Comparatively Study of Multi-Storeyed RC Buildings with Vertically Irregularities Using RSA & THA

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ABSTRACT: This paper is concerned with the effects of various vertical irregularities on the seismic response of a structure. The objective of the thesis is to carry out Response spectrum analysis (RSA) and Time history 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 history analysis. Comparison of the results of analysis and design of irregular structures with regular structure was done. The scope of the project also includes the evaluation of response of structures subjected to high, low and intermediate frequency content earthquakes using Time history analysis. Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. According to our 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. The mass irregular structures were observed to experience larger base shear than similar regular structures. The stiffness irregular structure experienced lesser base shear and has larger inter-storey drifts. The absolute displacements obtained from time history analysis of geometry irregular structure at respective nodes were found to be greater than that in case of regular structure for upper stories but gradually as we moved to lower stories displacements in both structures tended to converge. Lower stiffness results in higher displacements of upper stories. In case of a mass irregular structure, time history analysis gives slightly higher displacement for upper stories than that in regular structures whereas as we move down lower stories show higher displacements as compared to that in regular structures.

When time history analysis was done for regular as well as stiffness irregular structure, 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 structure.

Tall structures were found to have low natural frequency hence their response was found to be maximum in a low frequency earthquake. It is because low natural frequency of tall structures subjected to low frequency earthquake leads to resonance resulting in larger displacements. If a high rise structure (low natural frequency) is subjected to high frequency ground motion then it results in small displacements. Similarly, if a low rise structure (high natural frequency) is subjected to high frequency ground motion it results in larger displacements whereas small displacements occur when the high rise structure is subjected to low frequency ground motion.

KEYWORDS: RHA, THA.

I. 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 =regular' 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-

i **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 storeys 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 storeys 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 storeys. 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.

In these type of irregularities, we take a result of stiffness irregularity.

II. OBJECTIVES:

1) To calculate the design lateral forces on regular and irregular buildings using response spectrum analysis and to compare the results of different structures.
2) To study three irregularities in structures namely mass, stiffness and vertical geometry irregularities.
3) To calculate the response of buildings subjected to various types ground motions namely low, intermediate and high frequency ground motion using Time history analysis and to compare the results.
4) To carry out ductility-based earthquake-resistant design as per IS 13920 corresponding to equivalent static analysis and time history analysis and to compare the difference in design.

III. 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

IV. RESULTS :

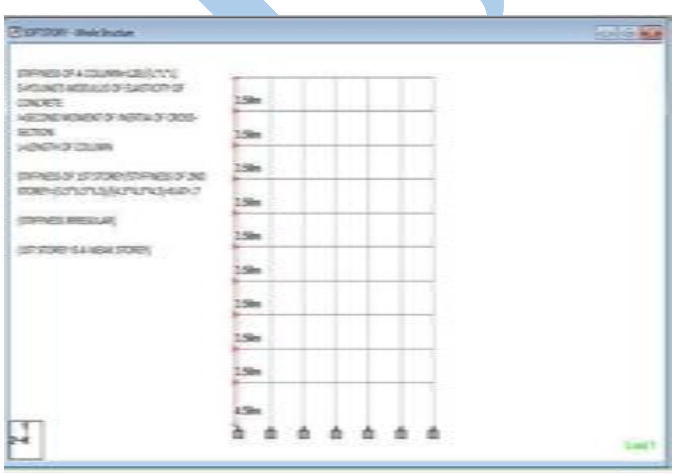

Fig.-Stiffness irregular structure (10 storeys)

Stiffness Irregular Structure (Soft Storey): The structure is same as that of regular structure but the ground storey has a height of 4.5 m and doesn‘t have brick infill.

Stiffness of each column= 12EI/L3

Therefore,

Stiffness of ground floor/stiffness of other floors=

(3.5/4.5)3 =0.47<0.7

Hence as per IS 1893 part 1 the structure is stiffness irregular.

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. Three types of ground motion with varying frequency content, i.e., low (imperial), intermediate (IS code),high (San Francisco) frequency were considered. Time history analysis (THA) was conducted for each type of irregularity corresponding to the above mentioned ground motions and 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 the result of RSA, the storey shear force was found to be maximum for the first storey and it decrease to a minimum in the top storey in all cases.
- According to the result of RSA, it was found that mass irregular building frames experience larger base shear than similar building frames.
- According to the result of RSM, the stiffness irregular building experienced lesser base shear and has larger inter storey drift.
- The absolute displacement obtained from time history analysis of geometry irregular building at respective nodes were found to be greater than that in case of regular building for upper stories but gradually as we move to lower stories displacements in both structures tended to converge. This is because in a geometry irregular structure upper stories have lower stiffness (due to L-shape) than the lower stories.
- Lower stiffness results in higher displacements of upper stories.
- In case of 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 done for regular as well as stiffness irregular building (soft storey), it was found that the displacement of upper stories did not very 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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