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A REVIEW OF DYNAMIC ANALYSIS OF VERTICALLY IRREGULAR RC BUILDING

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***Abstract*— This study summarizes state-of-the-art knowledge in the seismic response of vertically irregular building frames. Criteria defining vertical irregularity as per the current building codes have been discussed[1]. A review of studies on the seismic behaviour of vertically irregular structures along with their findings has been presented. It is observed that building codes provide criteria to classify the vertically irregular structures and suggest dynamic analysis to arrive at design lateral forces. Most of the studies agree on the increase in drift demand in the tower portion of set-back structures and on the increase in seismic demand for buildings with discontinuous distributions in mass, stiffness, and strength. The largest seismic demand is found for the combined-stiffness-and-strength irregularity.** [2]*

Keywords— Mass Irregularity, Set-back Structure, Stiffness Irregularity, Strength Irregularity, Vertical Irregularity

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.

Irregular buildings constitute a large portion of the modern urban infrastructure. The group of people involved in constructing the building facilities, including owner, architect, structural engineer, contractor and local authorities contribute to the overall planning, selection of structural system and to its configuration. This may lead to building structures with irregular distributions in their mass, stiffness and strength along the height of building. When such buildings are located in a high seismic zone, the structural engineer's role becomes more challenging. Therefore, the structural engineer needs to have a thorough understanding of the seismic response of irregular structures. In recent past, several studies have been carried out to evaluate the response of irregular buildings.

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:[1]
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.
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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.

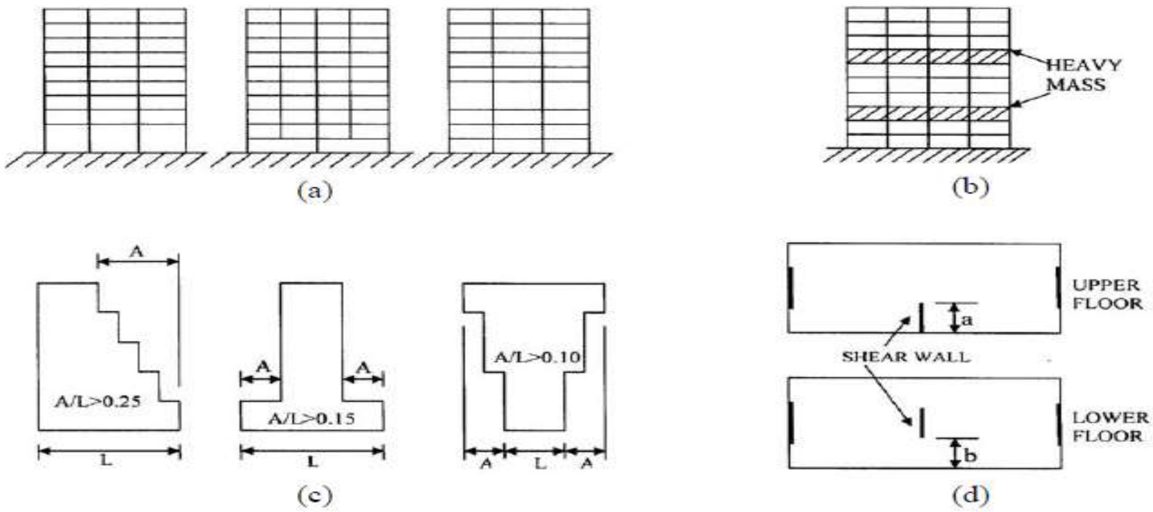

Figure [1](a) Stiffness/strength irregularity;
(b) Mass irregularity;
(c) Vertical geometric irregularity or set-back;
(d) In-plane discontinuity in lateral-force-resisting vertical elements when b > a: plan view (after BIS, 2002)

II. RESPONSE SPECTRUM ANALYSIS[3]

This approach permits the multiple modes of response of a building to be taken into account. This is required in many building codes for all except for very simple or very complex structures. The structural response can be defined as a combination of many modes. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response of the structure. In this the magnitude of forces in all directions is calculated and then effects on the building is observed. Following are the types of combination methods:

- absolute - peak values are added together
- square root of the sum of the squares (SRSS)
- complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The result of a RSM analysis from the response spectrum of a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, because information of the phase is lost in the process of generating the response spectrum.

In cases of structures with large irregularity, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static or dynamic analysis.

III. TIME HISTORY ANALYSIS[4]

Time history analysis techniques involve the stepwise solution in the time domain of the multidegree-of-freedom equations of motion which represent the actual response of a building. It is the most sophisticated analysis method available to a structural engineer. Its solution is a direct function of the earthquake ground motion selected as an input parameter for a specific building. This analysis technique is usually limited to checking the suitability of assumptions made during the design of important structures rather than a method of assigning lateral forces themselves.

The steps involved in time history analysis are as follows:

1. Calculation of Modal matrix
2. Calculation of effective force vector
3. Obtaining of Displacement response in normal coordinate

4. Obtaining of Displacement response in physical coordinate
5. Calculation of effective earthquake response forces at each storey.
6. Calculation of maximum response

IV. CONCLUSIONS

From the study of above research papers it can be concluded that,

- Time period and displacement is directly proportional to the height of the structure.
- There is no story drift at base of structure and it is maximum at first floor and minimum at top floor.
- Story displacement is found to be maximum at top floor and minimum at the base of structure.
- Tall structure has low natural frequency and short structure has high natural frequency. So, tall structures responses maximum at low frequency and short structure responses maximum at high frequency.
- Effect of strength irregularity is greater than effect of stiffness irregularity and the effect of combined stiffness and strength irregularity is the largest.

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