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Study of seismic responses of multi-storied RCC building with mass irregularity & column stiffness variation

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Abstract:

From past earthquakes it is proved that many of structure are totally or partially damaged due to earthquake. So, it is necessary to determine seismic responses of such buildings. There are different techniques of analysis of structure. This paper is concerned with the effects of various Mass and column stiffness Irregularity on the seismic response of a structure. The objective of the project is to carry out Response spectrum analysis (RSA) of vertically Mass and column stiffness Irregular RC building frames. Comparison of the results of analysis of irregular structures with regular structure will be done. Comparision of mass irregular buildings having different column stiffness will also be done. The scope of the project also includes the evaluation of response of structures for axial force, base shear, time period, bending moments, storey drift and storey displacement.

Keywords — **Seismic Analysis, response spectrum analysis, Base Shear, Drift, Displacement, ETABS, Mass irregularity.**

I. INTRODUCTION

Earthquake forces are the ocassional forces that may or may not occure on the structure but when they occure, causes serious impact on structure, which may lead to collapse of structure. hence in case of multistoried structure, it becomes mendatory to consider response of the structure for earthquakes. As per indian seismic code IS 1893-2002, there are five seismic zones having different potential for shaking intensity. During earthquake, failure starts at the point of weakness. This weakness may arises due to discontinuity of mass,stiffness & geometry of the structure. Structure with discontinuity is termed as irregular structure & vertical irregularities are one among the many major reasons of failure of the structure during earthquakes. vertical irregular structures are the structures having irregular distribution of mass, strength & stiffness along the height of building. The 2002 version of insian seismic code clearly defines the irregular structure. structures due to the irregular distributions in their masses, strength and stiffness along the height of structure. When such buildings are to be constructed in high seismic zones, the analysis & design becomes more complicated. Basically there are two types of irregularities-

1. Plan Irregularities 2. Vertical Irregularities.

Vertical irregularities are mainly of three types, i.e, Stiffness irregularity, Mass irregularity & vertical geometric irregularity.

i) Stiffness Irregularity - Soft Storey-A soft storey is one in which the lateral stiffness is less than 70 percent of the storey above or less than 80 percent of the average lateral stiffness of the three storeys above.

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 need not be considered.

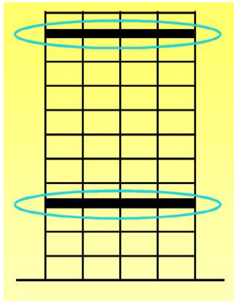

Fig -1 : Mass irregular structure.

iii) Vertical Geometric Irregularity- A structure is considered to be Vertical geometric irregular when the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey.

B) Response spectrum analysis:

Response spectrum method is a procedure for computing the statistical maximum response of a structure to a base excitation. The functions are defined to describe how the load varies as a function of period, time or frequency. Each of the vibration modes that are considered may be assumed to respond independently as a single degree of freedom system. Design codes specify response spectra which determine the base acceleration applied to each mode according to its period. Having determined the response of each vibration mode to the excitation it is necessary to obtain the response of structure by combining the effect of each vibration mode because the maximum response of each mode will not be necessarily occur at the same instant.

Undamped free vibration analysis of entire building shall be performed using appropriate masses and elastic stiffness of the structural system to obtained natural period and mode shapes of those of its mode of vibration. The modes to be considered in the analysis should be such that the sum total of masses of all modes considered is at least 90% of total seismic weight.

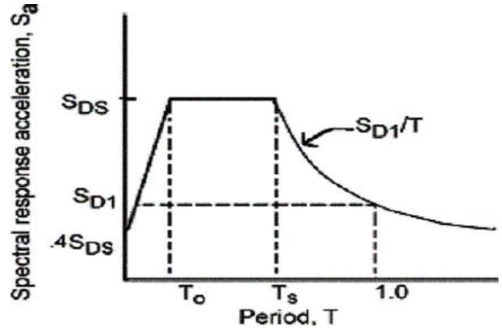

Fig -2 : Response Spectrum Analysis

For caring out response spectra analysis the building is may be considered as system of masses lumped at floor level with each mass having one degree of freedom.

C) Scope and Objectives

The primary objective of this work is to study the seismic response of multistoried RC framed building by Response spectrum analysis (RSA) Using ETABS software.

Scope of the work also include:

1.To analyze a multistoried RC framed building with mass irregularity & subjected to column stiffness variation.

2.To compare behaviour of multistoried RC framed building with same mass irregularity for different column stiffnesss in terms of various responses such as lateral displacements, base shear, and drift.

3.To compare behaviour of multistoried RC framed building with different mass irregularity for same column stiffnesss in terms of various responses such as lateral displacements, base shear, and drift.

II. LITERATURE STUDY

This section summarizes the work done by various authors in the field of Seismic analysis & irregularity as part of the literature survey.

Mayuri D. Bhagwat et al: In this study, dynamic analysis of G+12 multi-storied RCC building is done considering Koyna and Bhuj earthquake. Time history analysis and response spectrum analysis and seismic responses of such building are comparatively studied and modeled with the help of ETABS analysis package. Two time histories (i.e. Koyna and Bhuj) are used to fine response of the structure (base shear, storey displacement, storey drifts).

Himanshu Bansal et al : In this research, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases. It is found that mass irregular building frames experience larger base shear than that of similar regular building frames. The stiffness irregular building experienced lesser base shear and has larger inter storey drifts than regular frame. In case of mass irregular structure, Time History Analysis yields slightly higher displacements for upper stories than that in regular building, as we move down, lower stories showed higher displacements as compared to displacements in regular structures. In regular and stiffness irregular building, 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 stories were higher as compared to similar stories in regular buildings.

A. B. M. Saiful Islam et al: In this research study, analyses results shows that isolation system effectively reduce earthquake induced load on building. Method of analysis has been found to have considerable effect on the response of low to medium rise buildings. Time history analysis shows significant less base shear than that of response spectrum analysis. Also, less isolator displacement is obtained from time history analysis(THA) than that from the response spectrum analysis(RSA). Considering isolator displacement and base shear, HDRB is found to be better of the two types of isolators adopted in this study. Nevertheless, LRB is proved to be more effective in reducing individual floor acceleration and hence reducing the non structural damages.

III. METHODOLOGY

Mass irregularity is introduced to the structure by swimming pool & water tank at top whereas, only gravity loads at slab level is taken into account for analysis. Water tank and swimming pool are to be filled with equal volume of water. Methodology of the work includes,

1.Literature survey by referring books, research papers carried out to understand basic concept of topic.

2.Identification of need of research.

3.Formulation problem statement.

3.Selection of plan for study.

4.Analytical work of modelling is to be carried out using software.

5.Analysis of the various models by using ETABS analysis package.

6.Interpretation of results & conclusion.

Analysis will be done for 2 cases. Case 1 models are with columns 230mm width while case 2 models are with columns 300mm width. Different models are prepared for case 1 & 2 on ETABS are described as follows:

M11,M21: Regular frame.

M12,M22: Swimming pool at 5th slab

M13,M23: Swimming pool at 10th slab

M14,M24: Swimming pool at 15th slab

M14,M24: Swimming pool at 20th slab

M16,M26: Water tank at a location on terrace

Models M11 to M16 belongs to case 1 while model no. M21 to M26 belongs to case 2.

A) PROBLEM STATEMENT

A 20 storied residential building situated in zone V will selected for the analysis.. The building has a mass irregularity in plan due to a swimming pool situated at various intermediate floors & water tank at different locations on terrace of building. Along with mass variation, changes in column stiffness is introduced by changing column size. The building is modeled as a bare frame ignoring stiffness contribution of infill walls. The main aim is to evaluate the response building using response spectrum method. The analysis of the building is carried out by ETABS analysis package. The beams and columns are modeled as two nodded line element having six degrees of freedom at each node. Because it is lateral load analysis, slab is modeled as a membrane element having three degrees of freedom at each node. The swimming pool is modeled with hydrostatic load as a part of dead load.

B) Geometrical Paremeters of the structure:

Name of parameter	**Value**
Number of stories	20
Height of Building	60 meters
Floor to floor height	3 meter
Length in long direction	29.4 meter
Length in short direction	20.2 meter
Size of the columns for case I	230X1000 mm
Size of the columns for case II	300X1000 mm
Size of the beams	230X450 mm
Thickness of internal wall	0.15 meter
Thickness of external wall	0.23 meter
Live load on slab	2 Kn/square meter
Floor finish load	1.5 Kn/square meter
Grade of concrete	M30
Density of concrete	25 Kn/cubic meter
Unit weight of water	9.81 Kn/ cubic meter
Damping	5%
Seismic Zone	V
Importance factor (I)	1
Responded reduction factor	5
Soil type	Medium soil
Time period (X)	0.996 sec
Time period (Y)	1.202 sec

C) Modelling and analysis:

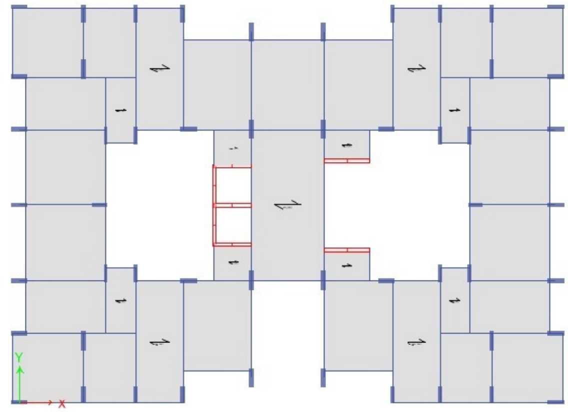

Fig -5 : Location at which swimming pool is located.

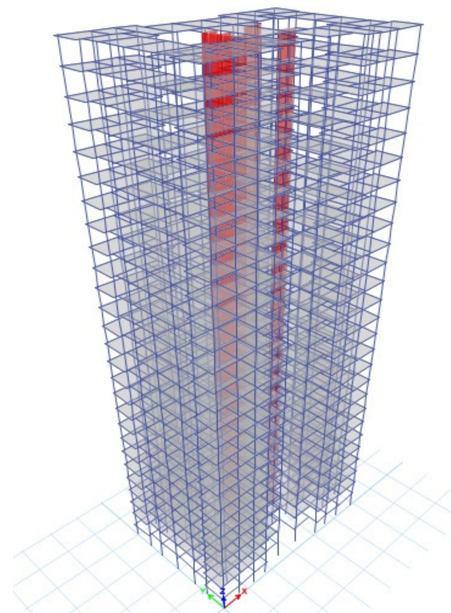

Fig -4 : 3D view of building.

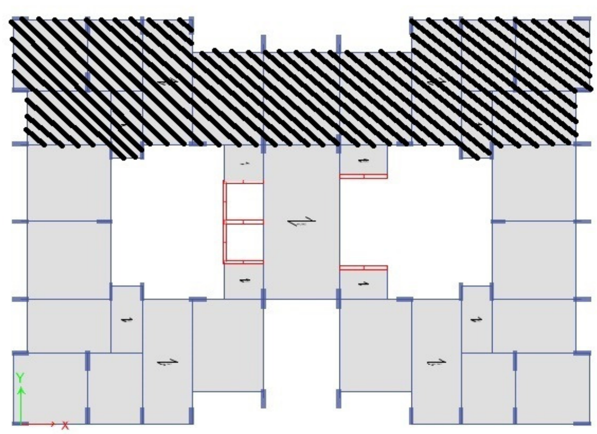

Fig -5 : Location at which swimming pool is located.

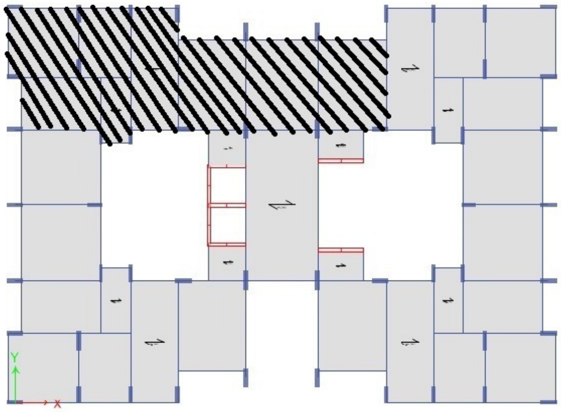

Fig -6 : Locations at which water tank is located.

IV. RESULTS

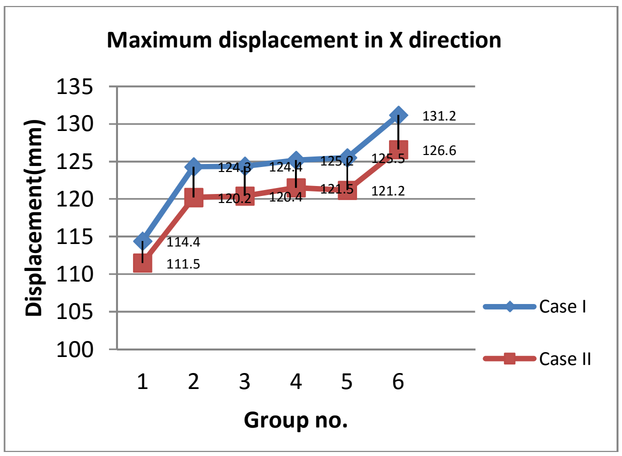

CHART -1: COMPARISON OF DISPLACEMENT IN X DIRECTION

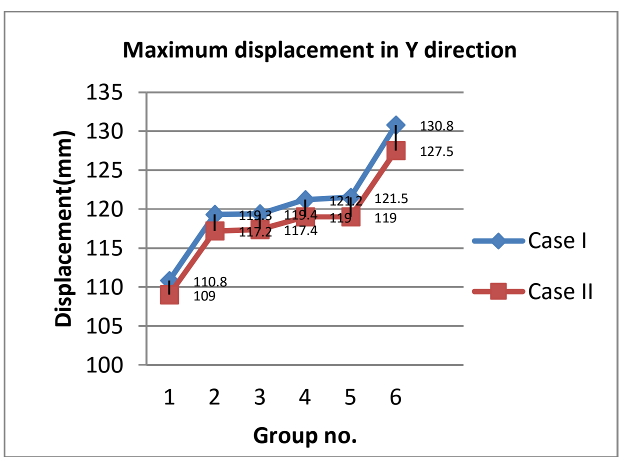

Chart -2: Comparison of Displacement in Y Direction

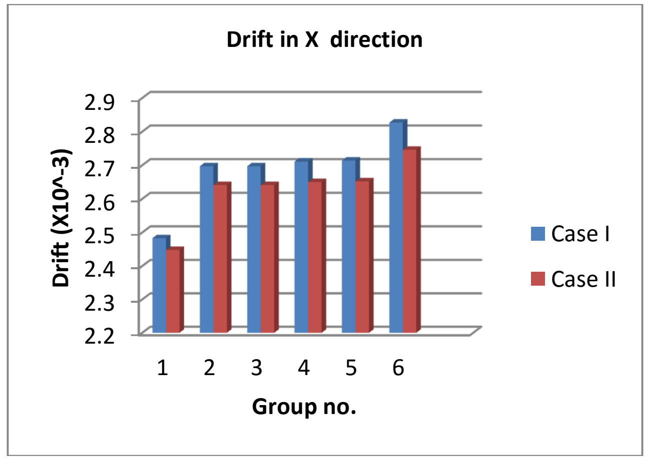

Chart -3: Maximum storey drift in X direction

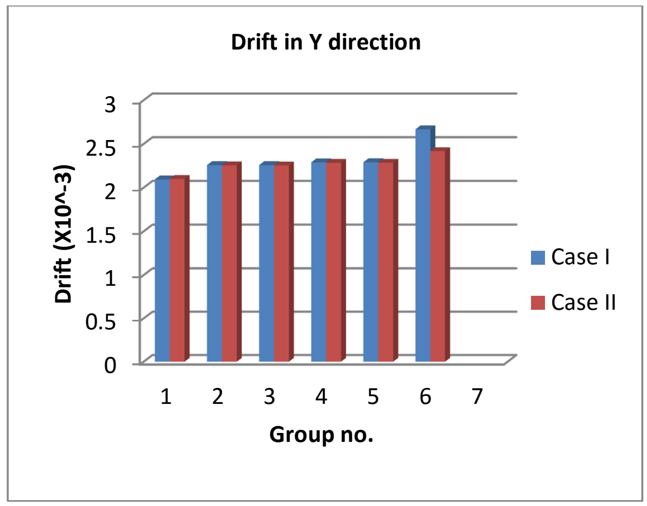

Chart -4: Maximum storey drift in Y direction

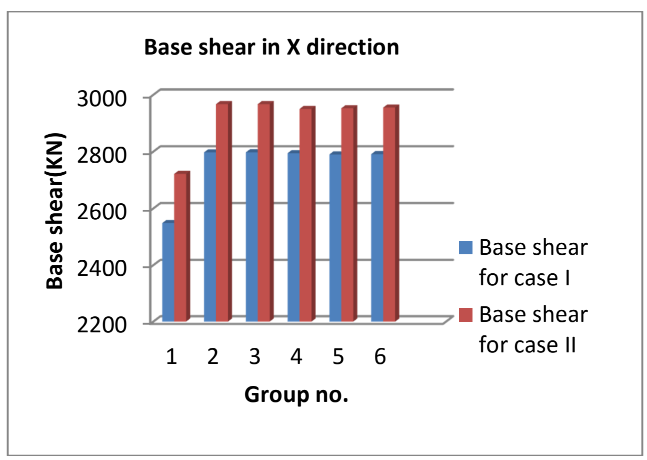

Chart -5: Base shear in X direction

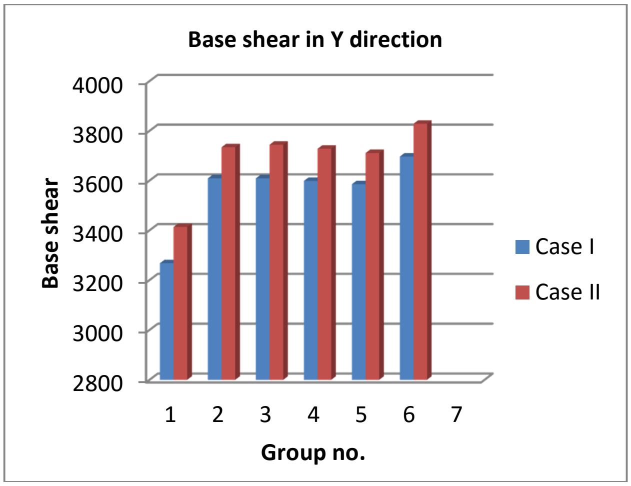

Chart -6: Base shear in Y direction

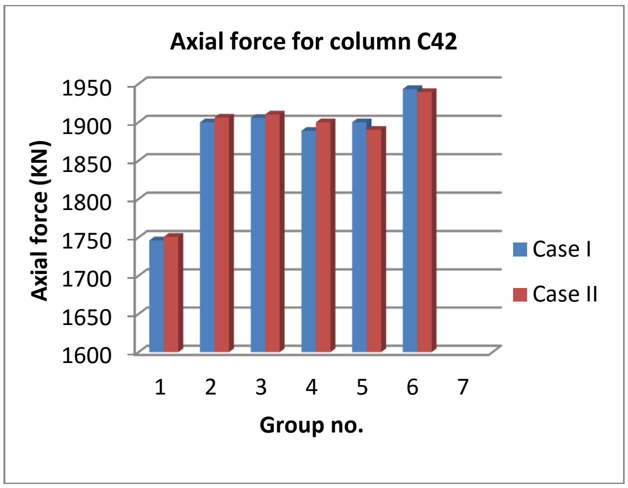

Chart -7: Axial force in column C42

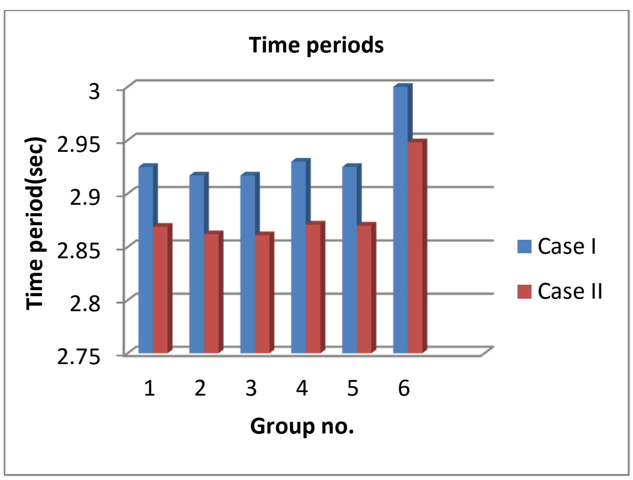

Chart -8: Modal time periods

V. DISCUSSIONS

1. The reduction of Maximum deflection of top storey in X direction & Y direction by 7% to 8% .
2. The reduction of Maximum Storey Drift in X direction by 12.34% and in Y direction by 19.38 %
3. The reduction of Fundamental Period By 2.99 %,
4. Base shear increases by around 7%- 8% for various models in case II.
5. Axial force of the column changes to positive side by around 1%-2%.

VI. CONCLUSIONS

On the basis of present study done & literature studied, and discussions, following conclusions can be made,

1. Irregular structure shows critical responses as compared to regular structure.
2. Frames having irregular floors at larger height from the ground are critical. hence as far as possible, irregularity should be introduced on the floor close to the ground.
3. Most economical combination for irregular structure can be worked out using present study.
4. Displacements, drift and time periods can be reduced by adopting columns with higher stiffness.
5. As we increase the column stiffness, axial forces in columns and base shear increases.

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