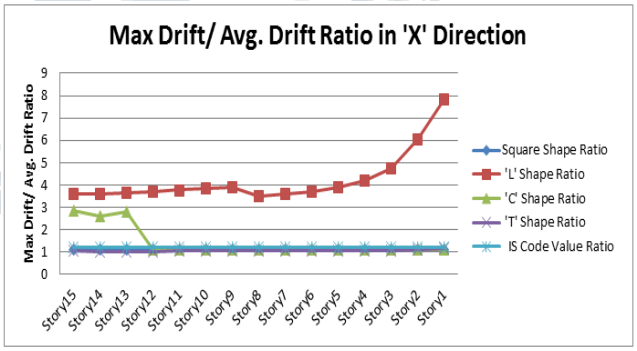

Fig 7: Max/ Avg. Drift Ratio in 'X' Direction

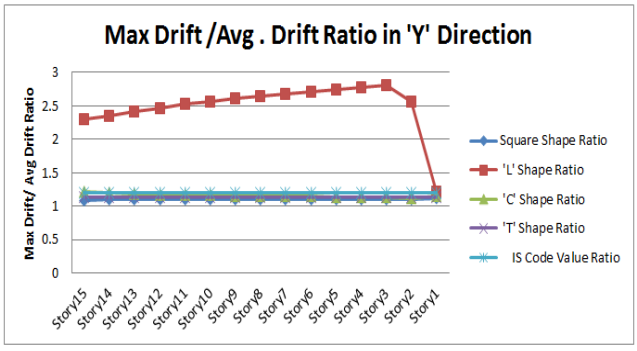

Fig 8: Max/ Avg. Drift Ratio in 'Y' Direction

RESULT AND CONCLUSION:

A linear time history analysis was performed and results were found in terms of storey drift, storey displacement and max. drift/avg. drift ratio. 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 3, in figure 3 and figure 4. The story drift behaviour of Square, 'L" shape, "C" shape and "T" shape building are increasing from 1st to 6th storey and then decreases thereafter. The maximum value of storey drift takes place in 'L' shape building at 6th story having a value of 8.656 mm in Y direction and minimum value for 'C' shape is 5.263 mm for same story. Maximum story drift for all models are within permissible limit according to IS code 1893:2002.

b). The comparative study of story displacement in X and Y direction for four models are represented in table 4, in figure 5 and figure 6. On comparing the story displacement of Square, "L" shape, "C" shape and "T" shape buildings, "L" shape building story displacements is 30.7 % more than square shape building. Maximum story displacement for all models are within permissible limit according to IS code 1893:2002.

c). The comparative study of torsion in X and Y direction for four models are represented in table 5, in figure 7 and figure 8. The torsional behaviour of the structure depends upon the max drift/avg. drift ratio of the storey. In "L" shape and 'C' shape building, this value exceeds the permissible limit as defined by IS 1893-2002 part 1. So 'L' and 'C' shaped buildings failed in torsion.
From the above study, we can conclude that 'L' and 'C' shaped buildings are more vulnerable to seismic excitation among four models.

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