Analysis of A G+11 Structure Considering 4 Different Diaphragm Irregularity Conditions Under Seismic Load Using ETABS: 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.*

In this paper, we are conducting a research on "analysis of a g+11 structure considering 4 different diaphragm irregularity conditions under seismic load using etabs"

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.

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.

Mohini R Bhanwase and Y. P. Pawar (2020) research paper identified seismic performance of multistoried building with diaphragm discontinuity by comparing with seismic performance of multistoried building without diaphragm opening. The effects of opening in slab were investigated.
Results stated that the impact of diaphragm opening of multistoried building on seismic response played a major role in base shear. Provision of diaphragm opening changes the seismic behavior of the building. Models having similar response for all parameters while models having change in the symmetry behaved differently. The diaphragm opening at center founds more effective i.e. internally diaphragm openings are more effective than external diaphragm opening.

K. Sanjay and P.Mallikharjuna Rao (2018) in the research paper, a residential G+11 multi story building was investigated for earthquake and wall loads using response spectrum method and STADD PRO. This analysis was

carried out by considering different seismic zones and for each zone the behavior was assessed by considering the soft soil. Different response like story drift, displacements base shear was plotted for different zones and different types of soils.
Results stated that Base shear and lateral displacements are gradually increased with increase in zone factors for both the models. The lateral displacement is less in regular model compare to vertical irregular model. The base shear is almost same in regular model and irregular model, max base shear is in zone 5 in regular is 1376.23 KN and in irregular 1351.44 KN. The regular model showed less displacement compare to irregular model (soft storey), max displacement in zone 5 in regular is 54.87mm and in irregular it was 58.36mm. The regular model showed less displacement compare to irregular model (soft storey), max displacement in zone 5 in regular is 54.87mm and in irregular it is 58.36mm.

Arya V Manmathan and Aiswarya S (2017) objective of the research paper was to investigate the seismic performance of a multistory building with slab openings by Response Spectrum analysis and identify suitable location of openings and effect of size of openings in slab. The modelling and analysis of the case study was done using analytical application ETABS.

Results stated that the percentage reduction of storey drift for slab opening at centre is 53.02% compared to corner and 64.13% compared to periphery position. The percentage reduction of base shear for slab opening at centre is 46.44% compared to corner and 57.3% compared to periphery position. The percentage reduction of storey base shear for circular column is 10.12% compared to rectangular column and 7.5% compared to square column. Considering the drift point of view, square column is better and from base shear point of view, Circular column is better. The percentage of slab openings at centre, corner and periphery positions in case of storey drift increases up to 2% opening and it reduces for 3% opening. It attains a constant value for 4% and 5% slab opening. As the percentage of slab opening increases, base shear also increases.

Reshma K Bagawan and M Q Patel (2017) in the research paper, two types of diaphragm discontinuities are considered as stiffness irregularity and mass irregularity in the slab portion considering a regular G+5 and G+10 reinforced concrete (RC) buildings modelled with and without diaphragm discontinuity and analyzed by computer software ETABS (2016). The building was 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 compared for regular building and building with diaphragm discontinuity.

Results 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 was less susceptible to earthquakes.

Reena Sahu and Ravi Dwivedi (2017) research paper portraited the behavior of multi storied buildings with diaphragm openings under earthquake static analysis and response spectrum analysis using STAAD.Pro. The primary objective of various models with varying percentages of diaphragm openings were analyzed and compared for seismic parameters like base shear, maximum storey drifts, shear force, bending moment and axial force.
Results stated that the base shear in the buildings calculated from the earthquake static analysis is higher than the response spectrum analysis. Provision of the diaphragm opening alters the seismic behaviour of the buildings. Models with a symmetrical opening in both directions expressed similar response for all the parameters while models with change in the symmetry behaved differently. Storey drift in the buildings calculated from the earthquake static analysis is higher than the response spectrum analysis. Shear force, bending moment and Axial Force obtained from the earthquake static analysis is higher as compared to response spectrum analysis.

Vinod V and Pramod Kumar H V (2017) author investigated the effect of discontinuities in the diaphragm namely 0%, 10%, 20%, and 30% openings while comparing the seismic behavior of four and eight story RC building. ETABS 2015, FE analysis software with response spectrum analysis as per IS 1893 was used to assess the seismic behavior. Parameters such as natural time period, base shear, mode shape, drift and displacements and internal forces in members was used to compare the seismic performance.

Results showed that building with stiffness diaphragm was better to use in all multi story building for those areas which are prone to earthquake. 20% of opening was better one when compared other condition. Optimum percentage 20% opening or Discontinuity of stiffness diaphragm can be used in the seismic prone RC multistory building, even the number of story height increases the same comparison results of 20% openings can be utilized Discontinuity in diaphragm shows that optimum percentage of openings with stand the seismic forces in earthquake areas.

Babita Elizabath Baby and Sreeja S (2016) in the research paper, a typical multi storeyed building was analyzed using

commercial software ETABS for nonlinear static (pushover) and dynamic (response spectrum) analysis. Slab openings were provided as discontinuity at different locations such as at center, at corners and at periphery further, linear and nonlinear analysis (push over analysis) was done.

Results stated that model having openings located at the periphery was more effective for resisting lateral forces. Comparisonwas done for the linear and nonlinear analysis and around 4% variation was visible for linear static analysis and response spectrum analysis. 7% variation was visible for linear static analysis and pushover analysis.

Hema Mukundan and S.Manivel (2015) in the research paper, a 10 storey building in Zone IV was presented to reduce the effect of earthquake using reinforced concrete shear wall-framed structures in the building. The response spectrum analysis was done using ETABS version 9.7.4 in the form of maximum storey displacements, base shear reactions, mode shapes and storey drifts. Effect of Irregularity was investigated by creating openings in shear wall and by varying the thickness of shear wall, along the storey‟s. Results inferred that shear walls are more resistant to lateral loads in regular/Irregular structure. The moments in the columns got reduced when shear wall is introduced in the structure. The maximum storey displacement of the building is reduced by 50% when shear wall is provided. Shear wall with openings and with varying thickness is still strong & stable enough to resist seismic loads. For safer design, the thickness of the shear wall should range between 150mm to 400mm.

S Monish and S Karuna (2015) objective of the research paper was to investigate two types of plan irregularities namely diaphragm discontinuity and re-entrant corners in the frame structure. These irregularities are created as per clause 7.1 of IS 1893:2002(part1) code. Various irregular models were considered having diaphragm discontinuity and reentrant corners which were analysed using ETABS to determine the seismic response of the building. The models were analysed using static and dynamic methods, parameters considered being displacement, base shear and fundamental natural period. The model which is most susceptible to failure under a very severe seismic zone is found, modelling and analysis is carried out using ETABS.

The results obtained from the response spectrum method are accurate, when compared with results of the equivalent static method, since the method is based only on an empirical formula. The performance of model D1 (H shaped) and L3 was more vulnerable to earthquakes than rest of the models. The results of fundamental natural periods have proved that, the code IS 1893:2002 doesn't consider the irregularity of buildings.

III. CONCLUSION

In this paper, we have reviewed some of the authors who tried to analyze different types of models under seismic load criteria by using different analysis and design software.

REFERENCES

[1] Hema Mukundan and S.Manivel, [Effect of Vertical Stiffness Irregularity on Multi-Storey Shear Wall-framed Structures using Response Spectrum Analysis], International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 3, March 2015.

[2] Y. Nanda Kishore, Dr. Vaishali G Ghorpade and Dr. H.Sudarsana Rao, [Effect of Diaphragm Openings in Multi-Storied RC Framed Buildings using Pushover Analysis], Multidisciplinary Journal of Educational Research, 2023.

[3] Babita Elizabath Baby and Sreeja S, [Analysis of Buildings with Slab Discontinuity], International Journal of Science and Research (IJSR), Volume 5 Issue 9, September 2016.

[4] Shaikh Mohammad Azhar Nizamoddin and Hamane A.A., [Effect of Diaphragm Discontinuity of RC Structure with Different Percentage of Diaphragm Discontinuities], International Research Journal of Modernization in Engineering Technology and Science, Volume:04/Issue:08/August-2022, ISSN: 2582-5208.

[5] Md Faisal Zia and Rajiv Banerjee, [Seismic Impact of Re-entrant Corner with Opening in Diaphragm on RC Building], International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277- 3878, Volume-9 Issue-1, May 2020.

[6] Akshay Nagpure and S. S. Sanghai, [Seismic Response of Irregular Building on Sloping Ground], International Journal of Advanced Research in Engineering and Technology (IJARET) 4 Volume 12, Issue 5, May 2021, pp. 181-202.

[7] Anjeet Singh Chauhan and Rajiv Banerjee, [SEISMIC RESPONSE OF IRREGULAR BUILDING ON SLOPING GROUND], International Journal of Advanced Research in Engineering and Technology (IJARET) 4 Volume 12, Issue 5, May 2021, pp. 181-202.

[8] Amaranth Dodamani and Sujeet Patil, [Seismic Analysis of Multi Storied Building with Diaphragm Discontinuity], International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 09 | Sep 2020.

[9] Mohini R Bhanwase and Y. P. Pawar, [Seismic Performance of Multistoried Building with Diaphragm Discontinuity], International Journal for Scientific Research & Development| Vol. 8, Issue 8, 2020| ISSN : 2321-0613.

[10] Sagar P. Khunt and Malay D. Shukla, [Performance Based Seismic Design of Multistorey RCC Buildings with Re-entrant Corner Combine Diaphragm Discontinuity], IJARIIE-ISSN(O)-2395-4396, Vol-8 Issue-3 2022.