Seismic Analysis of RC Framed Buildings with Different Irregularity

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Abstract*- Structural Analysis and design are predominant in finding out significant threats to integrity and stability of a structure. Multi storied structures, when designed are made to fulfill basic aspects and serviceability. To perform well in earthquake a building should possess four main attributes namely simple and regular configuration, adequate lateral strength, stiffness and ductility. This dissertation mainly deals with the comparative analysis of the results obtained from the analysis of a regular and irregular (as per IS-1893) multi storey building structure. The principle objective of this dissertation is the comparative study on analysis of multi-storied building by E-TABS software. In this dissertation we analyze the building for finding the shear forces, bending moments, deflections & reinforcement details for the structural components of building (such as Beams, columns & slabs). This analysis aims to the seismic response of various irregularity structures. The dissertation is done by Equivalent Static Analysis Method (ESAM) of RC Framed building. This study includes the modeling of regular and irregular building. The performance of this framed building during study earthquake motions depends on the distribution of stiffness, strength and mass in vertical and plan irregularities of the building. The seismic performance of multistory regular building is determined by Equivalent Static Analysis in E-TABS Software. Various seismic responses like base shear, frequency, node displacement, etc. are obtained.*

Keywords- regular-irregular configuration, plan irregularity, vertical irregularity, equivalent static analysis, seismic load.

I. INTRODUCTION

Earthquake or seismic analysis is a subset of structural analysis which involves the calculation of the response of a structure subjected to earthquake excitation. When earthquakes occur, the building undergoes dynamic motion because of the building is subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces are called as seismic loads. The ductility of a structure is the most important factors affecting its seismic performance and it has been clearly observed that the well designed and detailed reinforced structures behave well during earthquakes and the gap between the actual and design lateral force is narrowed down by providing ductility in the structure. 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. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. Height-wise changes in stiffness and mass render, the dynamic characteristics of these buildings different from the regular building. 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 become more complicated. The Present research focused on various techniques used to study the seismic demands of vertical irregular R.C. buildings with different seismic zones of India. Buildings serve quite a lot of needs primarily as a haven from the weather, living space, security, privacy, and are comfortable for living and also to work. Buildings can be classified as different types as residential and commercial.

NO.	TITLE OF RESEARCH PAPERS	CONTENTS
1	Seismic behavior of irregular reinforced-concrete structures under multiple earthquake excitations (Oct 2017)	This research paper studies on the recent Tohoku earthquake have reported collapse of structures due to multiple earthquake excitations in the earthquake affected region. Strength and stiffness degradation are shown to be the primary reason for the observed damage. The present study aims to investigate the degrading behavior of irregularly built reinforced concrete structures subjected to the Tohoku ground motion sequences.
2	Seismic Performance of existing R.C. framed buildzings (June 2015)	The earthquakes disasters basically occur due to buildings damage not because of the earth shaking. Therefore, the countries have been updated the seismic codes. The seismic loads for buildings design in Egyptian Code have been changed from (EC-1994) to (ECP-201, 2012). On the other hand, the need is raised to study the vulnerability of existing buildings, which can be divided into the buildings designed to resist the gravity loads only (GLD) and the buildings designed according to Egyptian code (EC-1994). To investigate the vulnerability of existing buildings, nonlinear static pushover analysis is conducted to evaluate the real strength of the existing buildings.
3	Seismic Response of building frames with vertical structural irregularities (Jan 1997)	In this paper, the mass, strength, and stiffness limits for regular buildings as specified by the UBC are evaluated. The structures studied are two-dimensional building frames with 5, 10, and 20 stories. Six fundamental periods are considered for each structure group. Irregularities are introduced by changing the properties of one story or floor. Floor-mass ratios ranging from 0.1 to 5.0 are considered, and first-story stiffness and strength ratios varying from 1.0 to 5.0 are included.
4	Seismic behavior of multistory RC building frames with vertical setback irregularity (Oct 2013)	This paper is the second of two companion papers that aimed to examine the behavior of irregular buildings subjected to seismic excitation. In the present study, seismic response of the building frames with setback irregularity has been determined. To achieve this purpose, building frames with different geometrical configurations of setbacks are modeled and analyzed using nonlinear dynamic analysis by subjecting them to an ensemble of 27 ground motions to generate 21060 nonlinear dynamic analysis results. These results are compiled to create a seismic response database consisting of parameters such as maximum roof displacement, maximum inter story drift ratio, maximum plastic hinge rotation and collapse risk parameters.
5	Least Favorable Probability of Failure for 5- and 10-story RC Frame Structures with Vertical Irregularities (Feb 2015)	This article evaluates the seismic control effect of vertical irregularity factors for RC frame structures using the Monte Carlo simulation method. Typical 5- and 10-story frame structures with different irregularities of strength or stiffness are assessed. The upper- and lower-bound probabilities of failure exceeding the limit state are studied. The results indicate that the exceeding probability increases as the vertical irregularity factor decreases. The upper-bound probability of failure, which is sensitive to the vertical irregularities and is an effective indicator for evaluating the performance control parameter, is significantly larger compared with the lower-bound probability of failure.

II. METHODS OF ANALYSIS

There are different types of earthquake analysis methods are adopted for Analysis & Design of RC framed building:

1. Equivalent Static Analysis
2. Response Spectrum Analysis
3. Time History Analysis
4. Ductility Based Analysis

2.1 Equivalent Static Analysis Method:

The response of a structure to earthquake-induced forces is a dynamic phenomenon. Consequently, a realistic assessment of the design forces can be obtained only through a dynamic analysis of the building models. Although this has long been recognized, dynamic analysis is used only in frequently in routine design, because such an analysis is both complicated and time-consuming. In the equivalent static analysis method, the response of the building is assumed as linear elastic manner. To calculate equivalent linear static, the IS 1893 (Part I): 2002 has given a formula as below.

Determination of base shear (VB) of the building
VB = A h W

The equivalent static analysis procedure is essentially an elastic design technique. It is, however, simple to apply than the multi-model response method, with the absolute simplifying assumptions being arguably more consistent with other assumptions absolute elsewhere in the design procedure.

The equivalent static analysis procedure consists of the following steps:

1. Estimate the first mode response period of the building from the design response spectra.
2. Use the specific design response spectra to determine that the lateral base shear of the complete building is consistent with the level of post-elastic (ductility) response assumed.
3. Distribute the base shear between the various lumped mass levels usually based on an inverted triangular shear distribution of 90% of the base shear commonly, with 10% of the base shear being imposed at the top level to allow for higher mode effects.

III. STRUCTURAL PROPERTIES AND DATA

3.1 Structural Properties of RC Framed Buildings:

Number of stories	G+9, G+11, G+14
Floor to floor height	3m
Basement height	3.5m
Size of column	0.40X0.40m
Size of beam	0.35X0.40m
Earthquake load	As per IS - 1893:2016
Slab thickness	0.200M
Live load including floor finish	4 KN/M2
Floor finishes	as per IS: part-I
Seismic zones	Zone III
Type of soil taken	Hardy rocky

3.2 Material Properties:

No.	Design Parameter	Value
1	Unit Weight of Concrete	25 kN/m^3
2	Unit Weight of Masonry	20 kN/m^3
3	Characteristic Strength of Concrete	415MPa
4	Damping Ratio	5%
5	Modulus of Elasticity of Steel	2E5 MPa

IV. CONCLUSION

- Minimum Displacement is occurring on I-Shape building.
- Maximum Story Displacement is occurring on L-Shape building compare to C and I Shape irregular buildings.
- Maximum Story Drift is occurring on L-Shape building.
- Results show that irregular shape buildings undergoes more deformation compare to regular shape building.
- Minimum Story Overturning Moment is occurred on C-Shape building.
- But in irregular shape, I and C–Shape buildings are good for future construction compare to L-Shape building.

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