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Seismic Analysis of a High-rise RC Framed Structure with Irregularities

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Abstract - *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.**

1. 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 behavior during shocks.

2. OBJECTIVES*:*

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

1. Analysis of 50 storied RC framed structure with different irregularities under seismic conditions. Irregularities considered are Re-entrant corner, mass irregularity, vertical geometric irregularity, diaphragm irregularity and stiffness irregularity.

2. Study the effect of seismic responses such as the storey lateral displacement, storey drift, storey shear, storey stiffness and mode period in zone IV.

4) To propose the best suitable building plan configuration in the existing condition.

3. 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.

4. METHODOLOGY

To study the effect of earthquake on a high-rise RC framed structure by considering different irregularities in earthquake seismic zone IV as per IS code 1893 (Part I):2002.

Following steps of methods of analysis are adopted in this study:
Step-1: Selection of the structures with different irregularities.
Step-2: Selection of seismic zone (IV).
Step-3: Formation of load combinations.
Step-4: Modelling of building frames using ETABS-V software.
Step-5: Equivalent static Analysis of all the models.
Step-6: Comparative study of results (seismic parameters) in terms of Storey lateral displacement and storey drift, Base shear, Storey stiffness, Mode Period.

5. STRUCTURAL MODELING:

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

Table 1: Details of Base Model

No. of stories	50
Height of the building (m)	150
Storey Height (m)	3
Plan Dimension (m)	50 * 50
Vertical aspect ratio	3
Horizontal aspect ratio	1
Bay width (m)	6
Beam dimension (mm)	300 * 450
Column dimension (mm)	800 * 800
Earthquake zone	IV
Type of Analysis	Equivalent static lateral force
Soil type	III (IS:1893-2002)
Zone factor	0.24 (Clause 6.4.2 of IS:1893-2002)
Importance factor	1 (Table 6, Clause 6.4.2 of IS: 1893-2002)
Response reduction factor	5 (SMRF) (Table 7 of IS:1893-2002)

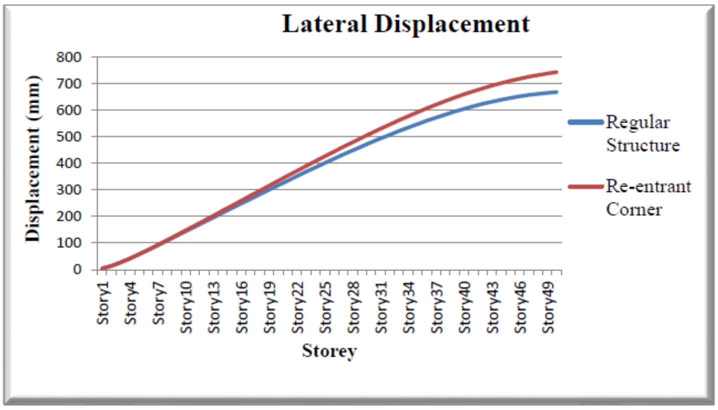
Table 2: Section and Loading Properties of model

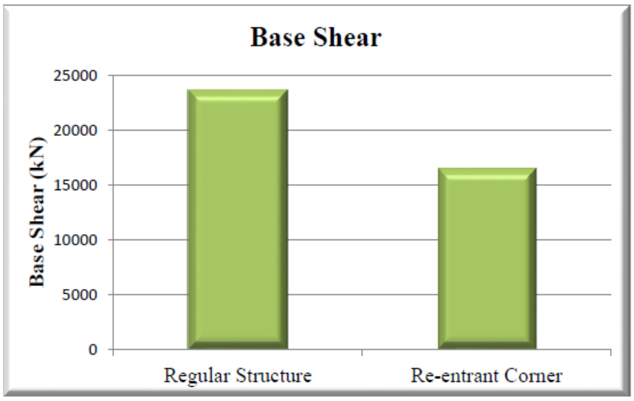
Section Properties	
Column size	800 * 800 mm
Beam size	300 * 450 mm
Slab thickness	150 mm
Wall thickness	200 mm
Loading Properties	
Live load	2 kN/m^2
SDL	2 kN/m^2
Specific weight of RCC	25 N/m^2

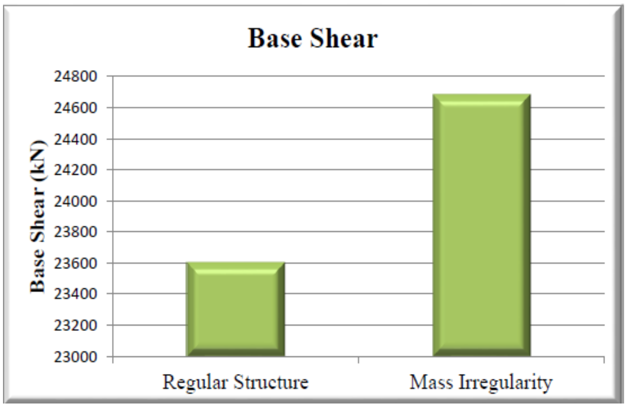
6. RESULTS AND DISCUSSIONS:

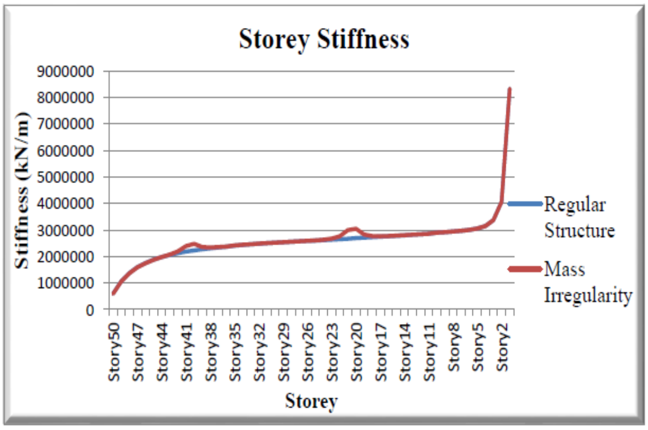
6.1. Comparison of irregular structures with respect to regular structure:

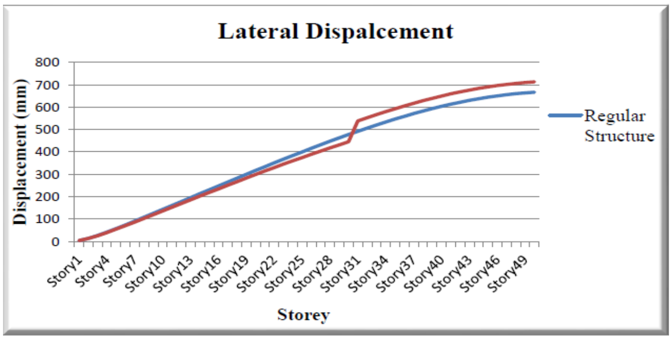
1. The mode period is found very high for stiffness irregular and is less for diaphragm discontinuity compared to that of the regular structure. This is because of the reduction in stiffness (k) of the irregular structure.
$T = 2\pi \sqrt{m/k}$
2. The lateral displacement is found very high for re-entrant corner structure compared to regular structure. This is due to change in geometry of the structure and also due to decrease in stiffness of the structure.
3. Storey drift is very high for irregular structures compared to regular structure.
4. Base shear (VB) is found high for mass irregular structure, but is found less for vertical geometric irregular, diaphragm discontinuity structure. This is due to increase in seismic mass (3.23%) of mass irregular structure (VB = A * W)
5. Storey stiffness is found high for regular structure compared to irregular structures which is due to reduction in stiffness of irregular structures.

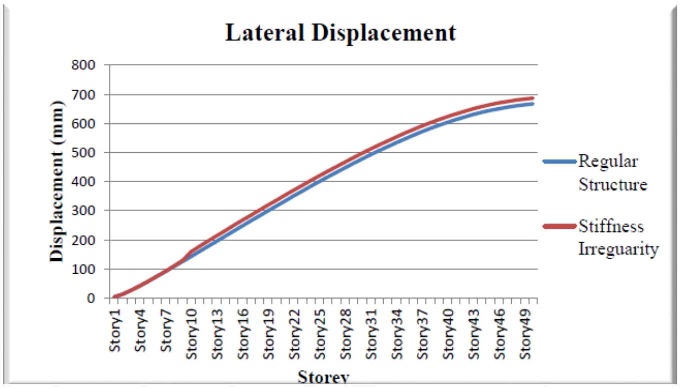












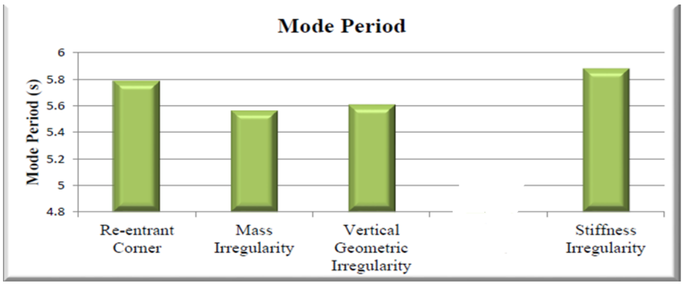
6.2 Comparison of irregular structures:

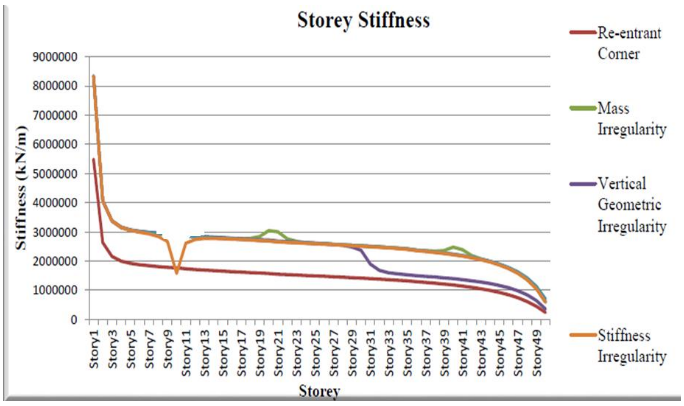
1. The mode period is found more for stiffness irregular structure, compared to other irregular structures (mass irregular, re-entrant corner, vertical geometric irregular,

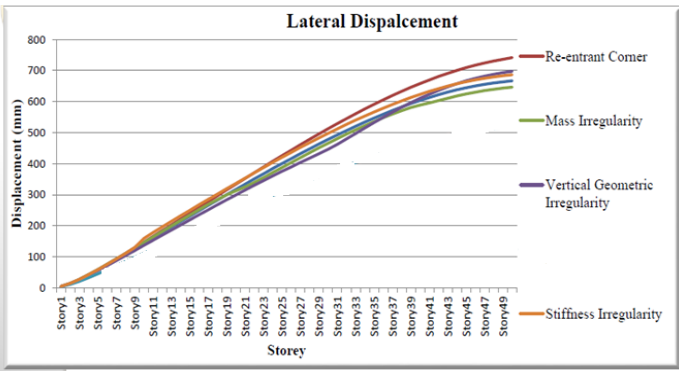
diaphragm discontinuity) because of reduced stiffness of stiffness irregular structure, as the height of storey is increased and also due to increase in mode period.

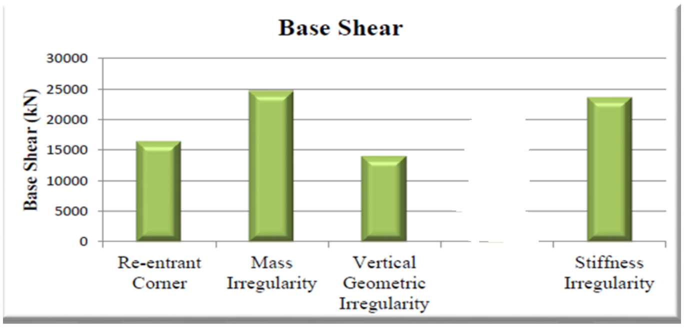
2. The storey lateral displacement is found very high for re-entrant corner structure compared to other irregular structures (mass irregular, re-entrant corner, vertical geometric irregular structure). This is due to change in geometry of the structure and the inertial forces are more and hence displacement is more.

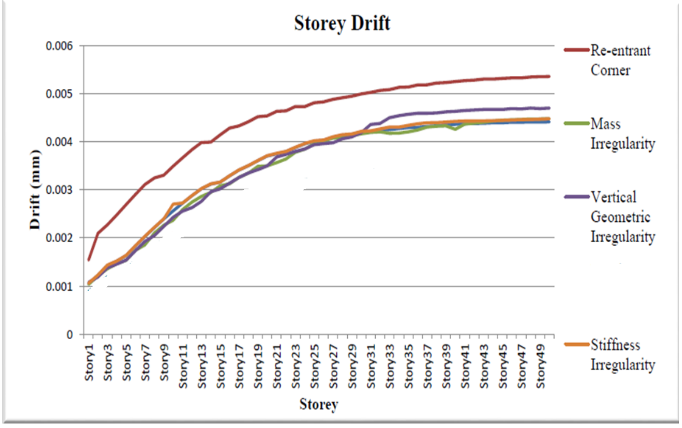
3. The storey drift is very high for re-entrant corner structure compared to other irregular structures (mass irregular, re-entrant corner, vertical geometric irregular structure). This is due to change in geometry of the structure, leading to reduction in stiffness and the inertial forces are more due to increased mode period.











4. The base shear is found very high for mass irregular structure compared to other irregular structures (mass irregular, re-entrant corner, vertical geometric irregular structure). This increase in base shear is due to increase in seismic mass of the structure and also increase in mode period and inertial forces of the structure.

5. The storey stiffness is found very low for re-entrant corner structure compared to other irregular structures (mass irregular, re-entrant corner, vertical geometric irregular structure). This decrease in stiffness is due to change in geometry (L-shape) of the structure, increased mode period and inertial forces of the structure.

7. CONCLUSIONS:

From the above conclusions it is clear that the regular structure with RC moment resisting frame and with masonry walls, perform better under the action of seismic load, compared to irregular structure. The irregular structures, especially the re-entrant corner structure shows the worst performance when subjected to seismic excitation compared to other type of irregular structures compared to other irregular structures (mass irregular, mass irregular, vertical geometric irregular structures).

The lateral displacement is increased in case of vertical irregular structure, re-entrant corner structure and stiffness irregular structure, from the storey where the irregularity is introduced.

The stiffness of the structure is reduced in vertical irregular, re-entrant corner and stiffness irregular structure.

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