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"BEHAVIORAL STUDY OF IRREGULAR STRUCTURE WITH SHEAR WALL AT ALTERED LOCATION" - A Literature Review

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ABSTRACT—

In the current context, the majority of RC buildings have irregular layouts, either in plan or elevation, which may be vulnerable to destructive earthquakes. In the event that it is necessary to determine the performance of structures to bear lateral loading, both new and existing ones. This research is concerned with architectural imperfections and the effects of lateral load resistance at various locations on a structure's seismic response. To avoid failure and reduce the susceptibility of irregular buildings subjected to lateral stresses, their responses must be thoroughly investigated. In this work, the responses of irregular structures are analysed using the RSA approach and compared to those of regular buildings with the same plinth area. In this study, we reviewed the parameters and established the optimal condition for them.

Keywords – Torsional Irregularity, Plan Irregularity, Sesimic analysis, Base Shear, Drift, Displacement, IS 1893 – 2016, ETABS 2018.

1. Introduction -

In present scenario, voluminous building involves irregularities that cannot be avoided. However, the behaviour of structures with these anomalies during earthquakes needs to be investigated. The primary goal of Earthquake Engineering is to design and build a structure in such a way that damage to the structure and its structural components is minimized during an earthquake. Seismic excitations can cause a variety of damage to structures. Despite having the same structural configuration, locale, and earthquake, the system's damages are not comparable or homogeneous. So, various aspects influence the seismic behaviour of a structure, including the structural system, earthquake characteristics, construction quality, soil location, and maintenance. However, based on previous and current earthquakes, the majority of the damage is caused by architectural and structural configurations in plan and elevation, as well as site ground impacts. Irregular buildings make up a substantial percentage of modern urban infrastructure. Adequate measures should be adopted. A thorough examination of the structural behavior of structures with irregularities is required for earthquake design and behavior. As a result, the structural engineer must have a good understanding of how irregular structures respond seismically. Several related researches have focused on assessing the reaction of "Regular Structures." Irregularities in seismic demand of building structures are often required.

According to IS 1893, the irregularities in the construction have been roughly divided into the following categories:

a. **Plan Irregularities:** According to Clause 7.1 of the Sixth edition of IS 1893-2016 (Part 1). Torsion irregularity, re-entrant corners, floor slabs with excessive cut-outs or apertures, out-of-plane offsets in vertical parts, and a non-parallel lateral force system are all examples of plan abnormalities.
b. **Torsion Irregularity:** A building is said to be torsion ally irregular when the maximum horizontal displacement of any level in the direction of the lateral force at one of the floors exceeds 1.5 times the minimum horizontal displacement at the far end in that direction.
c. **Vertical Irregularities:** According to Clause 7.1 of the Sixth revision of IS 1893-2016 (Part 1). Vertical irregularities are divided into four types: mass irregularity, vertical geometrical irregularity, stiffness irregularity, and in-plane discontinuity in vertical elements resisting lateral force.
d. **Mass irregularity** shall be regarded to exist when the seismic weight of any floor exceeds 150 percent of that of its surrounding floors. This requirement of 150 percent may be lowered in the case of roofing.
e. **Vertical Geometric Irregularity:** Vertical geometric irregularity is regarded to exist when the horizontal dimension of the lateral force resisting system in any storey exceeds 125 percent of that in its neighboring level

The goal of this hypothetical study is to investigate how abnormalities in buildings induce eccentricity between the building mass and stiffness centers, resulting in a negative effect on the building. Furthermore, designing and analyzing an irregular building necessitates a large amount of engineering and designer effort, whereas a regular building is simply evaluated and designed.

2. OBJECTIVES OF THE STUDY

To design an earthquake-resistant multi-story building, following points should be considered –

1. A strong structural layout is necessary.
2. Selecting the appropriate lateral load resisting system.
3. Dynamic properties.
4. Construction Quality

Structural eccentricity is also an important element that influences the seismic elastic response of irregular structures. When the structural system is aroused into the inelastic range, the resisting elements give, complicating the behaviour. As a result, this value, which captures the structure's inelastic reaction, requires further investigation. As part of our civil engineering work, or as civil engineers, it is our responsibility to design structures that can withstand severe earthquakes in diverse earthquake-prone zones, thereby reducing the suffering caused by catastrophic and economic losses.

The primary goal of this work is

- To analyze the behavior of structures and implement the approach.
- To limit the damage caused by seismic activity.
- Understanding the behavior of structures during earthquakes with plan irregularities.
- Understanding the Torsion Response of a Structure Due to Plan Irregularity.
- Identifying and measuring the level of irregularity created.
- Improvements to the structural structure taking into account Torsion Seismic behavior.
- Comparison of models analyzed using IS codes 456-2000 and 13920-1993.
- To choose the most appropriate building configuration based on this study.

3. Literature Review –

Several research have been undertaken on the static and dynamic analysis, as well as the design, of such regular and irregular structures. The studies also show the issues that may develop in the seismic design of high-rise buildings in such situations. A few data points from prior studies have been discussed, along with the technique used and the conclusions reached. Many studies have been conducted on the torsional effect of multi-story constructions.

"Mayank Barser, Bush Rc, Anoop I Shirkol, **Performance analysis of asymmetrical RC structures using different configurations of shear wall, Materials today Proceedings, Science Direct,** Volume 88, Part 1, 2023, Pages 52-65, **https://doi.org/10.1016/j.matpr.2023.04.493" –** Unsymmetrical or irregular buildings are increasingly being built due to functional and aesthetic factors. The key parameters influencing the seismic behaviour of all buildings are ductility, lateral strength, and stiffness. The uneven shape, proportions, and geometry of a structure have a considerable impact during an earthquake. Buildings with basic geometry in the plan have previously survived big earthquakes with little damage; nevertheless, buildings with asymmetric designs have suffered significant damage. Torsional effects cause structural damage and failure in asymmetric buildings during powerful ground vibrations, which can be reduced by minimizing the distance between the centers of mass and stiffness. Torsion is minimized in the current study based on the center of mass and rigidity, as well as an examination of buildings (B1 + G + 10) with various irregular (L, H, U, and E) shapes, taking into account the shapes of shear walls at different locations. The placement of the shear wall is determined by the center of mass and stiffness. The analysis was done in ETABS. Variables such as torsional effect, displacement, storey drift, stiffness, base shear and time period, and modal mass participation ratio were examined for many models, and the results were compared. The results show that T-shaped shear walls perform better in all irregular constructions.

"Ragi Krishnan1∗, Vidhya Lakshmi Sivakumar2, A Comparative Study of Geometry and Locations of Shear Walls on Regular and Irregular RC Structures by Using Response Spectrum Analysis, INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY 16(30): 2358-2364. https://doi.org/ 10.17485/IJST/v16i30.1168 (2023)" - The current study aimed to examine the geometry and position of shear walls in regular and irregular constructions. Method: In this study, the dynamic properties of irregular and regular structures with different shear wall positions were compared using the ETABS software Response Spectrum method. Findings: The output entirely advantages the system with a shear wall over the one without one. The RC frame structure with the shear wall has a 50% to 60% shorter oscillation period than the RC frame G+14 multi-story construction without a shear wall. Stiffness and dynamic characteristics are also favorable Regular buildings with a shear wall. Novelty: This work is unique in that it compares regular and irregular structures while taking into account both criteria such as shear wall position as well as geometry and material nonlinearity.

"S**rinidhi G 1 , Dr. R. Subhash Chandra Bose2 , Dr. Govardhanswamy H S3, Study on Dynamic Behavior of Shear Walls in Vertically Irregular Building Frames, International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 10 Issue VII July 2022- Available at www.ijraset.com,"** According to recent studies, the shear wall construction is the most effective weight-restraining technique now in use. Shear walls are among the most achievable and so commonly used horizontal load opposing components in elevated constructions. It is supplied by advancing through the design levels, beginning with the basic level. The scope of the ongoing study is to establish the optimal location of the shear walls in plans with incorrect shear wall placements, such as I frame, L packing, and T frames for various zones in G+17 stories, with each story level measuring 3.2 meters. Shear walls are installed at the design's corners and edges. Furthermore, the influence of seismic zone results based on IS CODE 1893(Part 1): 2016 has been demonstrated.

"H M Arshiya Firdose 1* , A Shashi Kumar 2 , Dr. G Narayana3 , Dr. B K Narendra, Study on Dynamic Behaviour of Irregular R.C Framed Structures with Different Location of Shear Walls, ISTCE 2021 IOP Conf. Series: Earth and Environmental Science 982 (2022) 012076 IOP Publishing doi:10.1088/1755-1315/982/1/012076," According to recent study, the most appropriate loads resisting system in recent and current years is the shear wall system. In high-rise buildings, shear walls are one of the most feasible and so widely employed lateral load resisting components. It is installed throughout the building, from the base to the top. The current work aims to determine the best site for shear walls in plan irregular

constructions with shear walls such as I frame, L frame, and T frame for various zones in G+17 stories, with each storey having a height of 3.2 m. Shear walls are provided at the building's corners and periphery. The seismic study was carried out using ETABS 18.1.0, a well-known analytical and design software. The building's seismic performance was studied using specifications such as storey displacement, storey drift, storey shear, base shear, and mode time period.

"**Salunkhe and Kanase "Optimization of Location of Shear Wall in Irregular Multi Storey Building" International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE) Vol 3, Issue 4, April 2021, ISSN (Online) 2456-1290. (2021)"** It was determined that the reaction of a mass irregular construction should be researched for an earthquake scenario. In this study, the researchers use several analysis approaches to examine RCC-framed structures in both regular and mass irregular configurations.

"Oman Sayyed (2021) "**Comparative Study on Seismic Analysis of Multi Storey Building Having Mass Irregularity Using Etabs", International Journal of Research in Advent Technology, 6(5)".** His research was on the impact of infill and mass irregularity on various floors of RC buildings. The findings revealed that brick infill improves the seismic performance of RC structures while mass irregular buildings exhibit poor seismic responses, indicating that they should be avoided in seismically sensitive places.

"P A Krishnan1, and N Thasleen2, Seismic analysis of plan irregular RC building frames, 5th International Conference on MODELING AND SIMULATION IN CIVIL ENGINEERING IOP Conf. Series: Earth and Environmental Science 491 (2020) 012021 IOP Publishing doi:10.1088/1755-1315/491/1/012021" The existence of irregularity in buildings is a stuff of apprehension when it is exposed to shattering earthquakes. An abrupt change in vertical or plan layout in buildings can weaken the structure. To prevent failure and reduce the danger potential of irregular buildings, their responses to lateral loads must be thoroughly investigated. This research examines the reactions of irregular buildings using Pushover analysis. Ten re-entrant corner models are examined to determine their impact under IS 1893 (Part 1): 2016 codal regulations. The analytical tools utilized were ETABS v 16.2.0 software and Seismo Match 2018. The factors studied in this study include storey displacement, stress concentration, and performance levels. The approaches for strengthening vulnerable models are also highlighted. The acquired findings are compared to those of a regular structure.

"Sagar et al. (2020) "Torsional Behavior of Asymmetrical Buildings," International Journal of Modern Engineering Research (IJMER) Vol.3, Issue.2, March-April. 2020 pp-1146-1149 ISSN: 2249-6645" analyzed the performance on several types of irregularities. Considered: (a) Horizontal irregularity-plan irregularity (b) Vertical irregularity-mass irregularity. To meet the project's goals, time history analysis and response spectrum analysis methods were used.

"Ramesh Konakalla "Effect of Irregular Configurations on Seismic Behavior of RC Buildings", International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE), 3(4), 2456- 1290, (2020)" - Using Linear Static Analysis, investigated the influence of vertical irregularity under dynamic loads on four distinct 20-story buildings. The responses to all scenarios are compared, and it is concluded that in regular structures, there is no torsional influence in the frame due to symmetry. The reaction to vertically uneven buildings differs for columns positioned in the plane perpendicular to the action of force. This is caused by the structure's torsional rotation.

"Bansal, and Gagandeep "Design and Analysis of regular and vertical irregular building by using E-TABS", International Journal of Management, Technology and Engineering, ISSN No.: 2249-7455 (2019)" The study of ductility-based design is carried out considering vertical irregular buildings, and the methods used are RSA and THA. We evaluated three forms of irregularities: mass irregularity, stiffness irregularity, and vertical geometry irregularity.

"Himanshu Bansal (2019) "Seismic Analysis of RC Frame with Different Irregularities", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 14(4)" Vertical irregular buildings were analyzed using Response Spectrum Analysis and Time History Analysis. Irregularities considered include mass irregularity, stiffness irregularity, and vertical geometry irregularity. The storey shear force was found to be maximal in the first storey and decreasing to a minimum in the top storey in all cases.

"Prof. Sujeet Patil1, Pooja Matnalli2, Priyanka S V3, Rooparani4, Rajamma5, SEISMIC ANALYSIS OF PLAN REGULAR AND IRREGULAR BUILDINGS, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072". However, for medium to high-rise buildings, this sort of structure is no longer economically viable due to increased dead load, reduced stiffness, and span restrictions. So structural engineers are faced with the challenge of achieving the most efficient and cost-effective design solution. This research attempts to examine and compare the seismic performance of G+14 Storey buildings with 7 bays X 9 bays irregular and regular plans using ETABs 2015 software. The structure is assessed in earthquake zone IV on medium soil. The equivalent static analysis (ESA) and response spectrum analysis (RSA) methods are employed. Storey displacement, drift, and base shear are used as parameters.

"S.Varadharajan et al. (2018) "Seismic Response of Vertically Irregular RC Frame with Stiffness Irregularity at Fourth Floor", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 8, August 2018" evaluated prior work on plan anomalies and supported the choice for multistory building models over single-story building models.

"Purushottam Dewangan1 & Tushar Saxena2, "Seismic Analysis of Regular & Irregular Structures and its Comparison" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 09 | Sep 2018 www.irjet.net p-ISSN: 2395-0072" For the same structural configuration, region, and earthquake, system damages are neither equivalent nor homogeneous. Seismic analysis of buildings has become an important aspect of modern structural design since earthquakes cause significant damage and loss of life. Multi-story structures made of reinforced cement concrete are vulnerable to significant seismic wave activity during an earthquake. The primary cause of RC building failure is irregularity. The irregularities could be in its plan size or lateral force distribution.

"Aijaj and Rahman (2018) "Seismic Analysis Of Structures with Irregularities", IOSR Journal of Mechanical and Civil Engineering, Volume 3, Issue 2,March- April 2018 pp-63-66" Attempts were made to analyze the proportional distribution of lateral forces involved in earthquakes for each storey due to changes in stiffness of vertically uneven structures.

"Poncet, L. And Tremblay "Seismic Assessment of Braced Steel Frames,"(2018) Procedia Engineering, Science direct. The Twelfth East Asia-Pacific Conference on Structural Engineering and Construction (2018)" proposed the impact and effect of mass irregularity considering case of an eight-storey concentrically braced steel frame structure with different setback configurations. Methods used in present paper are equivalent static load

method and the response spectrum analysis method.

"Ravindra N. Shelke, "SEISMIC ANALYSIS OF VERTICALLY IRREGULAR RC BUILDING FRAMES", International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 1, January 2017, pp. 155–169, Article ID: IJCIET_08_01_017" This study focuses on the consequences of numerous vertical abnormalities on a structure's seismic response. The project's goal is to perform response spectrum analysis (RSA) on vertically irregular RC buildings. The analysis and design outcomes for irregular structures were compared to those for regular structures. We evaluated three forms of irregularities: mass irregularity, stiffness irregularity, and vertical geometry irregularity. The mass irregular structures were found to have more base shear than similar regular ones. The stiffness uneven construction received less base shear and had greater inter-storey drifts. The absolute displacements acquired from time history analysis of geometry irregular structure at respective nodes were found to be bigger than those obtained from regular structure for upper stories, but as we progressed to lower stories, displacements in both structures started to converge. Lower rigidity causes greater displacement of upper stories.

"Devesh P. Soni "Seismic Performance Evaluation of RC Framed Buildings - An Approach to Torsionally Asymmetric Buildings" IOSR Journal of Engineering (IOSRJEN) (2016)" considered several vertical irregular buildings for analysis. Various criteria's and codes have been discussed and reviewed in this paper. Vertical irregular structure performance and response is reviewed and presented. The studies suggested that for combined stiffness and strength irregularity large seismic demands are found.

"Vipin Gupta and Dr. P.S. Pajgade A review of research on seismic behavior of irregular building structures since 2002", Bulletin of Earthquake Engineering [2015]" Exploration done on the torsional behaviour of multi-storey buildings with plan and vertical imperfections. It also focuses on the codal provisions for torsion. Based on their analysis, they determined that torsion is the most essential element contributing to major damage or complete collapse of a building; thus, symmetric buildings must also be assessed for torsion. As a result, buildings should be planned with consideration for both design eccentricity and incidental eccentricity. It was discovered that irregular profile structures experienced greater stresses and displacement than regular ones. Structures are never totally regular, thus designers must periodically assess the anticipated degree of irregularity and its impact on a structure during an earthquake.

"**Amin Alavi et al., "Mode Mitigation of Seismic Irregular Structure" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 11 | Nov 2015 www.irjet.net p-ISSN: 2395-0072 [2015]"** An attempt was made to model the seismic response of the structures for various locations of shear walls on RC buildings with re-entrant corners in high seismic zones. They examined a five-story building with six distinct shear wall locations. They took into account the unintentional torsion of both negative and positive X and Y directions. The findings revealed that irregular structures are more fragile, and that eccentricities between the center of mass and the center of resistance had a greater impact on the torsional behaviour of structures during an earthquake.

"Gunay ozmen "ENHANCING SEISMIC PERFORMANCE THROUGH THE IMPLEMENTATION OF SHEAR WALL AT RE-ENTRANT CORNER IN BUILDING WITH PLAN IRREGULARITIES" Industrial Engineering Journal ISSN: 0970-2555 Volume : 52, Issue 8, No. 4, August : 2015]" The conditions under which the torsional irregularity coefficient exceeds the upper bound of 2 are examined. A series of eight walled and framed sample structures with various structural shear wall configurations were selected, and their behaviour under earthquake loading was investigated. The torsional irregularity coefficient was found to be highest when the number of axes and stories were low. Also, when structural walls are put as close to the gravity centers as possible without intersecting them, the coefficient is shown to be the highest.

"R.Riddell and J.Vasquez, "Study of Torsion Effects on Building Structures Having Mass and Stiffness Irregularities", International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 IJERTV4IS061059 Vol. 4 Issue 06, June-2015 [2015]" The presence of centers of resistance as roots of eccentricity is limited to a specific class of structures, and such conceptions are physically meaningless for a normal multi-story building. They created a false model and used torsional uncoupling. They discovered that the definition of centers of resistance as origins for measuring eccentricity must take into account the potential of torsion-free dynamic reactions. Furthermore, it was discovered that the centers of resistance must be such that when the eccentricity is zero at all levels, the building's vibration modes are uncoupled into purely torsional and solely translational modes. When centers of resistance exist, they all lie in a vertical line, and torsion-free vibration occurs when all centers of mass are on the same line.

"O. A. Mohamed and O. A. Abbass [2013] "Investigation of Seismic Performance of Vertically Irregular Reinforced Concrete Buildings", Life Science Journal 2013" Discusses how to account for torsional irregularity in Modal Response Spectrum Analysis. Their research aims to assess the consequences of torsional irregularity on seismic reaction as per ASCE 7-10, using MRSA to calculate seismic forces and drifts. They talked on why torsional irregularity should be reflected, even when MRSA is utilized. Based on their review findings, they concluded that the torsional irregularity of building diaphragms or floor frameworks causes increased structural reactions such as bending moments and drift, which should be accounted for in the computational model to keep structural failures and building pounding at bay.

"Han Seon Lee, Dong Woo Co "Displacement-based seismic design of structures" IUSS press, Pavia, Italy, [2010]" The seismic response properties of high-rise RC wall constructions with varied flaws in the lower levels were studied. They looked into the seismic response of high-rise RC-wall buildings with a variety of flaws. In this study, they examined three models and three distinct cases. The first model has a symmetrical moment-resisting frame, the second has an infilled shear wall at the center frame, and the third has infilled shear walls on the majority of the outside frames at the lowest two floors. Model testing is performed on a shake table. All models are compared in terms of base shear, storey drift, and axial forces in their respective columns. The failure mode and crack pattern for each model are analyzed.

"Emrah Eeduran "An integrated design technique of advanced linear-mode-shape method and serviceability drift optimization for tall buildings with lateral–torsional modes," Engineering Structures, www.elsevier.com/locate/engstruct [2006]" A review of existing nonlinear static techniques for calculating torsional effects in low-rise frame buildings. This study focuses on two types of eccentricity. To do this, two models are tested: one with unidirectional eccentricity and one with bidirectional eccentricity. The response history analysis is carried out on both models. The findings indicate that nonlinear static techniques offered for asymmetric buildings are more effective at generating torsional effects. This also demonstrated that for the unidirectional eccentric system, underestimating torsional rotations results in typical displacement demand estimates for the torsionally rigid side.

"Mr. Sandesh N. Suryvanshi, Prof. S. B. Kadam, Dr. S. N. Tande [2006] "Torsional Behavior of Asymmetrical Buildings", International

Journal of Modern Engineering Research, Vol.3, Issue.2, March-April. 2006 pp 1146-1149" studied Torsional behavior of asymmetric buildings in plan under seismic loading. They studied the torsion behavior of an irregular structure. They focused on three types of structures: symmetrical, T-shaped, and L-shaped layouts. Each example compares two models with floors of G+3 and G+6. The modeling and analysis are done with SAP2000 software. The conclusions are established by comparing all models with base shear, time period, and torsion moment.

3. Conclusion –

Regular and symmetrical structures have more favorable and predictable earthquake response than irregular structures. As a result, the utilization of irregular constructions in earthquake-prone areas requires increased consideration. In the case of an irregular building, the difference in center of mass and center of stiffness at floor level has a greater effect on inter-storey drift, necessitating adequate design. Based on all prior studies, the following conclusions have been reached:

- Analyse irregular building behaviour under lateral loading using fundamental mode forms, time period, frequency, and modal mass participating ratio.
- To investigate the structural response to torsional anomalies.
- Determine seismic response of irregular constructions using shear walls at various sites.
- Compare the stiffness of the staircase in the building's FEM model.
- Complex-shaped structures are becoming increasingly fashionable, yet they are vulnerable to seismic damage. As a result, such structures must be carefully constructed to account for their dynamic behaviour.
- The Response Spectrum Method for seismic analysis improves the safety of structures designed according to IS code.

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