

Seismic Performance of Flat Plate Floor Building with Diaphragm Discontinuity

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Abstract— The objective of this study is to determine how a diaphragm discontinuity will affect a flat plate slab, multi-story building (G+15) with a shear wall. The ETABS v13.2.0 software is used to model a 15-story flat plate R.C.C.-framed building for equivalent static method analysis and response spectrum analysis. A horizontal structural component called a diaphragm transfers lateral loads to the structure's vertical load-bearing components. Discontinuities in the diaphragm are used for illumination, aesthetic appeal, and other purposes, but these openings in the diaphragm cause stress at discontinuities at joins with the building components. When subjected to lateral loads, buildings with diaphragm discontinuity typically sustain damage. However, the structure's susceptibility to damage can be reduced by strategically positioning this diaphragm discontinuity. The strength and serviceability of the structure can be improved by strategically placing the diaphragm discontinuity. Additionally, their existence can significantly change how the diaphragm functions. In this project, the effects of variables like the position and eccentricity of the diaphragm discontinuity are investigated. For all the investigated examples, post analyses of the structure, such as maximum story displacement, base shear, and story drift, are computed and then compared.

Keywords: Diaphragm Discontinuity, Flat Plate Slab System, Seismic Analysis, Response Spectrum Analysis, Story Displacement, Story Drift, Story Shear, ETABS

I. INTRODUCTION

Most buildings today are created with aesthetics in mind. As a result, the elevation and plan arrangements of the constructions will be irregular. Earthquake damage in multi-story framed buildings typically starts where structural weaknesses occur in lateral load resisting frames. The proportion of mass, stiffness, and strength in the buildings' horizontal and vertical planes determines how well structures perform during strong earthquake events. These limitations may possibly be caused by discontinuity in stiffness, strength, or mass throughout the diaphragm. Such diaphragm discontinuities are typically connected to sudden change in frame geometry that can occur anywhere along the building's length. Structural engineers have developed to prioritize structures with more or less homogeneous mass, stiffness, and strength distributions. For several reasons, such as stairwells, lighting, and architectural design, floor openings are common. Tensions develop at the openings' discontinuities. As the load distribution discontinuities are brought on by openings in the slab, buildings with diaphragm discontinuity typically damage when exposed to lateral loads. However, the vulnerability of the building to destruction can be diminished by strategically arranging these openings. Openings can be strategically positioned to increase the

strength and effectiveness of a structure. Additionally, their existence can significantly change how the diaphragm functions. It's critical to evaluate the structural performance of both new and old buildings to determine their resilience to disaster.

Residential, commercial, and contemporary trend buildings have all become significantly taller. The two most appealing and widely used systems today are the shear wall and flat slab systems. Flat slabs are RC slabs with vast spans that are spread over numerous bays and merely supported by columns, without beams. It is fairly easy to design a flat slab system, and it is effective in that it just calls for the bare minimum building height for a specified number of stories. A zone of supports experiences vertical forces, and the structure in question has a significant bending moment. In comparison to reinforced concrete, this results in a very efficient structure that uses less materials and has a shorter economic lifespan. The structural behaviour of steel is enhanced by post tensioning. The structural behaviour of flat slab structures is significantly improved by post tensioning. Many designers find this concept to be more acceptable. In some office buildings, it is used. The flat slabs are plates that have drop panels or column capitals to reinforce them close to the column supports (which are generally concealed under drop ceilings). Because of its improved ability to withstand shear and hogging moments close to the supports, it is appropriate for higher loads and longer spans. For spans of 4 to 9 metres, the slab thickness ranges from 125 mm to 300 mm. The flat slab system has the largest dead load per unit area when compared to the other floor types.

The size, geometry, and shape of the structure all have a significant impact on how it responds during an earthquake. Numerous structural irregularities, including plan irregularity and vertical irregularity, have been specified by the Indian code IS-1893: 2002 (Part-I). The study focuses on how flat plate floor slab buildings with diaphragm discontinuity behave during earthquakes. This has been accomplished using the finite element computer programme ETABS (V. 9.7.1). The main objective of the study is to evaluate the effects of diaphragm discontinuity on RC flat plate floor structures using linear static seismic analyses (Equivalent Static Method) and linear dynamic seismic analyses (Response spectrum analysis). The response characteristics that are used to measure the performance of the structure are maximum displacement, story shear, and story drift. The analysis was performed for soil type III (soft soil) and zone III of India. The primary objective of this study is to compare various factors, including the position, and symmetry of diaphragm discontinuity. Results and conclusions are determined from the response parameters listed above.

II. OBJECTIVES OF THE PRESENT WORK

The main objective of this work includes the following:

- To carry out response spectrum analysis of RC flat plate slab building with diaphragm discontinuity using ETABS.
- To study the seismic behaviour of RC flat plate slab building with diaphragm discontinuity.
- To know the behaviour of the building with change in the position of the diaphragm discontinuity.
- To study the influence of symmetry of the diaphragm discontinuity on the seismic performance of RC flat plate slab building.
- To study the parameters such as storey drift, storey displacement, story shear in RC flat plate slab building.

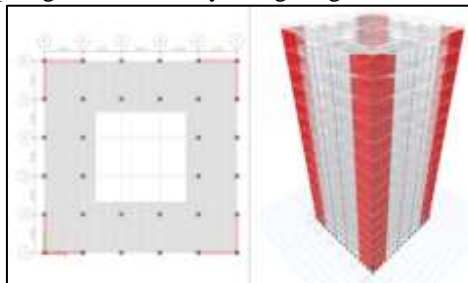
III. MODEL DESCRIPTION

In the present study 5 different models of 15 storey which is having 5 bays of 4m in both x- direction and y direction with the plan dimension of 20m X 20m and a storey height of 3m. Materials used are M25 & Fe415, Depth of slab 10 cm, floor finish - 1kN/m², Imposed load 3 KN/m², Unit weight of concrete 25 KN/m³, Modulus of elasticity, E-2.48×10⁷ KN/m² and Shear modulus of concrete, G - 1.03 ×10⁷ KN/m². Shear walls are provided at the exterior corners of the building. The building was modelled in ETABS for all types of models which have different arrangements of diaphragm discontinuities. Also, the building is in seismic zone III with zone factor- 0.16, site- type 2, I-1, and R-5.

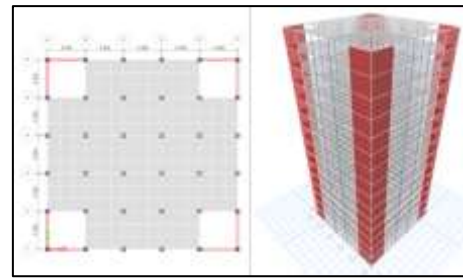
IV. MODELS CONSIDERED FOR ANALYSIS

Following 5 models are analysed by equivalent static method and response spectrum method using ETABS software.

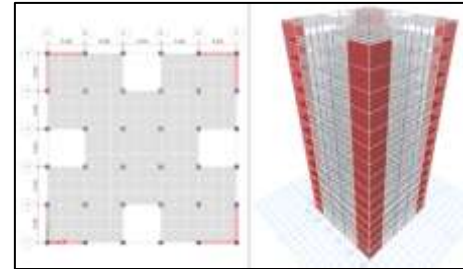
- 1) Model 1: Flat plate floor building with diaphragm discontinuity at centre
- 2) Model 2: Flat plate floor building with diaphragm discontinuity at corner
- 3) Model 3: Flat plate floor building with diaphragm discontinuity at periphery
- 4) Model 4: Flat plate floor building with asymmetric diaphragm discontinuity along transverse axis
- 5) Model 5: Flat plate floor building with asymmetric diaphragm discontinuity along longitudinal axis



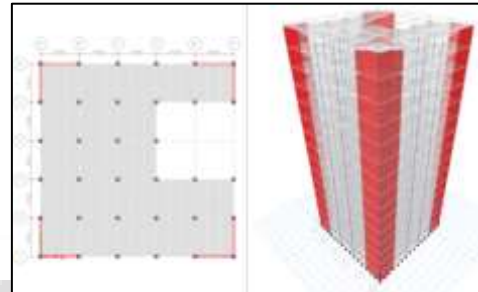
Model 1



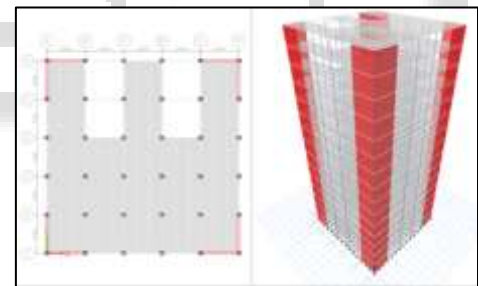
Model 2



Model 3



Model 4



Model 5

Fig. 1. Models

V. RESULTS AND DISCUSSION

For the parameters base shear, story drift, and story displacement, the results of the ETABS analysis of the G+15 model using the response spectrum method with and without a diaphragm discontinuity are tabulated and discussed.

A. Base Shear

The maximum expected lateral force that will result from seismic ground motion at the base of a structure is estimated as base shear.

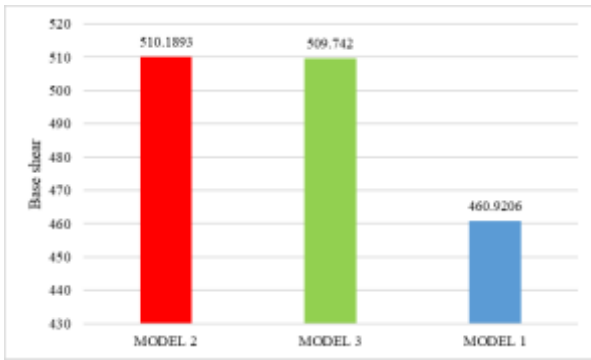


Fig. 2: Base shear comparison for various position of diaphragm discontinuity

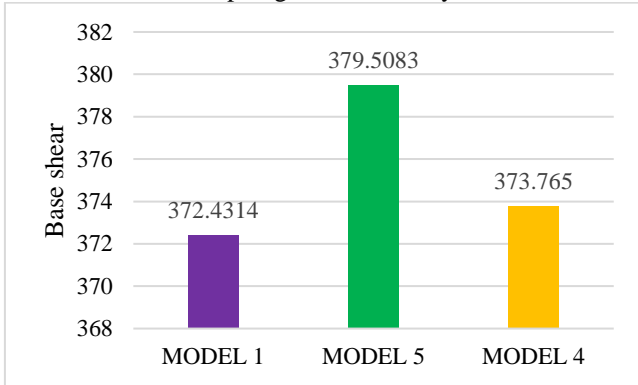


Fig. 3: Base shear comparison for symmetric and asymmetric diaphragm discontinuity

The base shear comparison for position and symmetry of diaphragm discontinuity is as shown in “Fig.2” and “Fig.3” Highest base shear has been observed in MODEL 2 and least in MODEL 1. Also, Seismic base shear is more in MODEL 5 and less in MODEL 1.

B. Storey Displacement

When a structure is subject to wind and seismic pressures, storey displacement is an important factor. The key factor is the structure's height; taller buildings are more adaptable to lateral loads. At the top story, displacement values will be higher, and at the bottom, it will be lower.

The influence of position and symmetry of diaphragm discontinuity on the maximum displacement of the building is as shown in “Fig.4” and “Fig.5” respectively. Model 1 offers least displacement than MODEL 2 and MODEL 3. Also, MODEL 1 shows least displacement than MODEL 4 and MODEL 5.

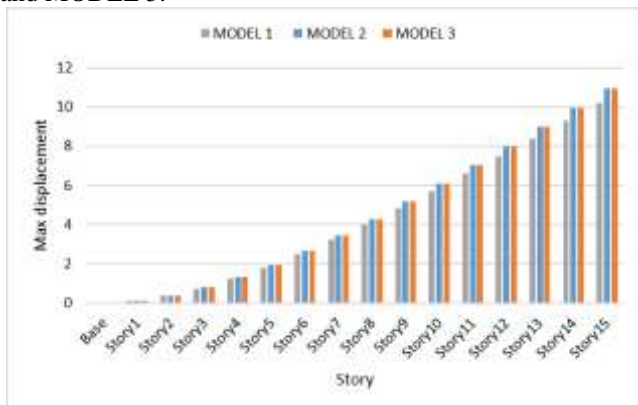


Fig. 4: Max Displacement comparison for various position of diaphragm discontinuity

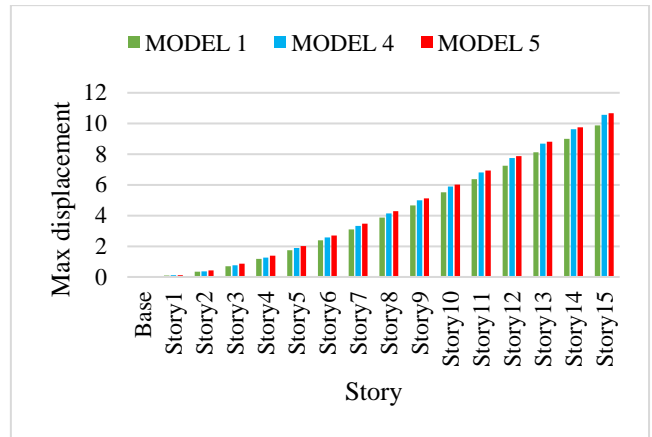


Fig. 5: Max Displacement comparison for symmetric and asymmetric diaphragm discontinuity

C. Storey Drift

It is nothing more than the differential for how one story is moved relative to the other story. According to rules, its value should not be greater than 0.004 of the story's height. At mid stories, its value is typically at its highest.

“Fig.6” and “Fig.7” shows the story drift comparison of position and symmetry of the diaphragm discontinuity. In this study MODEL 1 has shown least drift and highest on MODEL 3 and MODEL 5.

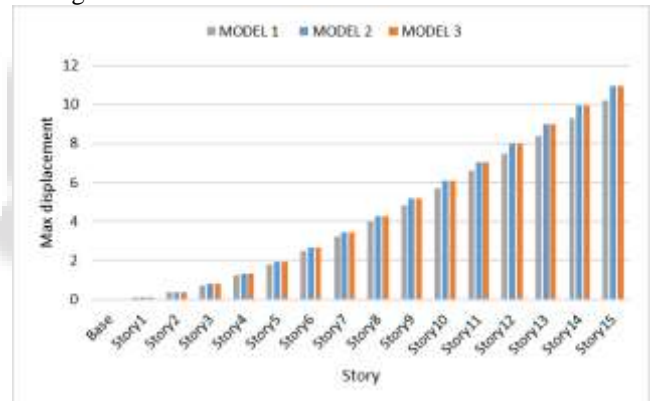


Fig. 6: Story drift comparison for various position of diaphragm discontinuity

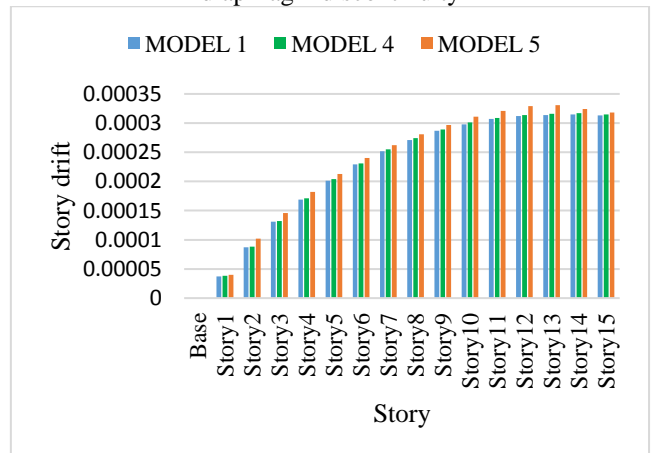


Fig. 7: Story drift comparison for symmetric and asymmetric diaphragm discontinuity

VI. CONCLUSIONS

From the results obtained by the analysis, following conclusions are drawn.

- 1) Opening located at centre offers least displacement and drift than openings located at corner and periphery respectively.
- 2) Also, highest displacement and drift has been observed for opening located periphery.
- 3) Seismic base shear is more at diaphragm discontinuity located at centre and less in corner.
- 4) Hence diaphragm discontinuity located at centre is more effective in terms of displacement, drift, and base shear.
- 5) Asymmetric diaphragm discontinuity along longitudinal axis offers the highest story displacement and drift.
- 6) Least story displacement and story drift are observed for the model having symmetric diaphragm discontinuity.
- 7) In case of base shear, asymmetric diaphragm discontinuity along longitudinal axis offers high base shear having asymmetric diaphragm discontinuity along longitudinal axis.
- 8) The displacement and drift are proportional to the height of the building.
- 9) Story drift acting on all models are with the limit as per the code.
- 10) From the study it can be concluded that a symmetric diaphragm discontinuity at the centre position of the plan area will be the optimum one.

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