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A Review Paper on Seismic Impact of Re-entrant corners with varying angle on G+15 Story Y Shaped Irregular Building

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Abstract: This dissertation is concerned with the study of the behaviour of re-entrant corners with different angles on a Y-shaped high-rise building with G+15 floors under seismic loading using dynamic analysis (response spectrum analysis). Unfortunately, India is the most populous country today. The main reason for adopting this building Y-shaped can provide several advantages over traditional rectangular or square buildings, increased natural light and ventilation, and dynamic and interesting designs. ... The objective of the current analytical study is to determine how certain parameters affect the behaviour of a structure with re-entrant corners with different angles in a Y-shape. The aspect of different performances of a building with different angle limb Y-shape under seismic forces is described in this work, specifically for different angle Y-shaped building structures. In this paper, a fifteen-story building in RC -a frame structure for the IV zone is studied. The eight models of the fifteen-story RC -frame building was created with different angles 30 °,45 °,60 °,75 °,90 °,120 °,135 °, and 150 °. The bare frame model, the infill and eight versions of the infilled frame were studied, each with different angles (one angle at a time from bottom to top). The computer program ETABs is used to model the entire building. The analytical results are discussed in terms of base shear, lateral displacement, lateral forces and maximum bending moment, storey drift and storey disbarment

Index Terms – Re-entrant corner, varying angle, etab high rise building, seismic analysis, Response spectrum method

I. Introduction

An earthquake is a natural phenomenon that results from a sudden release of energy in the earth's crust, triggering seismic waves that can shake the ground and rupture the surface. The effects of earthquakes can be devastating, causing ground shaking, liquefaction, landslides, tsunamis, and building collapses. To mitigate the risks associated with earthquakes, civil engineers, architects, and urban planners employ a number of strategies, including seismic design, building codes and standards, and hazard mitigation planning. Many structures have been damaged by irregular construction. Seismic design requirements for buildings do not provide appropriate criteria for predicting the actual displacement of such structures. A Y-shaped building is usually a triaxially symmetrical building in which three separate legs are bridged in a central core section. Due to certain engineering or architectural requirements, the symmetry between the wings is not properly maintained, and the angle of the legs may be changed.

The behavior of a building depends on the arrangement of the structural elements that are present in it. The main aspects on which the structural configuration depends are geometry, shape and size of the building. When a building is subjected to dynamic loads, inertia forces develop that are concentrated at the center of mass of the structure. Typically, the vertical members such as columns and shear walls resist the horizontal inertia forces, and the resultant of these forces is concentrated at a point called the center of stiffness. When the center of mass doesn't coincide with the center of stiffness, eccentricity occurs in the structure. The eccentricity is caused by the irregular arrangement of the structural configuration, which in turn causes torsion in the structure. The location and size of the structural elements have a significant effect on torsional coupling, which causes damage to the structures. Regular structures don't exhibit significant discontinuities in plan or vertical configurations. Irregular structures exhibit certain physical discontinuities in either plan or elevation, or both, that affect the behavior of the structure under lateral loads. Irregularities in the distribution of mass, stiffness, and geometry over the height of a building are called vertical irregularities. Horizontal irregularities can be attributed to the presence of discontinuities in the floor plan. Various structural irregularities affect the seismic behavior of structures in different ways of change in response depends on the nature, extent, and location of the irregularities present. The wise choice of these parameters in the design of structures improves the performance of the structure.

To date, many researchers have studied the effects of seismic response on structures with vertical and horizontal irregularities. The study includes the dynamic analysis of H- and L-shaped buildings the paper suggests that H- and L-shaped buildings should be divided into rectangular blocks separated by seismic joints. Researchers found that the response of L-shaped building due to torsion is higher than that of regular frame. Patil et al. (2017) studied the dynamic response of multistory buildings with plan asymmetry. They numerically analyzed multistory frames with different plan shapes. They reported that the increase in the height of T-shaped and L-shaped buildings increases the displacement response and the stress at the **re-entrant** corners

Re-entrant corners in buildings affect stress concentration and cause problems due to torsion during earthquakes. Plan configurations of a structure and its lateral resisting system that contain re-entrant corners are prone to two sorts of issues, according to IS 1893 Part 1: 2016 Torsion is the second issue, whereas the first is causing a localized stress concentration in the notch of the re-entrant corner. It is quite challenging to research the resulting forces. There is a connection between the effects of torsion and stress concentration. The building's mass, the type of structural systems, and the length, height, and aspect ratios of the wings will all have an impact on the forces' magnitude.

II. LITERATURE REVIEW

- **Sagar R Padol[1] , Rajashekhar S. Talikoti[2](2015)]: -** A review of the seismic responses of multistory RC buildings with unequal mass was conducted for this work. Time history analysis is one of the most important techniques for structural seismic analysis since the examined structural response is often nonlinear. This study examines and highlights the effects of mass irregularity on different floors of RCC buildings over time using the ETABS software. Numerous past studies have shown that shear walls, base isolation, and other strategies can be used to lessen the effects of earthquakes on buildings.

- ***Mr. Pathan Irfan Khan[1], Dr. Mrs. N.R. Dhamge[2] (2016): -*** This paper highlights the effect of mass irregularity on different floor in RCC buildings with as Response Spectrum analysis using STAAD-Pro V8i software. In this project work seismic analysis of RCC buildings with mass irregularity at different floor level are carried out.. The Model Considered was of G+10 having swimming pool on 3rd, 6th and 9th Floor. Maximum Base Shear along X and Z directions is also calculated. Lateral Displacements and Storey Drift is also evaluated for X and Z directions. Axial Forces, Torsion and Bending Moment are calculated for six different columns. Mass irregularity is an important factor to be considered along with other relevant. Joint displacement, base shear and storey drift will help to decide which structure is efficient.

- ***Gauri G. Kakpure[1], Ashok R. Mundhada[2]* [2016]:-** The paper presents an overview of earlier research on multistorey buildings in relation to earthquake analysis. Building static and dynamic analysis is the main topic. For lower stories, the difference in displacement values between static and dynamic analysis is negligible; however, the difference increases for higher stories, and static analysis provides higher displacement values than dynamic analysis. In comparison to standard buildings, those with re-entrant corners showed increased lateral drift and decreased base shear capability. The value of the tale drift is higher in the regular configuration as compared to the irregular arrangement. Story drift increases as a building's height does

- ***Mya Mya Aye[1], P. Narasimharao[2]*** [2017]: - Analyses of time history for the zone IV-containing G + 11 structure. Time history analysis, mass irregularity, seismic responses, and seismic demands Storey Shear, Storey Displacements, and Story Moments. Software called ETABS was used to design the superstructure. The highest storey drifts are found in storeys seven in the X-direction and three in the Y-direction. Maximum X-direction storey shear is precisely equivalent to maximum Y-direction storey shear. In all orientations, storey one has the highest storey moments. Storey drift and shear parameters.

- ***Ravindra N. Shelke[1], U. S. Ansari[2] [2017]; -*** studied on the G+14, zone 3, and E-shaped building design. with summing pool on the fifth floor, planar and vertical irregularity. There is a procedure called response-spectrum analysis. Vertically irregular structures defined by IS 1893.The maximum tale drift and story displacement will rise in proportion to the models' corresponding increases in vertical irregularities. Lateral displacement, foundation shear, storey drifts, and soft story.

- ***Rajat Srivastava[1], Sitesh Kumar Singh[1]2[2018]:-***In this Investigated by the Using STAAD pro, G+9 Story Building Software. The project building is situated in Delhi (Zone area) and uses parameters like story drift and base shear. With the aid of STAAD PRO software, it is suggested in the current study that a seismic investigation of multi-story RCC structures be completed. This method will take mass irregularity into consideration.

- ***Nirmal Raj[1], Nandini Devi[2] [2018]:-*** Analysed to the G +15 story in seismic zone 4 Software used STAAD pro with various irregularities at re-entrant corners and irregular vertical geometric stiffness. Among the abnormalities taken into consideration, the re-entrant corner irregularity exhibits the worst seismic performance. Response spectrum analysis is used to do the analysis. It is discovered that the regular structure's base shear is 3027 KN. For a normal construction, the SD, BM, and displacement are respectively 0.2 mm, 162 km, and 2.75 mm. The BS for a corner I re-entrant structure is determined to be 1913 KN. For a re-entrant corner, the measured SD, BM, and displacement are 0.9 mm, 191 km, and 12.75 mm, respectively.

- ***[1]Siva Naveen, [2]Nimby Mariam Abraham, [3]Anita Kumari [2019]: -*** in this study Siva and nimby using the shape building T, C, E, Rectangular, + vertical, and plan were employed to form the structure. Story drift (1.5mm) on the second floor and inconsistency in the parameter mass. Displacement(10mm). Seven different combinations of abnormalities were present in twenty cases. Less displacement response has been observed when re-entrant corners and vertical geometric imperfections are combined.

- ***Bharat Khanal[1], Hemchandra Chaulagain[2] [2019]:-*** the present study evaluates the effect of plan configuration irregularity when subjected to the varying angle of the input response spectrum. For this, one regular and six different L-shaped RC building frames were modelled for numerical analysis. The analysis was done through an equivalent static lateral force method and response spectrum analysis (dynamic analysis). The structural responses were measured in terms of story displacement, inter-story drift ratio, torsional irregularity ratio, torsional diaphragm rotation, normalized base shear force, and overturning moment. The results indicate that buildings with plan configuration irregularity are more sensitive to the varying angle of the input response spectrum as compared to the symmetrical building model. The significant increase in seismic response demand was observed when the finite element models were subjected to a 135-degree angle as compared to the zero-degree angle of seismic incidence. The second part of this study is to determine the response of the different models when subjected to the varying angle of the input response spectrum. The induced absolute story displacement and inter story drift response demands show a lower value for the input response spectrum for case II as compared to case I. whereas on the other hand the response induced significantly increases when the L-shaped models are subjected to the 135-degree angle of input response spectrum (case III) as compared to the case I and case II. The increased response could be due to the increase in the eccentricity of the irregular buildings and its associated torsional behaviour. Among all the cases of the input response.

- ***Allauddin Shaik[1] (2019): -*** The purpose of this study paper is to introduce the idea of the response spectrum for analysing multi-story buildings in different seismic zones and to highlight the need to consider this influence into account when setting earthquake resistance requirements. The IS:1893 (Part 1)-2002 code's codal requirements for response spectrum analyses of multi-story buildings are also described. Base shear legitimately depends on seismic acceleration. In light of this, a structure's design base shear would be low if it weren't subjected to powerful seismic forces. Story displacement is the term used to describe the overall estimated movement of the story caused by lateral forces.

- ***Rajiv Banerjee[1], J.B. Srivastava[2](2019):-*** The major objective of the study is to determine the optimal shear wall position for zones III and IV in an irregular building. A G+15 story building is the subject of this investigation. The structure is unevenly formed and has a T shape. A comparison analysis is carried out to decide where the shear wall should be located in the structure. For the sake of efficiency, the overall length of the shear wall in the construction is kept constant. The comparison inquiry is built on the base shear, story displacement, and tale drift. The comparison study came to the conclusion that the placement of the shear wall is essential for increasing resistance to lateral loads.

- ***A. S. Dhanyashree[1], R. Akash[2], M. Ashok[3], S. R. Premsa[4]i, B. N. Bhavyashree[5]: -*** The goal of the current work was to investigate how vulnerable re-entrant building corners are. For the parametric analysis, a variety of re-entrant corner instances were taken into consideration. In this regard, various building shapes of four and eight stories have been taken into consideration and analysed using an equivalent static technique. This model's performance has been compared to that of a box-shaped building in order to better understand it. A critical structure is identified, and the effectiveness of the bracing is tested. Particularly in high seismic zones, buildings with a higher percentage of re-entrant corners are more vulnerable to seismic damage. Compared to a standard building, a building with a re-entrant corner exhibits greater displacement at the notches. Building performance was improved above that of the building without bracing at the re-entrant corner.

- ***Yash Chhatani[1], Dr. Prashant Y Pawade[2], Dr. Kuldeep.R Dabhekar[3], Dr. Isha P Khedikar[4][2020]: -*** If they are not high rises, L-shaped structures are securer-entrant column stress concentration and torsion effect reduction. PARAMETER SUCH AS reactions at the building's base and along its height include inter-story drift, story shear force, overturning moment, and torsion-moment reactions. Use ETabs software.IS 1893 (PART-1):2016 conducted the seismic investigation. In this study the vinched column are fail due to high stresses and high stresses in the re-entrant corner.

- **P A Krishnan[1], and N Thasleen[2][2020]: -** According to this study Krishnan take the building with re-entrant corner and say According to IS 1893-2016, the pushover method is used to examine a G + 15 structure with re-entrant corner irregularity (T, L, + Shape). At each of the re-entrant corners, there is a high concentration of stress. We see failure in the members close to re-entrant corners. L-shaped models have been found to have a significant top story displacement but a reduced stress concentration. It has been found that P-shaped models have a high-stress concentration but a lower top story displacement.

- **Md Faisal Zia[1], Rajiv Banerjee[2] [2020]: -** This study looks at how reinforced concrete structures with re-entrant corners and structures with diaphragm discontinuities respond to earthquakes. Research is done in seismic zones 4 and 5 that combines these two plan irregularity criteria and evaluates the results. Three corner structures with re-entry and one ordinary building are available for this. Nine structures are produced when these buildings and the two anomalies are combined. Software called tabs analyses structures. Measurements of story displacement, drift, base shear, and overturning moments are made, and the outcomes are contrasted with those of typical structures.

- **Md Faisal Zia[1], Rajiv Banerjee[2] [2021]: -** in this work STAAD pro v 8i is used to model and examine an asymmetrical layout for a G+20 and G+22 floor skyscraper. Building forms are composed of T, L, U, AND. Stress developed consistently. a five-structure diaphragm discontinuity with openings of 0%, 4%, 16%, and 24%, and 36%. such as base sharing, bending moment, and tale drift. More opening % means less drift value, whereas a more variable re-entrant percentage means greater drift. Smaller overturning moment due to large slab opening.

- **Jerin Mathew Jose[1] , Kesiya Josy V[2] , Likhith Koruthe Varghese[3] , Nayana P[4], Adithya Viswambaran[5] 2021**The article reviews the structural behavior of atypical buildings for a variety of shapes, including rectangular, C, L, and I. The ETABS program will be used to model a 15-story RCC-framed skyscraper for analysis. Maximum shear forces, bending moments, and maximum story displacement are calculated for each analyzed structure before being compared. Using ETABS software, modal mass participation ratios were compared. Very little variance was seen. Comparison of story displacement values resulted in 0.35 variation. The difference of 1.27mm in tale drift value was determined through comparison. We measured narrative shear results of almost 2800kN.

- **Nikhil Dixit[1], Abhishek Jhanjhot[2] [2021]: -** In this review paper, Nikhil and Abhishek investigate the types of irregularity considered, which include Horizontal Irregularity as "Re-entrant corner" and Vertical Irregularity as "Mass Irregularity." In this work, the seismic analysis of an asymmetrical building, which has two distinct shapes, T and L. Building re-entrant corners influence stress concentration and create torsion. Pushover analysis will be used to examine buildings. The main purpose is to compute additional shear owing to torsional response in columns, supply curved beams at every re-entrant corner, and use shear walls and other imperfections in buildings as stiff resisting elements. Storey displacement and drift are factors in irregularly shaped buildings. more sensitive. A regular structure has a larger base shear, ductility ratio, and response reduction factor than an irregular structure. Buildings with re-entrant corners are more prone to the Torsional effect, which causes earthquake damage. The probability of a crack increases as the torsion is greatest at the base because the narrative overturning moment is greatest.

- **Dheeraj Kaul[1], Sagar Jamel[2], Lalit Belhar[3] [2021]: -** In this paper, a G+19 building with a re-entrant connector on an alternate level was used to investigate various characteristics such as base shear, maximum displacement, axial force, shear force, bending moment, maximum stresses, and so on. The major theme of this work has increased stability by offset in the re-entrant corners in Semi Commercial Building, (G+19) multistorey building under seismic stress. Stability of the Structure IRS Case 2 may be observed and obtained as an economical and satisfying IS 1893-2016 (part 1) or IS 456-2000, IS 13920 efficient case and should be recommended when this type of technique is used in earthquake zone III.

- **SK Abid Sharief[1], M Shiva Rama Krishna[2], S V Surendar[3] [2021]** "This case study examines an irregular structure's seismic performance in Andhra Pradesh, which is in seismic zone III. The results of reconnaissance studies on the seismic response of college buildings are first presented. This scenario shows that the seismic effect depends on the type of irregularity and site hazards, but that the seismic effect will be greater in irregular structures than in regular structures. Three-types of analysis are performed for the buildings to understand the seismic response of the structure in an efficient manner. Linear static method, linear dynamic analysis & non-linear time history analysis has done. As we go to the higher storeys it is observed in the analysis performed that factors like storey drift and storey displacement are more sensitive. Major Mode shapes identified have a modal mass contribution of greater than 90% to total mass of the structure.

- **Mr. Abdul Lateef Najjar[1], Mr Akshay Madhukar Shamkuwar[2], Mr. Nilesh Dharmapala Tirpude[3], Mr. Rajani Ramakrishna Mandal[4], Mr. Rameshkumar Babura Oji Thakur[5], Prof. Asif Baig[6]** "In this paper researchers working on the ground motion. The site of the structure, near Jalandhar, is an RCC-encircled five-story building that was built to withstand earthquakes that the Indian seismic zone IV is prone to. The STAAD-pro 2000 calculator is the tool used. Code used IS 456-2000.875:1987(part 2and 3),13920.1993. Due to the absence of block infill boards, the structure's parallel solidity may have been overestimated, making the plan less secure. As far as more work is concerned, the infill boards may be used for evaluation and a more effective plan can be obtained. Due to the absence of block infill boards, the structure's parallel solidity may have been overestimated, making the plan less secure. As far as more work is concerned, the infill boards may be used for evaluation and a more effective plan can be obtained.

- **M. A. Amzar Kamrudin[1], S. W. Ahmad[2], W. A. R. Wan Ariffin[3] (2021*): -*** This study looks at how shear walls affect how high-rise buildings behave to different types of earthquakes. Two models, one with a shear wall and the other without one, were made and examined using ETABS software. The findings of the seismic research revealed that the shear wall-equipped building is more resilient and sturdier than buildings without shear walls. Buildings with shear walls are more valuable than those without them, according to base shear studies. A shear wall increases the stiffness of the stories in a building more than a shear wall does not. The findings of the seismic research revealed that the shear wall-equipped building is more durable and sturdier than buildings without shear walls.

- **Sahil Tomer[1], Mohit Bhandari[2] (2022): -** In this paper, an assessment of the seismic performance of irregular buildings is presented, taking into account vertical irregularity subjected to earthquake loadings. Using both linear and nonlinear time history analysis, seismic performance can be discovered. To evaluate the structure's performance during earthquakes, various forms of asymmetrical buildings are examined. When compared to other forms of building abnormalities, it was discovered that structures with soft stories and variable storey stiffness produce high inter-storey drift values, which indicate more damage.

- **Praveen K[1], Chethan V R[2](2022): -** Five distinct models are examined by altering the size and placement of openings, comparing the outcomes of all analyses, and determining the most appropriate opening site. The seismic Zone V and type 2 soil conditions of the structure are examined. Results like story drift, maximum displacement, and story shear are compared. Buildings with shear walls have openings for windows and doors for ventilation. Depending on the need and the architectural consideration, the opening's size and position may alter. Most buildings supply the size and location of openings without taking into account how those choices would affect the building's structural behavior. The G+10 story building is analyzed in this study utilizing the response spectrum approach and ETABS 2016. Storey drift is greater in model 2 and less in model 1, and it grew in models 3, 4, and 5 by 10%, 7.61%, 7.5%, and 7.5%, respectively, on the X- and Y-axes. Storey displacement increased along the X-axis and Y-axis in model 3 by 8.29%, model 4 and model 5, and it increased in model 2 by more and model 1 by less. Storey shear is greater in model 1 and less in model 2, and it reduced by 1.18%, 1.27%, and 1.27% along the X-axis and Y-axis in models 3, 4, and 5. Base shear is greater in model 1 and less in model 2, and it reduced by 1.18%, 1.27%, and 1.27% along the X-axis and Y-axis in models 3, 4, and 5.

- **Jwala S Manoj[1], Richu George Varghese[2](2022): -** Building irregularity is taken into account in both the plan and the vertical irregularity of the building. In this essay, an irregular building is defined as one that has an irregular building plan. Here, the seismic behavior of an irregular G+11 building is examined. A case study of a G+11 structure resting on level ground is currently being conducted. According to IS 1893-2016, IS 456-2000, and IS 875 (part 3)-2015, the analysis is completed. The ETABS 18 program is used to perform the analysis and modelling. Response Spectrum Analysis is used to do the seismic analysis. This analysis can reveal the dynamic response characteristics, such as base shear, tale deflection, narrative drift, and story shear. The maximum permitted displacement is determined using Eurocode-8 as follows: H/250. The highest permissible displacement determined from the calculations above is 0.1872 mm, which is within the permitted range. Consequently, the irregular building under analysis is secure from storey displacement.

III. Conclusion: -

The aforementioned literature study sheds light on numerous architectural anomalies and problems that developed during the design and detailing of such structures under seismic loads. Previous studies have shown that irregular buildings exhibit greater sensitivity to storey drift and displacement during inelastic seismic behaviour compared to symmetric and asymmetric buildings. Compared to an irregular structure, a regular structure has higher base shear, ductility ratio, and response reduction factor. Any structure may fail from top to bottom or vice versa. As the percentage of irregularity rises, the building's lateral displacement falls. The members near re-entrant corners exhibit failure.

1. As the percentage of irregularity increases, the building's lateral displacement decreases. It is seen that the members fail close to re-entrant corners.
2. The re-entrant corner story has the worst seismic and lateral displacement performance.
3. As the vertical abnormalities in models rise, the maximum narrative drift and tale displacement will as well.
4. Height causes an increase in storey displacement and drift.
5. Re-entrant corners are under a lot of stress.
6. It is seen that the members fail close to re-entrant corners.
7. At the irregular story, there has been a rapid fall in the building's rigidity.
8. More opening % means less drift value, whereas more variable re-entrant percentage means greater drift.
9. By including a shear wall, lateral force and torsional effect can be reduced.

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