Study on Seismic Induced Torsion of a Multi-Storied Building with Different Irregularities with & without Base Isolation System

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Abstract— The rapid expansion of the urban population and consequential demand on limited space has significantly increased the construction of multi-storey buildings. Therefore, the principle objective of the Structural Engineer is to design and construct the structure by taking in to consideration, the dynamic actions caused on the building, in terms of earthquake forces, in such a way, that the damage caused to the structure due to these dynamic actions are minimized. The paper aims at evaluating the seismic actions by considering various CODAL provisions, which are particularly provided for the analysis of RC building with unsymmetrical configuration and with different types of irregularities. The analysis is carried out on a model of G+49 stories of RC framed structure with unsymmetrical floor plan located in Zone IV, soil type III, using finite element based ETABS (V 13.1) software. The various structural response parameters such as, storey displacement, storey drift, base shear and storey stiffness are determined by considering different irregularities such as mass irregularity, vertical geometric irregularity, re-entrant corner, diaphragm discontinuity and stiffness irregularity in the model and the structural parameters stated above are compared for the models having different irregularities. Seismic analysis is carried out using response spectrum method for both symmetrical and unsymmetrical building. The extensive literature survey is carried out by referring to the technical journal papers, books, articles, etc. to familiarize with fundamental concept of the topic. The need for research is identified and the procedure to carry out the analysis is formulated. The data required for the input is collected from IS code 1893 (Part I):2002. Then the analytical work is carried out as per the procedure formulated and the results are obtained and varied conclusions are arrived at. The major part of the study includes the comparison of values of set of response parameters such as, mode period, storey lateral displacement, storey drift, base shear and the storey stiffness.

Key words: Multi-Storey Building, Unsymmetrical Configuration, ETABS V, Seismic Performance, Structural Response Parameters

I. INTRODUCTION

The effect of dynamic actions on the buildings on account of earthquake forces (lateral forces) are very much important from the structural engineers view point. The unique philosophy of structural design uses force as the basis for design. In the earthquake design, the building is subjected to a random ground motion or vibration at its base, which causes inertia forces in the building that in turn induce stresses; this is referred to as the displacement type loading also expressed as load-deformation curve of the building or a structure.

The four important virtues of buildings or structure that architects and the design engineers should look into in order to create an earthquake - resistant building design, are namely, structural configuration, lateral stiffness, lateral strength and ductility. These aspects can be followed by the building design codes. But, the seismic structural configuration can be taken care of by adopting the following architectural features or characteristics that result in improved structural behaviour during shocks.

II. OBJECTIVES

The present study aim to understand the importance of codal provisions, provided for irregular RC structures.

1) Analysis of 15 storied RC framed structure with different irregularities under seismic loads. Irregularities considered are Re-entrant corner, mass irregularity, vertical geometric irregularity and stiffness irregularity.
2) All the above mentioned structures are modelled separately with a fixed base and with base isolation system.
3) Study the effect of seismic response parameters such as storey lateral displacement, base shear, storey stiffness and mode period.

III. LITERATURE REVIEW

Sanjay Kumar Sadhu and Dr. Umesh Pendharkar studied the effect of Aspect Ratio and plan configurations on seismic performance of multi-storeyed regular R.C.C. buildings. They found that Seismic parameters increase with number of bays and number of storeys. Also Square configuration (horizontal aspect ratio=1) gives better performance and Vertical aspect ratio should be kept less than 4.

M Anvesh, Shaikh and Pavan Kumar studied the Effect of mass irregularity on RCC framed structure (G+10). They observed that size of structural members increase in mass irregular structure thus consuming more steel.

Ankesh Sharma and Biswobhanu Bhadra carried out Seismic analysis of vertically irregular RCC frames (G+10) They observed an increase in Base shear for mass irregular structure, large inter-storey drift in stiffness irregular structure And also large displacement in geometric irregular structure.

Dileshwar Rana, Prof. Juned Raheem studied seismic analysis of regular & vertical geometric irregular RCC framed building. They concluded that 4 bay frames is appropriate for lower building height and for higher stories, 8 bay frames is suitable. Seismic performance improves with number of bays.

Shaikh Abdul Aijaj, Abdul Rahman and Girish Deshmukh PERFORMED a study on seismic response of vertically irregular RC frame with stiffness irregularity at fourth floor: they found large displacements.

IV. METHODOLOGY

In the present work, the response spectrum method of analysis is made use of, as these method is aplicable for the structeurs whose modes other than the funda mental one affect the response of the structure. Here, each response of the multi - degree of freedom (MDOF) system is super posed on the modal response and each modal response is found from the spectral analysis of single degree of freedom (SDOF) system, which are later on, combined to compute the total response. The peak seismic response parameters such as, lateral displacement, storey stiffness, mode period and base shear are combined as per Complete Quadratic Combination (CQC) method

V. STRUCTURAL MODELING

In this study, 4 types of building configurations have been considered: Mass irregularity, Re-entrant corner irregularity, Vertical geometric irregularity, Stiffness irregularity.

Structure type	R.C.C (SMRF)	No. of stories	50
Plan dimension	25 x 25 m	Height of the building (m)	150
Height of the structural frame	G+1 4= 15 stories (45m)	Storey Height (m)	3

Table 1: Details of Base Model

Section Properties	
Column size	800 * 800 mm
Beam size	300 * 450 mm
Slab thickness	150 mm
Wall thickness	200 mm
Loading Properties	
Live load	2 kN/m^2
SDL	2 kN/m^2
Specific weight of RCC	25 kN/m^2

Table 2: Section and Loading Properties of model

VI. RESULTS AND DISCUSSIONS

A. *Comparison of structures with fixed base and LRB*

1) The mode period is greater for the structure with Lead rubber bearing system, compared with the fixed base regular structure.
2) The storey displacement is less in the case of a regular structure with LRB, compared to the structure with fixed base. Also the displacement is higher in Zone IV due to higher seismic prone area, compared to Zone III. For a structure with LRB, the displacement values are observed to be lesser compared to fixed base structure for both the zones.
3) The base shear is slightly higher for the structure with LRB, compared to fixed base structure in both the zones. But the base shear values are very high for the structure located in zone IV, compared to zone III.

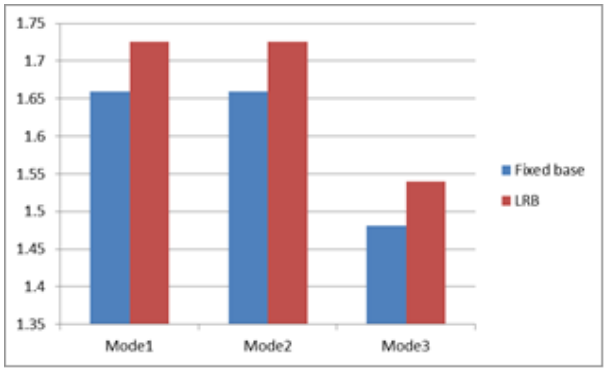
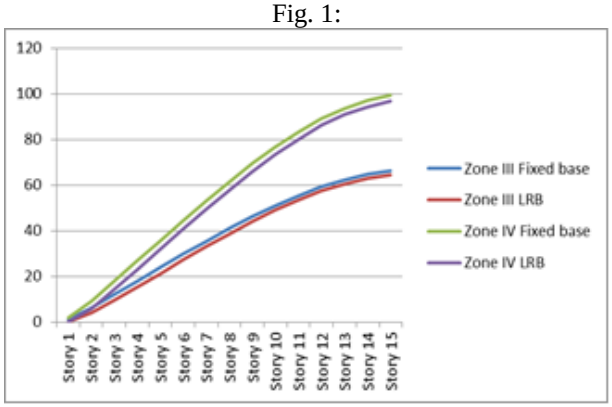


Fig. 1:



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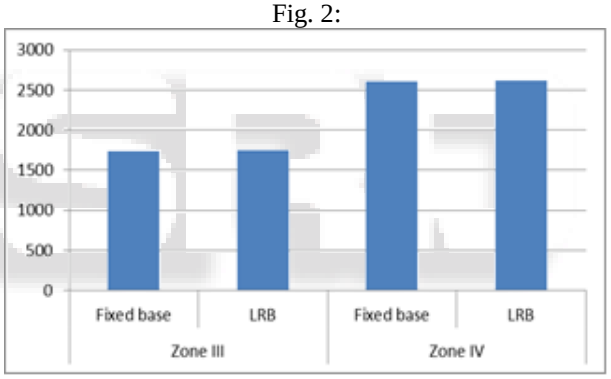

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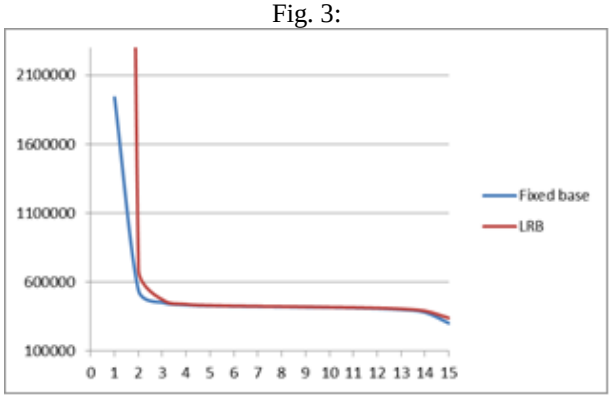
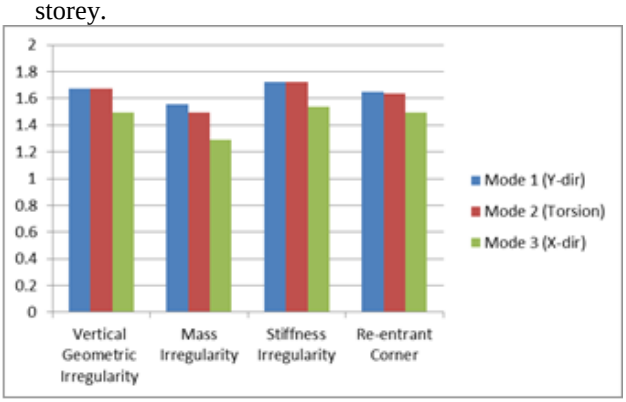


Fig. 4:

B. *Comparison of Irregular Structures*

1) The mode period is high for the stiffness irregular structure. This increase in period is due to the reduction in the stiffness of the structure.
2) The storey displacement is higher for vertical irregularity structure and re-entrant corner structure. This increase in displacement is due to change in the geometry of the structure which results in reduction in the stiffness.

3) The base shear is greater for mass irregular structure, due to increase in mass in 8th and 9th storeys, resulting in greater inertial forces.
4) The storey stiffness is decreased for re-entrant corner structure due to change in the geometry of the structure, as it is made L-shape. Also in the vertical irregular structure, the stiffness starts reducing from 11th storey since it is made vertically irregular from 121th to 15th storey.



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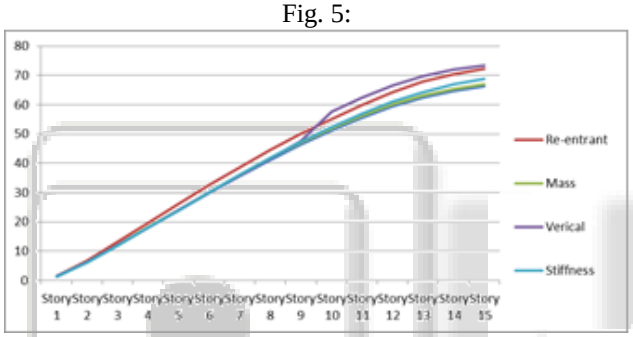

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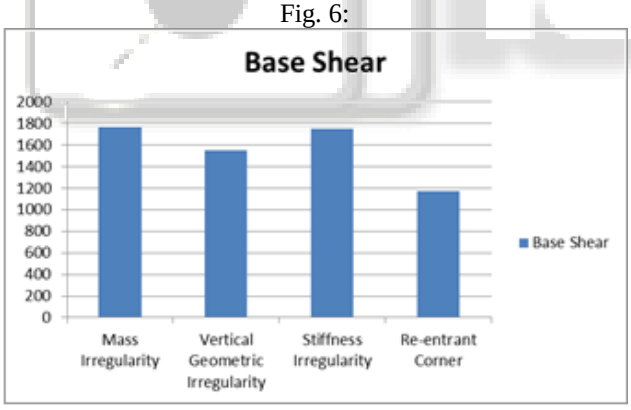

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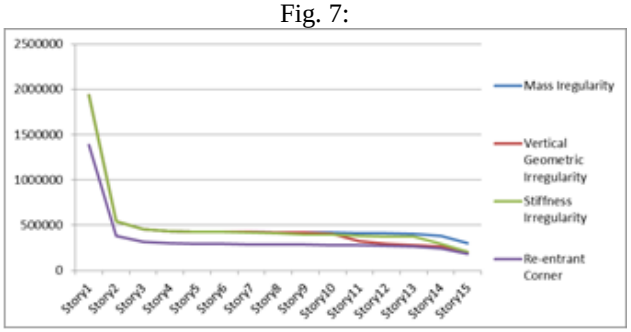

Fig. 8:

VII. CONCLUSIONS

From the seismic analysis carried out, the mode period of the Lead rubber bearing system is greater compared to the structure with fixed base for all the 6 models considered? The base isolation reduces the natural frequency of the structure, that is, on the other hand increases the period of the structure, thereby it shifts the structure in the spectrum from the peak platau region to the lower levels. Also due to the increase in mode period, the structure will dissipate more energy, thereby reducing the seismic responses. The storey displacement is found to be higher for the structure with a fixed base for all the 6 types of the models. The structure located in zone IV show a higher increase in displacement compared to zone III structures for all the models. Since the superstructure and the base is decoupled with the incorporation of a lead rubber bearing system, the mode period of the structure will be on its higher end so that the responses of the structure can be reduced. Also the isolation system offers additional damping at the base level of the structure, hence reducing the displacements at the storey level. The LRB system introduces flexibility to the structure at its supports, and hence the period and other seismic reponse parameters will be reduced. Also from the seismic analysis of all the irregular structures, the vertical geometric irregular and re-entrant corner structures are the most affected during earthquake actions, since the stiffness degradation takes place and hence when these type of the structures are to be constructed on demand, then they should be provided with a relevant base isolation system also with a damping system.

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