Study on Behaviour of Unsymmetrical Concrete Buildings under seismic load

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In the present paper study different irregularities in the Building is studied which may be due to mass, strength and stiffness along the height. When such buildings are constructed are constructed in high seismic zones, the analysis and design becomes more complicated. Non-linear time history dynamic analysis is performed on typical modular structure to access the seismic performance of the structures. The study revealed significant global seismic capacity as well as satisfactory performance at design intensity levels.

Keywords: Time History Analysis, Seismic responses, Multistoried buildings, Scaling

INTRODUCTION

The demand of high rise buildings increasing day by day for due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damages to those high rise structures. Since earthquake forces are random in nature and unpredictable, the engineering tools need to be sharpened for analyzing structures under the action of these forces. Earthquake loads are required to be carefully modeled so as to assess the real behavior of structure with a clear understanding that damage is expected.

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: causes different shaking intensities at different locations and the damage induced in buildings at these locations is also different. Thus, there is necessary to construct a structure which is earthquake resistance at a particular level of intensity of shaking a structure, and not so much the magnitude of an earthquake.

OBJECTIVES

1. To study three irregularities in structures namely mass, stiffness and vertical geometry irregularities.
2. To study the effect of vertical irregularity on the fundamental natural period of the building and its effect on performance of the structure during earthquake for different building models selected.
3. To calculate the response of buildings subjected to various types of 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

SCOPE OF THE STUDY

1. Only RC buildings are considered.
2. The vertical and other irregularity was studied.
3. Linear elastic analysis was done on the structures.
4. Column was modelled as fixed to the base.
5. The contribution of infill wall to the stiffness was not considered. Loading due to infill wall was taken into account

Types of Irregularities

According to IS 1893 (Part-1) :2016 Vertical irregularities are;

1. Stiffness Irregularity
2. Mass Irregularity
3. Vertical Geometry Irregularity
4. Strength Irregularities or weak storey

Stiffness Irregularities

A soft storey is a storey whose lateral stiffness is less than storey that of above.

Mass Irregularities

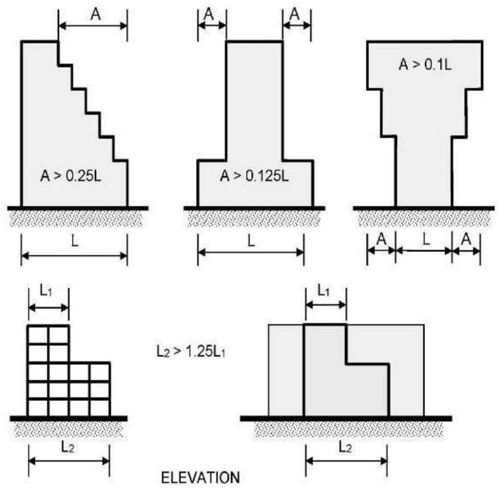
Mass irregularities shall be considered to exist, when the seismic weight of any of the floor is more than 150 percent of the floor below.

Vertical Geometry Irregularities

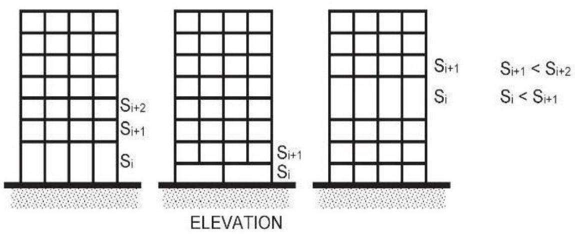
Vertical Geometry irregularities shall be considered when the horizontal dimension of the lateral force resisting system in any storey is more than 125 percent of the storey below.

Strength Irregularities (Weak Storey)

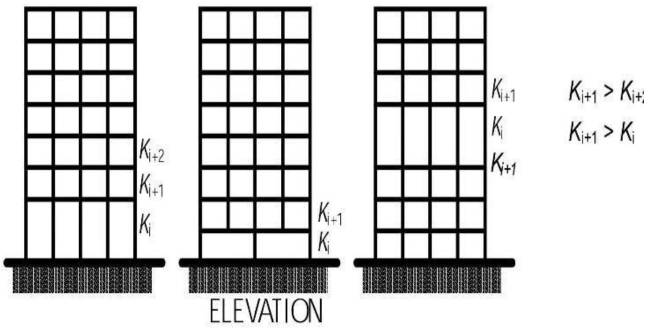
A weak storey is storey whose lateral strength is less than that of the storey above.



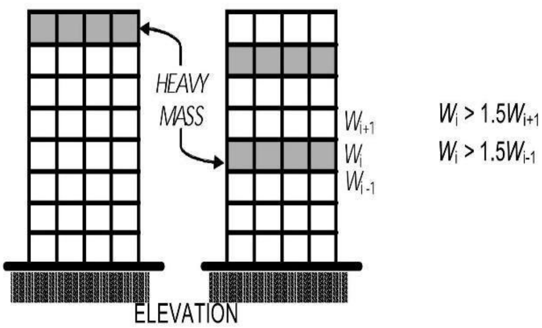
VERTICAL GEOMETRIC IRREGULARITY



STRENGTH IRREGULARITY (WEAK STOREY)



STIFFNESS IRREGULARITY (SOFT STOREY)



MASS IRREGULARITY

As per IS 1893, Part 1 Linear static analysis of structures can be used for regular structures of limited height as in this process lateral forces are calculated as per code based fundamental time period of the structure. Linear dynamic analysis are an improvement over linear static analysis, as this analysis produces the effect of the higher modes of vibration and the actual distribution of forces in the elastic range in a better way.

Buildings are designed as per Design based earthquake, but the actual forces acting on the structure is far more than that of DBE. So, in higher seismic zones Ductility based design approach is preferred as ductility of the structure narrows the gap. The primary objective in designing an earthquake resistant structure is to ensure that the building has enough ductility to withstand the earthquake forces, which it will be subjected to during an earthquake

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.

Time History Analysis:

Time history analysis techniques involve the stepwise solution in the time domain of the multi degree-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

ANLYTICAL MODEL

The analytical model of the structures was developed using the SAP2000 software. This

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

program is finite element software which is capable of conducting step by step non-linear time history analysis.

Natural Record of Earthquake Ground Motion

The various natural ground acceleration time histories have been used for the dynamic analysis of the structural models. All these acceleration data are collected from Strong Motion Database available in the website of COSMOS Strong Motion Data, (https://www.strongmotioncenter.org/). The main characteristics of the input motion used are summarized in Table below.

STRONG-MOTION VIRTUAL DATA CENTER (VDC)
Global Component of the Center for Engineering Strong Motion Data
Home · Login/Logoff · Download · AboutUs · Contact ·
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Bhuj/Kachchh 2001-01-26 03:16:40 UTC

Region: India
Latitude: 23.4200
Longitude: 70.2300
Depth: 16.0 km
Mechanism: Unknown
ML: 7.0
References

Jump within page to:
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Add all data on this page to the download bin

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Ahmedabad, India Hypocentral dist: 239.0 km
IITR station ahmd
Processing by: IITR
Data Available: corrected acceleration, velocity, displacement, & spectra
Summary Page for this Station Plot Acceleration
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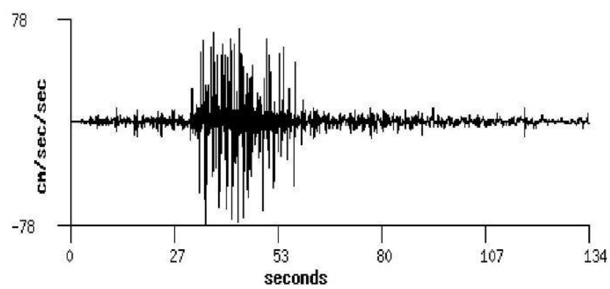
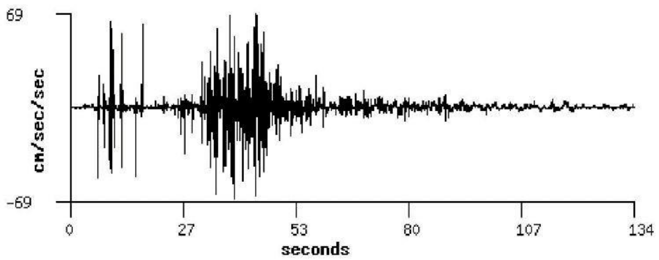
Add all of this station's data to the download bin Go to Bin

Component: 348	PGA (cm/s/s): 78.20	PGV (cm/s): -	Add this to bin
Component: 78	PGA (cm/s/s): -103.80	PGV (cm/s): -	Add this to bin
Component: Up	PGA (cm/s/s): 68.60	PGV (cm/s): -	Add this to bin

Component: 348



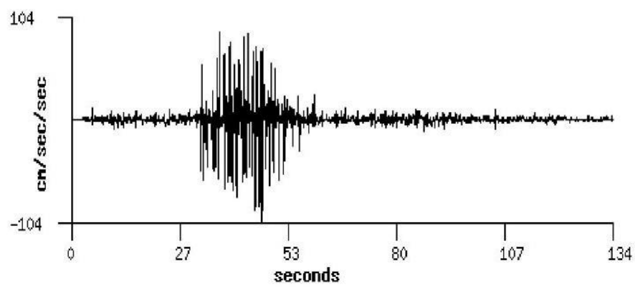
COSMOS: Data Plot Ahmedabad, India Bhuj/Kachchh



Ground Motion Characterization

The selection of ground motion record is very important for accurate analysis of building. It is difficult to determine a single parameter that best characterizes earthquake ground motion. The recorded of time histories, even at the same site, shows variations in information. Earthquake ground motion amplitude, duration, frequency and the number of peaks in the time history above certain amplitude are some of the characteristics important for determining structural response and damage. Ground motion amplitude is measured in terms of acceleration, velocity and displacement.

Component: 78



The frequency content of an earthquake time history is important in identifying the amount of energy imparted at different frequencies. The strong motion duration of an earthquake time history is the time interval during which most of the energy of that time history contained. Peak ground acceleration (PGA) has frequently been used as a parameter to characterize ground motion. Other parameters included Arias intensity, ratio of PGA to PGV.

CONCLUSION

1. The absolute displacements 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.

2. 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.

3. 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.

4. Tall structures have low natural frequency hence their response was found to be maximum in a low frequency earthquake.

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