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Effect of Different Irregularities on Multistoried Building for Lateral Loading

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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. 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. In this study analysis results of ETABS for lateral stability are checked as per IS code 1893:2016 provisions for seismic loads. In this paper irregularities in structures namely mass, stiffness, diaphragm discontinuity, plan and vertical geometry irregularities are considered.*

***Key Words*:** ETAB software, Structural irregularities, Response spectrum method, Earthquake, IS 1893.

1. 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.

1.1 Scope of the Study

1. Only RC buildings are considered.
2. Linear elastic analysis was done on the structures.
3. Column was modeled as fixed to the base.
4. The contribution of infill wall to the stiffness was not considered.
5. Loading due to infill wall was taken into account.
6. The effect of soil structure interaction is ignored.

1.2 Methodology

1. Review of existing literatures by different researchers.
2. Selection of types of structures.
3. Modelling of the selected structures.
4. Performing dynamic analysis on selected building models and comparison of the analysis results.
5. Ductility based design of the buildings as per the analysis results

2. PROBLEM STATEMENT

Fifteen 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 fy = 500 N/mm2
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+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

3. 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 peer IS 1893:2002 and IS 1893:2016. The building is analyzed in 6 stages as follows,

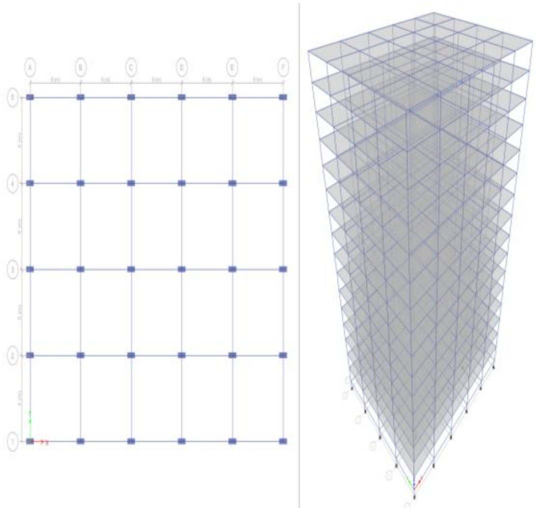

Fig 1- Plan & isometric view of regular structure

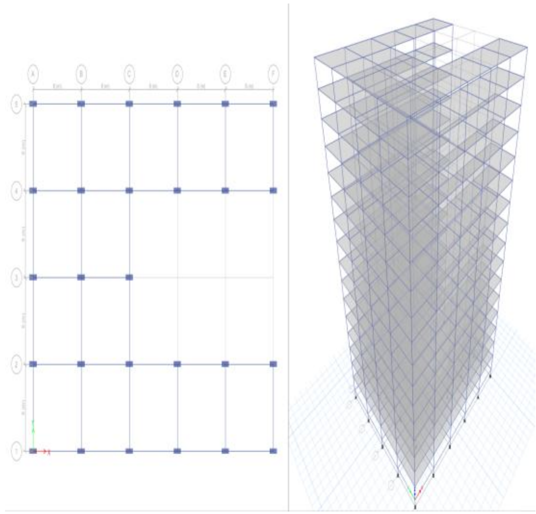

Fig 2- Plan & isometric view of Structure with plan irregularity

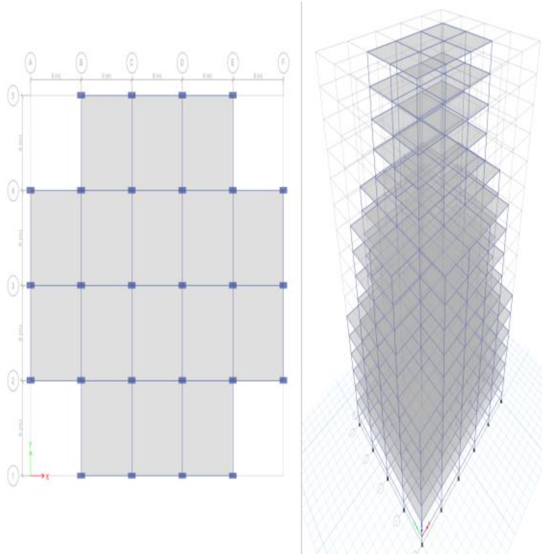

Fig 3- Plan & isometric view of Structure with vertical irregularity

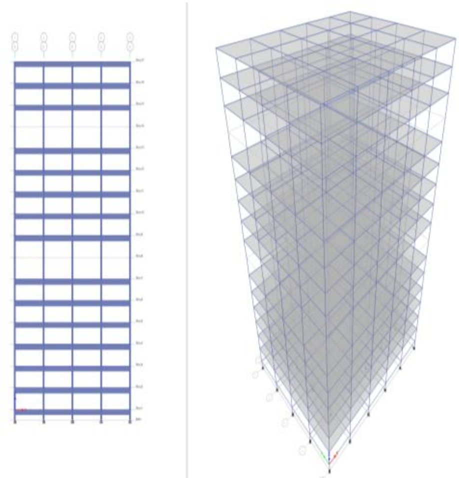

Fig 4- Elevation & isometric view of Structure with stiffness irregularity

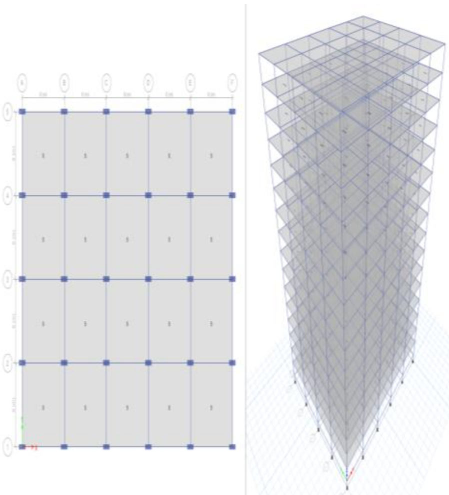

Fig 5- Plan & isometric view of Structure with mass irregularity

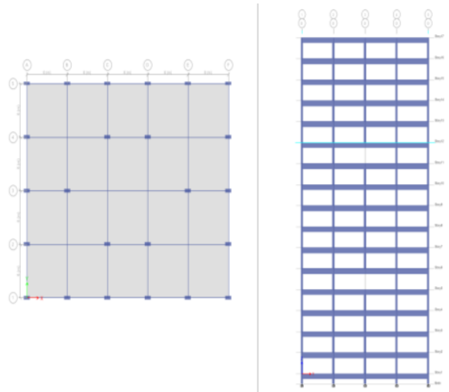

Fig 6- Plan & Elevation of Structure with strength irregularity

4. 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
Base Shear (kN)	7239.7738	5660.18	5425.95	6386	7292.96	7228.81

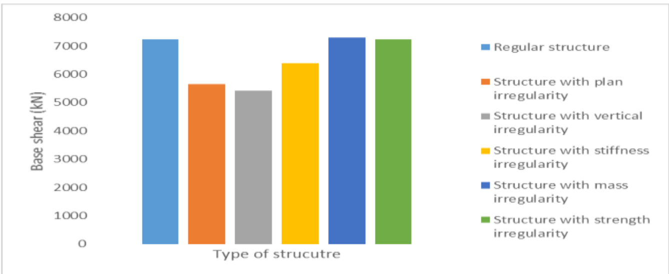

Fig 7- Base shear (kN) in X-direction

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
Base Shear (kN)	6474.81	5064.09	4854.43	5710.24	6523.98	6464.93

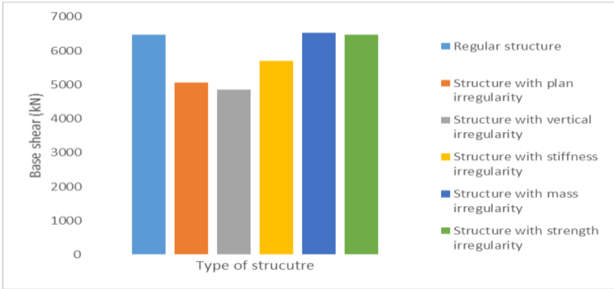

Fig 8- Base shear (kN) in Y-direction

Table 3- Maximum Lateral Displacement (mm) 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
Maximum Lateral Displacement (mm)	94.991	88.114	75.573	102.095	95.742	97.078

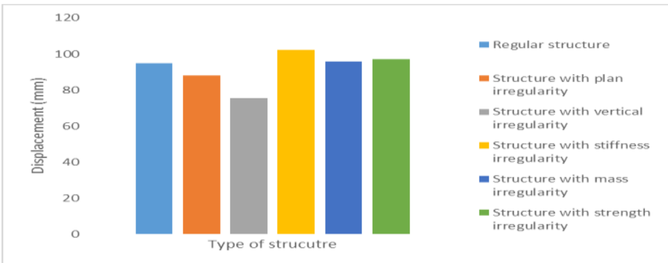

Fig 9-Maximum Lateral Displacement (mm) in X-direction

Table 4- Maximum Lateral Displacement (mm) 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
Maximum Lateral Displacement (mm)	143.133	166.703	115.023	173.324	144.262	148.168

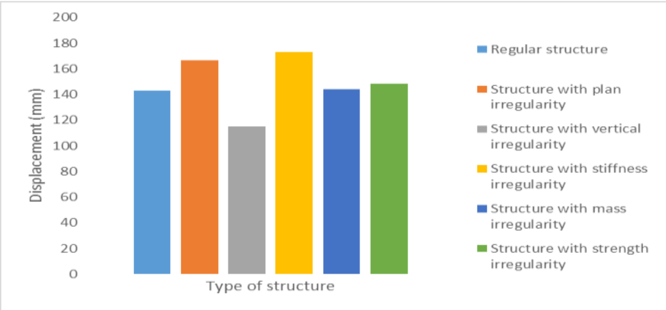

Fig 10-Maximum Lateral Displacement (mm) in Y-direction

Table 5- 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
Axial Force (kN)	10478	9567.02	9813.1	9294.1	10788.6	12929.6

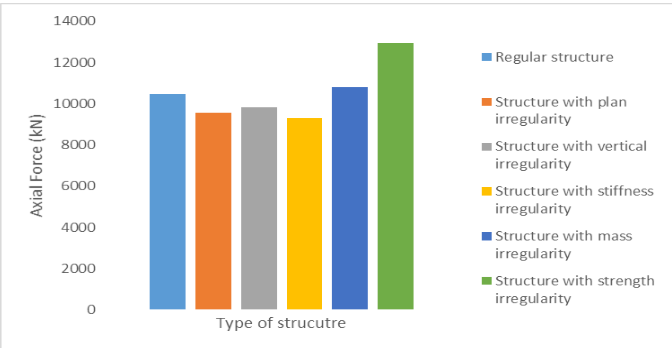

Fig 11-Maximum axial force (kN) in columns

Table 6- 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
Moment (kNm)	707.716	728.373	568.996	633.728	712.192	743.402

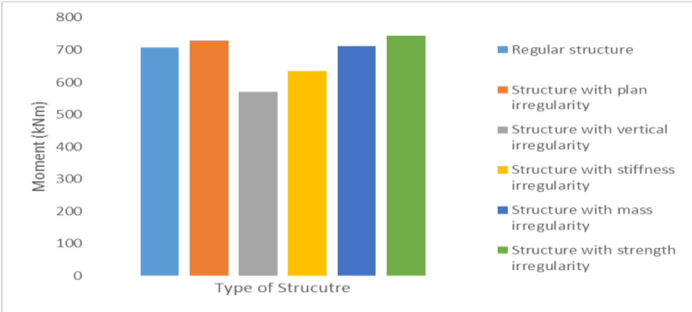

Fig12-Maximum moment (kNm) in beams

5. CONCLUSIONS

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 stories 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 stories 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 shear and base shear in both the directions i.e. along X-direction and along Y-direction are increased by nearly same amount i.e. approximately 15% when using IS 1893:2016.
4. In X direction, nodal displacement for stiffness irregularity is more as compared to other types of irregularity. Vertical irregularity has least nodal displacement as compared to other types of irregularity. Approximately on an average 25% nodal displacement is decreased or increased between all studied types of irregularities.
5. In Y direction, nodal displacement for stiffness irregularity is more as compared to other types of irregularity. Vertical irregularity has least nodal displacement as compared to other types of irregularity. Approximately on an average 25% nodal displacement is decreased or increased between all studied types of irregularities.
6. Axial force in column is rise upto 30% in building with strength irregularity as compared to regular structure.
7. Also shear force and moment in beam is rise upto 35% in building with strength irregularity as compared to regular structure.

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