Study of Seismic Responses of Multistoried RCC Building with Mass Irregularity and Column Stiffness Variation

Samadhan D. Shinde, Nilesh P. Karwar, Swati D. Nagare, Sheetal S. Banote
B.E Student
B.V.C.O.E&R.I, NASHIK, MAHARASTRA, INDIA

Abstract:- From recent 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. Also presence of mass irregularity in the structure may lead structure to the failure if not taken into account. There are different techniques of analysis of structure. Response spectrum analysis is one of the important dynamic methods of analysis which will be used in this project work.

This paper is concerned with the effects of various Mass and column stiffness Irregularity on the seismic response of a structure. The primary objective of the project is to carry out Response spectrum analysis (RSA) of vertically Mass irregular RC frames with column stiffness variation. Comparison of the results of analysis of irregular structures with regular structure will be done. Comparison 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, storey drift and storey displacement.

***Keywords**:- Mass irregularities, Column Stiffness, Seismic Analysis, response spectrum analysis, Base Shear, Drift, Displacement.*

I. INTRODUCTION

Earthquakes are occasional forces on structures that may occur rarely during the lifetime of buildings. It is also likely that a structure may not be subjected to severe earthquake forces during its design lifetime. Reinforced Concrete Multi-Storied buildings (RCMS) are supposed to be of engineered construction in the sense that they might have been analyzed and designed to meet the provisions of the relevant codes of practice and building bye-laws; the construction might have been supervised by trained persons. In such cases, even if earthquake forces have not been considered precisely, the structures would have adequate in-built strength and ductility to withstand some level of earthquake intensity.

An earthquake is the perceptible shaking of the surface of the Earth, which can be violent enough to destroy major buildings and kill thousands of people. The severity of the shaking can range from barely felt to violent enough to toss people around. Earthquakes have destroyed whole cities. They result from the sudden release of energy in the Earth's crust that creates seismic waves. The seismicity, seismic or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time.

II. LITERATURE SURVEY

A S Patil et al: This research paper shows a similar variations pattern in Seismic responses such as base shear and storey displacements in horizontal directions with intensities V to X. Based on the study it is concluded that for multistoried RC frame structure, Time History method of analysis becomes necessary to ensure the safety of structure against earthquake forces.

Mayuri D. Bhagwat et al: In this project study, dynamic analysis is performed on a G+12 multi storied RCC building considering Koyna and Bhuj earthquake. Time history analysis (THA) and response spectrum analysis (RSA) are performed and seismic response of such building are comparatively studied with the help of ETABS analysis package. Two time histories (i.e. Koyna and Bhuj) are used to determine seismic behavior of the structure i.e, base shear, storey displacement, storey drift S.S. Patil et al: This study deals with the seismic analysis of high-rise building using STAAD Pro package by considering the various conditions of lateral stiffness system. Various models are prepared which are in the form of structural frame, brace frame and shear wall frame. Analysis is performed by response spectrum analysis (RSA) method. This analysis produces output in the form of higher modes of vibration & actual distribution of forces in elastic range in a better possible way. Test results like base shears, story drifts and story deflections are studied to get effective lateral load resisting system.

III. MODELLING AND ANALYSIS

The variation of seismic response of mass irregular building for different column stiffness is calculated by

Response spectrum method. The comparison of various irregularities for two different column stiffness present in the building are studied in subsequent chapter.

A 20 storied residential building situated in zone V will be selected for the analysis. The building has a mass irregularity in plan due to a swimming pool situated at various intermediate floors of building & water tank at specified position on roof.

Along with mass variation, changes in column stiffness are introduced by changing column size. The main aim is to evaluate the response of building using response spectrum method.

Name of parameter	Value	Unit
Number of stories	20	Nos.
Height of Building	60	M
Floor to floor height	3	M
Length in long direction	29.4	M
Length in short direction	20.2	M
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	M
Thickness of external wall	0.23	M
Live load on slab	2	KN/M
Floor finish load	1.5	KN/M
Grade of concrete	M30	-
Density of concrete	25	KN/M3
Unit weight of water	9.81	KN/M3
Damping	5	%
Seismic Zone	V	-
Importance factor (I)	1	-
Responded reduction factor	5	-
Soil type	Medium	-
Time period (X)	0.996	Sec
Time period (Y)	1.202	Sec

Table 1. Model details

Different models are prepared for case 1 & 2 on ETABS having different mass irregularities at various floors due to addition of swimming pool and water tank at various locations on terrace. Models M11 to M16 belongs to case 1 while model no. M21 to M26 belongs to case 2.

A. Models are described as below

MODEL NO.	DESCRIPTION
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
M15 , M25	Swimming pool at 20th slab
M16 , M26	Water tank at a location on terrace

Table 2. Described as below

B. Building model

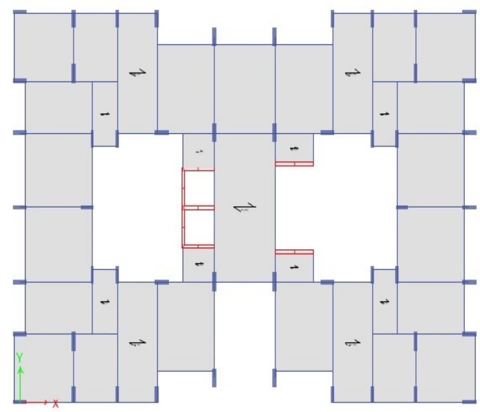

Fig 1:- Plan view of model

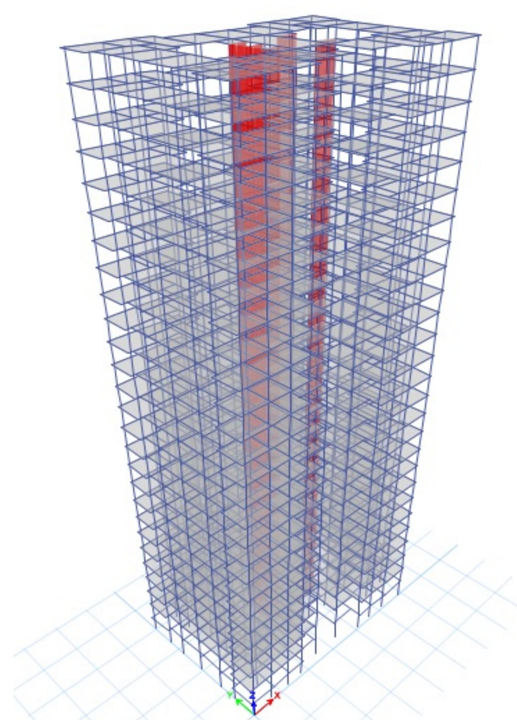

Fig 2:- D view of model

C. Method of analysis

- *Dynamic analysis*

Structural analysis is mainly concerned with finding out the behavior of a physical structure when subjected to force. This action can be in the form of load due to the weight of things such as people, furniture, wind, snow, etc. or some other kind of excitation such as an earthquake, shaking of the ground due to a blast nearby, etc. In essence all these loads are dynamic, including the self-weight of the structure because at some point in time these loads were not there. The distinction is made between the dynamic and the static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. If a load is applied sufficiently slowly, the inertia forces (Newton's second law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics, therefore, is a type of structural analysis which covers the behavior of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquakes, and blasts.

- *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.

IV. RESULTS

Modeling and analysis work is carried out in ETABS analysis package. Response spectrum analysis is performed on the model which yields following results.

Displacements(mm)					
MODEL	X dir	Y dir	MODEL	X dir	Y dir
M11	114.4	110.8	M21	111.5	109
M12	124.3	119.3	M22	120.2	117.2
M13	124.4	119.4	M23	120.4	117.4
M14	125.2	121.2	M24	121.5	119
M15	125.5	121.5	M25	121.2	119
M16	131.2	130.8	M26	126.6	127.5

Table 3. Maximum lateral displacements in X & Y direction

Story drift					
MODEL	X dir	Y dir	MODEL	X dir	Y dir
M11	2.483	2.095	M21	2.448	2.1
M12	2.697	2.095	M22	2.641	2.255
M13	2.697	2.258	M23	2.641	2.254
M14	2.711	2.29	M24	2.65	2.284
M15	2.714	2.291	M25	2.652	2.284
M16	2.827	2.668	M26	2.746	2.418

Table 4. Storey drifts in X & Y direction

Base shear (KN)					
MODEL	X dir	Y dir	MODEL	X dir	Y dir
M11	2548.7	3267.4	M21	2721.85	3413.3
M12	2797.4	3608.9	M22	2967.2	3734.1
M13	2797.48	3608.9	M23	2967.22	3744.11
M14	2794.54	3598.5	M24	2950.3	3727.8
M15	2790.2	3585.2	M25	2952.6	3710.7
M16	2791.2	3696.6	M26	2955.2	3828.4

Table 5. Base shear in X & Y direction

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V. TIME PERIOD

Time periods			
Model	Time Period	Model	Time Period
M11	2.925	M11	2.869
M12	2.917	M12	2.862
M13	2.917	M13	2.861
M14	2.93	M14	2.871
M15	2.925	M15	2.87
M16	3.00	M16	2.948

Table 6. Time period

VI. CONCLUSIONS

From discussions it can be concluded that, irregular structure shows critical responses as compared to regular structure. 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. Most economical combination for irregular structure can be worked out using present study. Displacements drift and time periods can be reduced by adopting columns with higher stiffness. As we increase the column stiffness, axial forces in columns and base shear increases.

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