IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 45-48

Seismic Analysis by Variances in Irregularities of R.C.C. Structure.

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Abstract— *In recent years the topic of seismic loads and analysis has become of increasing importance in all over the world. This is due largely to the frequency of large magnitude seismic events that have been witnessed, often in large metropolitan areas, typically resulting in tragic loss of life. As a direct result greater efforts have been made to understand and quantify loads that might be experienced during an earthquake. But now-a-days depending on the location's seismicity, its soil properties, the natural frequency of the structure, and its intended use, this method was refined to enable increasingly adequate designs. Buildings have longer periods of vibration and periods of vibration, composed largely of orthogonal, closely spaced modes. Hence, Equivalent static analysis method was adopted in order to design buildings and overcome effect of earthquake on it. In this study performed static analysis as per IS 1893-2002. To study the effect of irregular plan and shape configuration, i.e. study three irregularities in structures namely mass, stiffness and vertical geometry irregularities. And then 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. 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. In ETABS, the nonlinear time-history analysis can be carried out. 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.*
Keywords— *Equivalent static analysis, ETABS, Natural Frequency.*

I. Introduction

Failure of structure starts at points of weakness, During an earthquake. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having discontinuity are termed as irregular structures. Irregular structures contribute large portion of urban infrastructure. During earthquakes Vertical irregularities are one of the major reasons of failures of structures. For example structures with soft storey were the most notables structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really very important. Height-wise changes in mass and stiffness render the dynamic characteristics of these buildings different from the 'regular' building. IS 1893 definition of

Vertically Irregular structures:

The irregularity in the R.C.C building structures may be due to irregular distributions in their, stiffness, strength and mass along the height of building. When such R.C.C. buildings are constructed in high seismic zones, the analysis and design becomes more complicated nd difficult. 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 not greater than 70 percent of the storey above or not greater 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 not greater than 60 percent of that in the storey above or not greater than 70 percent of the average stiffness of the three storeys above.[5]

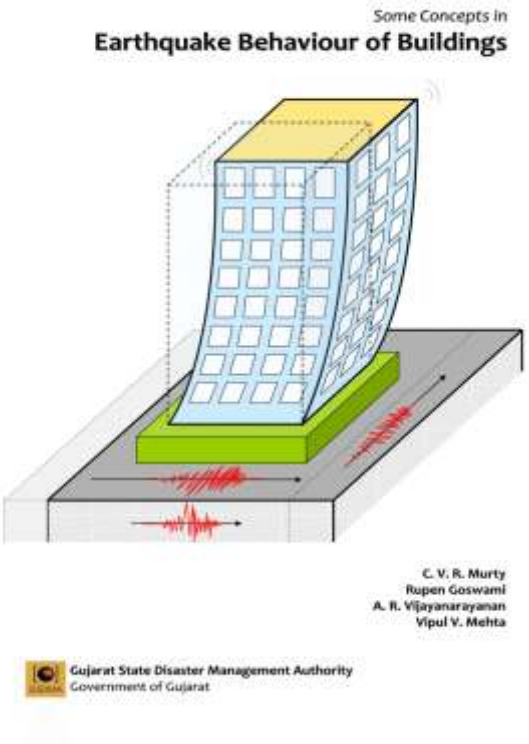
ii) Mass Irregularity-Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storeys. In case of roofs irregularity more need not be considered.

iii) Vertical Geometric Irregularity- A structure is considered to be irregular Vertical geometric 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 not less 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.

As per IS 1893, Part 1 Linear static analysis of structures is 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 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.



II. Methodology

If the structure is not properly designed and constructed with required quality they may cause large destruction of structures due to earthquakes. Time history analysis is an useful technique for seismic analysis of structure when the structure shows nonlinear response. This method is step by step analysis of the seismic responses of a structure to a specified loading that may change with time.

1. Review of existing literatures by different researchers. Extensive literature survey by referring books, technical papers carried out to understand basic concept of topic
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
6. Interpretation of result and conclusion. In the present work it is proposed to carry out seismic analysis of multistored RCC buildings using time history analysis method considering mass irregularity at different floor levels with the help of ETABS software.

- **Analysis Methods:**
- **Seismic Analysis:**

Seismic analysis 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. Equivalent Static Analysis

II. Response Spectrum Analysis

III. Time History Analysis

- **Response Spectrum Analysis:**

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 .[2] 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.

- **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

III. Literature Review

1] Arvindreddy and R.J.Fernandes (2015).

Reinforced concrete multi storey buildings are subjected to most dangerous earthquakes. It was found that main reason for failure of RC building is irregularity in its plan dimension and its lateral force resisting system. In this paper an analytical study is made to find response of different regular and irregular structures located in severe zone V. Analysis has been made by taking 15 storey building by static and dynamic methods using ETABS 2013 and IS code 1893-2002 (part1). Linear Equivalent Static analysis is performed for regular buildings up to 90m height in zone I and II, Dynamic Analysis should be performed for regular and irregular buildings in zone IV and V. Dynamic Analysis can take the form of a dynamic Time History Analysis or a linear Response Spectrum Analysis. Behaviour of structures will be found by comparing responses in the form of storey displacement for regular and irregular structures. Different type of analysis methods such as equivalent static method and response spectrum method are adopted in order to study the storey displacement. Pushover curve is obtained, the main objective to perform this analysis is to find displacement vs. base shear graph and also time history analysis will be carried out taking BHUJ earthquake. In this present work two types of structures considered are reinforced concrete regular and irregular 15 storey buildings and are analyzed by static and dynamic methods. For time history analysis past earthquake ground motion record is taken to study

response of all the structures. Presently there are six models. One is of regular structure and remaining are irregular structural models. [4].

2] Dhiman Basu and Sudhir Jain (2004)

Even though a rigid floor diaphragm is a good assumption for seismic analysis of most buildings, several building configurations may exhibit significant flexibility in floor diaphragm. However, the issue of static seismic analysis of such buildings for torsional provisions of codes has not been addressed in the literature. Besides, the concept of center of rigidity needs to be formulated for buildings with flexible floor diaphragms. In this paper, the defination of center of rigidity for rigid floor diaphragm buildings has been extended to unsymmetrical buildings with flexible floors. A superposition-based analysis procedure is proposed to implement code-specified torsional provisions for buildings with flexible floor diaphragms. The procedure suggested considers amplification of static eccentricity as well as accidental eccentricity. The proposed approach is applicable to orthogonal as well as nonorthogonal unsymmetrical buildings and accounts for all possible definitions of center of rigidity.[6]

3] Rajeeva and Tesfamariam (2012)

Fragility based seismic vulnerability of structures with consideration of soft -storey (SS) and quality of construction (CQ) was demonstrated on three, five, and nine storey RC building frames designed prior to 1970s.Probabilistic seismic demand model (PSDM) for those gravity load designed structures was developed, using non-linear finite element analysis, considering the interactions between SS and CQ. The response surface method is used to develop a predictive equation for PSDM parameters as a function of SS and CQ. Result of the analysis shows the sensitivity of the model parameter to the interaction of SS and CQ. [12]

IV. Conclusion

Many of the studies have shown seismic analysis of the RCC structures with different irregularities such as mass, stiffness irregularity and vertical geometry irregularity. Whenever a structure having different irregularity, it is necessary and very important to analyse the building or R.C.C buildings in various earthquake zones. From many past studies it is clear that effect of earthquake on different type of structure can be minimize by providing shear wall, base isolation etc.

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