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Seismic Performance of Irregular Building

Deepak K V
Post Graduate student, Structural Engineering
School of Mechanical and Building Sciences (SMBS)
VIT Chennai, Chennai-600127, India

Abstract: *Structural buildings undergo lateral deflections under earthquake loads. The structural system, mass of the structure and mechanical properties of the structural elements are the key factors governing the magnitude and nature of such lateral deflections. The buildings should be designed to resist earthquake induced deflections and internal forces. The seismic performance of the structures is mainly influenced by the Structural and load irregularities. The irregular structures experience varying storey drifts, excessive torsion, displacements etc. In this research, effects of irregularity on structural buildings are studied. The modelling of different number of floors and floor areas, are done by Staad-Pro software. Results are analysed and necessary considerations shall be taken to prevent damages caused by irregularity under seismic loading.*
Keywords: *Seismic performance, Irregular structures, Torsion, Seismic analysis.*

I. Introduction

Buildings with simple and uniform plan are prone to less damage. A proper space in building may lead to stress concentration and deformation at any place of discontinuity for which it leads to failure of members at critical places like joints and building collapse structures. The building behaviour during an earthquake depends on several factors such as good structural configuration, reasonable lateral stiffness, minimum lateral strength and good ductility. The buildings with regular shape where the centre of mass and centre of stiffness coincides building will be safe. But in present situation the need and demand of the current generation and increasing population has made the structural engineers incapable of planning irregular structure.

1.1 Objective of the Study

To study the Seismic performances of irregular structures for the irregular models and to identify the most vulnerable model among them. To compare story drifts, story displacements, time period for models created and also to check the torsional irregularity of the buildings.

1.2Scope of the study

The present study is focused on seismic behaviour of irregular plan structure for the seismic zone V (hard rock) of India. The configuration involves few models with plan irregularities such as varying in-plane stiffness in floor over the vertical height, diaphragm discontinuity, re-entrant corners and geometrical irregularities. The response spectrum analysis is carried and the performance is studied by considering storey displacement, story drifts, base reactions, story shears and time period using code IS1893 (Part1):2012. The modelling, analysis and design was carried out by using staad-pro software.

II. Modelling

Three models are created for the analytical purpose. First model is an irregular structure having 10 storeys. Second model is an irregular structure with high varying storey stiffness vertically. Here certain portion of floor area is removed across storeys for critical analysis. Third model is provided with shear walls at the corners of the second model. The general specification of all the three models are given in table 1.

Table 1: Specification of model

Type of building	RC Moment Resisting frame
Number of storeys	10
Floor height	3m
Grade of concrete	M25
Grade of steel	Fe500

The dimensions of structural elements are provided for all the three models after standard analysis. The dimensions of beam, column and slab provided for all models are same and given in table 2. For model 3 shear walls of thickness 200mm are provided at the corners of structure 2 as shown in figure 6. The plan for all the floors of model is as shown in figure 1 and plan for model 2 and 3 is as shown in figure 1, 2, and 3.

Table 2: Dimension of structural elements

Type	Dimension (m)
Beam	0.6x0.2
Column	0.75x0.2
	1.2x0.2
	0.9x0.2
	0.9x0.3
	1.0x0.2
	1.2x0.3
	1.5x0.2
Slab	0.3

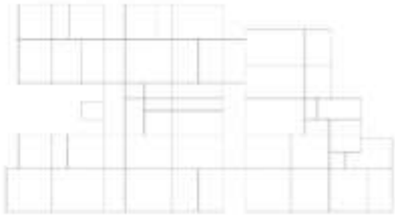

Figure 1: Irregular plan for floors 1,2 & 3

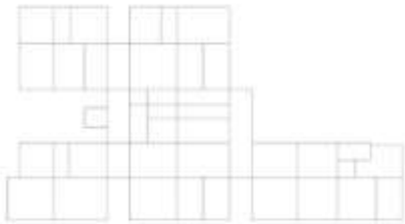

Figure 2: Irregular plan for floors 4,5, 6 & 7

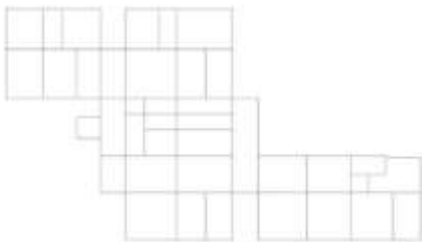

Figure 3: Irregular plan for floors 8, 9 & 10

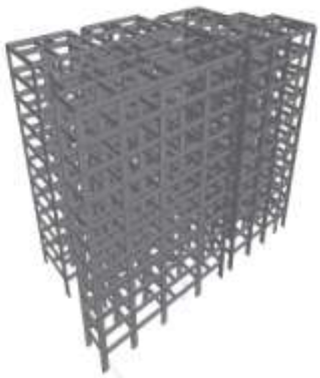

Figure 4: Model of Irregular structure 1

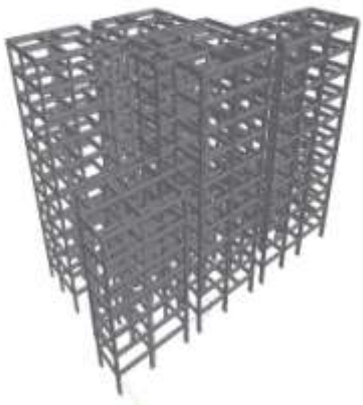

Figure 5: Model of Irregular structure 2

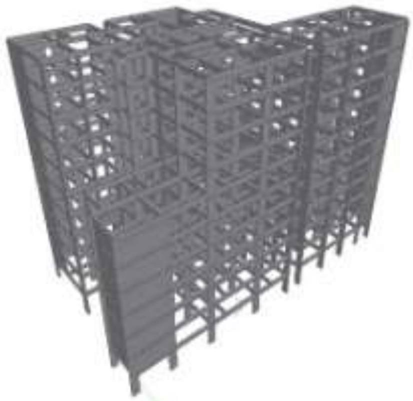

Figure 6: Model of Irregular structure 3

2.1Load cases

Dead loads and live loads are calculated as per IS875-1987 part 1 and part 2 and are given in table 3.

Table 3: Details of dead load and live load

Dead load - wall	11.4kN/m
Dead load - parapet wall	3.8kN/m
Dead load – slab	3.8kN/m^2
Live load – slab	2kN/m^2

Seismic loads are calculated for zone V (hard rock) as per IS1893 (part 1): 2012 and are given in table4.

Table 4: Details of seismic load

Zone	V
Soil type	Medium
Zone factor Z	0.36
Importance factor I	1
Response reduction factor R	5

III. Method Of Analysis Of Structure

The structural model was created in staad. It is possible action to carry out analysis to determine the seismically induced forces in the structure. Linear static analysis or equivalent static analysis(ESA) was carried out and linear dynamic analysis by response spectrum analysis was done. For regular structures, equivalent linear static analysis is usually done. The ESA will be done for regular and low height buildings and will give good results. Dynamic linear analysis will create more number of modes of vibration and distribution of forces in elastic limit. It is carried out for the buildings as specified by code IS 1893(part I):2016 Dynamic analysis was carried out by Response spectrum method.

Response spectrum analysis(RSA) represents maximum response of single degree freedom system having period, proof damping, during earthquake ground motions. The analysis was carried out according to the code IS 1893(part I):2016 the type of soil, seismic zone factor should be entered from IS 1893(part I):2016. The standard response spectra for medium type of soil was applied to building for the analysis in Staad-pro software. Following diagram shows the standard response spectrum that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).

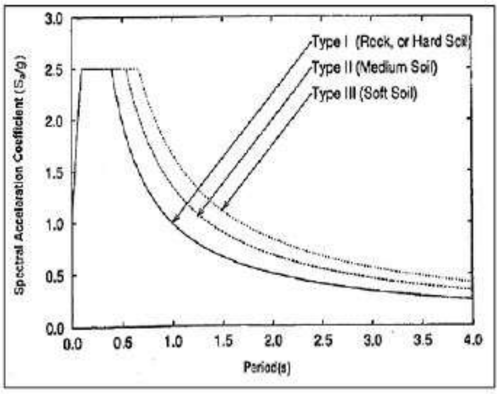

Figure 7: Response spectrum for medium soil type for 5% damping

According to IS 1893(Part 1):2016, clause 7.11.1 storey drift limitation should not exceed 0.004 times the storeyheight.From Table 4 IS 1893(Part 1):2016, torsional irregularity is to be considered to exist when the maximum storey drift is 1.2 times the average of storey drifts.

IV. Results and Discussion

Table 5: Values of storey displacement and storey drift of model 1 building

Height (m)	Displacement (mm)	Drift %
0	0.00	0.00
3	36.66	1.11
6	90.60	1.63
9	145.89	1.68
12	199.84	1.63
15	251.17	1.56
18	298.73	1.44
21	341.41	1.29
24	378.18	1.11
27	408.15	0.91
30	430.64	0.68
33	445.74	0.46

Table 6: Values of storey displacement and storey drift of model 2 building

Height (m)	Displacement (mm)	Drift %
0	0.00	0.00
3	14.28	0.43
6	35.72	0.65
9	59.94	0.73
12	84.93	0.76
15	109.40	0.74
18	132.38	0.70
21	153.06	0.63
24	170.76	0.54
27	184.95	0.43
30	195.27	0.31
33	201.74	0.20

Table 7: Values of storey displacement and storey drift of model 3 building

Height (m)	Displacement (mm)	Drift %
0	0.00	-
3	10.40	-
6	18.80	0.28
9	28.90	0.34
12	38.90	0.33
15	48.70	0.33
18	58.11	0.31
21	66.95	0.29
24	75.12	0.27
27	82.55	0.25
30	89.19	0.22
33	95.04	0.19

Table 8: Time period and Natural frequencies of the model – mode shape 1

Model	Time period (sec)	Natural frequencies (HZ)
1	1.480	0.676
2	2.253	0.444
3	1.219	0.820

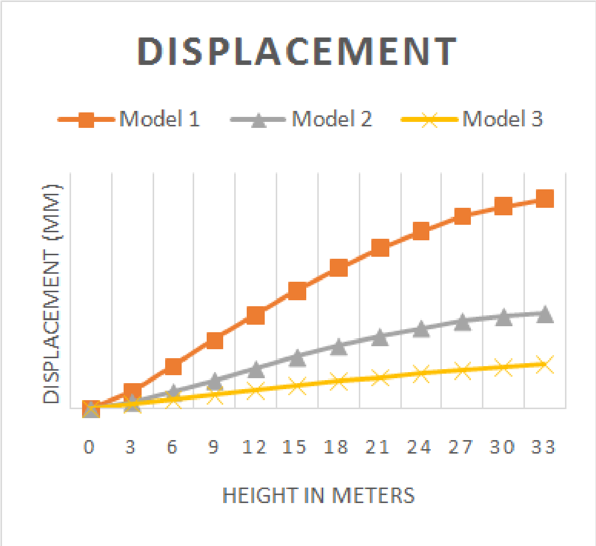

Figure 8: Graph of typical storey displacement

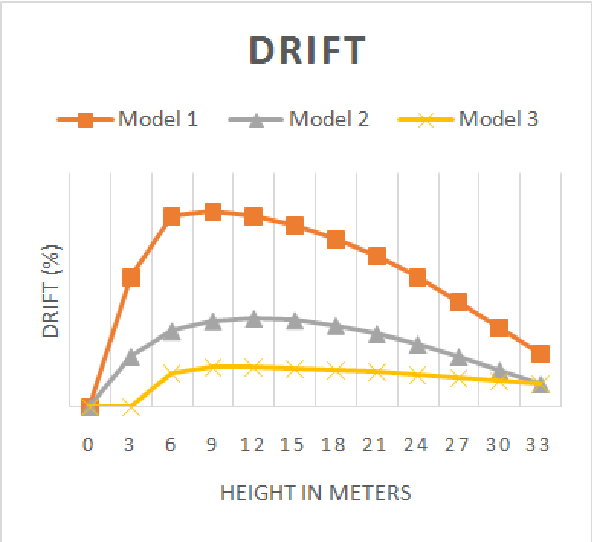

Figure 9: Graph of typical storey drift

V. Conclusion

1. From the results it can inferred that model 1 and 2 exceeds the maximum safe displacement value.
2. Model 2 due to its high varying storey mass has created torsional effect in the structural model.
3. Shear walls are provided at the corners of model 3 thereby the story drift and storey displacements are reduced and maintained within the safe limit.
4. The time period and natural frequencies for the model 1 and 3 are merely close to each other whereas for the model 2 there is great variation.

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