

Effect of Different Irregularities on Low Rise to High Rise Structures

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Abstract – The behavior of a building during an earthquake depends on several factors such as stiffness, lateral strength, and ductility, simple and regular configurations. The buildings with regular geometry, uniformly distributed mass and stiffness in plan as well as in elevation suffer much less damage compared to irregular configurations. But nowadays thirst and demand of the new generation engineers are planning towards an irregular configuration for better aesthetic perspective. Hence earthquake engineering has developed the key issues in understanding the role of different types of building configurations. Seismic analysis is a division of structural analysis and it involves the calculation of the different response of a building structure subjected to earthquakes with different irregularities.

Keywords- Response spectrum method, ETAB, IS 1893:2016, Plan irregularity, stiffness irregularity

I- INTRODUCTION

Irregular buildings constitute a large portion of the modern urban infrastructure. Structures are never perfectly regular and hence the designers routinely need to evaluate the likely degree of irregularity and the effect of this irregularity on a structure during an earthquake. Need for research is required to get economical & efficient lateral stiffness system for high seismic prone areas. For optimization & design of high rise building with different structural framing systems subjected to

seismic loads. To improve the understanding of the seismic behavior of building structures with different irregularities.

Objectives:

1. To check the analysis results of ETABS for lateral stability checks as per IS code 1893:2016 provisions for seismic loads.
2. Analysis of 5 storied, 10 storied and 15 storied RC framed structure with different irregularities under seismic conditions. Irregularities considered are Re-entrant corner, mass irregularity, vertical geometric irregularity, plan irregularity and stiffness irregularity.
3. To calculate the response of buildings subjected to seismic zone IV using response spectrum and to compare the results.
4. Study the effect of seismic responses such as the storey lateral displacement, storey drift, storey shear, storey stiffness and mode period in zone IV.

II- PROBLEM STATEMENT

Six storey (G+5), Eleven storey (G+10) and Sixteen storey (G+15) reinforced concrete frame buildings have been considered & analyzed with the help of ETAB software by using Response spectrum method. Following properties are considered for buildings.

Analysis Property Data

- a) Material used was M40 Grade Concrete.
- b) Yield stress $f_y = 500 \text{ N/mm}^2$

- c) Compressive Cube Strength of Concrete = 25 N/mm²
- d) Poisson's ratio = 0.15

e) Analysis was done using ETABS Software 9.7

Building Details

a) Type of frame: Special RC moment resisting frame fixed at the base

b) Number of storey: G+5, G+10, G+15

c) Ground Floor height: 3m

d) Floor height: 3.0 m

e) Depth of Slab: 120 mm

f) Size of beam: (250 × 800) mm

g) Size of column: (400 × 900) mm

h) Spacing between frames : (i) 6 m in X & Y direction (General),

(ii) 30 m × 24 m in X & Y

direction

i) Live load on floor: 2 kN/m²

j) Floor finish: 1.0 kN/m²

m) Thickness of wall: 230 mm

o) Density of concrete: 25 kN/m³

p) Density of masonry wall: 19 kN/m³

Depth of foundation from ground level = 1.5 m

Seismic Data

a) Type of soil: Medium

b) Seismic zone: IV

c) Importance factor: 1.2

d) Reduction factor: 5

e) Response spectra: As per IS 1893(Part-1):2016

s) Damping of structure: 5 percent

III- MODELING

The main aim of the model is to study the change in building responses (mainly deflection and storey drift) due to various irregularities as per IS 1893:2016. The building is analyzed in 6 stages as follows,

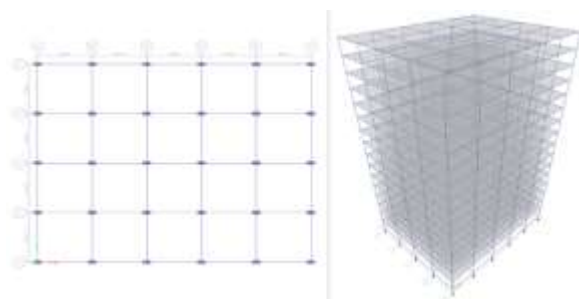


Fig. 1- Plan & isometric view of regular structure

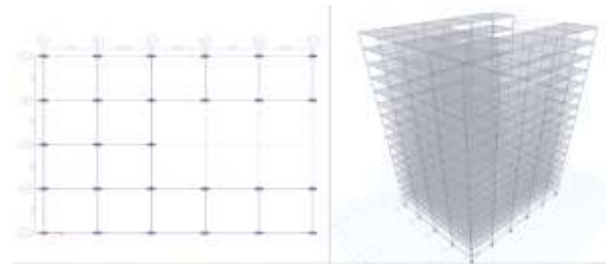


Fig. 2- Plan & isometric view of Structure with plan irregularity

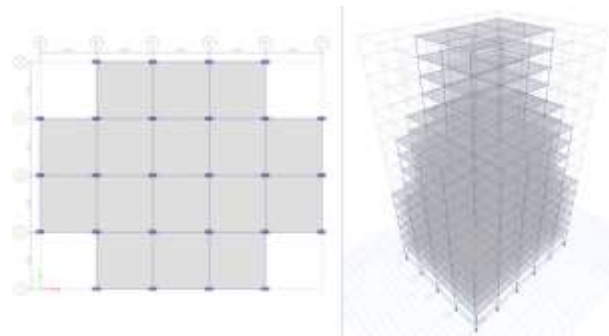


Fig. 3- Plan & isometric view of Structure with vertical irregularity

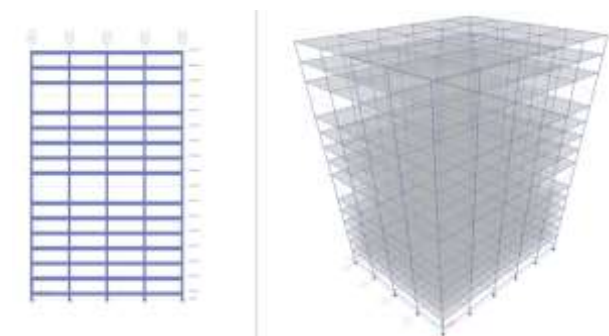


Fig. 4- Elevation & isometric view of Structure with stiffness irregularity

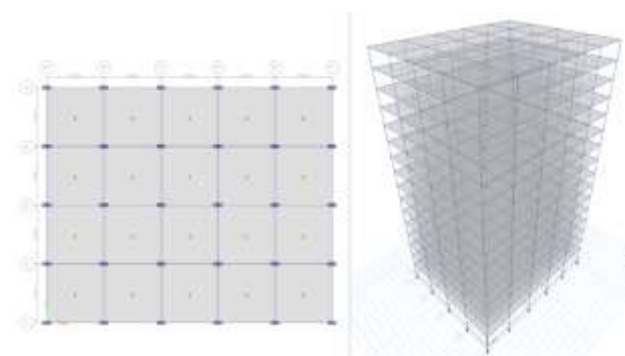


Fig. 5- Plan & isometric view of Structure with mass irregularity

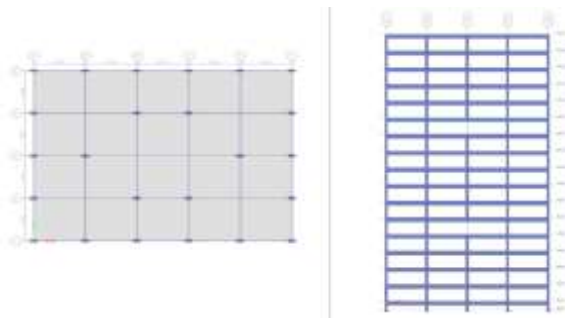


Fig. 6- Plan & Elevation of Structure with strength irregularity

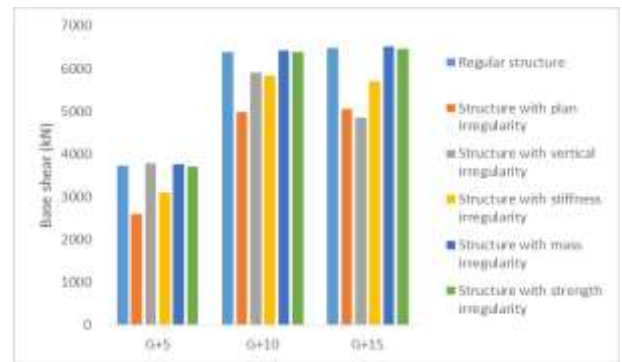


Fig. 8- Base shear (kN) in Y-direction

IV- RESULTS

Table 1- Base shear (kN) in X-direction

| Type of Structure | Regular structure | Structure with plan irregularity | Structure with vertical irregularity | Structure with stiffness irregularity | Structure with mass irregularity | Structure with strength irregularity |
|-------------------|-------------------|----------------------------------|--------------------------------------|---------------------------------------|----------------------------------|--------------------------------------|
| G+5 | 3721.1648 | 2903.39 | 3783.62 | 3100.48 | 3760.02 | 3709.9 |
| G+10 | 7108.5254 | 5556.11 | 6575.72 | 6491.15 | 7149.61 | 7090.51 |
| G+15 | 7239.7738 | 5660.18 | 5425.95 | 6386 | 7292.96 | 7228.81 |

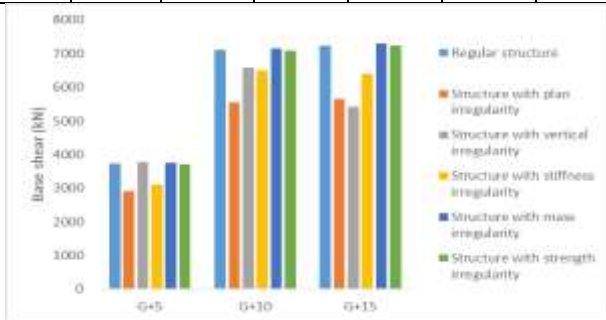


Fig. 7- Base shear (kN) in X-direction

Table 2- Base shear (kN) in Y-direction

| Type of Structure | Regular structure | Structure with plan irregularity | Structure with vertical irregularity | Structure with stiffness irregularity | Structure with mass irregularity | Structure with strength irregularity |
|-------------------|-------------------|----------------------------------|--------------------------------------|---------------------------------------|----------------------------------|--------------------------------------|
| G+5 | 3719.99 | 2604.9 | 3781.53 | 3099.96 | 3760.87 | 3710.09 |
| G+10 | 6381.6 | 4987.91 | 5903.98 | 5826.81 | 6418.45 | 6379.75 |
| G+15 | 6474.81 | 5064.09 | 4854.43 | 5710.24 | 6523.98 | 6464.93 |

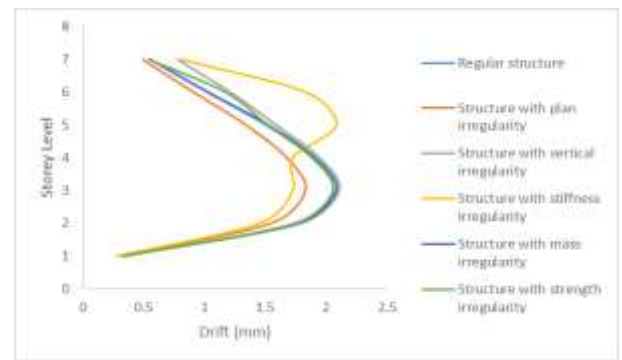


Fig. 9- Storey Drift (mm) in X-direction (G+5) building

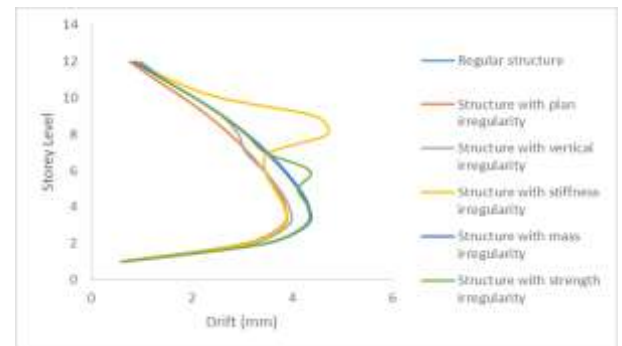


Fig. 10- Storey Drift (mm) in X-direction (G+10) building

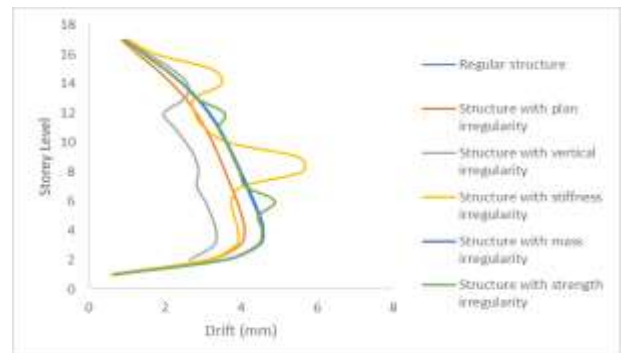


Fig. 11- Storey Drift (mm) in X-direction (G+15) building

Table 3- Maximum axial force (kN) in columns

| Type of Structure | Regular structure | Structure with plan irregularity | Structure with vertical irregularity | Structure with stiffness irregularity | Structure with mass irregularity | Structure with strength irregularity |
|-------------------|-------------------|----------------------------------|--------------------------------------|---------------------------------------|----------------------------------|--------------------------------------|
| G+5 | 3818.677 | 3745.119 | 4063.997 | 3188.378 | 3980.474 | 4349.743 |
| G+10 | 7249.73 | 6766.29 | 7222.21 | 6619.24 | 7411.18 | 9019.31 |
| G+15 | 10478 | 9567.02 | 9813.1 | 9294.1 | 10788.6 | 12929.6 |

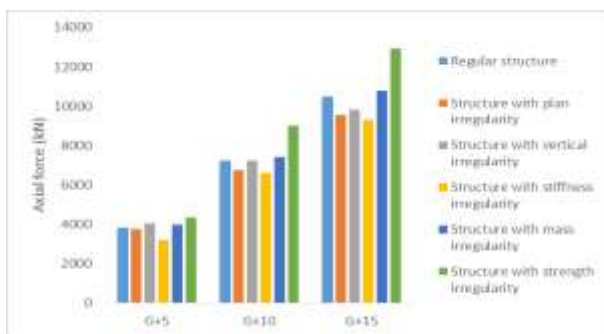


Fig. 12- Maximum axial force (kN) in columns

Table 4- Maximum moment (kNm) in beams

| Type of Structure | Regular structure | Structure with plan irregularity | Structure with vertical irregularity | Structure with stiffness irregularity | Structure with mass irregularity | Structure with strength irregularity |
|-------------------|-------------------|----------------------------------|--------------------------------------|---------------------------------------|----------------------------------|--------------------------------------|
| G+5 | 438.194 | 408.514 | 445.906 | 378.077 | 441.877 | 443.717 |
| G+10 | 695.937 | 697.463 | 653.889 | 641.869 | 699.215 | 715.411 |
| G+15 | 707.716 | 728.373 | 568.996 | 633.728 | 712.192 | 743.402 |

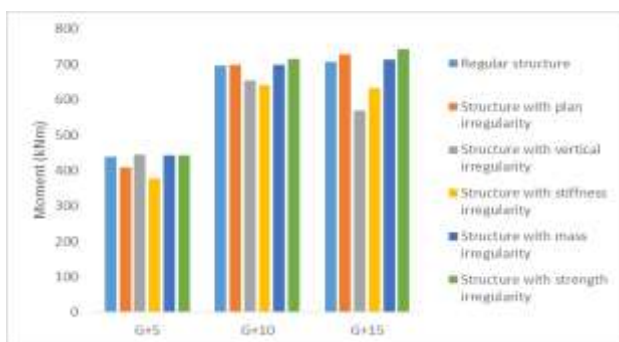


Fig. 13- Maximum moment (kNm) in beams

V- CONCLUSION

1. In X direction, Lateral force or storey shear at each consecutive storey level for mass irregularity is more as compared to other types of irregularity. Vertical irregularity has least lateral force on consecutive story's as compared to other types of irregularity. Approximately on an average 15% lateral force or storey shear is decreased or increased between all studied types of irregularities.
2. In Y direction, Lateral force or storey shear at each consecutive storey level for regular structure is more as compared to other types of irregularity. Vertical irregularity has least lateral force on consecutive story's as compared to other types of irregularity. Approximately on an average 15% lateral force or storey shear is decreased or increased between all studied types of irregularities.
3. Storey drift ratio for stiffness irregularity is more as compared to other types of irregularity. mass irregularity has least drift ratio as compared to other types of irregularity. Approximately on an average 25% storey drift is decreased or increased between all studied types of irregularities.
4. Axial force in column is rise upto 30% in building with strength irregularity as compared to regular structure.
5. Moment in beam is rise upto 35% in building with strength irregularity as compared to regular structure.

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