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Analysis of a Structure Under Diaphragm Irregularities A Review

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ABSTRACT

Many buildings in the present scenario have irregular configurations both in elevation and plan. This in future may be subject to devastating earthquakes. It is necessary to identify the performance of the structures to withstand disaster for both new and existing buildings. Now a days openings in the floors is common for many reasons like stair cases, lighting architectural etc., these openings in diaphragms cause stresses at discontinues joints with building elements. Discontinuous diaphragms are designed without stress calculations and are thought-about to be adequate ignoring any gap effects. Earthquakes are natural dangers under which catastrophes are primarily caused by destruction or fall of structures. In the current situation, the majority of buildings are planned and erected on the premise of looks which occurs to disregard the underlying concepts of earthquake resistance, where researchers come across several buildings having uneven shapes both in height and plan.
Keywords: Earthquakes, gap effects, Analysis, Staad, Forces.

I. INTRODUCTION

In multi-storied framework structure, damages from earthquake usually starts at sites of structural flaws present in the horizontal load bearing frames. This behavior of multi-storey framework structures during powerful seismic movements relies on the arrangement of mass, rigidity, strength in both the vertical as well as horizontal lines of buildings. In few instances, these vulnerabilities may be caused by gaps in rigidity, strength or bulk along the diaphragm. Such gaps between diaphragms often are linked with abrupt changes in the frame shape along length of the structure. Structural engineers have acquired trust in the construction of structures in which the divisions of mass, rigidity and strength are largely consistent. There is a less trust about the construction of buildings having uneven physical shapes (diaphragm discontinuities) (diaphragm discontinuities).

According to IS-1893:2002: Diaphragms with sudden gaps or differences in stiffness, which encompasses some these having cut-out or uncovered sections larger than 50 percent of the total contained diaphragm surface, or changes in functional diaphragm rigidity of more than 50 percent through one level to the next. In structural engineering, a diaphragm is indeed a structural device used to transmit horizontal stresses to shear walls or frameworks mainly through in-plane shear stress. Lateral pressures are typically wind and seismic stresses. Two main kinds of diaphragm are stiff and pliable. Flexible diaphragms withstand transverse pressures based on the region, independent of the elasticity of the parts that they are transmitting force to. Stiff diaphragms transmit weight to frameworks or structural walls based on their elasticity and their position in the construction. Flexibility of a diaphragm effects the spread of lateral pressures to the vertical components of a lateral force resisting parts in a building.

To provide a detailed review of the literature related to diaphragm discontinuity in its entirety would be difficult to address here. A brief review on diaphragm discontinuity of previous studies is presented here. This literature review focuses on recent contributions related to diaphragm and past efforts most closely related to the needs of the present work.

II. LITERATURE REVIEW

Amruta Murali and Reni Kuruvilla (2023) research paper presented the seismic behaviour of a 20 storied building with different slab openings using response spectrum analysis in ETABS. The analysis was considered on parameters such as base shear,and story drift and compare them with the regular model. Results stated that the story drift reduced for slab opening at the center up to 53.22% compared to the corner and 64.19 % compared to the periphery position for 1% of slab opening. The base shear reduced for slab opening at the center upto 46.64 % compared to the corner and 58.91% compared to the periphery position for 1% of slab opening. Slab opening at the center was found to be more effective in resisting lateral forces. The base shear of the regular building was less compared to the base shear values of the diaphragm having openings. Maximum story drift of a regular building was less compared to the maximum story drift values of the diaphragm having an opening.

Y. Nanda Kishore et.al (2023) objective of the research paper was to investigate the behaviour of G+15 multi storeyed with diaphragm having opened under non-linear static (Pushover) analysis utilizing ETABS to achieve these outcome various models with various proportion of diaphragm openings were analyzed and contrasted for seismic parameters like maximum story displacement, base shear, maximum story drifts, as well as pushover results.
Modal Analysis results stated that there are some unusual modes when diaphragm discontinuity modelled. However, the mass participation for those modes is found to be negligible. Provision of diaphragm opening alters the seismic behavior of the buildings. Models with symmetrical opening in both directions expressed similar response for all the parameters while models with change in the symmetry behaved different. The influence of diaphragm openings on the seismic response of multi-storied buildings played a major role in reducing the Maximum story displacement, story drift and base shear, hence attracting lesser seismic forces than the conventional structure.

Rohan V. Thakar and Jigar Zala (2022) research paper presented analysis to compare the influence of rigid and flexible diaphragm using the finite element software Midas gen. Rectangular, L shape, U shape, T shape were employed, as well as storey variation G+5, G+10, G+15. Each model examined both with and without a shear wall in place. IS 1893:2002 response spectrum analysis was used to analyse response quantities like storey drift, storey displacement, fundamental natural period, and column axial force.

Comparing the response in terms of fundamental natural period of all buildings, fundamental period was larger when flexible diaphragm is used, whereas rigid diaphragm underestimate the natural period of the building in shear wall or without shear wall resisted structure. In shear wall resisted structure ignoring the diaphragm flexibility cause large underestimate of storey drift, storey displacement, and Fundamental natural period. The response in terms of storey drift flexible diaphragm structure will give higher drift in middle storeys, as the height increases percentage difference between rigid and flexible diaphragm also increases in all shapes.

Sagar P. Khunt and Malay D. Shukla (2022) research paper presented a performance based seismic design of re-entrant corner G+10 RCC Buildings with different shapes of opening in diaphragm under the zone III and zone v by choosing performance criteria in terms of Inter-storey drift (IDR) and inelastic displacement demand ratio (IDDR). The Capacity Spectrum Method of Pushover Analysis was performed in SAP 2000, based on FEMA 365 and ATC 40 guidelines, to investigate the performance of RC buildings designed as per IS 1893:2016 with Re-entrant Corner combined diaphragm discontinuity.
Results stated that pushover curve shows opening in Diaphragm decrease base shear capacity significantly. At performance point reduction of base shear is almost 22.05%, 37.46%, 9.85%, and 37.47% in both directions for all the Models compared to model I (For Initial Section Size). The L-shape of the building had base shear reduced but the building base shear increased.

S.M. Nizamoddin and Hamane A.A (2022) research paper presented the effect of diaphragm discontinuity and optimization of structural response of RC structure with varying percentage of diaphragm discontinuities. A plan of school building was considered with the different percentage of opening for analysis and modelling using E-tabs software. Seismic behaviour of the model was obtained by performing model analysis to compare the results of base shear, story drift, maximum story displacement.

Results stated that the story shear was maximum for 20% opening having shear wall at corners which showed decrease in the story shear increases opening percentage. Storey displacement was higher without shear walls as compared to the model with shear wall. Story drift ratios for all models within the limits of 0.004H as per codal provision of IS 1893-2002 and base shear was greater only in structure with shear walls at corners and at the periphery of wall.

Akshay Nagpure and S. S. Sanghai (2021) in the research paper, RCC framed building structures was analyzed using ETABS software by linear time history analysis by changing flexibility of the floors and simultaneously when plan irregularities are provided. Time history record of El Centro Earthquake was provided to the software. The primary aim was to compare the responses of the structures when floor diaphragm flexibility changed and simultaneously plan irregularities was provided.
Conclusion stated that floor diaphragm flexibility affects base shear of the building, column forces, beam forces but doesn't show considerable difference in time period and storey drift. Orientation of the openings in the building plan changes the responses of the structure under seismic load. The Flexibility of the slabs plays vital role in reducing base shear, column axial forces. Opening at the faces of the floors in shorter side gives comparatively larger Base Shear but Column forces where found higher when openings were in longer side.

Anjeet Singh Chauhan and Rajiv Banerjee (2021) in the research paper, G+10 RCC Stepback building having each storey of height 3.6m with a horizontal angle of inclination 20°, 30°, 40º, and 45° on the sloping ground was analyzed in seismic zone V by Response Spectrum method by Etabs software as per IS 1893:2016 to compare the building based on their dynamic response properties like mode Period, Base Shear, Story deflection, Story drift, and story shear and identified the frame vulnerability in irregularities of structure on the sloping ground.

Results stated that the stepback bare frame with mass irregularity was more vulnerable and not suitable on the sloping ground during the seismic excitation due to excessive seismic weight and more dynamic response as compare to other models. The stepback bear frames with Diaphragm irregularity was less vulnerable and suitable on the sloping ground during the seismic excitation due to less seismic weight and fewer values of dynamic response as compare to other models.

Andrea Roncari et.al (2021) research paper dealt with a steel-CLT-based hybrid structure built by assembling braced steel frames with CLT-steel composite floors. Preliminary investigation on the performance of a 3-story building under seismic loads was presented, with particular attention to the influence of in-plane timber diaphragms flexibility on the force distribution and lateral deformation at each story. The building complies with the Italian Building Code damage limit state and ultimate limit state design requirements by considering a moderate seismic hazard scenario. Nonlinear static analyses are performed adopting a finite-element model calibrated based on experimental data.
The actual in-plane stiffness of floor diaphragms induces a reduction of the lateral building's stiffness (ki) between 24.2% and 27.5% compared to ideal rigid floor diaphragms. The CLT-steel composite floor in-plane deformability shows mitigated effects on the load distribution into the bracing systems compared to the ideal rigid behavior. On the other hand, the lateral deformation always rises at least 17% and 21% on average, independently of the story and load distribution along the building's height.

Nishad N (2021) objective of the research paper was to investigate the effect of diaphragm flexibility on the ductility demand on the LLRS, the impact of post-yield hardening in LLRS on the response of the system, the distribution of shear forces and bending moments along the length of the diaphragm when the system was subjected to ground motions, the effect of pinching behaviour in LLRS on the total response and behavior of the system, the consequence of nonlinear behaviour in the diaphragm system and the concept of diaphragm acting as the main energy dissipating member during earthquakes. The modelling and analysis of the building with precast wall panels was done using ETABS.
The rigid diaphragms connected with cladding panel, load bearing wall and shear wall, totally encountered a reduction in in-plane stresses with a range of 5%-33%, 6%-33% and 3%-8% respectively, than semi-rigid and flexible diaphragm. The discontinuity had no major impact on Cladding Panels, as the overall stresses experienced on Cladding Panel is almost half of that experienced for Load Bearing Walls Shear Wall met up with comparatively more in-plane stresses, bending moment and out-plane stresses exceeding Load Bearing Wall with a range of 2%-10%Load Bearing Wall is subjected to comparatively less axial force than Cladding Panel and Shear Wall Torsion is induced in a greater proportion on the Load Bearing Wall and Shear Wall The extreme distinction between the uncracked and cracked status of Load Bearing Walls, indicated its lower stability.

Amaranth Dodamani and Sujeet Patil (2020) in the research paper, a regular 15 storey RC buildings having slab opening at central, corner and peripheral opening are provided with different stiffness modifiers according to code IS 16700:2017 was modelled and analysed by ETABS (2018). Response spectrum method is adopted for the analysis and the parameters like storey displacement, storey drift, base shear was compared and investigated.

Results stated that storey drift value in structure without slab opening had more drift when it compares to structure with slab opening. Storey displacement value in structure without slab opening has more displacement when it compares to structure with slab opening. Structure with unfactored stiffness modifiers has less deflection compared factored modifiers. From maximum storey drift and base shear view, slab openings at centre was found to be more effective in resisting lateral forces.

Md Faisal Zia and Rajiv Banerjee (2020) objective of the research paper was to investigate the retaliation of plan irregular structures as per IS 1893 part 1 in seismic zones IV and V and collate with reaction of regular building model. Modelling and analysis are done as per IS 1893 part 1 by response spectrum method in etabs software and comparative results were evaluated on parameters of base shear, max. story displacement, max. story drift, overturning moment.

Results stated that regular building showed maximum lateral force at the base. Irregular plan building shows decrease in the value f base shear when percentage of irregularity increases. But when it comes combined irregular building model showed maximum base shear. Hence, weight of building also effects base shear, more weight more base shear. Results further concluded that due to more weight of the building base shear and overturning moment is more and due to unsymmetry of the structure max. displacement and story drift is more.

III. CONCLUSION

The seismic behavior of multi-storied building frame during an earthquake motion depends upon the distribution of strength, mass and stiffness in both horizontal and vertical planes. All models are analyzed by using design and analysis software ETABS or SAP and designed as per IS 456:2000 and IS 1893:2002. Push over analysis is a non linear static analysis had been used to obtain the inelastic deformation capability of frame. Only non-linear dynamic analysis is more accurate than pushover analysis; where non-linear dynamic analysis is time taking to perform. In order to obtain dynamic response of the structure, Time history analysis is carried out. So we can conclude that pushover analysis is the appropriate method to use for performance based design to get the response of the structures. Boskey Bahoria gives the idea about the post tensioned flat slab building structure having four cases depending upon by varying the span length by 0.5 m interval and discuss the comparative study of four cases with respect to economy.U. Prawatwong makes a two models one with drop panel shows the connections between slab-column and another is without drop panel shows connection between interior columns with PT flat plate and bonded tendons having seismic performance on two three fifth scale pattern under constant gravity load to investigate the seismic performance. Using the RAPT and ETABS softwares, Jnanesh Reddy RK examines the cost effectiveness of the post-tensioned flat slab with respect to the RCC flat slab, concluding that the PT flat slab is preferable to the RCC flat slab since it lowered the dead load by reducing slab thickness.

The drop panels and columns only provide a direct support for the slab in certain construction styles, according to the summary. Floor to floor height of the building decreases as a result of direct support from drop panels and building columns, making more space accessible for our usage. When we compare a flat pt slab to a regular slab, the results show that the cost and reinforcement are both 30% higher for the conventional slab. Due to the beam's ability to handle a greater load, the post-tensioning slab required more reinforcing. Formwork can be removed early when post tensioning with a reinforcement beam, however it cannot be removed earlier in a usual situation. More concrete is needed for one level in a PT slab with a reinforced concrete beam than in a PT slab alone.

IV. CONCLUSION

Here author stated that the results we opted from different researches explains the utilization of researches related to analysis of structures.

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