

# “Comparison and analysis of regular and irregular configuration of multistorey building in various seismic zones and various type of soil”

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**Abstract:** Multistory RC Structure subjected to most dangerous earthquakes. It was found that main reason for failure of RC building is irregular distributions of mass, stiffness and strength or due to irregular geometrical configurations. In reality, many existing buildings contain irregularity due to functional and aesthetic requirements. However, past earthquake records show the poor seismic performance of this structure. This is due to ignorance of the irregularity aspect in formulating the seismic design methodologies by the seismic codes (IS 1893:2002, UBC 1997, NBCC 2005 etc.). The review of seismic design codes and reported research studies show that the irregularity has been quantified in terms of magnitude ignoring the effect of location of irregularity. The principle objective of this project is to study the structural behavior of multistory RC Structure for different plan configuration such as rectangular building along with L- shape and C- shape and H-shape in accordance with the seismic provisions suggested in IS: 1893-2002 using STAAD Pro V8i. The analysis involves load calculation and analyzing the whole structure on the STAAD Pro V8i version for dynamic analysis i.e. Response Spectrum Analysis & Time History Analysis confirming to Indian Standard Code of Practice. For time history analysis past earthquake ground motion record is taken to study response of all the structures. These analyses are carried out by considering different seismic zones (II, III, IV and V) and for each zone the behavior is assessed by taking hard, medium and soft soil. Post analysis of the structure, different response like maximum storey displacement, maximum storey drift, storey shear and maximum overturning moment are plotted in order to compare the results of the linear and non-linear dynamic analysis.

**Keywords:** Irregularities, Configuration, Geometry.

## I. INTRODUCTION

Earthquakes are most unpredictable and devastating of all-natural disasters. Earthquakes have the potential for causing the greatest damages among all the natural hazards. Since earthquake forces are random in nature and unpredictable. They not only cause great destruction in human casualties, but also have a tremendous economic impact on the affected area. The concern about seismic hazards has led to an increasing awareness and demand for structure designed to withstand seismic forces. When a structure is subjected to ground motions in an earthquake, it responds by vibrating. Those ground motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. During an earthquake, the damage in a structure generally initiates at location of the structural weakness present in the building systems. High-Rise RC structures are a special class of structures with their own peculiar characteristics and requirements. These structures are often occupied by a large number of people. Thus, their damage, loss of functionality, or collapse can have very severe and adverse consequences on the life and on the economy of the affected regions. Each high-rise structure represents a significant investment and as such high-rise structure analysis is generally performed using more sophisticated techniques and methodologies. Thus, to understand modern approaches for seismic analysis of high-rise RC structures are valuable to structural engineers and researchers. In the modern era, most of the structures are delineated by irregular in both plan and vertical configurations. Moreover, to analyze or design such irregular structures high level of effort is needed. In other words, damages or loss in those structures with irregular options are over those with regular one. Thus, irregular structures would like careful structural analysis to succeed in an acceptable behavior throughout a devastating earthquake. In most of the situations the shape of the plot for the construction of a structure may not be a regular one. Thus, the shape of the structure may be influenced by the plot configurations. Further it will be interesting to study the stability of buildings with different geometry of shape and their behavior against seismic and other forces. No any structural engineer can design 100% earthquake proof structure, only its resistance to earthquake can be increased. Proper design or maintenance to be given

depends on the zone in which structure is situated. It is necessary to check or think right from the planning stage to the completion of the structure to avoid failure of structure or to overcome loss of property.

### 2.1 Classification of Irregularity

The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of the building. When such buildings are constructed in high seismic zones, the analysis and design become more complicated. There are two types of irregularities;

1. Plan Irregularity
2. Vertical Irregularity

#### Plan Irregularities:

Asymmetric or plan irregular structures are those in which seismic response is not only translational but also tensional, 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.

**Torsion Irregularity:** To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Tensional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure.

**Re-entrant Corners:** Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 % of its plan dimension in the given direction.

## II. LITERATURE REVIEW ON IRREGULARITIES

**Ravindra N. Shelke et.al** [1] studied the effects of various vertical irregularities on the seismic response of a structure. He concluded that, base shear and lateral displacement with height of the structure as the seismic intensity increases from zone-2 to zone-5 which indicates more seismic demand the structure should meet.

**Ravikumar C. M., Babu Narayan K. S., Sujith B. V. and Venkat Reddy D.** [6], (2012), presented a paper to study two kinds of irregularities in the building models namely plan irregularity with geometric and diaphragm discontinuity and vertical irregularity with setback and sloping ground. These irregularities are created as per Indian Standard code, IS 1893: 2002 (Part I). In Order to identify the most vulnerable building among the models considered, the various analytical approaches are performed to identify the seismic demands in both linear and nonlinear way. It is also examined the effect of three different lateral load patterns on the performance of various irregular buildings in pushover analysis.

**Mohammed Rizwan Sultan and D. Gouse Peera** [15], (2015), presented a paper on ‘Dynamic Analysis of Multi-Storey Building for Different Shapes’. The main objective of this study is to grasp the behavior of the structure in high seismic zone and also to evaluate Storey overturning moment, Storey Drift, Displacement, Design lateral forces. In this paper 15 storey-high building on four totally different shapes like Rectangular, L-shape, H-shape, and C-shape are used as a comparison. The complete models were analyzed with the assistance of ETABS 9.7.1 version. And also, comparative Dynamic Analysis for all four cases has been investigated to evaluate the deformation of the structure. The results indicate that, building with severe irregularity produces more deformation than those with less irregularity particularly in high seismic zones. The storey overturning moment varies inversely with height of the storey. The storey base shear for regular building is highest compare to irregular shape buildings.

### 3.1 Conclusion on Literature Review

From the researches carried out on regular and irregular shape of buildings it was found that this study presents an analytical approach for seismic assessment of RC frames using different analysis method. The analytical models are validated against available experimental results and used in a study to evaluate the seismic behavior of these 15 story frames. It is concluded that both the ductile and the nominally ductile frames behaved very well under the considered earthquake. while the seismic performance of all irregular frames appears to be equally satisfactory, not inferior to that of the regular ones, even for motions twice as strong as the design earthquake. So due to lack of space in urban area it preferred that to construct multistory building (regular or irregular) with high sustainable earthquake loading.

## III. MODELLING OF R.C.C. FRAMES

An R.C.C. 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 this structure is from slabs to beams, from beams to columns, and then ultimately from columns to the foundation, which in turn passes the load to the soil. In this structural analysis, study, we have adopted four cases by assuming different shapes for the same structure, as explained below.

1. Rectangular plan
2. C-shape plan
3. L-shape plan
4. H-shape plan

#### IV. COMPARISON AND ANALYSIS

##### 5.1 Modeling of building frames

The R.C.C. Structures is mainly an assembly of Beams, columns and slabs and foundation -connected to each other as a single unit. Generally the transfer of load in these structures is from slab to beam, from beam to column and finally column to foundation which in turn transfers the entire load to the soil. In this study, we have adopted 4 cases by assuming different plan shapes such as Rectangular shape, C-shape L-shape H- shape

Detail of buildings considered in this work are as follows

Type of structure- Residential building

**Shape of building – Rectangular, C-Shape, L-Shape, H-Shape Buildings,**

Number of stories 15

Height of typical floor: 3.3m

Column size: 300mm X750mm

Beam size: 300 mm X 450mm

Slab thickness: 125 mm

Masonry wall thickness: 230 mm

Live load : 2 Kn/m<sup>2</sup>

Floor finish : 1 Kn/m<sup>2</sup>

All the columns are assumed to be fixed at their base.

Characteristic compressive strength of concrete,  $f_{ck}$ : 25N/mm<sup>2</sup>

Grade of steel : 500 N/mm<sup>2</sup>

Density of concrete : 25N/mm<sup>2</sup>

Modules elasticity of concrete : 2500N/ mm<sup>2</sup>

poison's ratio of concrete: 0.3

Density of brick masonry : 19.2 KN/m<sup>3</sup>

Modulus elasticity of brick masonry: 14000N/mm<sup>2</sup>

Poison's ratio of brick masonry : 0.2



Fig.No.5.1 3D Elevation and plan of of Rectangular Building

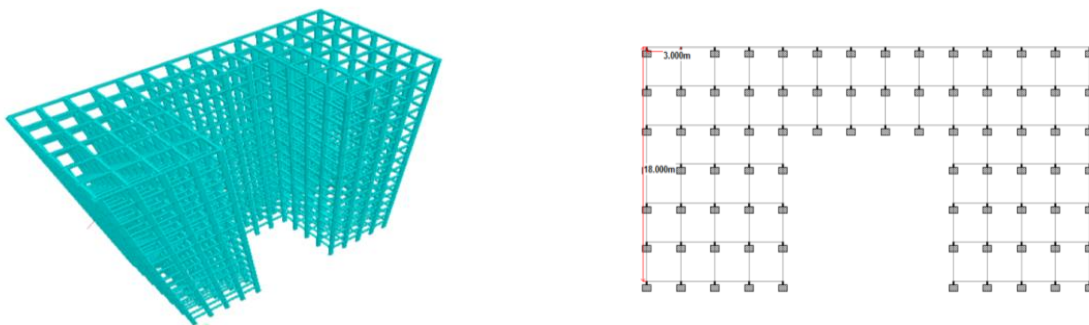


Fig No. 5.2 3D Elevation and plan of C-shape building

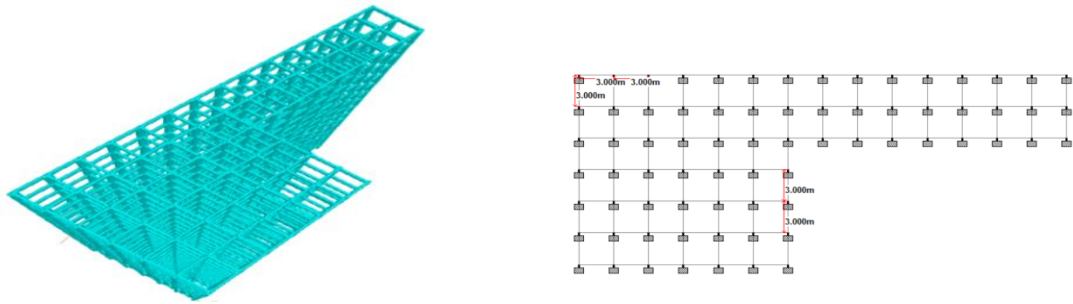


Fig. No. 5.3 3D Elevation and plan of L- Shape Building

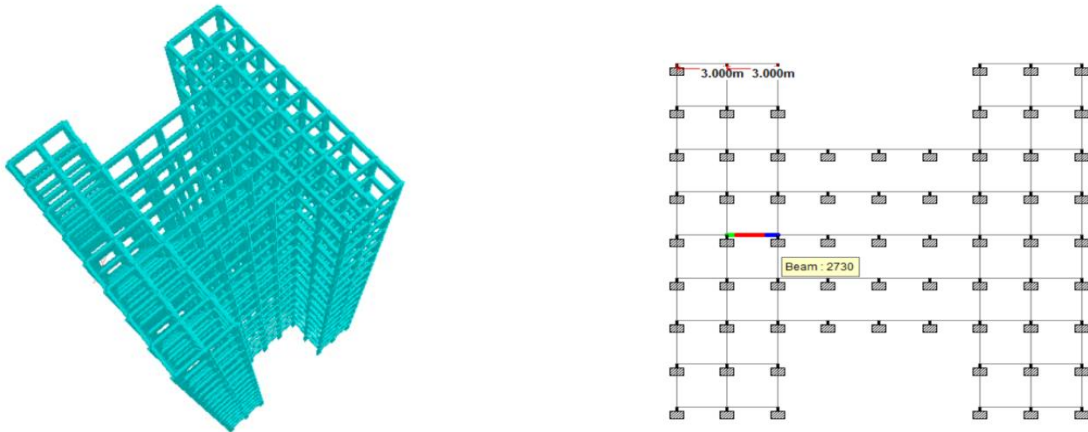


Fig.No.5.4. 3D Elevation and plan of H- shape building

### V. RESULT AND DISCUSSION FOR ALL SHAPES OF BUILDINGS

The four types of RCC building frames viz.(1) Rectangular (2)C-shape (3) L-shape (4) H-shape. The result obtained by the analysis regarding the structural behavior of each building are tabulated and explain as follows.

Table. no. 6.1 Comparison of Maximum Lateral/Storey Drift for various Shape of Building

Storey	Lateral Drift (mm)			
	Rectangular	C-Shape	L-Shape	H-Shape
0	0	0	0	0
1	3.9	3.8	3.7	3.8
2	7.2	7.4	7.2	7.2
3	7.9	8.3	8.4	8
4	8.1	8.9	8.6	8.1
5	8.2	10.02	8.9	8.2
6	8.2	10.01	10.02	9.6
7	9.3	9.7	10	9.6
8	9.1	8.9	9.7	9.7
9	9	8.5	9.4	9.2
10	7.9	9	8.8	8.3
11	6.2	8.2	8	7.6
12	5	7.3	7.2	6.1
13	3.7	6.5	6.2	5.4
14	2.4	5	4.8	4.3
15	2.6	3.9	3.8	3.2

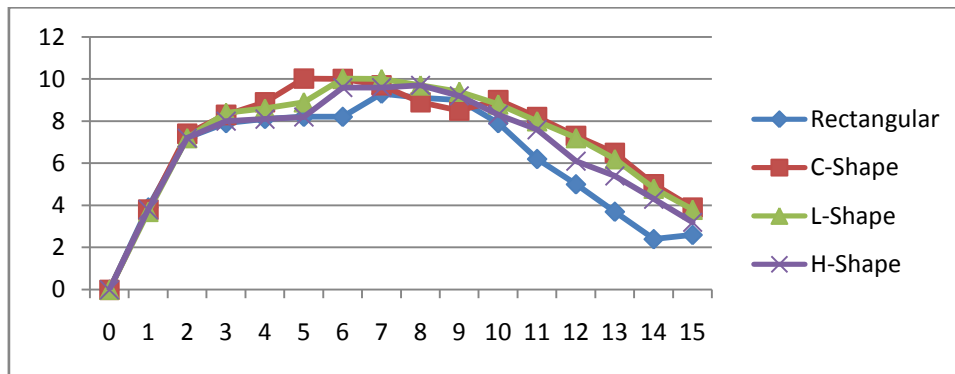


Fig. No. 6.1 Showing results of Maximum Lateral/Storey Drift for Various Shapes of Buildings

2) For determining most stable structure among all models that we have studied, graphs and tables have drawn for different shapes. Results for maximum bending moment and shear force of beam and column for different shapes of the building are shown here.

Table.No.6.2 Comparison of Maximum B.M and Shear Force.

<b>Maximum B.M and Shear Force of Beam</b>				
Force	Rectangular	C-Shape	L-Shape	H-Shape
B.M. $M_y$	88.75	95.86	112.07	99.52
B.M. $M_z$	0.112	1.12	1.246	0.64
Shear Force $F_y$	159.12	157.24	158.07	154.23
<b>Maximum B.M. and Shear Force of Column</b>				
Forces	Rectangular	C-Shape	L-Shape	H-Shape
Axial Force $F_x$	383.73	430.18	430.18	392.40
Shear Force $F_y$	86.01	85.12	86.12	90.15
Shear Force $F_z$	88.54	87.23	94.33	94.23
B.M. $M_y$	174.23	174.18	175.18	173.22
B.M. $M_z$	173.46	176.12	154.2	168.54

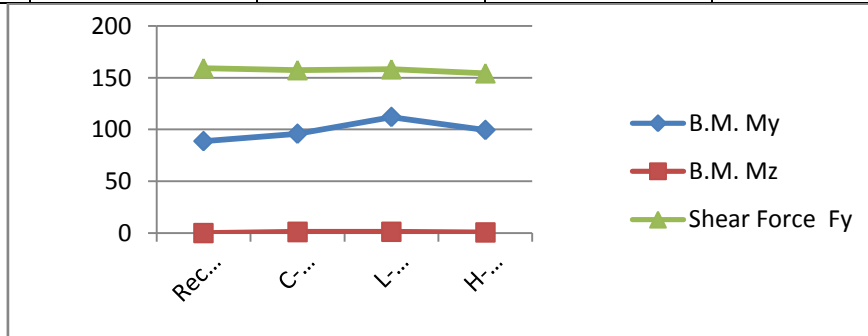


Fig. No. 6.2 Shows result of Maximum Bending Moment along Y and Z Direction and Maximum Shear Force. From above Table we can see that the maximum bending moments and Shear force occur in H-shape building while less in Rectangular shape of building.

Table.No.6.3 Comparison of Maximum Displacement on top storey for all zones

Zone	Displacement (mm)			
	Rectangular	C-Shape	L-Shape	H-Shape
2	22	19	26	18
3	35.2	36.2	42.8	23
4	52.8	58.6	62.6	58.13
5	79.1	87.5	84.3	80.57

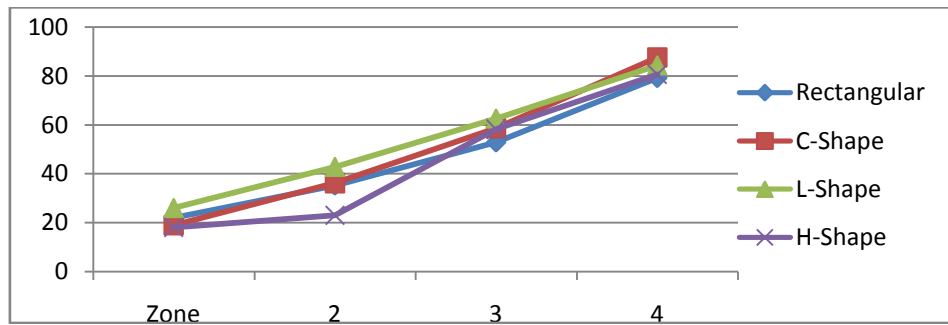


Fig.No.6.3 Showing results of Comparison of Maximum Displacement for all zones

Above figure No.6.3 Shows that maximum storey displacement increases with the increasing in zone and height of the storey. Displacement for rectangular shape of building is less as compare to other shape of building.

**Table.No.6.4 Comparison of Base Shear**

Shape	Zone	Base Shear (kn)		
		Hard Soil	Medium Soil	Soft Soil
Rectangular	2	442.15	515.64	623.14
	3	512.63	614.23	715.23
	4	546.28	724.68	715.23
	5	675.43	812.24	956.18
C-Shape	2	527.16	617.23	684.23
	3	564.13	738.82	715.26
	4	612.68	725.23	802.36
	5	675.43	816.23	1038.25
L-Shape	2	612.54	620.23	736.15
	3	610.44	756.58	856.46
	4	689.58	812.62	802.19
	5	712.65	912.25	1102.25
H-Shape	2	565.56	617.28	512.36
	3	568.29	738.96	716.23
	4	613.58	819.56	725.23
	5	712.36	896.32	1023.56

Above Table No.6.4 shows that in rectangular shape of building the base is less as comparative other shape of buildings. Maximum base shear occurred in L-Shape building in zone no.5.

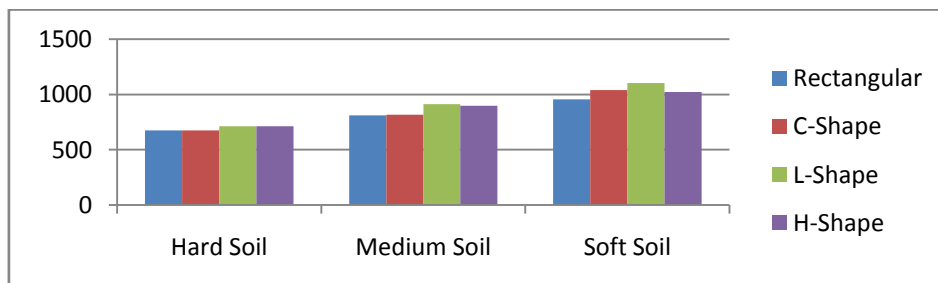


Fig.No.6.4 Shows that the comparison of base shear for all zones and different types of soil for different shape of buildings.

### VI. CONCLUSION

- Irregular shapes are severely affected during earthquakes especially in high seismic zones.
- Maximum storey drift is occurring on top storey of L-shape building while the minimum storey drift occur on Rectangular shape of building.
- Maximum bending moment is occur on H-shape of building.

- Maximum axial force imposed on H-shape of building.
- Minimum Displacement is occurring on Rectangular shape of building.
- Base shear is calculated by using IS 1893-2002 method for all four models in (Table No.4.28) illustrate the comparison of base shear using response spectrum method. The lower base is getting in rectangular shape building and the higher base shear is getting in H-Shape building.
- The table No.4.28 Shows that irregular shape building undergoes more deformation and hence regular shape building must be preferred.
- Result has been proved that C-Shape building is more vulnerable compare to all other different shapes of building.

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