Analysis of Effect of Structural Irregularity in Multistorey Building under Seismic Loading

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***Abstract*: Previous earthquakes in India have discovered that most of the buildings aren't designed to be earthquake resistant. In general, buildings are designed taking into account just the gravity loads. The existing work describes the various reinforced concrete (RC) frames having various irregularities but with same dimensions which are analyzed to study the behavior of theirs when put through seismic lateral loads. All of the frames were analyzed with the same strategy as mentioned in Is 1893-Part-1:2002. By the end result, it's been interpreted the base frame (regular) evolves least damage while the structure with irregularity shows maximum damage. The evaluation proves that irregularities are unsafe for the buildings and it's crucial that you have regular and simpler shapes of frames in addition to uniform load distribution within the building. The complex shaped structures are days getting common, but they have a threat of sustaining damages during earthquakes. Thus, such buildings must be designed effectively taking proper care of the dynamic behavior of theirs.**

***Keywords*: Dynamic response, structural irregularity, mass irregularity, vertical geometric irregularity.**

1. INTRODUCTION

1.1 GENERAL

As per IS 1893:2002, A structure can be classified as vertically irregular if it contains irregular distribution of mass, strength and stiffness along the building height. The building can have irregular distributions of mass, strength and stiffness along plan also, in such a case it can be said that the building has a horizontal irregularity. Vertical irregularities in structures are extremely typical function in Area that is urban. In many of situations, buildings start to be vertically irregular within the planning phase itself as a result of several architectural and functional purposes. This kind of buildings demonstrated more vulnerability within the past earthquakes. The topics regarding of vertical irregularities have been in focus of research for many years. Numerous studies have been performed in this specific area in deterministic domain. Hence the focus of existing study is assessing the relative performances of typical vertically irregular structures in a Probabilistic domain.

1.2 Classification of vertical irregularity

In the prior code of IS1893-2002, there was no design recommendations particularly for OGS frames mentioned for vertical irregularity. However, in the after Bhuj earthquake was revised in 2002. In the latest version of code IS 1893 (2002) (part1)-, incorporated a brand-new design recommendation for OGS buildings. As per is actually 1893 (2002) code, 5 kinds of irregularities for structures are listed out as follows:

i) Stiffness Irregularity -
a) Soft Storey: is identified to occur when there's a Storey in which the lateral stiffness is under 70 % of which within the Storey above or perhaps less than 80 % of the common stiffness of the 3 stories above.
b) Extreme Soft Storey is identified to occur where there's a Storey in which the lateral stiffness is under 60 % of which within the Storey above or perhaps under 70 % of the common stiffness of the three stories above.

ii) Weight (Mass) Irregularity - It's deemed to occur where real mass of every Storey is much more than 150 % of the effective mass of an adjacent Storey.

iii) Vertical geometric irregularity - It shall be regarded as to occur where horizontal dimension of the lateral force resisting method in virtually any Storey is much more than 150 % of which within an adjacent Storey.

iv) In plane Discontinuity - In Vertical Lateral-Force-Resisting Elements is defined to exist where an in plane offset of the lateral-force-resisting elements is greater than the length of those components or even where there's a decrease in stiffness of the resisting component within the Storey below.

v) Discontinuity in Capacity weak Storey - The weak Storey is only one in that the Storey lateral strength is under 80 % of which in the above mentioned Storey. The Storey lateral strength is definitely the complete lateral strength of all the seismic-resisting elements sharing the Storey shear in the consideration direction.

1.3 OBJECTIVE

The main objective of this particular study

1. To Study the Seismic response of structure subjected to vertical irregularities using soft computed tools (ETAB).
2. To understands the behavior of the structure in higher seismic zone. For this purpose, a 8 storey-high building on various configurations is analyzed.
3. To Obtained the Displacement, Storey Drift curves and Shear stress curve under Seismic Load.
4. To study IS Code 1893 (Part I): 2002 the entire models have been analyzed with the help of ETAB.

2. LITERATURE REVIEW

1. **Isha Rohilla , S.M. Gupta , Babita Saini et. al. [2015],** discussed the critical position of floating column in vertically irregular buildings for G+5 and G+7 RC buildings for zone II and zone V. Also, the effect of size of beams and columns carrying the load of floating column has been assessed. he response of building such as storey drift, storey displacement and storey shear has been used to evaluate the results obtained using ETABS software. Conclude That, increasing dimensions of beams and columns of only one floor does not decreases storey displacement and storey drift in upper floors so dimensions should be increased in two consecutive floors for better performance of building.
2. **Kavya N, Dr. K.Manjunatha, Sachin.P.Dyavappanavar et. al. [2015],** studied the seismic behaviour of the RC multi-storey buildings with and without floating column are considered for zone IV. The analysis is carried out for the multi-storey buildings of G+3 situated at zone IV, using ETABS software. Hence, from the study it can be concluded that as far as possible, the floating columns are to be avoided especially, in the seismic prone areas.
3. **Ashvin G. Soni, Prof. D. G. Agarawal, D. M. A. Pande et al. (2015),** carried out the performance evaluation of RC (Reinforced Concrete) buildings with irregularity. Structural irregularities are important factors which decrease the seismic performance of the structures. The study as a whole makes an effort to evaluate the effect of vertical irregularity on RC buildings. conclude that that irregularities in buildings are harmful for the structures and it is important to have simpler and regular shapes of frames as well as uniform load distribution of load around the building.
4. **A. E. Hassaballa, M. A. Ismaeil, A. N. Alzead, fathelrahman M. Adam et al. (2013),** carried out Seismic analysis of a multi-Storey RC frame in Khartoum city was analysed under moderate earthquake loads as an application of seismic hazard and in accordance with the seismic provisions proposed for Sudan to investigate the performance of existing buildings if exposed to seismic loads. The frame was analysed using the response spectrum method to calculate the seismic displacements and stresses. The results obtained, clearly, show that the nodal displacements caused drifts in excess of approximately 2 to 3 times the allowable drifts.
5. **Himanshu Bansal, Gagandeep et al. (2012),** carried out Response spectrum analysis (RSA) and Time hiStorey Analysis (THA) of vertically irregular RC building frames and to carry out the ductility based design using IS 13920 corresponding to Equivalent static analysis and Time hiStorey analysis. Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. According to observation, the storey shear force was found to be maximum for the first storey and it decreases to minimum in the top storey in all cases.
6. **Poonam ,Anil Kumar and Ashoke K. Gupta et al. (2012),** carried out the Results of the numerical analysis showed that any storey, especially the first storey, must not be softer/weaker than the storeys above or below. The irregularities, if required to be provided, need to be provided by appropriate and extensive analysis and design processes.
7. **Pradip Sarkar, A. M. Prasad, D. Menon et al. (2010),** proposed a new method of quantifying irregularity in vertically irregular building frames, accounting for dynamic characteristics (mass and stiffness). An empirical formula is proposed to calculate the fundamental time period of stepped building, as a function of regularity index.
8. **Valmundsson and Nau et al. (1997)** evaluated the earthquake response of 5-, 10-, and 20Storey framed structures with non-uniform mass, stiffness, and strength distributions. The response calculated from TH analysis was compared with that predicted by the ELF procedure embodied in UBC. Based on this comparison, the aim was to evaluate the current requirements under which a structure can be considered regular and the ELF provisions applicable.
9. **Karavasillis et al. (2008)** studied the inelastic seismic response of plane steel moment-resisting frames with vertical mass irregularity. The analysis of the created response databank showed that the number of storeys, ratio of strength of beam and column and the location of the heavier mass influence the height-wise distribution and amplitude of inelastic deformation demands, while the response does not seem to be affected by the mass ratio.
10. **Lee and Ko et al. (2007)** subjected three 1:12 scale 17-Storey RC wall building models having different types of irregularity at the bottom two stories to the same series of simulated earthquake excitations to observe their seismic response characteristics. The first model had a symmetrical moment-resisting frame (Model 1), the second had an infilled shear wall in the central frame (Model 2), and the third had an infilled shear wall in only one of the exterior frames (Model 3) at the bottom two stories. The total amounts of energy absorption by damage are similar regardless of the existence and location of the infilled shear wall. The largest energy absorption was due to overturning, followed by the shear deformation.
11. **Karavasillis et al. (2008)** studied the inelastic seismic response of plane steel moment-resisting frames with vertical mass irregularity. The analysis of the created response databank showed that the number of storeys, ratio of strength of beam and column and the location of the heavier mass influence the height-wise distribution and amplitude of inelastic deformation demands, while the response does not seem to be affected by the mass ratio.

3. METHODOLOGY

3.1 SEISMIC ANALYSIS OF FRAMES

Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. In the past the buildings were designed just for gravity loads and seismic analysis is a recent development. It is a part of structural analysis and a part of structural design where earthquake is prevalent.

There are different types of earthquake analysis methods. We are using Response Structural Analysis.

3.2 METHODOLOGY

Analysis methods are broadly characterized as linear & nonlinear static as well as dynamicThe primary distinction in between the equivalent fixed process as well as dynamic analysis process is based on the magnitude as well as distribution of lateral forces with the level of the buildings. s.

A. Modeling of Building :

Here the study is carried out for the behaviour og G+8 storied building with mass and vertical geometric irregularity.

B. Building Models :

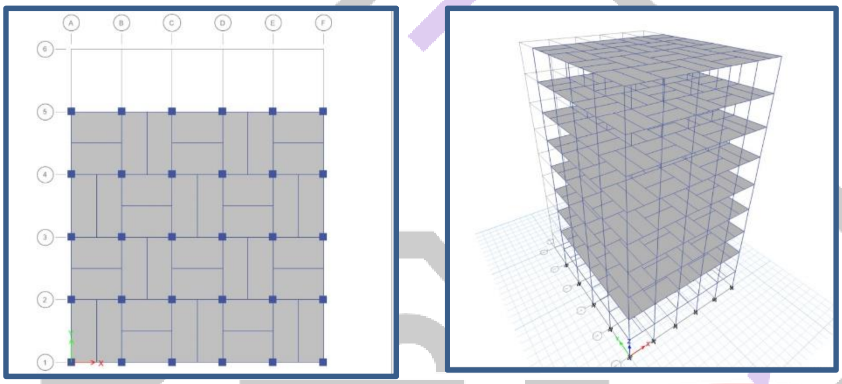

Fig.1 Regular Frame

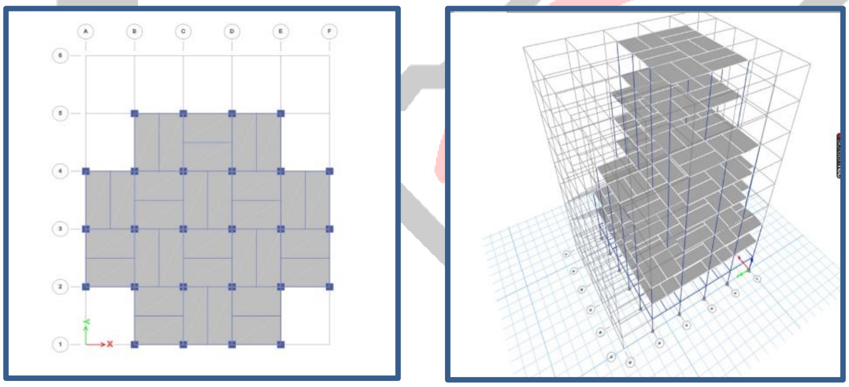

Fig.2 Vertical geometric irregular Frame 1

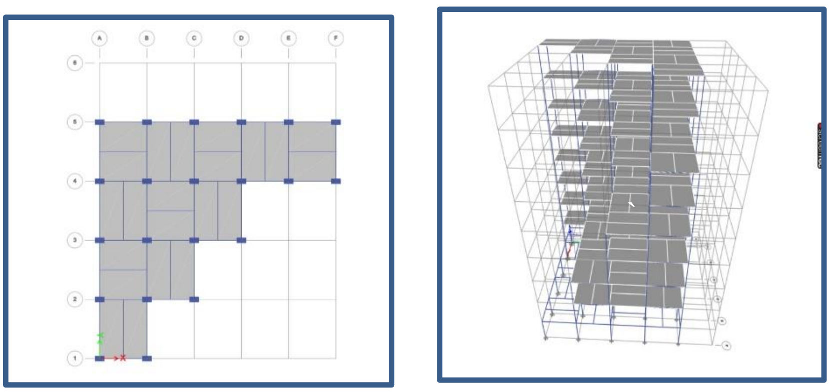

Fig.3 Vertical geometric irregular Frame 2

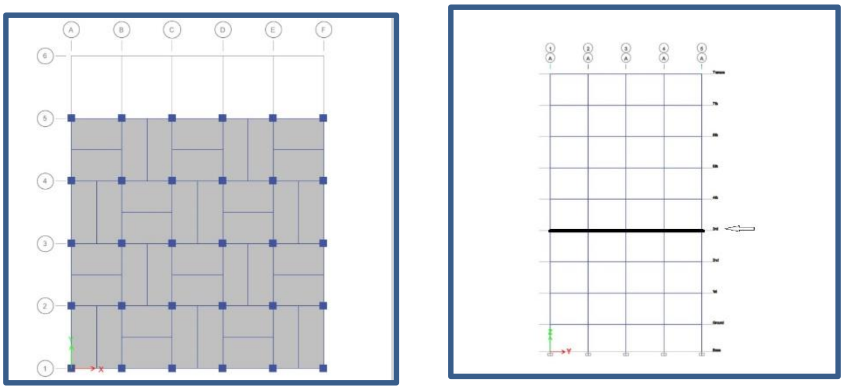

Fig.4 Mass irregular Frame 1

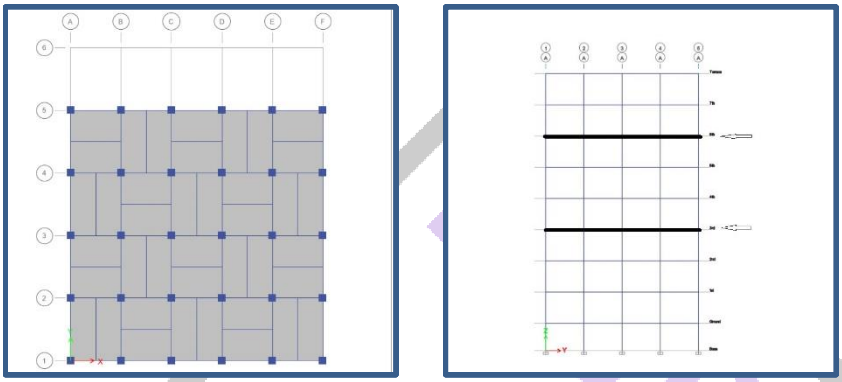

Fig.5 Mass irregular Frame 2

C. Load consideration:

Live load	4 KN/m2
Roof live load	1.5 KN/m2
Floor finish	1KN/m2

Table 1: load consider

D. Earthquake load data:

Earthquake Zone	IV
Damping Ratio	5%
Importance factor	1
Type of Soil	Medium
Zone Factor Z	0.24
Response Reduction Factor R	5

Table 2: Earthquake data

E. Building with Irregularity:

A G+8 building is considered in zone IV. A medium soil stratum is considered at the location. The third and sixth floor has swimming pool which leads to mass irregularity and there are vertical setbacks at different floor which causes vertical geometric irregularity.

4. RESULT AND DISCUSSSION

A. Storey Displacement

Fig 6: storey displacement for all models in X directions

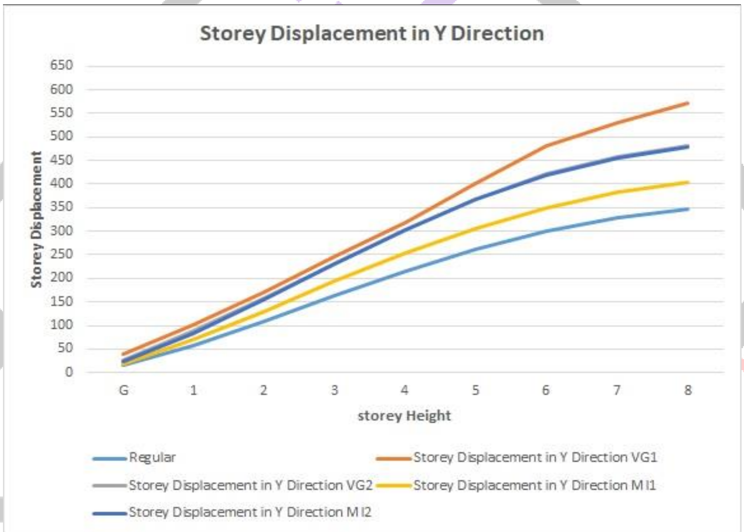

Fig 7 : storey displacement for all models in Y directions

B. Storey Drift

Fig 8 : storey drift for all models in X direction

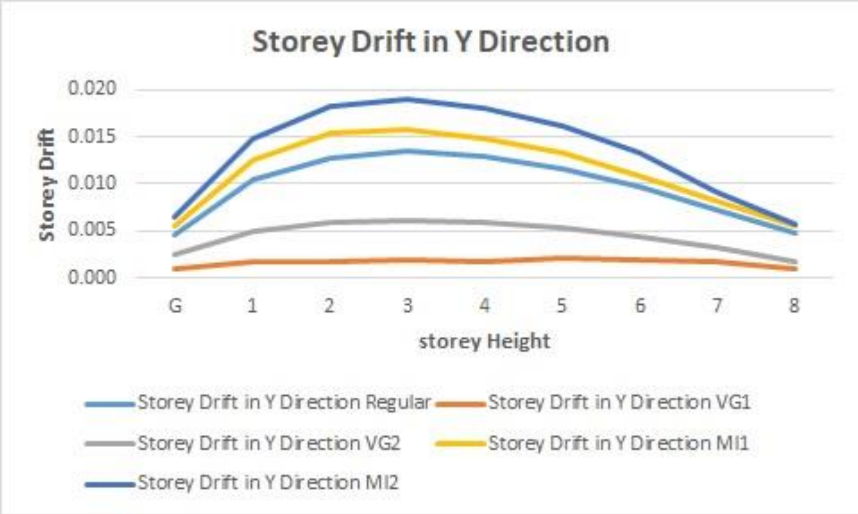

Fig 9 : storey drift for all models in Y direction

C. Storey Shear

Fig 10 : Storey shear for all the models in x direction

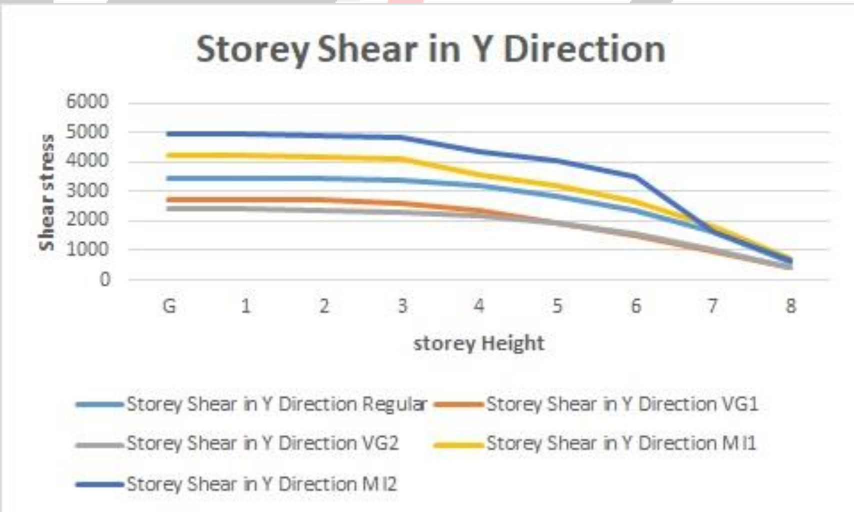

Fig 11 : Storey shear for all the models in y direction

CONCLUSION

The following conclusions were drawn at the end of the study:

- Fig 6 and fig 7 shows the displacement of each storey along the height of the building for different s models along X and Y directions respectively. From the graph of displacement of the building in X and Y directions, it can be observed that, the pattern of displacement in X and Y direction is almost same for all the models from base to roof. In both direction Vertical Geometric Irregular Frame 1 shows more displacement from base to top, and less displacement where observed in regular frame.
- Fig 8 and Fig 9 shows the storey drift along the height of building for each model in X and Y direction respectively. From the data tabulated it can be observed that the storey drift is zero at base and more at storey where mass irregularity present and ,at point of sudden drop of setback for all the models.
- Maximum storey drift is observe in case of vertical geometric irregular frame and mass irregular frame.
- Fig 10 and 11 shows storey shear along height of building for each model in X and Y direction respectively. From the data tabulated it can be observed that the storey shear decreases with storey height. storey shear is maximum at base and minimum at top for all models.
- In Mass irregular frame 2 the storey shear is maximum at base, and drops along height and minimum at top.
- Storey shear is more in irregular model compare to regular model.
- Finally, we can say that regular shape of the building performs well during Earthquake because it shows less response compare to irregular frame.

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