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SEISMIC ANALYSIS AND DESIGN OF VERTICALLY IRREGULAR RC BUILDING FRAMES

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Abstract

From past earthquakes it is proved that many of structure are totally or partially damaged due to earthquake. So, it is necessary to determine seismic responses of such buildings. There are different techniques of seismic analysis of structure. Pushover analysis is one of the important techniques for structural seismic analysis generally the evaluated structural response is non-linear in nature. In this project work seismic analysis of RCC buildings with mass irregularity at different floor level are carried out. This paper highlights the effect of mass irregularity on different floor in RCC buildings with pushover analysis is done by using SAP 2000 software.

Keywords— *Seismic Analysis, Pushover Analysis, Irregular Structure, Storey displacement, Base reaction.*

1. INTRODUCTION

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the irregular building.

IS 1893 definition of Vertically Irregular structures:

The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated.

There are two types of irregularities-

1. Plan Irregularities
2. Vertical Irregularities.

Vertical Irregularities Are Mainly Of Five Types

a) Stiffness Irregularity — Soft Storey-A soft storey is one in which the lateral stiffness is less than 70 percent of the storey above or less than 80 percent of the average lateral stiffness of the three storey’s above.

b) Stiffness Irregularity — Extreme Soft Storey-An extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storey’s above.

ii) Mass Irregularity-Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storey’s. In case of roofs irregularity need not be considered.

iii)Vertical Geometric Irregularity- A structure is considered to be Vertical geometric irregular when the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey.

iv) In-Plane Discontinuity in Vertical Elements Resisting Lateral Force-An in-plane offset of the lateral force resisting elements greater than the length of those elements.

v) Discontinuity in Capacity — Weak Storey-A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above.

2. ANALYSIS METHODS:

SEISMIC ANALYSIS:

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. Some of them used in the project are-

I. Response Spectrum Analysis
II. Equivalent Static Analysis
III. Time History Analysis

I. RESPONSE SPECTRUM ANALYSIS:

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Response Structure analysis was performed on regular and various irregular buildings using Staad-Pro. The storey shear forces were calculated for each floor and graph was plotted for each structure.

1. Regular structure (10 storey's)

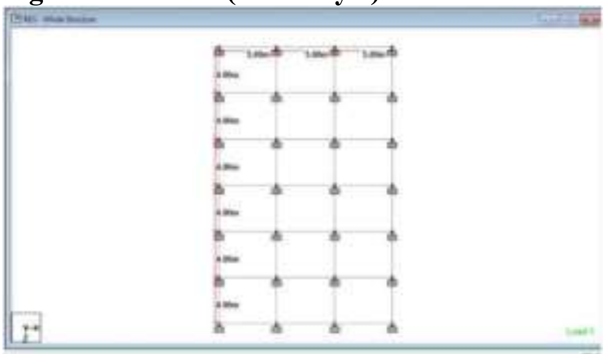

Fig. 1: Plan of regular structure (10 storey's)

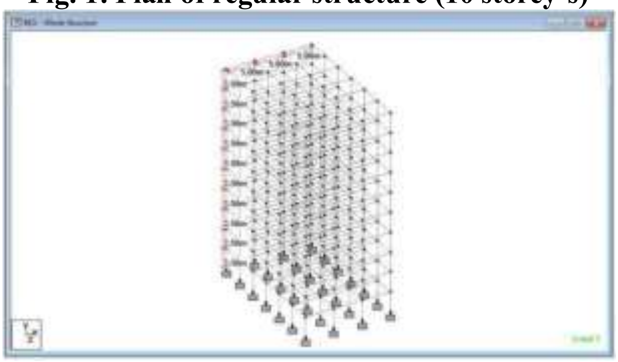

Fig. 2: 3D view of regular structure (10 storey's)

2. Mass Irregular Structure(10 storey's)

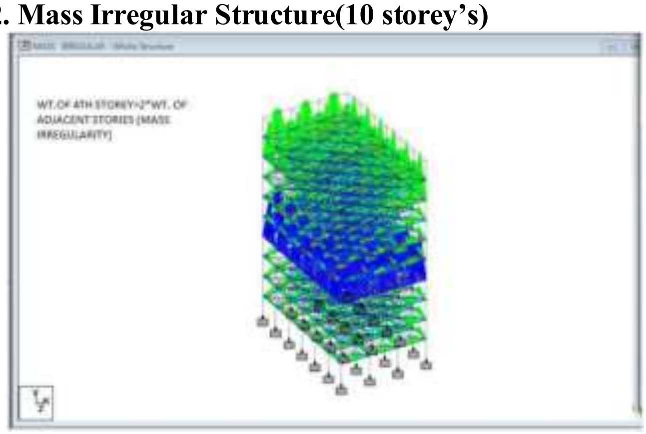

Fig. 3: 3D view of mass regular structure (10 storey's) with swimming pools on 4th and 8th storey's

3. Stiffness Irregular Structure (Soft Storey)

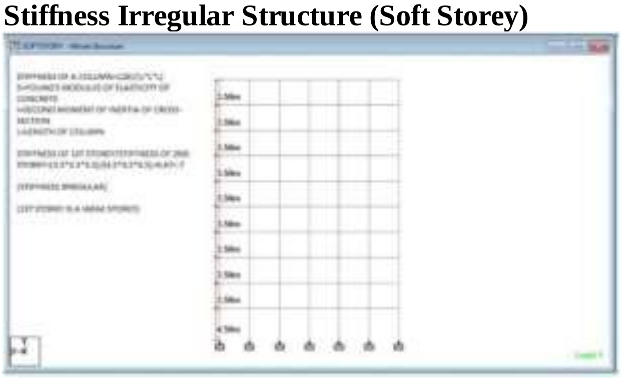

Fig. 4: stiffness irregular structure (10 storeys)

4. Vertically Geometric Irregular

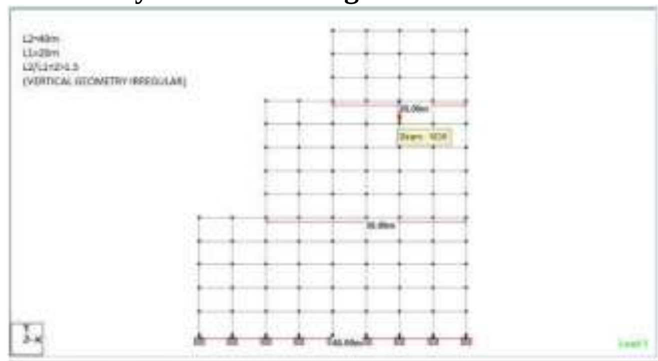

Fig. 5: Vertical Geometric irregular structure (14 storeys)

II. TIME HISTORY ANALYSIS

2.1 INTRODUCTION TO IS CODE GROUND MOTION USED

Regular and various types of irregular buildings were analyzed using THA and the response of each irregular structure was compared with that of regular structure for IS code Ground motion. The IS code ground motion used for the analysis had PGA of 0.2g and duration of 40 seconds.

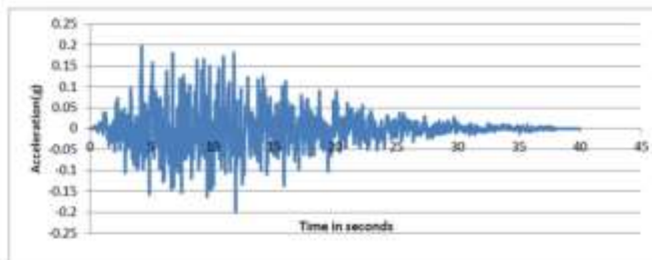

Fig. 6: IS code ground motion with PGA scaled to 0.2g and duration equal to 40 seconds

3. DUCTILITY BASED DESIGN

DUCTILITY BASED DESIGN

Ductility in the structures results from inelastic material behavior and reinforcement detailing such that brittle fracture is prevented and ductility is introduced by allowing steel to yield in a controlled manner. Thus the chief task is to ensure that building has adequate ductility to withstand the effects of earth quakes, which is likely to be experienced by the structure during its lifetime. Ductility of the structure acts as a shock absorber and reduces the transmitted forces to the structure. The ductility of a structure can assess by-

- Displacement ductility
- Rotational and Curvature ductility
- Structural ductility

CONCLUSION

Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. All three kinds of irregular RC building frames had plan symmetry. Response spectrum analysis (RSA) was conducted for each type of irregularity and the storey shear forces obtained were compared with that of a regular structure. Time history analysis (THA) was conducted for each type of irregularity corresponding to the above mentioned ground motions and nodal displacements were compared. Finally, design of above mentioned irregular building frames was carried out using IS 13920 corresponding to Equivalent static analysis (ESA) and Time history analysis(THA) and the results were compared. Our results can be summarized as follows

- According to results of RSA, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases.
- According to results of RSA, it was found that mass irregular building frames experience larger base shear than similar regular building frames.
- According to results of RSM, the stiffness irregular building experienced lesser base shear and has larger inter storey drifts.
- In case of a mass irregular structure, Time history analysis yielded slightly higher displacement for upper stories than that in regular building, whereas as we move down, lower stories showed higher displacements as compared to that in regular structures.
- When time history analysis was done for regular as well as stiffness irregular building (soft storey), it was found that displacements of upper stories did not vary much from each other but as we moved down to lower stories the absolute displacement in case of soft storey were higher compared to respective stories in regular building.
- Tall structures have low natural frequency hence their response was found to be maximum in a low frequency earthquake.

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