

Nonlinear Behavior of Building with Varying Percentages of Slab Opening



Syed Haneef Ali, A Vimala

Abstract: The work describes about irregular plan geometric forms that are more in metro cities. Irregularities are not avoidable in construction of buildings. In present scenario many buildings have irregular configurations both in elevation and plan. Now a day's openings in the floors are common for many reasons like stair cases, lighting architectural etc. The present study focuses on the behavior of 10 storey reinforced concrete buildings under seismic zone-v, the plan dimensions is taken as 28 m x 28 m. The plan irregularities such as openings in slab with varying percentages is taken in this study. Study is done on various plan configuration buildings and the action of structural diaphragm on its performance during earthquake is studied. Pushover analysis is performed by using ETABS software, for present work five models are studied 1) building without opening in slab 2) plan irregular building with 10% opening in slab 3) plan irregular building with 20% opening in slab 4) plan irregular building with 30% opening in slab 5) plan irregular building with 40% opening in slab. Output from software consisting of Pushover curve and hinge formation results of all five models which are presented. Plan irregularity find better structural system solution such as in 20% opening shows better base shear.

Keywords: Plan irregularity, pushover analysis, roof displacement, Base shear

I INTRODUCTION

The buildings with regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation suffer much less damage compared to irregular configurations. But nowadays need and demand of the latest generation and growing population has made the architects or engineers inevitable towards planning of irregular configurations in modern days, with more advancement in the rapid growth of urbanization and for aesthetic purpose buildings are constructed with irregular structural configurations. The structural irregularity causes non-uniform load distribution in various members of buildings. This building configuration provides to irregular distribution of strength, mass and stiffness from this it may lead to damage of the frame during earthquakes. Modern construction demands the architect to plan irregular buildings in plan and elevation. The structural engineer on the other hand has a major responsibility to make the structure safe against all external forces; when such irregular buildings are constructed in a high seismic zone, the structural engineer's role becomes further challenging.

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II OBJECTIVE OF THE STUDY

The objectives of the present study are:

- To determine seismic response of reinforced concrete framed buildings by providing varying percentages of openings in slab (according to IS 1893- 2002) by using Push Over analysis.
- To study the displacement and Base Shear of buildings at each floor level.

III MODELLING AND ANALYSIS

A. Modelling and Material Properties:

In this work, five models are considered to understand the seismic behavior of plan irregular building. The models consist of 1) plan irregular building without opening in slab 2) plan irregular building with 10% opening in slab 3) plan irregular building with 20% opening in slab 4) plan irregular building with 30% opening in slab 5) plan irregular building with 40% opening in slab. The building frames are assumed to be located in seismic zone V, type II soil condition. Characteristics strength of concrete M25 and steel were taken as fe500.

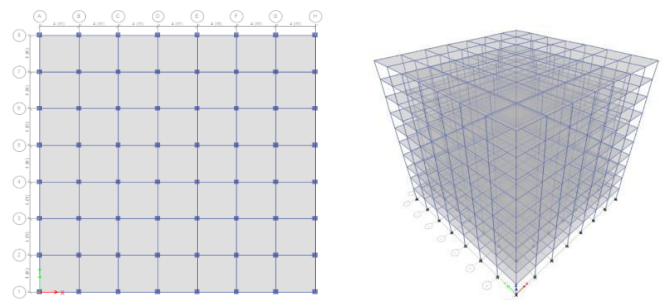


Figure 1: Plan and 3-D elevation of building without opening in slab

The above figure 1 shows plan and 3-D elevation of RC building having a plan size of 28mX28m and the supports are fixed. Live load is considered as 3KN/m².

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Table 1: Details of Structural Elements and Material Used

Plan dimension	28m x 28m
Column Size	450mm x 450mm
Beam Size	230mm x 300mm
Slab Thickness	180mm
Floor to Floor Height	3m
Grade of Concrete	M25
Grade of Steel	Fe500
No. of Storeys	10
No. of bays in x-direction	8
No. of bays in y-direction	8
Live load	3KN/m ²
Importance factor	1
Soil type	II - Medium

Building Models:

Plan of building which are studied in this work

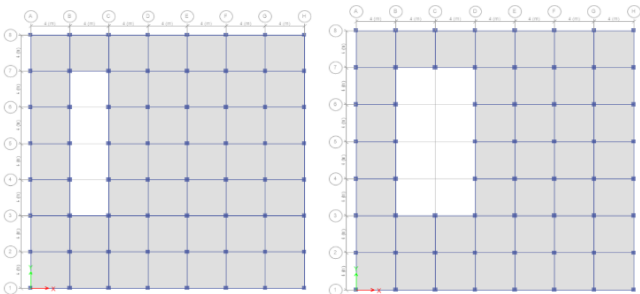


Figure 2: Plan of building with 10% & 20% opening in slab

The above figure 2 shows plan of a 10 storey RC building having plan size 28mX28m with 10% & 20% opening in slab and the supports are fixed. In this study live load and dead load are considered as per IS 875:1987. Live load on all slabs are taken as 3 KN/m

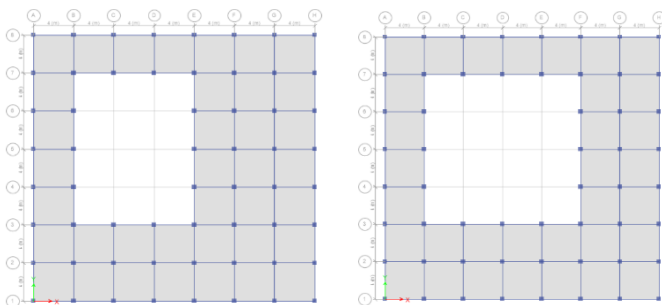


Figure 3: Plan of building with 30% & 40% opening in slab

The above figure 3 shows plan of a 10 storey RC building having plan size 28mX28m with 30% & 40% opening in slab and the supports are fixed. In this study live load and dead load are considered as per IS 875:1987. Live load on all slabs are taken as 3 KN/m²

IV RESULTS AND DISCUSSION

A comparison made between building models to know the seismic behavior of plan irregular building models. Nonlinear static analysis is performed on 1) building without opening in slab 2) plan irregular building with 10% opening in slab 3) plan irregular building with 20% opening in slab 4) plan irregular building with 30% opening in slab 5) plan irregular building with 40% opening in slab.

A. Capacity Curve

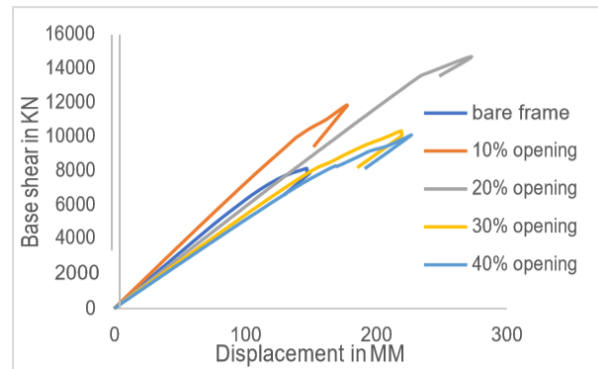


Figure 4: Capacity Curve of All Frames

From above figure 4 we can observe that Frame building model without opening in slab has less displacement and base shear as compared to models having opening in slab. Frame building model with 10% opening in slab has more base shear and less displacement as compared to 20% and 30% opening in slab.

Frame building model with 20% opening has more base shear and displacement as compared to bare frame and building having opening of 10%, 30% and 40%.

Frame building model with 30% and 40% opening has almost same base shear and displacement but has less base shear as compared to 20% opening in slab.

B. Hinge Formation:

Plastic hinge, is used to describe the deformation in a structure where plastic bending moment occurs. Therefore, hinge formation during Nonlinear static analysis is studied.

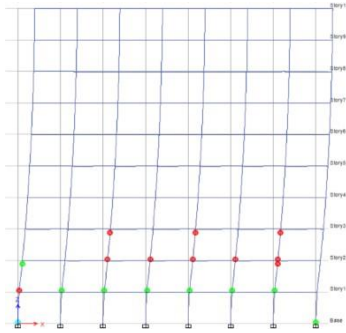


Figure 5: hinge formation for frame without opening

The plastic hinges in the building are formed at different displacement levels. First Plastic hinge formation starts at displacement of 57.05mm at a base force of 3687.89KN at first and second storey beams. It is observed that collapse hinge is formed at ground storey column at a displacement of 147.18mm and base force of 8175.46 KN.

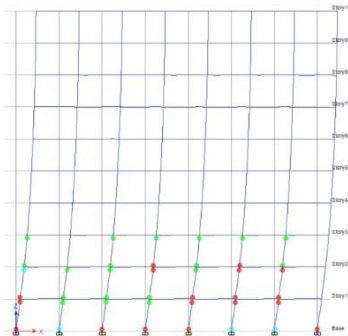


Figure 6: hinge formation for 10% opening in slab

The plastic hinges in the building are formed at different displacement levels. First Plastic hinge formation starts at displacement of 128.91mm at a base force of 9266.96KN at Ground storey column and first storey beam. It is observed that collapse hinge is formed at ground storey column at a displacement of 177.94mm and base force of 11875.53 KN

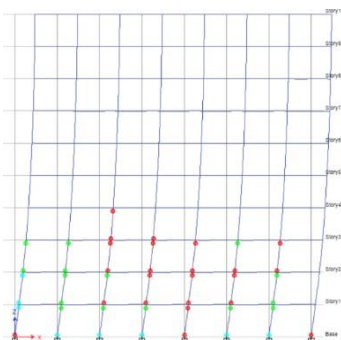


Figure 7: hinge formation for 20% opening in slab

The plastic hinges in the building are formed at different displacement levels. First Plastic hinge formation starts at displacement of 47.96mm at a base

force of 2757.01KN at first storey beams. It is observed that collapse hinge is formed at ground storey column at a displacement of 270.84mm and base force of 14697.86 KN.

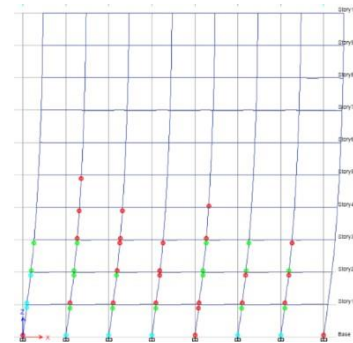


Figure 8: hinge formation for 30% opening in slab

The plastic hinges in the building are formed at different displacement levels. First Plastic hinge formation starts at displacement of 46.8mm at a base force of 2563.85KN at first storey column. It is observed that collapse hinge is formed at ground storey column at a displacement of 219.85mm and base force of 10366.28 KN.

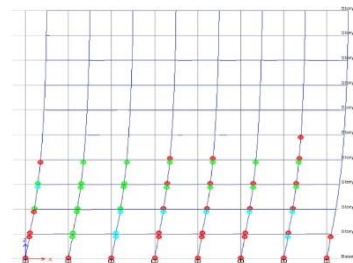


Figure 9: hinge formation for 40% opening in slab

The plastic hinges in the building are formed at different displacement levels. First Plastic hinge formation starts at displacement of 77.75mm at a base force of 2015.99KN at ground storey column. It is observed that collapse hinge is formed at ground storey column at a displacement of 227.85mm and base force of 10101.28 KN.

V. CONCLUSION

1) Frame building model with 10% opening in slab has 1.45 times more base shear as compared to frame without opening in slab and displacement has increased 1.49 times more than frame without opening in slab. From above we can conclude that base shear has been increased when opening is introduced in building.

2) Frame building model with 20% opening in slab has 1.23 times more base shear as compared to 10% opening in slab and displacement has increased 1.53 times more than 10% opening in slab.

From the above observation we can conclude that frame with 20% opening has better base shear than 10% opening base shear increased when opening is increased in frame.

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- 3) Frame building model with 30% opening in slab has 1.41 times less base shear as compared to 20% opening in slab and displacement has decreases 1.24 times less than 20% opening in slab. From above we can conclude that the base is decreased when opening in slab is increased more than 20%.
- 4) Frame building model with 40% opening in slab has 1.45 times less base shear as compared to 20% opening in slab and displacement has decreases 1.20 times less than 20% opening in slab. From above we can conclude that the base shear and displacement is decreased when opening is increased more than 20%.
- 5) From the above results it can be concluded that the optimum percentage of opening which can be introduced in a building is 20% as it has more displacement and base shear as compared to frame without opening and frames with opening of 10%, 30% & 40%.
- 6) In seismic prone areas where opening in slab is to be provided for architectural purpose 20% opening in slab can be provided as it performs better.

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