SEISMIC ANALYSIS OF BUILDINGS WITH VERTICAL GEOMETRIC IRREGULARITY BY USING RESPONSE SPECTRUM METHOD

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Abstract - *This analysis aims to the seismic response of various vertical irregularity structures. The project is done by Response spectrum analysis (RSA) of vertically irregular RC building. This study includes the modelling of regular and irregular building having area of 20X20m and height of 3.25 m from each G+6 storey. The performance of this framed building during study earthquake motions depends on the distribution of stiffness, strength, and mass in both the horizontal and vertical planes of the building. The main aim of this work is comparative study of the stiffness of the structure by considering the three models in Regular Structure and three models in Plan irregular structure with different Vertical irregular structure. All models are analyzed with dynamic earthquake loading for the Zones V. Result found from the response spectrum analysis that in irregular shaped building displacements are more than that of regular shaped building. All building frames are modelled& analyzed in software Staad Pro V8i. Various seismic responses like base shear, frequency, node displacement, etc. are obtained. The overall performance of regular building is found better than irregular building. The seismic performance of multi-story regular building is determined by Response Spectrum analysis in STAAD Pro. Software.*

Key Words: **Response spectrum, Stead pro, seismic analysis, vertical irregularity, dynamic analysis**

1. INTRODUCTION

India is a developing country and has a large population. So to provide shelter for more people multi-story buildings are used. Now, in India cities and towns are adopting multi-story buildings quickly. They are different shapes of buildings mainly categorized as regular buildings and irregular buildings. Regular shapes are square, rectangular, and circular. Irregular shapes are T-shape, inverted U, L-shape, etc. It's uneconomical to design in irregular shapes as compared to regular shapes, because regular shapes resist more design lateral force than irregular shapes. These regular(symmetric) and irregular(asymmetric) buildings are analyzing with help of response spectrum using staad.pro. Indian codes standards made it compulsory for designing earthquake-resistant structures. So we've to follow IS:1893(PART-1)-2002 to design-earthquake resistant structures by using the various methods like the seismic co-efficient method, the time history method, and the response spectrum methods.

1.1 Objective

1. To compare the behaviour of a regular(symmetric) buildings and an irregular(asymmetric) buildings in terms of response spectrum analysis.
2. To compare the maximum base shear, node displacement, time period, and frequencies of different types vertically regular(symmetric) buildings and irregular(asymmetric) buildings.
3. To identify the simplest structure configuration from this analysis.

1.2 Scope of study

1. Vertical geometric irregularity is considered and studied.
2. Seismic analysis is carried out with the response spectrum analysis.
3. For this case study, the buildings are in the seismic zone –v only considered.

2. METHODOLOGY

The study is carried out for the behavior of G+6 story buildings, floor height is 3.25m and other properties are defined for the structure. The modelling of structures is done with the help of staad pro software. Soil type is hard and seismic zone is zone V. Regular and irregular structures are analyzed as per the Indian standard code of practice. For Seismic analysis IS 1893-2002(PART-1) is considered. Dead loads, live loads, and seismic loads are applied concerning IS 875 part-1, IS 875 part-2, and IS1893-2002 respectively. The structure is analyzed by response spectrum analysis using staad pro application. The analysis is carried out to determine maximum base shear and maximum node displacement. After analysis, the structures are compared based on their results respectively and the conclusion is given.

Table -1: Specifications of buildings

Type of structure	Special moment-resisting frame (SMRF)
Floor to floor height	3.25m
Number of storeys	7
Seismic zone	V
Type of soil	Hard (type –I)
Size of column	0.600m x 0.450m
Size of beam	0.600m x 0.300m
Depth of slab	125mm
Grade of concrete	M30
Grade of steel	Fe 500
Modulus of elasticity of concrete	27386.12 N/mm^2
Zone factor (Z)	0.36
Importance factor (I)	1
Response reduction factor (R)	5 (SMRF)
Time period in x-direction (T)	0.45 seconds

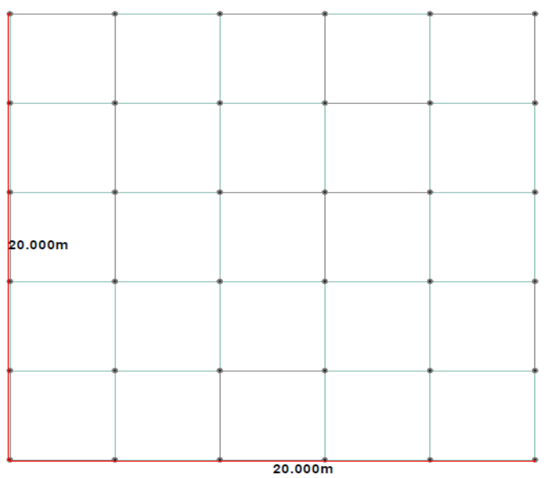


Fig -1: Plan of model

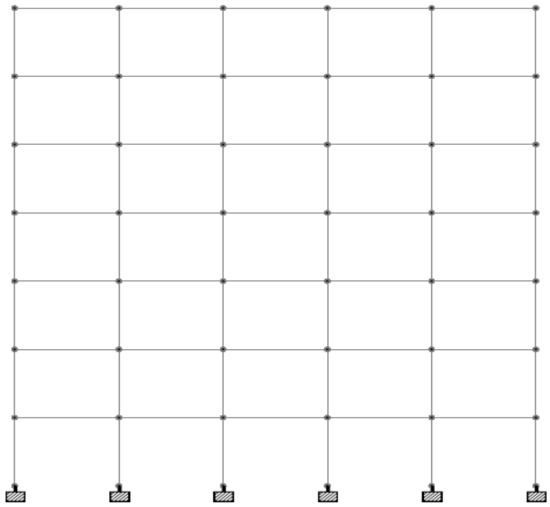


Fig-2: Elevation of model

2.1 loads

Dead load:

The Self-weight frame will be automatically taken by giving a command in staad pro software.

Slab dead load - 0.125 X 25 =3.125KN/m^2

Self-weight of walls – 2.65 X 0.23 X18.20 = 11kN/m

Self-weight of parapet walls -1.5 X 0.15 X 18.20 =4 kN/m

Floor finishing's - 0.0635 X 20.39 = 1.3 kN/m^2

Live load**:**

Live load – 2kN/M^2

Seismic load:

Seismic Zone Factor, (Z) =0.36(IS 1893:2002 PART-1, TABLE -2)

Response Reduction Factor, (R) =5 (SMRF) (IS 1893:2002 PART-1, TABLE -7)

Importance's Factor, (I) =1 (normal buildings) (IS 1893:2002 PART- 1, TABLE -6)

Soil type = I (HARD SOIL) (IS 1893:2002 PART-1 TABLE -1)

Time period =0.09h/(d)$^{1/2}$ = (0.09 X19.2)/ (20)$^{1/2}$=0.38 seconds

Spectral acceleration coefficient (Sa/g) =2.5

Design Horizontal Seismic co-efficient, Ah= (Z x I x Sa)/ (2 x R x g) = (0.36 x 1 x 2.5)/ (2 x 5) =0.09

2.2 Frame models

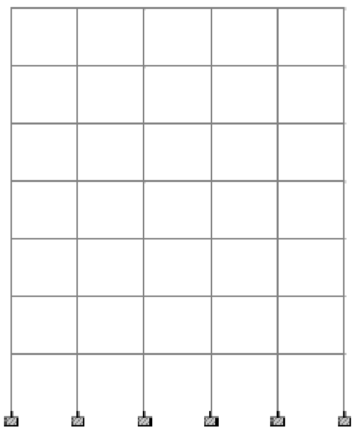


Fig-3: Regular building-1

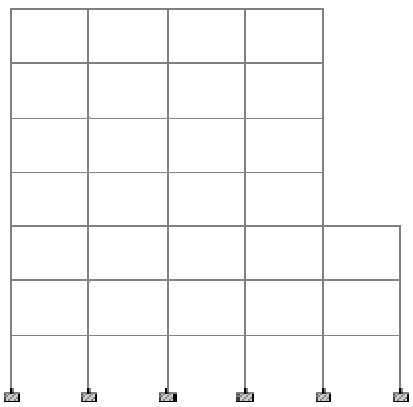


Fig-4: Regular building-2

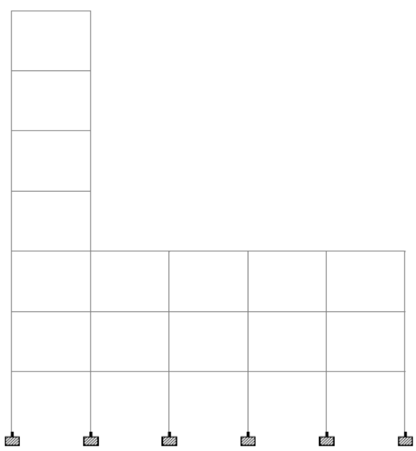


Fig-5: Irregular building-1

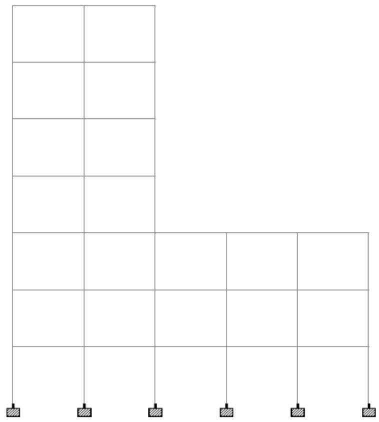


Fig-6: Irregular building -3

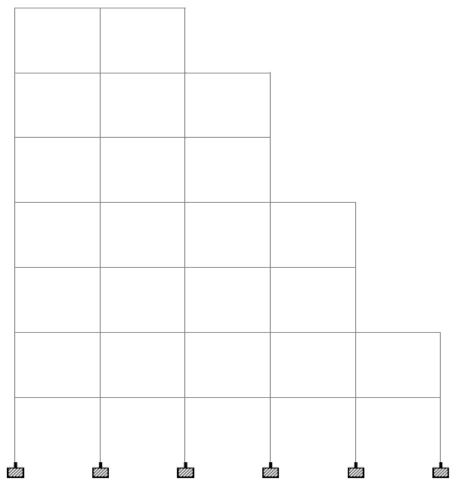


Fig-7: Irregular building-4

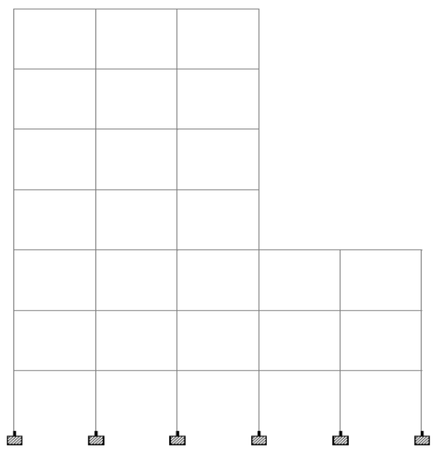
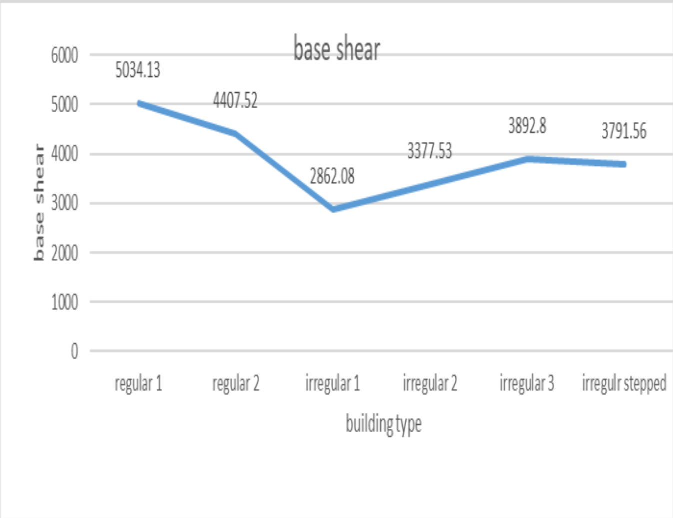


Fig-8: Irregular building-2

3. ANALYSIS AND RESULTS

The building with regular and irregular geometry are analyzed by response spectrum analysis. The base shear, node displacements, and time period vs frequency values of both regular and irregular are tabulated below.

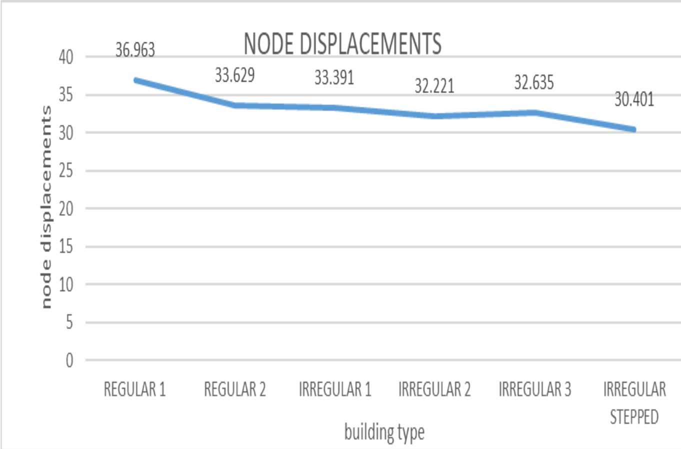
Base shear: Graph base shear



Building type	Base shear(kN)
Regular building 1	5034.13
Regular building 2	4407.52
Irregular building 1	2862.08
Irregular building 2	32377.53
Irregular building 3	3892.80
Irregular building stepped	3791.56

Table-2: base shear

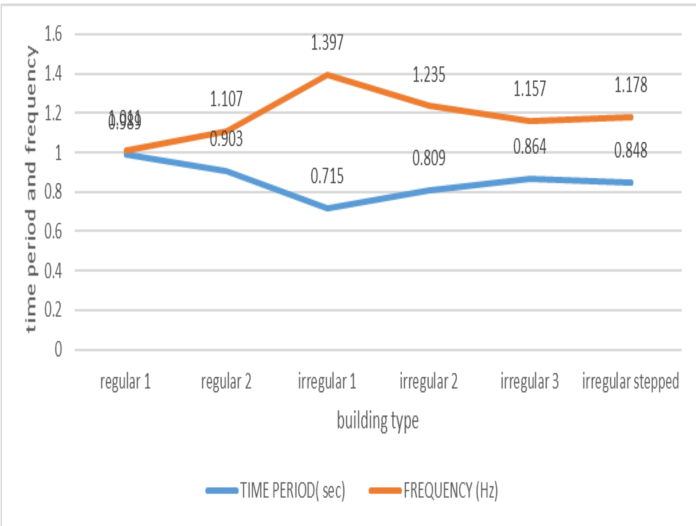
Node displacements: Graph Node displacements



Building type	Node displacements(mm)
Regular building 1	36.963
Regular building 2	33.629
Irregular building 1	33.391
Irregular building 2	32.221
Irregular building 3	32.635
Irregular building stepped	30.401

Table-3: Node displacements

Time period vs Frequency: Graph Time period vs Frequency



Building type	Frequency (hz)	Time period (sec)
Regular building 1	1.011	0.989
Regular building 2	1.107	0.903
Irregular building 1	1.397	0.715
Irregular building 2	1.235	0.809
Irregular building 3	1.157	0.864
Irregular building(stepped)	1.178	0.848

Table-4: Time period vs Frequency

4. CONCLUSIONS

1. The response spectrum method allows a transparent understanding of the contributions of various modes of vibration. It is also useful for the approximate evaluation of the seismic reliability of structures.
2. Comparing the maximum base shear for both regular building and irregular building the maximum shear is obtained for regular building.
3. The Time period is maximum for regular shaped building configuration.
4. The Frequency was maximum for Irregular Buildings.
5. Maximum displacement for regular-shaped buildings and minimum for irregularly shaped buildings.
6. Regular building-1 has maximum displacement compared to other buildings.

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