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Seismic Effect of Vertical and Mass Irregularity on Multistoried Building

Sumit M. Netke[1], Padmakar J. Salunke[2]
[1]*M. E. Student, Department of Civil Engineering, MGM College of Engineering, Mumbai, India*
[2]*Professor and HoD, Department of Civil Engineering, MGM College of Engineering, Mumbai, India*

***Abstract*: This Project is concerned with the effects of vertical and mass irregularities on the seismic response of multistoried structure. It aims to carry out a comprehensive investigation on seismic effect of high-rise structures vertically irregular with mass irregularity at different levels of the structure. Two types of irregularities namely mass irregularity and vertical geometric irregularity were considered. Comparison of the results of regular and irregular structure was also done. Modelling and analysis was done on Finite element based ETABS 2016 (V 16.2.0) software and of the Four G+40 structures were considered with Vertical Irregularity and Mass Irregularity at Base, Middle & Top Story. The main influencing parameters considered for this study were Lateral Displacement, Story-drift, Base shear, Bending Moment.**

***Keywords*: Vertical Irregularity, Mass Irregularity, Lateral Displacement, Storey-drift, Base shear, Bending Moment, Etabs 2016 (V 16.2.0)**

1. Introduction

In last few years different floors of structures are utilized for various capacities like vehicle parking, putting away heavy mechanical apparatuses, for Lobbies etc. as in the urban areas the space available for the construction of buildings is limited. To fulfill this demand, buildings with irregularities is the only option available. This winds up in variety of mass, strength and stiffness at different stores. The structures having this discontinuity are named as Irregular structures. Vertical and Mass irregularities are one of the significant reasons of failure of structures in the seismic period. Analyzing the structure for different Indian seismic zones and checking for various criteria at every level has turned into a fundamental. This building structure is getting progressively popular in current multi-story building development mostly in view of its functional and aesthetic design. During an earthquake, structure failure begins at points of weakness. Specifically lack of strength of structure is because of geometry, mass discontinuity and stiffness of structure. This Project is concerned with the effects of vertical and mass irregularities on the seismic response of Multi-stored structure. It aims to carry out a comprehensive investigation on seismic effect of high-rise structures vertically irregular with mass irregularity at different levels of the structure. Two types of irregularities namely mass irregularity and vertical geometric irregularity were considered. Comparison of the results of regular and irregular structure was also done. Modelling and analysis of the structure was done on Finite element based ETABS 2016 (V 16.2.0) software. The main influencing parameters considered for this study are Lateral Displacement, Store-drift, Base shear, Bending Moment.

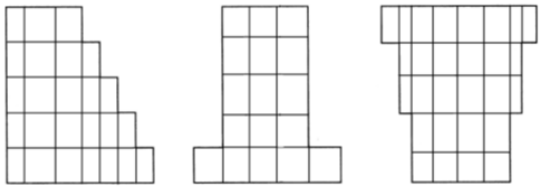

Fig. 1. Vertical irregularities with abrupt change in geometry

2. Literature review

Ravindra N. Shelke (2017) "Seismic analysis of vertically irregular rc building frames": This project was studied about the impacts of different vertical irregularities on the seismic response of a structure. The goal of the undertaking was to do Response spectrum analysis (RSA) of vertically irregular RC building. Three sorts of irregularities to be specific mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. The mass irregular structures were seen to encounter larger base shear than comparable normal structures. Patel Kevins J (2017)," Effects of Irregularity on Progressive Collapse of RCC Building". This paper states that Progressive collapse of a structure was caused because of the evacuation of vertically load carrying member. In this project, a progressive collapse assessment according to the GSA guideline was completed for a G+10, G+15, G+20, G+25, G+30 story RCC building considering irregularity of various tallness of building, G+15 and G+20 story RCC building considering mass irregularity, G+15 story RCC building considering different sloping ground point 100 and 150 using linear dynamic analysis. S.Varadharajan (2015),"Seismic behavior of Multi store RC Frames with vertical mass irregularities" Studied that The buildings with mass irregularity act distinctively when contrasted with regular buildings. In this investigation, a parameter called mass irregularity list has been proposed to measure the mass irregularity. The proposed factor depends for the most part upon magnitude and area of mass irregularity. Time period stated by IS 1893:2002 and connection between mass irregularity coefficient and time

Table 1
Dead and live loads considered

Mode Type	M1	M2	M3	M4
Mode Description	Vertically irregular without having Mass irregularity	Vertically irregular having Mass irregularity at Top floor	Vertically irregular having Mass irregularity at Middle floor	Vertically irregular having Mass irregularity at Ground floor
Dead load	IF =1.5KN/m² TF= 3 kN/m²	IF =1.5K/m² TF =3 kN/m²	IF=1.5Kn/m² TF =3 kN/m²	IF=1.5kN/m TF =3kN/m²
Live load	IF = 2 & 3 kN/m² TF = 1.5 kN/m²	IF =2 & 3 kN/m² TF = 20 kN/m²	IF =2 & 3 kN/m² TF = 1.5 kN/m² MF (20th)=20 kN/m²	IF =2 & 3 kN/m² TF = 1.5 kN/m² GF = 20 kN/m²

(Where, IF= Internal Floors, TF = Top Floors, MF = Middle Floors, GF = Ground Floors)

period is computed. For this investigation a group of 108 frames with mass irregularity have been demonstrated and examined by time history analysis.

3. Objectives

- To analyses the multi storied building by Dynamic Analysis with Vertical and mass irregularity during seismic forces for safety of structure.
- Modelling and analyzing effect of Vertical and mass irregularity for different stories location of multistoried R.C.C. building.
- To study Effect of Variation in the results due to combination of Vertical and Mass Irregularity.
- Study the behavior of structure with parameters like base shear, store drift, lateral displacement, Bending moment of R.C.C. building

4. Description of structural model

- *Model M1:* This is G+40 vertically irregular structure without having any mass irregularity.
- *Model M2:* This is G+40 vertically irregular structure having Mass irregularity at the Top store which is at 40th floor.
- *Model M3:* This is G+40 vertically irregular structure having Mass irregularity at the middle store which is at 20th floor.
- *Model M4:* This is G+40 vertically irregular structure having Mass irregularity at bottom store which is at Ground floor.

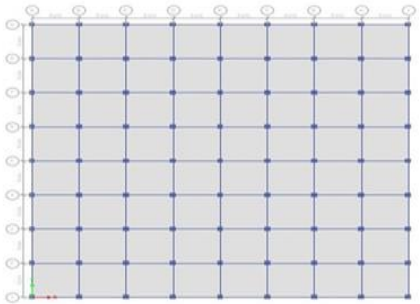

Fig. 2. Ground Floor Plan of building in ETABS Software

As According to IS code 1893:2002 part 2 Vertical irregularity is achieved for the modeling of structure in the Etabs 2016. If (A / L > 0.25) then Vertical irregularity is said to be present in the structure. As shown in the figure below, A=20 m and L=20 m which gives (A / L > 0.25) and hence vertically irregular structure is modeled in the Etab 2016.

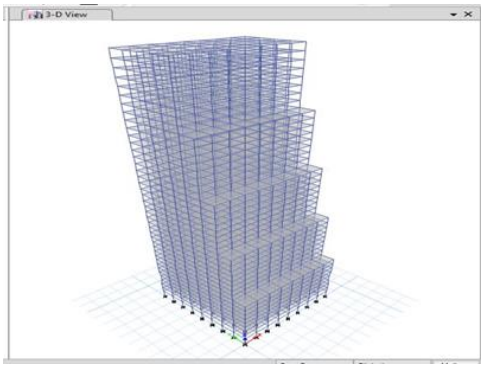

Fig. 3. 3-D model of building in ETABS software

5. Results and discussion

As analysis of G+40 building is done by using ETABS software using Response spectrum analysis method and the following results are obtained. As shown in Tabular form and represented graphically for M1, M2, M3, M4 Model by using ETABS software. Story Forces, Story Displacement, Story Drift and Moment at each floor are obtained and are graphically represented to compare results with different conditions which are as follows

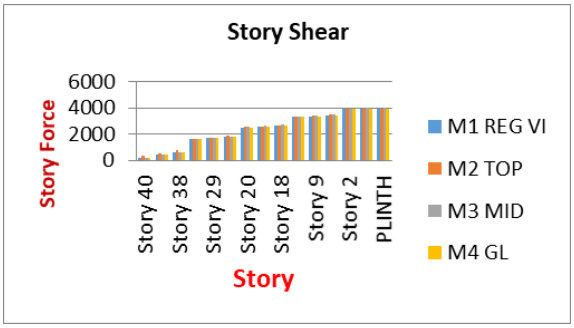

Fig. 4. G+40 Building (Story height vs. Story Shear (KN)

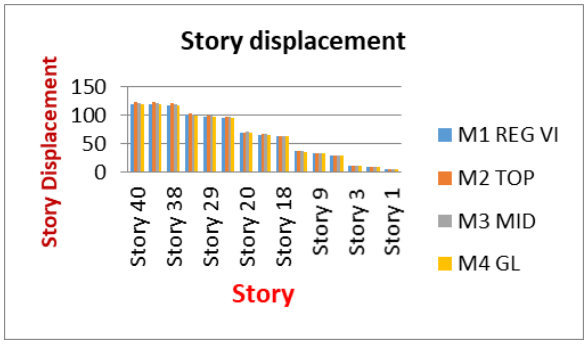

Fig. 5. G+40 Building (Story vs. Story Displacement (mm)

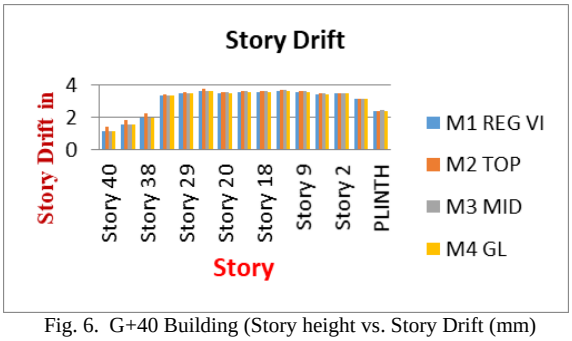

Fig. 6. G+40 Building (Story height vs. Story Drift (mm)

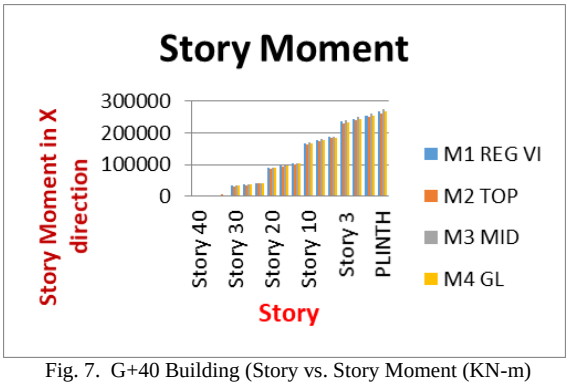

Fig. 7. G+40 Building (Story vs. Story Moment (KN-m)

6. Conclusion

- According to results of RSA, the store shear force was found to be maximum for the first store and it decreased to a minimum in the top store in all cases.
- According to results of RSA, it was found that mass irregular building frames experience larger Story shear, Story moment than similar irregular building without mass irregularity.
- The slight variation is observed in the results of story shear in the Model M1, M3 and M4 but Model M2 shows 69% increase in the top store i.e. at 40th store in both X and Y directions as compared to other models.
- According to results of RSA, the story drift for Model M1, M3, M4 Slight increase or decrease is observed but Model M2 shows 25.36 % increase in X direction and 23.01% increase in Y direction in the Top stores.
- In the case of Story displacement, Model M2 shows 3.05% increase in the X direction and 3.24 % increase in the Y direction at the Top store where as Model M1, M3 and M4 shows slight increase from bottom to Top stores.
- From Graphs, It was found that from bottom to Top store large story moment is experienced in all the Models but Model M2 shows 70% increase in the top story in the both directions.
- Out of all four models Model M1 shows better performance to resist lateral loads due to earthquake compared to all other models such as mass irregularity in bottom stores, middle store and top store whereas Model M2 experiences abrupt sudden changes in 20th Story shear, Story Displacement, Story Drift and Moment. Hence any structure with equal distribution of mass in all the stores will give better performance. The result shows that, the buildings with mass irregular are more vulnerable compared to buildings without mass irregularity during earthquake.

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