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Seismic Performance Study of RC Framed building with Diaphragm Discontinuity

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Abstract - *Now a day's many buildings are constructed in irregular configuration both in plan and elevation. In future these buildings may subject to highly earthquakes. Structural irregularities are more important factors which decrease the seismic behavior of the structures. In this study to investigate the proportional distribution of forces due to the earthquake all story. It has been observed that the storey shear, story drift, displacement and time period are depending on the lateral storey stiffness distribution. A regular G+5 and G+10 reinforced concrete (RC) buildings are modeled with and without diaphragm discontinuity and are analyzed by computer software ETABS (2016).*

In this project two types of diaphragm discontinuities are considered as stiffness irregularity and mass irregularity in the slab portion. The building is analyzed by Responses spectrum analysis and Time history analysis. The Response quantities like; modal period, storey shear, story displacement and storey drift are estimated and Time history quantities like base force, joint displacement and column forces are estimated and are compared for regular building and building with diaphragm discontinuity. From this study it is concluded that building with diaphragm discontinuity has the more displacement and drift compared to regular building and regular building has greater time period and shear force then irregular building. Hence regular building is less susceptible to earthquakes.

Key Words: Seismic performance of irregular structures, Response spectrum method, time history method, diaphragm discontinuity.

1. INTRODUCTION

Earthquake is the danger that occurs at some distance downward the land level which causes sensations at the land plane. The location, time, duration, scale and rate of recurrence of earthquake are totally unidentified. Also, these sensations are quick, happening for a little as. It should be noted that earthquakes are totally impulsive. The main cause for earthquake is structural weaknesses there in structure. Well-built earthquake motion depend on the sharing of mass, inflexibility, force in both the horizontal and vertical planes of buildings.

1.1 Diaphragm Discontinuity

Diaphragm is defined as discontinuities or variations in stiffness and mass in the form of slab openings and variation in slab thicknesses is called as diaphragm discontinuity**,**

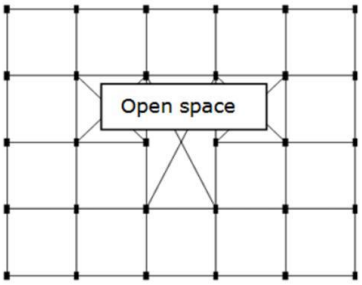

Fig2.1. Example of Diaphragm Discontinuity.

2. MODELLING

In the presents study, an attempt is made to quantify the seismic performance study of RC Framed building with diaphragm discontinuity. For this purpose typical 5 and 10 storey structures modeled are analyzed using ETABS software.

Table. I. Structural details of the model

No of storey	5 and 10
Storey height	3.5
Number of Bays	6 bays in both directions
Spacing of Bays	6m in both direction
Beam Size	300x450mm
Column size	500x500 mm and 700x700(for 5 and 10 storey respectively)
Grade of Materials	M25 and Fe 500
Slab Thickness	150mm
Live Load Considered	4 kN/Sqm
Finishing	1.5 kN/Sqm
Seismic Zone and Soil Type	Zone III and Medium Type soil

Response Reduction Factor	3
No of storey	5 and 10
Storey height	3.5

The models considered are described as following
MODEL REG: Regular model is considered without diaphragm discontinuity
MODEL C1: Regular model with 11.11% of concentric diaphragm discontinuity.
MODEL C2: Regular model with 44.44% of concentric diaphragm discontinuity.
MODEL EC1: Regular model with 27.77% of eccentric diaphragm discontinuity.
MODEL EC2: Regular model with 30.55% of eccentric diaphragm discontinuity.
MODEL EC3: Regular model with 36.11% of eccentric diaphragm discontinuity.
MODELIRR1, MODELIRR2, MODELIRR3: Regular model with varying in slab thickness and Live loads at particular location in building plan.
The analysis is carried out for the regular building and building with diaphragm discontinuity as shown below

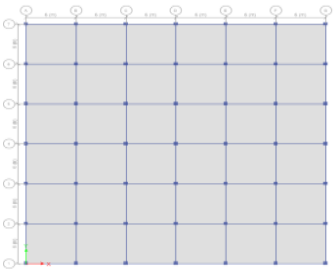

Fig.1. Regular model

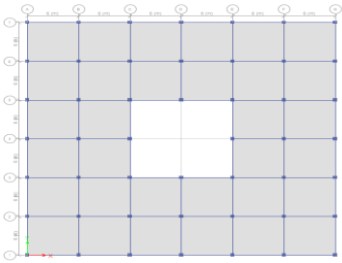

Fig.2. Model C1

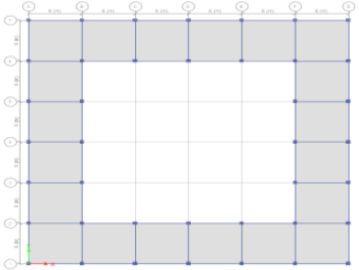

Fig.3. Model C2

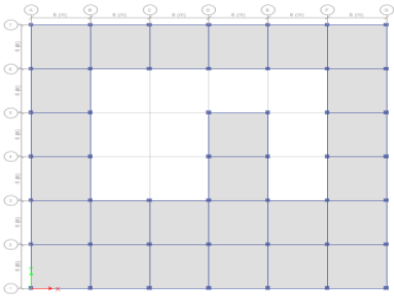

Fig.4. Model ec1

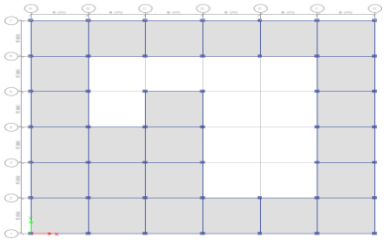

Fig.5. Model EC2

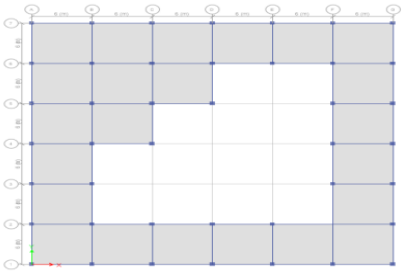

Fig.6. Model EC3

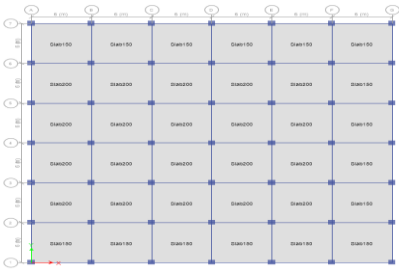

Fig 7. Model IRR1

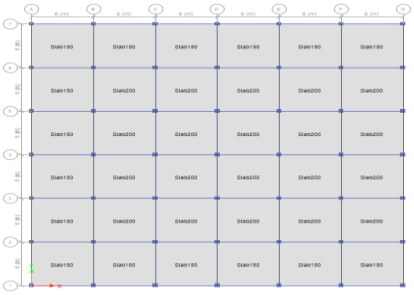

Fig 8. Model IRR2

Fig 9. Model IRR3

Similarly, this diaphragm pattern is considered for both 5 story and 10 story.

3. RESULTS AND DISCUSSIONS

The Regular models with two types of irregularities such as Model C1, Model C2, Model EC1, Model EC2, Model EC3, are Stiffness irregularity and Model IRR1, Model IRR2 and Model IRR3 are Mass irregularity. These structures are compared with regular model to study the basic difference between these structures. Mainly results are compared to find which type of structure will be more effective for seismic performance of the structures.

A. Response Spectrum Analysis

The results of analysis compared include displacement storey drift storey shear and modal periods in x direction and y direction.

i. Displacement

Storey displacement is the lateral movement of the structure caused by lateral forces. The deflected shape of the structure is most important and most clearly visible point of comparison for any structure.

a) For Five story

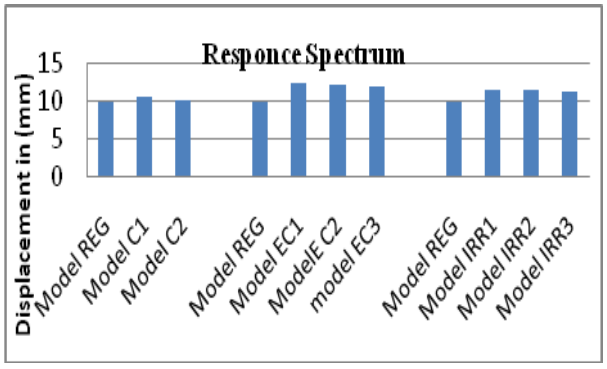

Fig.1. Comparison of displacement in x direction

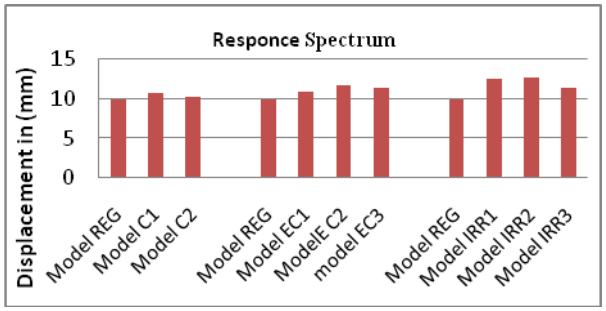

Fig.2. Comparison of displacement in y direction

b) For Ten story

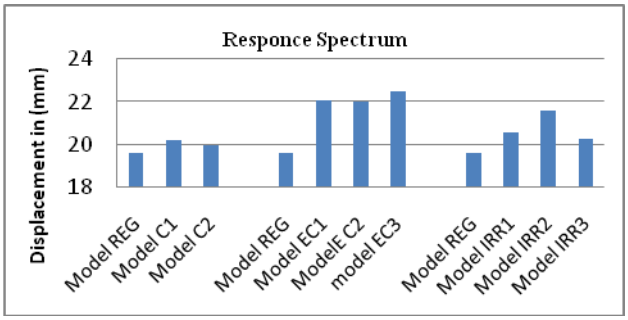

Fig.3. Comparison of displacement in x direction

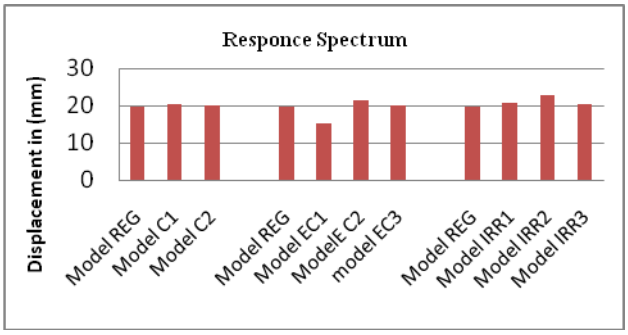

Fig.4. Comparison of displacement in y direction

Fig.1 and Fig.4 present that the concentric models, Model C1 has 7.69% and Models C2 has 3.26% more displacement than Model REG. Eccentric models Model EC1 has 20.21%, Model EC2 has 18.73% and Model EC3 has 17.89 % more displacement than Model REG, In case of mass irregular models Model IRR1 has 14.14%, Model IRR2 has14.73% and Model IRR3 18.68% more displacement than Model REG.

ii. Storey drift

In this study, storey drifts are expressed as a percentage of storey height. Damage to non-structural components of buildings depends on drift. The following figures illustrate the storey drift in x and y direction respectively.

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a) For Five story

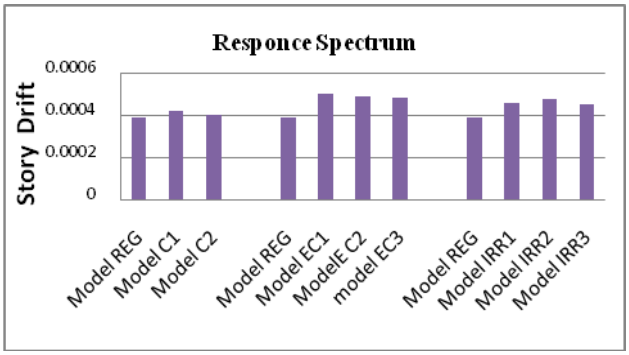

Fig.5. Comparison of storey drift in x direction

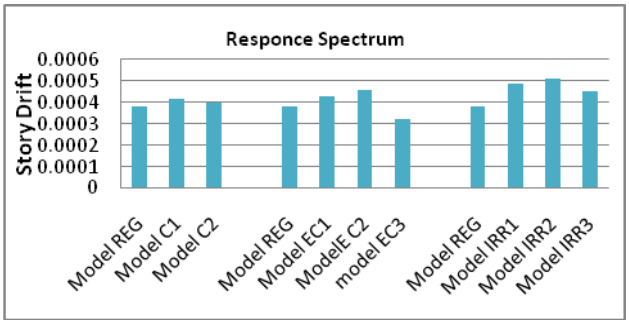

Fig.6. Comparison of storey drift in y direction

b) For Ten story

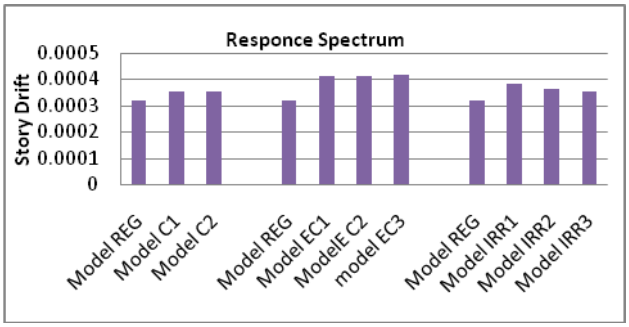

Fig.7. Comparison of storey drift in x direction

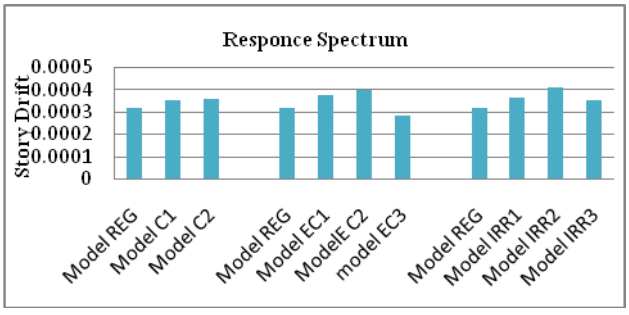

Fig.8. Comparison of storey drift in y direction

From the above Fig.5 and Fig 8 it is observed that concentric models and eccentric models have more story drift compared to Regular model because of reduction of mass and Fig mass irregular models have more drift compared to Regular model.

iii. Storey Shear

The base shear is a function of mass and stiffness of the structure.

a) For five story

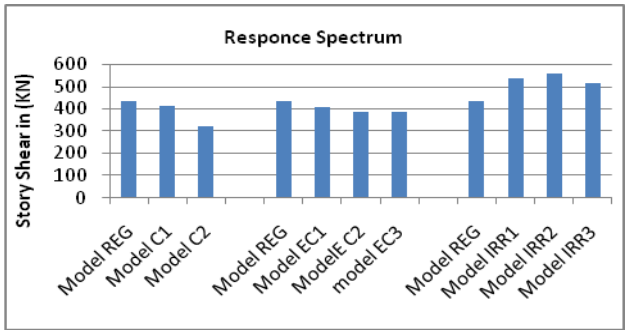

Fig.9. Comparison of storey shear in x direction

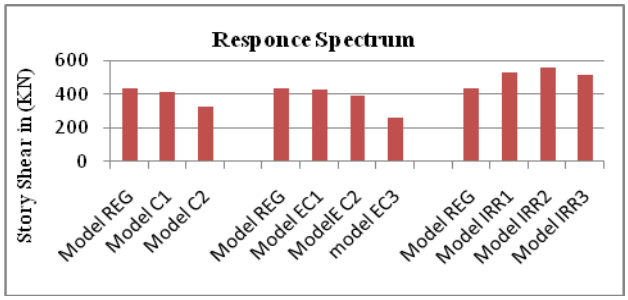

Fig.10. Comparison of storey shear in y direction

From the above figure it is observed that Regular model has more shear than concentric and eccentric models but Regular model less than mass irregular models.

a) For Ten story

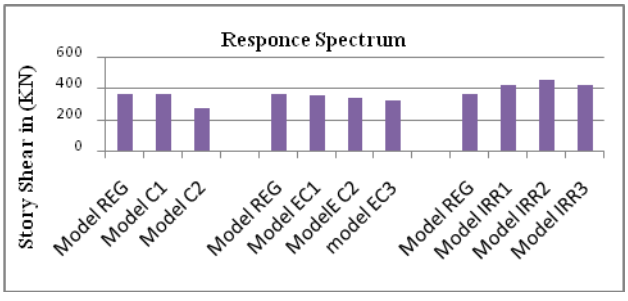

Fig.11. Comparison of storey shear in x direction

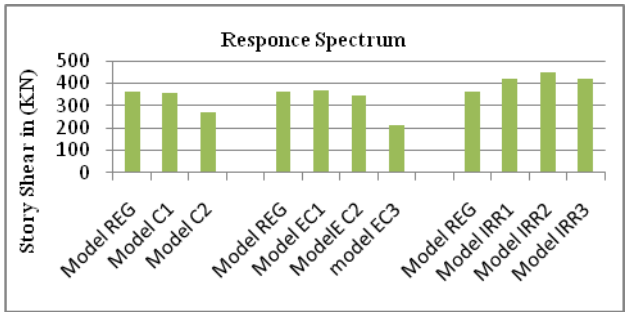

Fig.12. Comparison of storey shear in y direction

iv. Modal periods

a) For Five story

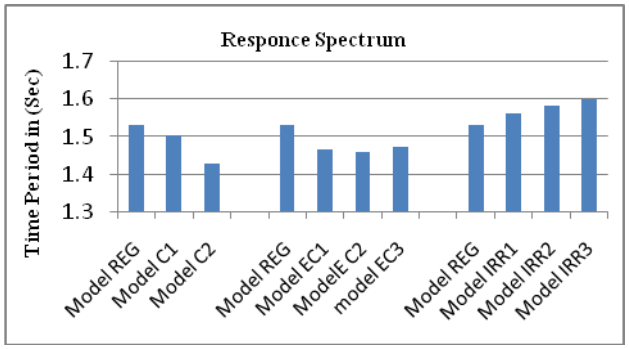

Fig 13Result comparison of Modal periods

b) For Ten story

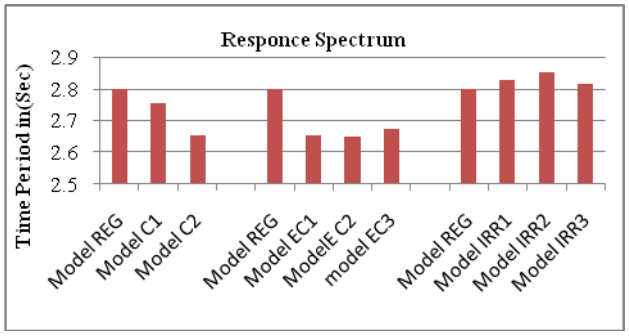

Fig 14 Result comparison of Modal periods

From above figure it is observed that, regular models longest time in case of concentric and eccentric models and less than mass irregular models. It can be conclude that provision of diaphragm to the structure decreases with the time of concentric and eccentric mode.

B. Time history analysis

The parameters considered for the comparison of results in time history analysis include base shear, joint displacement and column force.

i. Base shear

a) For Five story

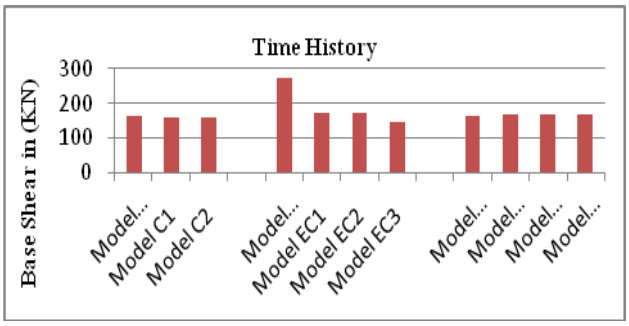

Fig.15. Comparison of base shear

b) For Ten story

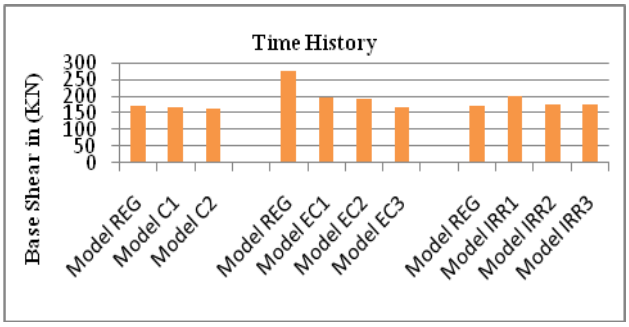

Fig.16. Comparison of base shear

From Fig.15 and Fig 16 it is observed that base shear is higher for regular structure compared concentric and eccentric models. It can be observed that in case of mass irregular IRR4 model has higher base shear.

ii. Joint displacement

For all models one common joint is selected to represent the displacement and for this Joint displacement is taken for column 7 of 5th storey for five story structure and column no 7 of 10th story for ten story structure

a) For Five story

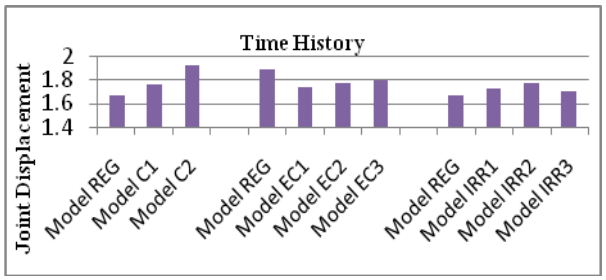

Fig.17. Comparison of joint displacement

b) For Ten story

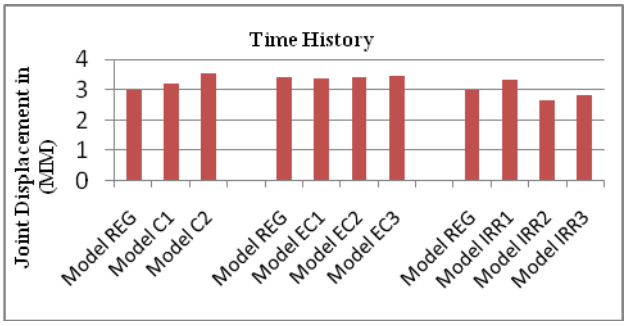

Fig.18. Comparison of joint displacement

From above it is observed that depending on the joint no 7 and location of diaphragm the concentric models have more joint displacement compared toRegular model, eccentric models have less joint displacement than regular and In case of mass irregular models Model IRR1 has more joint displacement than regular and other mass irregular models.

iii. Column Force

Column selected for comparison of column force is column 7 of first storey.

a) For Five story

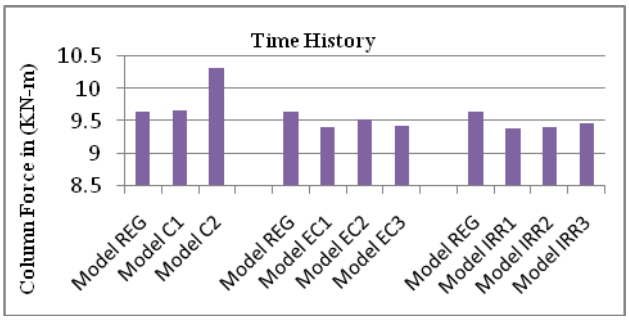

Fig.19. Comparison of column force

b) For Ten story

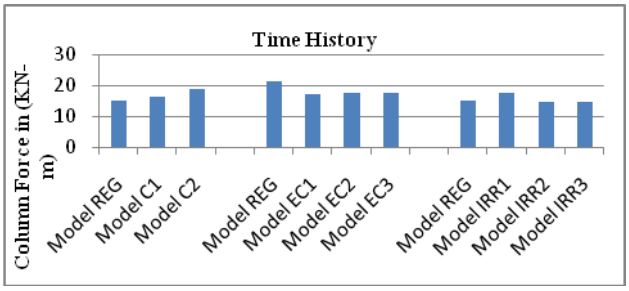

Fig.20. Comparison of column force

From Fig.16 it is observed that concentric models have higher column force compared to regular model, eccentric models and mass irregular models have less column force compared to regular model.

4. CONCLUSION

1. The response spectrum and time history analysis for 5 storey and 10 storey building with and without diaphragm discontinuity concludes the following.
2. Model C1 has more displacement and drift than Model REG because of provision of 11.11% diaphragm openings which reduces the mass of the structure and also reduces stiffness of the structure.
3. Model C2 has more displacement and drift than Model REG and less than Model C1 because of provision of 44.44% diaphragm opening. Provision of more openings reduces the total mass of the structure, where lateral forces depend on total mass of the structure. If mass is reduced lateral forces also reduces which causes reduction in displacement.
4. In case of eccentric models Model EC1 has 27.77% diaphragm opening, Model EC2 has 30.55% and Model EC3has 36.11% diaphragm openings. In this case, increase in percentage of diaphragm openings reduces the displacement and drift. In comparison to Model REG the eccentric models have more displacement and drift in x and y directions.
5. In the in-plane mass irregularity models Model IRR1, Model IRR2 and Model IRR3 have more displacement and drift compared to Model REG because of variation of slab thickness 150mm and 200mm at different location. The Variation of slab thickness increases the mass of the structure but stiffness of the structure remains constant for both regular and mass irregular models.
6. Concentric models Model C1 and Model C2 has less shear force than Model REG due to the reduction in mass of the structure. The eccentric models also have less shear force than Model REG.
7. In mass irregular models Force is directly proportional to displacement, as the displacement is more shear force will be more because stiffness of the structure remains constant for all structures. Therefore Model IRR1, Model IRR2 and Model IRR3 have more shear force than Model REG.
8. The concentric models Model C1 and Model C2 have less time period compared to Model REG because it has lesser shear force. The eccentric models also have lesser time period then Model REG.
9. In case of in-pane mass irregular models increase in shear force increases the time period of structure, hence in-plane mass irregular models have more base shear and time period compared to regular model.
10. From the time history analysis concentric models Model C1 and Model C2 and eccentric models Model EC1, Model EC2 and Model EC3 have less Shear than

Model REG, but mass irregular models Model IRR1, Model IRR2 and Model IRR3 more shear compared to Model REG.

11. From time history analysis concentric models, eccentric models and mass irregular models have mare joint displacement compared to Model REG.
12. In time history analysis for column force we have considered column No-7 and story-1, depending on this column and on the bases of diaphragm opening concentric models have more column force, eccentric models have column force and mass irregular models have column force.
13. Provision of diaphragm discontinuity in structure reduces the stiffness of the structure which effect on performance of the building.
14. By considering above all points provision of diaphragm openings reduces the performance of structure during earthquakes.

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