A Review Study on Belt Wall in Non-Regular Buildings in Various India Earthquake Zones

Maitrey Jambhulkar[1], Dr. Ashwini Tenpe[2]

G H Raisoni Institute of Engineering & Technology Nagpur

Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur

ABSTRACT

To reinforce a building's central walls and external columns and boost its stability against overturning, outriggers are robust horizontal frameworks like beams and frames. While cantilevers have been an attribute of buildings for more than fifty years, their performance has been enhanced by innovative design concepts. The structural system known as the foundation system is made up of horizontal cantilever portions that are fastened to the structure's external columns and interior core. The system's lateral stiffness and central moment arm are both enhanced by this link. By joining the core and the building supports, the stabilizer lowers the back moments inside the core and transfers moments from the core to the exterior supports. Steel, concrete, and composite materials are just a few of the elements that can be used to make stabilization systems. Usually the core is positioned on one side of the building and the stabilizers expand on the opposite side, or the stabilizers expand on one side of the central core. To stop lateral movement, the perimeter of the building is attached together and expanded by column-connecting walls. Wall-mounted stabilizers are more efficient than wall-free ones. The center wall cannot freely rotate on the external columns due to the stabilizing arm. The location of outriggers and tie rods, the quantity of outriggers, the form of the structure, the type of core (steel or concrete), and the height from floor to ceiling are just a few of the elements that might impact how well outriggers and straps function in the structure. Several studies were selected for this review study with the purpose of analyzing the impact of belt walls on irregular structures. Obtain a thorough analysis of the types of irregular buildings and how earthquakes affect these constructions. Earthquake zones are used in India to categorize the degree of seismic loading.

Keywords: *Belt Wall, earthquake zone, Irregularities of Building, Storey displacement, bending moment etc.*

I. INTRODUCTION

Tall building structural systems have developed to more effectively provide increased lateral stiffness because lateral stiffness determines the design of high-rise structures. There are several structural systems designed for high-rise buildings, some of which have diagonal line outlines, such as: B. Assist with designs and piping. Frequently quite successful. This is done in order to divide the structural system by positioning the structural elements on the building's margins and to accept lateral loads by using the axial movement of the primary structural components. The stabilization system is a modern structural technology that is also highly popular and effective. A cantilever building, which efficiently resists the cantilever construction's overturning moment, connects the huge connecting columns to the central load-bearing wall structure. Stabilizers are stiff horizontal components that connect the spine or act to the soundtracks, improving stiffness and roll ratios. cantilever system as well, which offers a superior entire structural output than the systems by joining two structural systems, typically a central system and a perimeter system. The stabilizing technique has the benefit of lowering backlogs, which cause structures to deteriorate, and raising effective efficiency.

The lack of proper plans for development and building has put a lot of strain on our nation's metropolitan centers. Big cities like Kolkata, Mumbai, and Delhi were chosen at random. Additionally, there was a greater demand for human clothes. The fundamental structure is frequently utilized in the building of residential high-rise structures since it is simple to expand upon and construction proceeds quickly. Worldwide, there are many earthquakes. The magnitude, location, and timing of an earthquake cannot be predicted. Structures intended to withstand wind, dead weight, live weight, and other general stresses are not robust enough to withstand seismic loads. During an earthquake, there is no practical or affordable way to keep building structures strong. Even in the case of a sudden collapse, structures are guaranteed to be able to survive minor earthquakes without suffering significant structural damage thanks to the method of design used in the Indian Code of Standards for Design of Earthquake Resistant Structures (Part I) 2016, as well as being resilient to indicator earthquakes. There are also non-structural earthquakes; however, even in the rare instance that a building does not collapse, damage could still result from an earthquake of medium or greater magnitude. India has seen a number of severe earthquakes in recent years. India has few and far-between earthquakes. Though they still happen frequently throughout India, earthquakes are more common in northeastern India. The structure began to collapse as a result of the earthquake. Based on the results from rigid mass and strength loss. to deal with irregularities as though they were aberrant structures. Unpredictable irregularities in the building structure can arise based on its mass, quality, and strength. Apart from home height, one of the main factors contributing to structure damage in modern earthquakes is inconsistency. The location and design of safety components such as supports, volumes, partitions, and floor structures define the irregularities in the floor surface. Two subtypes of anomalies include vertical discrepancies and planar irregularities. Vertical discontinuities are used to explain vertical irregularities in mass propagation, stiffness, and control.

II. LITERATURE REVIEW

Sutar S and R. D. Patil. (2023) [1]: the author of this study made comparisons at various layer levels between a frame tube system and a shear wall system. The seismic strength of reinforced concrete (BA) structures was examined in this study. The purpose of the ETABS software was to analyze the behavior of building structures under wind and seismic pressures. The primary focus of this study was layer displacement analysis, which was a crucial performance indicator for lateral load-resisting systems. Apply the response spectrum concept to the structure's analysis. According to the data, frame-and-tube structures were more earthquake-resistant than load-bearing wall systems because they had higher drift rates, smaller displacements, more base shear, and more ductility. These results suggest that tubular frame structures can be an alternative for high-rise buildings in seismic zones. During the design phase, it is necessary to consider rigidity and adequate resistance to avoid excessive deformations and damage. This study also highlights the importance of studying the material properties, loading patterns, and interactions with soil structure that influence the seismic stability of these systems.

Hossain, Sabbir, and S. K. Singh (2023) [2]: the aim of this investigation was to compare base shear and maximum storey displacement. It was discovered that the g+9 and g+25 concepts had the largest floor displacement and base shear, while the zone 5 model had the highest floor displacement out of all the other models. The two building models perform better in the lower region in terms of base shear and maximum floor displacement. Based on the measurements, two asymmetrical reinforced concrete (RCC) building plans—a 25-story structure above ground level (r+25) and a 9-story structure above ground level (r+9)—were divided into four distinct buildings for this study. Belt from eight different areas. Modeling the behavior of structures under seismic and gravitational loads. The Indian Standard (IS) 1893's seismic loading procedure was applied after the design was based on the response spectrum method (RSM). The behavior of imperfections in buildings under seismic loading was studied in this research.

Simbolon Steffy Catharina Rebeccha et al. (2023) [3]: The purpose of this study was to evaluate the horizontal structure in accordance with SNI Regulation 1726:2019, which aimed to investigate any irregularities, and to determine the performance of the current building structure of the simpang tem mrt duku atas jakarta building in regards to displacement, floor displacement, and structural stability limits with regard to seismic loads. Etabs software was used for 3D building modeling, time history, and response spectrum analysis in the analysis process. The seismic reaction spectrum was supported by the time history studied, which made use of earthquake data from El Centro, Taiwan, China, and Kobe, Japan. Program-based results were examined for the purpose of comparing the two approaches. The results of the analysis showed that the building was irregular in the horizontal direction, that average displacement values in the horizontal direction x from the uppermost leveled to the twelfth floor exceeded the drift value limit, and that the torque ratio was too large to be above 1. 4. The stability limits of the structure remain unchanged from the results of the stability limits of the structural resistance to displacement based on the p-delta effect. It could be claimed that the structure was safe and stable.

Banerjee Mr Rajiv and J. B. Srivastava. (2022) [4]: the "C"-shaped structural load-bearing walls were placed as precisely as possible in the structural design to reduce the torsional impacts of the floor irregularities on the structure. The basis of this concept was the selection of the ideal site that fulfills the ideal criteria for the structural and technical specifications of a "c"-shaped building with a set length of load-bearing walls. The authors examined 14 load-bearing wall placement models of a c-shaped building (14.5% floor-to-wall surface area ratios) with a fixed load-bearing wall length, considering a 15-storey G+ structure as a specific model for a frame structure Wall surfaces . The analysis results from each model were compared with the bare frame design in terms of acceleration, time period, static eccentricity, base shear, and top board displacement and deflection. The proposed design provides a reference for choosing the best placement for shear walls in "c"-shaped structures when used with the examples that were given.

Verma, Atul, et al. (2022) [5] In order to effectively control excessive deflections carried on by lateral stress and reduce the risk of both structural and non-structural destruction, cantilever systems and beamed walls were frequently employed in structural systems. seismic forced. High-rise structures using this technology could be deemed appropriate, particularly in regions with significant seismic activity or strong wind loads. For tall buildings, cantilevering was a method of building used to reduce the structure's reaction to wind. In order to decrease the lateral displacement of structures under lateral loads and increase the lateral stiffness of the structural support system, stabilization systems were frequently employed in conjunction with shear wall framing systems in high-rise buildings. Standard stabilizer systems provided great contributions, but they also had significant drawbacks and problems that affected structural modeling. Among these were the designers' increased utilization of interior space and their difficulties connecting the stabilizer to the central core.

Makrani Gagan and Kishor Patil. (2022) [6]: this study aims to conduct a comparison of the results. From the points of view of various researchers, the effects of significant elements that affect the bowstring support structures of tall building legs and walls. Both high-risk and low-risk seismic locations would benefit from this research. This article used design software to investigate the impact of significant structural elements on the adoption of an outrigger bracing system with wall bracing in buildings that also include a wall chord bracing system. The effects of seismic and non-seismic activity on tall structures were also covered in this article, along with the significance of concrete for wall support systems and stabilizers. Analysis of studied areas was another tool used for software measurements.

Ercan, I. S. I. K., Fatma Peker, and Aydın Buyuksarac (2022) [7]: the present investigation examines the seismic activity of four distinct settlements: Bitlis, Konya, Samsun, and Izmir. These nations' seismic parameters and hazards were compared. Steel constructions with ten stories and identical structural features were examined individually in these studies. The seismic building code of Turkey in 2018 and the fundamentals of design, as well as the calculation and building of steel structures in 2016, were taken into consideration when developing the scenarios for building models. A nonlinear temporal analysis approach was formed for each of the steel structure instances, taking into account the various seismic directions, using the SAP200 program. The displacements, fundamental shear forces, and moments in all directions were calculated for each instance. Assessing the earthquake's direction and the impact of various seismic zones was the objective of this study. Significant displacement, rotation, base shear, and moment values were also present in areas with high PGA values. This investigation revealed that the earthquake's vertical effects had no discernible effect on the findings that were gathered horizontally.

Khalil Ahmed, et al. (2021) [8]: A few methods for reducing the barrier gap on the stabilization bar were described in this paper. In order to improve lateral displacements, drifts, thrust foundations, base moments, core moments, and environment-basic moments in various core systems, a comparison was carried out between a 40-story core design and a standard stabilizer. An affordable way to make buildings more seismically sound was to install stabilization systems. Numerous studies have been carried out to determine the stabilizer system's ideal settings. The population of the area was crucial, though, as yearly stabilizers often had limits to the machine's floor or the bunker. 11 ground motions were made throughout the occurrence in order to mitigate the greater ground acceleration that was expected in Cairo. The study ends with recommendations for the stabilizer's recommended design, better manufacturing methods, and supply of more free space in comparison to traditional stabilizers.

Singh Gurkirat and S. K. Singh (2022) [9]: the authors of the research analyzed several G+9 composite frame structure shapes using ETABS with belts and frame stabilizers. Seismic loads were taken into consideration in the response spectrum analysis, both static and dynamic. The researchers also take into consideration factors like historical displacement, historical flow, and the creep of different structural foundations. Buildings with remarkable aesthetics and unique characteristics are becoming more and more necessary in today's modern world to set them apart from other structures that result in defects in the structure. They also understand that irregular structures are susceptible to structural instability and that they are more brittle than regular structures. Current issues call for contemporary answers, and cities, for example, could be more secure and stable through the use of modern technologies.

Patel Pankaj and Rahul Sharma (2021) [10]: there was a connection between the structural stabilization system and the horizontal support system. This approach connected the twisted ties to the building's central core, which connects all of the external columns to the perimeter, using stabilizers to stop the exterior pillar column from rotating. Shear walls with tires were designed to resist lateral forces; a system of legs and wall tie rods is used in the construction to accomplish this. Seven different cases, numbered ra1 through G7-OTB, were used in this study to investigate the layout of a G+10 slab. Through a unique stabilizing system composed of a sliding central frame with an optimum frame support system. These frames were placed at various points below the seismic zone III. 315 m2 was the building area assigned to the different scenarios. A comparison examination of each instance following the results of the analysis reveals that the RA4 case was the most efficient example in the research mentioned above. Both forms of optimized truss belt reinforcement have been demonstrated to be effective in increasing the design's efficiency, to the point where they were always minimum.

Shanker Battu Jaya Uma, G. Kiran Kumar and R. Sai Kiran (2020) [11]: In this paper, the authors examine regular and irregularly shaped buildings made with linear dynamic statistical analysis approaches utilizing the etabs software. Buildings made of steel and reinforced concrete were susceptible to earthquakes. According to research, irregular geometry, or a dispersion of mass, stiffness, and strength, were the primary reasons that reinforced concrete buildings collapsed. Actually, a lot of the buildings that were still in place had irregularities because of their attractive and handy locations. However, historical earthquake records demonstrate that the structure's seismic performance was weak. The present research was mostly focused on providing multilevel functions for various design shapes, including square, plus sign, h-shape, u-shape, and l-shape. Using etabs programming, demonstrate the construction of a 12-storey reinforced concrete frame. Determine the structure's bending moment, the maximum layer displacement, and the maximum shear force. Then compare the analytical findings for each scenario. Structural analysis was done using response spectrum analysis.

Khatri Yagya Raj and Prasenjit Saha (2020) [12]: in this research work author consider irregular building with and without shear walls with different configurations are analyzed using the IS: 456 2000 and seismic code IS: 1893 2016. The earthquake loads are analyzed using static (Equivalent Static Method) and dynamic (Response Spectrum) methods as per IS: 1893 2016 and the time history method using acceleration time history of Bhuj 2001. Based on the comparisons done during this study, the lateral stiffness of the buildings is enhanced by the introduction of shear walls at the building which leads to better performance against lateral loads. While the y-direction shear wall configuration offers the best performance for lateral loads in the y-direction, the raised core shear wall configuration performed well for lateral loads in both the x- and y-directions. Installing shear walls at the right lengths and locations could enhance the performance of high-rise structures. The most effective way to distribute lateral loads and lessen eccentricity was to arrange shear walls.

Arvindreddy R. J and M. Fernandes (2015) [13]: the two types of structures studied in this paper were 15-story reinforced concrete regular and irregular buildings, which were studied using both static and dynamic methods. The ground motion recorded from previous earthquakes was analyzed for time-history analysis in order to examine how each structure responded. As of right now, six models exist. The other structural models were asymmetrical, with one having a regular structure. This essay demonstrates how irregular structures behave differently from regular structures. An analytical investigation was conducted in this research to determine the response of various regular and irregular structures situated in severe zone V. A fifteen-storey structure had been analyzed using both static and dynamic approaches, utilizing code 1893-2002 (part 1) and Etabs 2013. Regular and irregular buildings in zones iv and v were evaluated by dynamic modeling, while regular buildings in zones i and ii that were less than 90 meters in height were subject to linear equivalent static analysis. Linear analysis or dynamic history analysis were also possible. Response spectrum examination. By contrasting the displacement responses of regular and irregular structural layers, one could ascertain the behavior of the structure. The displacement of the deck plate were studied using a variety of analytical approaches, including the response spectrum method and the static equivalent analysis method. We obtain the pushover curve. This analysis's main goal was to provide a base shear vs. displacement diagram. Additionally, a historical examination of the Bhuj earthquake was done. In zones i and ii, buildings that were less than 90 meters in height were subject to linear equivalent static analysis; in zones iv and v, regular and irregular buildings were subject to dynamic analysis. Linear analysis or dynamic history analysis were also possible. Response spectrum examination. Through analyzing the displacement response of regular and irregular structures. The displacement of the deck plate was studied using a variety of analysis methods, including the response spectrum method and the static equivalent analysis method. Authors obtain the pushover curve. This analysis's main goal was to provide a base shear vs. displacement diagram. An examination of the Bhuj earthquake's past was also carried out.

III. PROBLEM STATEMENT

- G+11 models are ready to be studied in this research project. In the IS code, there are actually four different earthquake zone, all zones of earthquake should be chosen for analysis because they both have different intensity of loading conditions, meaning that to study a structure having maximum damage due to earthquake and controlled by belt wall.
- Some parameters are selected to study like shear force, storey drift, joint displacement, bending moment, base shear etc.
- Approach for professional practice in the field of structural engineering. Compare both results generated from controlled and un-controlled cases.
- To reduce the effect of lateral load with belt wall and compare their result data to analyse them to understanding of seismic load design concept for structure.

V. RESEARCH GAP

- Most of author study on symmetrical structure for study and use bracings to reduce effect of earthquake load and also consider one earthquake zone for area of study.
- Wind load was majorly considered as lateral load, seismic load analysis was missing by some authors.
- Irregularities on behalf of shape like plus, L T are used for study.
- Some researchers use unsymmetrical structure for study but use bracings do not take into account decreasing the impact of earthquake load.
- A small number of studies done on irregular building with different earthquake zone.

V. FINDINGS

- According to the results, frame-and-tube systems are more earthquake-resistant than load-bearing wall systems because they have smaller displacements, greater drift rates, more base shear, and more ductility. The structure and the earthquake are displayed in the study's results of the structure's compressive strength. [1]
- The buildings in the higher section feature larger floor changes in the G+9 and G+25 model layouts. It is evident from this study that model 5 structures have more ground displacement and ground displacement. [2]
- The suggested structure acts as a reference for choosing the best placement for the shear walls in "C"-shaped structures, along with the scenarios that are given. [4]
- In high-rise buildings, stabilization systems are frequently used in conjunction with shear wall framing systems to improve the lateral stiffness of the supporting structure system and lessen the lateral displacement of buildings under lateral loads. [5]
- From the points of view of various researchers, the effects of major components on high-rise structures using wall and beam support systems. [6]
- Determining the earthquake's direction and the impact of various seismic zones is the goal of this study. Higher displacement, movement, base shear, and moment values are also present in areas with high PGA values. [7]
- A vital aspect of improving stabilizer performance is diaphragm stiffness. The study concludes with ideas for the stabilizer's preferred design, better manufacturing practices, and the supply of more free space in comparison to traditional stabilizers. [8]
- Lowering laterality can be achieved effectively with stabilizers and pretensions. At the location of the stabilizer installation, there is a noticeable decrease in lateral movement. At the site of the stabilizer installation, there was a sudden drop in the maximum lateral motion. [9]
- Both truss belt reinforcement designs work well and have been shown to be the best at increasing the design's efficiency; in fact, they perform as little as possible in every situation. [10]
- Many structures have a greater displacement than others because the shape of the structure varies based on its load capacity. The irregularity of the structure grows with the base ratio in comparison to a regular-shaped structure, while the displacement of the building remains constant. [11]

- The use of shear walls at building heights increases the lateral stiffness of the structure, which increases its resistance to lateral loads, according to the comparisons done in this study. The construction of suitable-length and functional shear walls can enhance the performance of skyscrapers. The best way to distribute lateral loads and lessen instability is by positioning shear walls. [12]
- According to earlier assessments, among all the structures, 15-storey buildings with stiffness irregularities have the lowest fundamental strength. The stiffness irregularity behaves nonlinearly in the initial phase in comparison to all other structures, as the pressure curve illustrates. Because of this, rigid and irregular constructions are more vulnerable to earthquakes. [13]

VI. OUTCOMES

- In comparison to the load-bearing wall design, the tubular frame system has a 40% smaller lateral displacement. The increased shear force on the foundation is a result of [1].
- The multi-storey G+9 and G+25 building designs were shown to function well in regions with low risk for earthquakes. [2]
- The structural stability limits remain unchanged from the results of the displacement-based P-delta structural stability limits. It can be described as secure and well-organized. [3]
- Membrane displacement is decreased when wall panels are placed differently than in buildings without panels. Time history analysis and response spectrum analysis both show it. Additionally, the displacement between the floors in the lower levels is greatly impacted by the positioning of the shear walls. [4]
- The study demonstrated that the vertical earthquake's impact had no significant effect on the findings in this regard. This study aims to demonstrate the effects of various design spectra based on seismic zones as well as the influence of earthquakes on the seismic performance of structures in strategic placements. [7]
- It is possible to alter the basic parameters of the first and second stiffness and structural approaches. Your building's structural performance can be enhanced by adding a conventional column, or half a column, to a newly stabilized floor. The term "semi-virtual stabilizer" relates to this water. Designers should select a system that satisfies the architectural criteria from the several systems that are accessible. [8]
- On the other hand, when the stabilizer is combined with the grid strips, there is a noticeable increase in content. Compared to traditional structures, composite structural pieces are simpler to handle and carry. Labor is needed to construct composite and traditional buildings. [9]
- Through the research, it has been concluded that the maximal displacement for RA4's decrease that was discovered in the X and Z axes. [10]
- Additionally, it is concluded that while the building's height and plan area remain constant, its position and the amount of irregularities entirely determine the structure's shape and maximal displacement. [11]
- The floor shifts more in the static load situation with linear loading (around 15% more) than in the load case with the response spectrum pointing in the same direction. It should therefore be pointed out that the response spectrum load situation also results in a significant ground movement (up to 75%) in a direction orthogonal to the load case's ground

displacement. Only roughly 5% and 2% of displacement, respectively, are caused in the direction perpendicular to the load case by the linear static load case and the hysteretic load case. [12]

- Structures with built-in stiffness irregularity will be non-conservative in nature. Time history study also shows that the behavior of stiffness irregularity and diaphragm irregularity reverse as storey height increases. [13]

VII. REFERENCES

1. Sutar, S., and R. D. Patil, 2023. "Evaluating the Seismic Behavior of RC Structures: A Comparative Study of Framed Tube and Shear Wall Systems for Varying Numbers of Stories”
2. Hossain, Sabbir, and S. K. Singh, 2023. "Comparative analysis of irregular RCC buildings in different zones." *IOP Conference Series: Earth and Environmental Science.* Vol. 1110. No. 1. IOP Publishing,
3. Simbolon, Steffy Catharina Rebeccha, Sudarno P. Tampubolon, and Agnes Sri Mulyani, 2023. "Performance analysis of horizontal irregular buildings based on response spectrum and time history methode." *Jurnal Pensil: Pendidikan Teknik Sipil* 12 363-374.
4. Banerjee, Mr Rajiv, and J. B. Srivastava, 2022. "Optimization of Shear Wall location in C Shaped Reinforced Concrete Framed Building subjected to earthquake loading."
5. *Verma, Atul, et al,* 2022. "Analysis of C, Plus and Rectangular Building with and Without Belt Wall."
6. Makrani, Gagan, and Kishor Patil, 2022. "Analysis of Wall Belt Support in Multistorey Building with Higher Importance Factor."
7. Ercan, I. Ş. I. K., Fatma Peker, and Aydın Büyüksaraç, 2022. "The effect of vertical earthquake motion on steel structures behaviour in different seismic zones." *Journal of Advanced Research in Natural and Applied Sciences* 8.3: 527-542.
8. *Khalil, Ahmed, et al.* 2022. "Seismic Behavior of Virtual Outrigger System."
9. Singh, Gurkirat, and S. K. Singh, 2023."Dynamic Analysis of Composite Structures with Outrigger System using Response Spectrum Method." *IOP Conference Series: Earth and Environmental Science. IOP Publishing* Vol. 1110. No. 1
10. Patel, Pankaj, and Rahul Sharma, 2021. "Comparative analysis of Wall Belt Systems, Shear Core Outrigger Systems and Truss Belt Systems on Residential Apartment."
11. Shanker, Battu Jaya Uma, G. Kiran Kumar, and R. Sai Kiran, 2021. "Analysis and comparison of seismic behaviour of multi-storied RCC building with symmetric and asymmetric in plan." *AIP Conference Proceedings. AIP Publishing* Vol. 2358. No. 1.
12. Khatri, Yagya Raj, and Prasenjit Saha, 2020. "Effect of Shear Wall in Seismic Performance of High-Rise Irregular RC Framed Building." *International Journal of Science and Research* ISSN: 2319-7064
13. Arvindreddy, R. J., and M. Fernandes. 2015. "Seismic analysis of RC regular and irregular frame structures." *Int. Res. J. Eng. Technol* 2: 44-47.