Seismic Analysis of Multi-Storied Rcc Structure Considering Mass Irregularities

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Abstract- *Advancement in construction techniques, increasing population density and limited availability of land has shifted the focus of Civil Engineers towards the construction of tall structures. Structural design of high rise building is governed by lateral loads due to wind or earthquake. Many of the existing RCC structures located in the different seismic zones are unable to perform under seismic conditions. In India a large portion is under the influence to the damaging levels of seismic hazards. As the safety of the structure is of prime importance and thus the seismic loads are required to be carefully modelled to evaluate the behaviour of the structure during an earthquake. The Seismic performance of the structure mainly depends upon factors which include mass, stiffness, strength, ductility, lateral strength and regular configuration. The structure with above mentioned factors is less vulnerable to earthquake as compare to the Irregular structures. Therefore studies related to a structure of this kind which has a huge scope in future are highly desired.*

The present study is aimed to understand the different structural aspects related to this system. Linear dynamic analysis of different structures has been performed in ETABS using response spectrum method. Analysis results in terms of top storey displacement, inter-storey drift, base shear and time period have been compared to understand the variations. There were four models considered for the study which had irregularity at different storey level which were Mass irregularity at 1st and 2nd storey level in the Model 3.1, 10th storey level in the Model 3.2 & on the 18th and 19th storey level in the Model 3.3.

Keywords- Mass Irregularities, Conventional structure, ETABS, Mass irregularity index, Response spectrum analysis, Story displacement, Inter storey drift, Base shear.

I. INTRODUCTION

Due to rapid development of infrastructure and increasing number of the multi-storied buildings the seismic effect of such is to be taken into account. Many of the existing RCC structures located in the different seismic zones are unable to perform under seismic conditions. In India a large portion is under the influence to the damaging levels of seismic hazards. As the safety of the structure is of prime importance and thus the seismic loads are required to be carefully modelled to evaluate the behaviour of the structure during an earthquake. The Seismic performance of the structure mainly depends upon factors which include mass, stiffness, strength, ductility, lateral strength and regular configuration. The structure with above mentioned factors is less vulnerable to earthquake as compare to the Irregular structures.A classification irregularity of irregular buildings as;

- Plan irregularities
- Vertical irregularities
  - a) Stiffness irregularity
  - b) Mass irregularity
  - c) Vertical geometric irregularity
  - d) In-Plane Discontinuity in Vertical elements resisting lateral force
  - e) Discontinuity in capacity – Weak storey

II. OBJECTIVES OF THE WORK

The objectives of present work are:-

1. To review the existing literature related to Mass Irregularities.
2. Modelling of multi-storeyed R.C.C. building with mass irregularity and calculation of the mass irregular index.
3. Analysis of multi-storeyed mass irregular R.C.C. building by linear static and linear dynamic analysis as per IS 1893 (Part 1): 2002 code using modal analysis techniques.
4. Proposing design guidelines for calculation of modified Fundamental time period for structure with vertical mass irregularities.

III. MODELLING AND ANALYSIS

In ETABS a total of four models were modelled and analysed and the different results were interpreted. Out of the four models, one model was a regular one i.e. without any mass irregularity and the other three models were mass irregular ones at different locations. The details and notation the models are as given below

a) Model 3.1 – G+20 RCC structure with Mass irregularity at 1st and 2nd storey level in form of Podium parking.
b) Model 3.2 – G+20 RCC structure with Mass irregularity at 10th storey level inform of Gymnasium.
c) Model 3.3 – G+20 RCC structure with Mass irregularity at 18th and 19th storeylevel in form of Swimming pool & Club centre.
d) Model 4 - G+20 RCC structure without Mass irregularity on any of the storey.

Building Configuration

- Plan Dimension :- 35 m X 27 m
- Story Height :- 3.2 m
- Shear Wall Core Dimensions :-5 m X 9 m
- Number of stories :- 21 Stories

Load Definitions

- Dead load: - Self weight of the structure.
- Superimposed load due to finishing etc.:- 1 kN/m^2
- Live Load:- 2.5 kN/m^2, 3 kN/m^2,5.5 kN/m^2
- Earthquake in X-direction:- As per IS 1893:2002
- Earthquake in Y-direction:- As per IS 1893:2002
- Wind load:- As per IS 875 (Part 3)

Earthquake force data:

- Response reduction factor, R:- 5
- Seismic zone:- III
- Seismic zone factor, Z:- 0.16
- Soil type:- II
- Importance factor:- 1
- Time period:- Program calculated

Etab Models

Modelling of G + 20 storey residential building (Model 3.1 & Model 4)

Details	Description
Column Size	700 mm X 1000 mm (1st to 10th Floor)
	700 mm X 800 mm (11th to 20th Floor)
Beam Size	450 mm X 600 mm (1st to 10th Floor)
	400 mm X 600 mm (11th to 20th Floor)
Shear Wall	300 mm thick RCC
Slabs	200 mm thick RCC

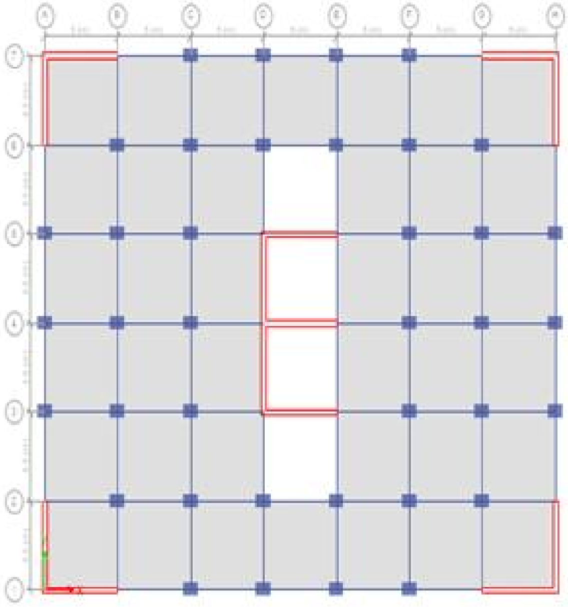

Fig.1 Plan of Building

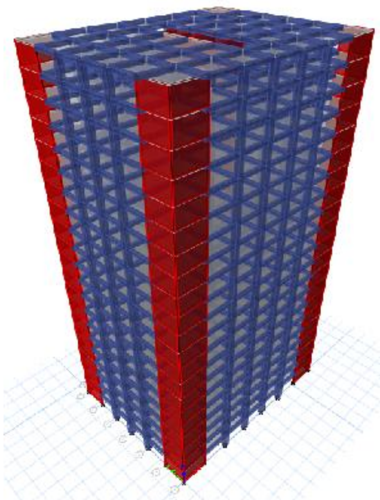

Fig. 2 3D ofBuilding

Modelling ofG + 20 storey residential building (Model 3.2)

The Material property, Geometry and other information of the building model 3.2 is as described earlier. The loads considered on the model are as mentioned below:

Details	Description
Live Load	2.5 kN/ m^2 (1st to 9th& 11th to 19th storey)
	5.5 kN/ m^2 (10th storey level)
SIDL	3 kN/ m^2
Roof Load	1.5kN/ m^2 (20th storey)

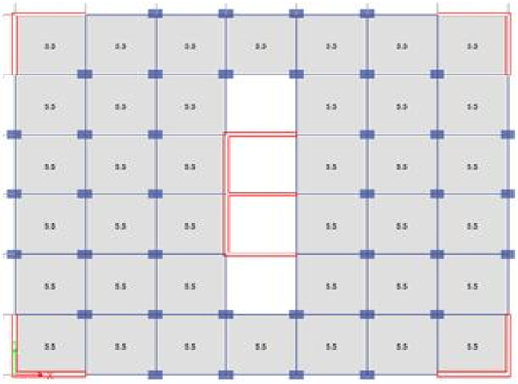

Fig.3Plan of Building at 10th Floor level (LL = 5.5 kN/sqm)

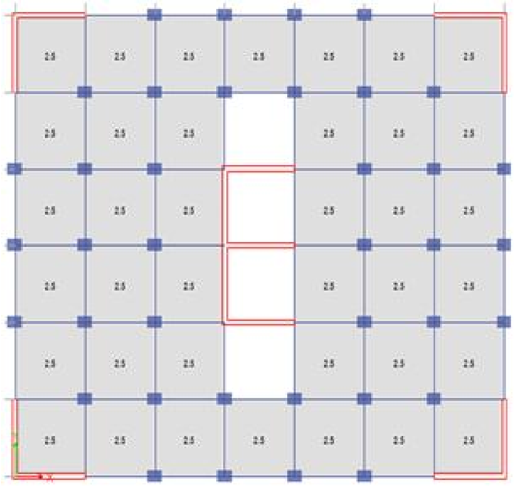

Fig.4Plan of Building at 1st to 9th and 11th to 20th Floor level (LL = 2.5 kN/sqm)

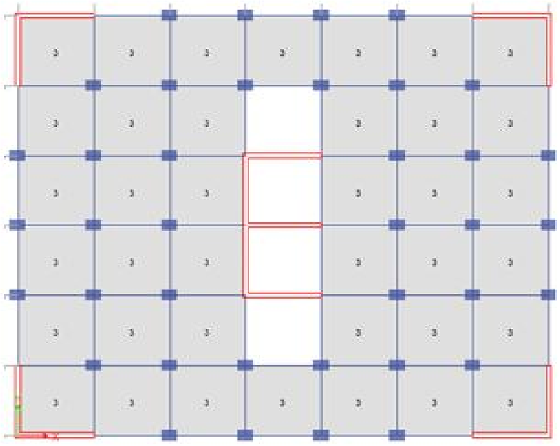

Fig.5Plan of Building at 10th Floor level (SDL = 3 kN/sqm)

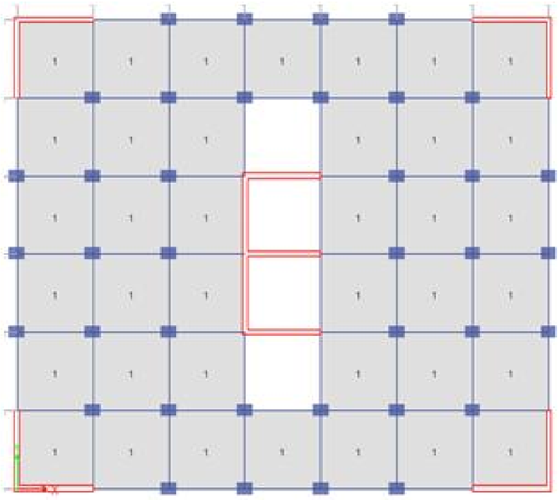

Fig.6Plan of Building at 1st to 9th and 11th to 20th Floor level (SDL = 1 kN/sqm)

Modelling ofG + 20 storey residential building (Model 3.3)

The Material property, Geometry and other information of the building model 3.2 is as described earlier. The loads considered on the model are as mentioned below:

Details	Description
Live Load	2.5 kN/ m^2 (1st to 17th)
	7.2 kN/ m^2 (18th storey level)
	18 kN/ m^2 (19th storey level)
SIDL	3 kN/ m^2
Roof Load	1.5kN/ m^2 (20th storey)

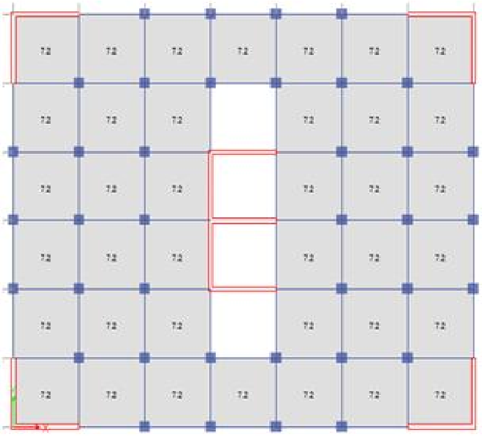

Fig.7 Plan of Building at 18th Floor level (LL = 7.2 kN/sqm)

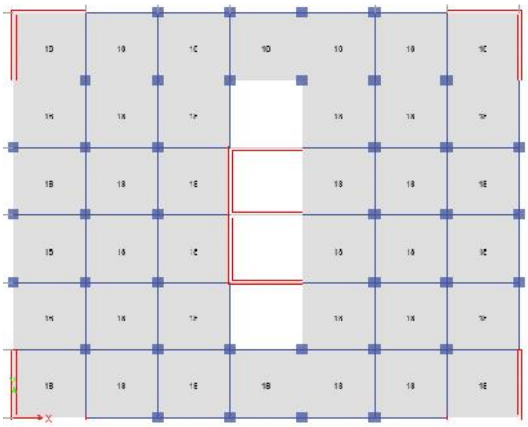

Fig.8Plan of Building at 19th Floor level (LL = 18 kN/sqm)

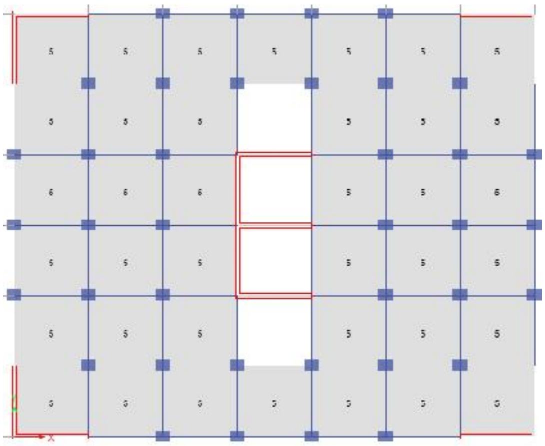

Fig.9Plan of Building at 18th and 19th Floor level (SDL = 5 kN/sqm)

IV. RESULT AND DISCUSSION

An effort in made to study the behaviour of regular RC buildings in comparison with RC buildings having mass irregularity at different floor level. Here in the present study, the behaviour of each models are captured and the results are tabulated in the form of Maximum storey displacement, Maximum storey stiffness, Base shear, Maximum Time Period in analysis.

Parameters	Model 4	Model 3.1
Maximum top storey displacement (mm)	20.9	21.3
Maximum Storey stiffness (kN/m)	20964302	21023552
Base Shear V_b (kN)	4468.0011	4537.6114
Maximum Time Period (s)	1.735	1.735

Parameters	Model 3.2	Model 3.3
Maximum top storey displacement (mm)	21	21.2
Maximum Storey stiffness (kN/m)	20950594	20956432
Base Shear V_b (kN)	4493.6608	4442.153
Maximum Time Period (s)	1.74	1.804

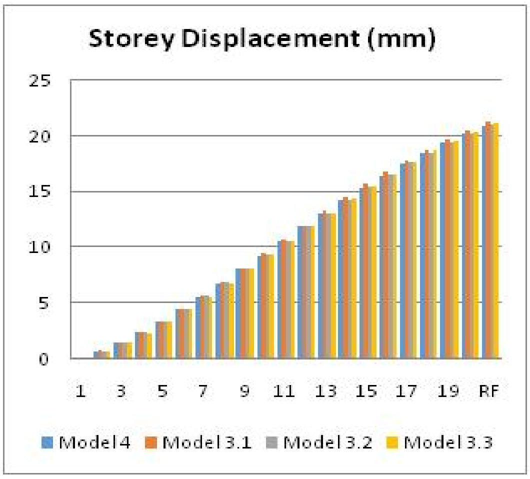

Fig. 10 Storey Displacement (mm)

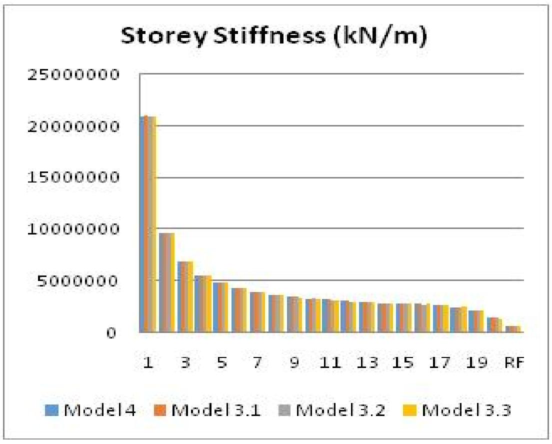

Fig. 11 Inter-Storey Drift Ratio ($x10^{-3}$)

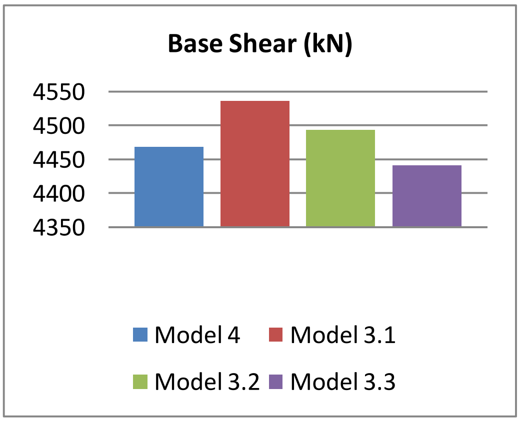

Fig. 12 Base Shear (kN)

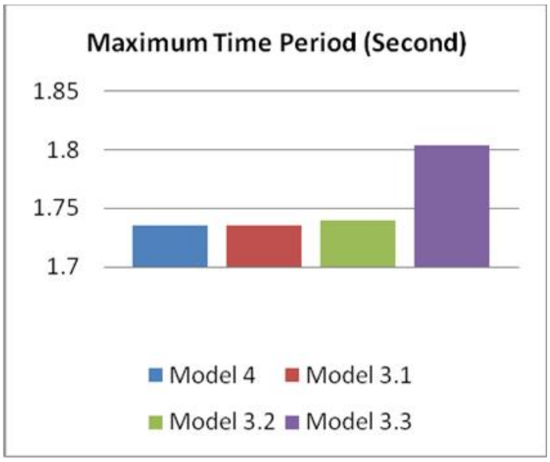

Fig. 13 Maximum Time period (Second)

V. CONCLUSION

The value of the Mass irregularity index suddenly increases as the mass irregularity increases according to the height i.e. Mass irregularity index is least for the building models in which irregularity is present in bottom storey. This can be seen as shown in the graph and can be concluded that the mass irregularity index is directly proportional to the mass irregularity along the height of the structure. The mass irregularity index increases with bay width and with number of bays.

As observed, there was an increase of 54.54% in the mass irregularity index was seen from first to second floor and similarly there was difference in the mass index on the higher floors 18th and 19th floor which was about 22.65%. This shows the consistency of mass irregularity index after a certain height.

The time period of structure increases with no. of bays, no. of stories and with increase in location of irregularity along the building height. The ratio of Time period Tr of regular structure and Time period Ti of the other three irregular structure was calculated and studied.

It is observed that ratio of Ti/ Tr ratio increases with the position of mass irregular floor, but it is seen that for the last floor the value decreases that means that the Ti/ Tr ratio not only depends on the mass irregularity but also on the other factors in the building.

This showed that as the position of Mass irregularity from bottom to top in any model also showed an change in the Ti/ Tr ratio used for calculating the Modified time period of structure.

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