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# Optimal Placement of Shear Walls in a Multi-Storey Building: A Comprehensive Review

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***Abstract***

This paper synthesises multiple studies on shear wall behaviour in multi storey buildings highlighting their effects on structural response to lateral loads for different seismic zone and building configurations. Shear wall serve as strong upright diaphragm in construction of building used for carrying lateral stresses from the exterior-wall, floor and roof to foundation. Parallel to their planes these walls are primarily designed to with stand wind and earthquake loads. The studies presented here collectively contribute to understanding the role of different locations of shear walls in multi-storey building design, considering their impact on seismic performance, resistance to lateral loads and overall structural stability. Furthermore, the analysis and design comparison presented by the researchers using different design software are also reviewed here.

***Index Terms:*** Shear wall, seismic analysis, ETABS, storey drift, storey shear Wall.

## I. INTRODUCTION

In the realm of structural engineering, the optimal placement of shear walls in multi storey buildings stand as a critical puzzle to solve. Shear walls are essential element that provide lateral stability as well as resistance to forces such as wind and seismic loads, ensuring the structural integrity of the entire building. Placing these walls optimally requires a delicate balance of structural considerations, architectural constraints, and efficiency in material usage. Shear walls play a pivotal role in safeguarding buildings against lateral forces that act perpendicular to the plane of the wall. By efficiently transferring these forces to the foundation, shear walls mitigate the risk of structural failure, ensuring the safety of occupants and preserving the longevity of the building. However, the placement of shear walls is not the one size fits all approach; it requires meticulous planning and analysis to achieve optimal performance.

The task of determining the optimal placement of shear walls presents several challenges. Architects often aim for open, flexible floor plans, which can conflict with the need for strategically positioned shear walls. Balancing the aesthetic and functional requirements of the building with structural stability is a complex undertaking. Moreover, site-specific factors such as soil conditions, building height, and local building codes further complicate the decision- making process.

Analysis & Design of any type of structure especially high-rise buildings by considering the seismic forces, re-evaluating and speedily revising the performance of multi storied structure by various available analysis methods which are provided by IS Codes.

## II. Literature Reviews

**2.1** Esmaili et al., 2008[1], studied the structural aspects of 56 storey high rise building located in high seismic zone. The study was done to find how the location of shear wall affect the response of building to lateral load. In order to evaluate seismic performance of the tower, non-linear analysis was performed to verify its behaviour with most prevalent retrofitting guidelines like FEMA 356. The increase in axial force increases R factor resulting in increase of both base shear and moment of inertia. As a result, one effective method of increasing ductility and achieving more stable behaviour is by confining concrete within shear walls. The critical condition occurs in the middle height of building when both time dependency of concrete and construction sequence loading are considered simultaneously in analysis.

**2.2** Samson et al., 2014[2], presented the study of a 25-storey shear wall building located in seismic zone-III. The models that were considered were building with L type shear wall and core-type shear wall. A total of 3 time-history analysis were conducted and maximum displacement occurred in building with L-type shear-wall. The storey drift was reduced for the building with core type shear wall. On the nodes of exterior faces the lateral forces were applied to analyse the wall-frame interaction behaviour. It was hence, concluded that as the height of building increases, the shear wall absorbs more lateral forces as compared to the frames.

**2.3** Le Yee Mon, 2014[3], considered 14 storey irregular building situated in Myanmar in seismic zone IV. A comparative analysis of high-rise RC irregular building was done on the basis of changing the location of shear wall, and determined parameters like storey drift, storey shear and storey moment using ETABS software. The seismic load was considered as external lateral load and all other necessary load combinations.

**2.4** Ravikanth Chittiprolu, 2014[4], presented study for an irregular multi-storey building for various locations of shear wall and determined its most advantageous location on the basis of different parameters like lateral load, storey drift and torsion. From the results it was inferred that shear walls are more resistant to lateral loads in an irregular structure.

**2.5** Jubair et al., 2014[5], analysed 5 storey RC building of variable geometric configuration, i.e., symmetrical, vertically irregular and horizontally irregular. The buildings were designed with and without shear wall having base isolation through high damping rubber bearing and friction pendulum system. The method used for analysis was Finite Element Method. For superstructure, the bilinear hysteretic model of base isolation system and Rayleigh damping framework were adopted. After analysis the result showed that shear walls had a very minimum effect on total base shear and maximum acceleration responses along with reduction in maximum relative displacement. It was also observed that due to presence of shear walls the twist values of irregular buildings were affected by changes in eccentricity values (between centres of mass and rigidity).

**2.6** Aminnia et al., 2015[6], analysed buildings of 7, 10, 12 and 15 storey building. The plans considered were L, T, U and Z shape and rectangular walls. The commonly used shapes were L, T, U and Z shape plan located as the core or in the outer frames of building structure. Using a set of chosen earthquake records and the findings of several nonlinear time history analyses, a comparison of the seismic behaviours of the buildings including maximum roof displacement and, in particular, the formation of plastic hinges and their distribution in the building's structures has been carried out. The findings demonstrated that the building exhibited more dependable seismic behaviour when shear walls with U shaped cross-section were positioned as the building's central core and walls with Z- shaped cross-section were put at corners.

**2.7** Kammar et al., 2015[7], used pushover non-linear static method for the assessment of building under seismic load. The primary aim of the research was to examine the behaviour and performance level of an irregularly planned building with re-entrant corners when a shear wall was present. According to FEMA 365's codal provisions, the hinge qualities were applied by default and the software used was SAP 2000. It was observed that base shear increases and displacement reduces due to shear wall. It was also observed that buildings with re-entrant corners were more prone to earthquake damage causing torsional damage.

**2.8** Pawar et al., 2016[8], did seismic analysis of buildings with shear wall located on hill slope. It was observed that buildings located on hill slope have high displacement and base shear as compared to buildings located on plain ground when subjected to seismic load. It was also observed that step back building proved more vulnerable to seismic load.

**2.9** Akash S. Waghmode, 2016[9], resolved that within new era of fundamental progress skill is scope to choose improvement in conditions of serviceableness, feasibility and frugality of building. So, skill is need to grow in dignity on account of shortage of space in city extents. For the multi-storey form the challenge is to manage doable in conditions of lateral load on account of wind and temblor that exceptionally dominates the structure. However, this study focussed on cut divider forms because the clip obstruction helps restore the makeup's workability when side loads occur by strengthening the substance and rigidity. To study the conduct of the building, comparative reasoning was planning evenness and irregularity for the unchanging arrangement of allure area, altitude, and terrain for drift and dislocation.

**2.10** Dr. Vatsal Patel, 2017[10], proposed research work of modelling and study of G+14 RCC construction with various concerning manipulation of numbers configurations and supplying of clip wall at various area for district IV and V. The various limits like sideways dislocation, storey drift, drift ratio and base cut were distinguished for construction models which were grown by utilizing SAP2000 accompanying and without cut obstruction. The supplying of cut wall in multi-framed construction in district V improved sideways load giving competency and also additional limits were reinforced in comparison accompanying construction in district IV.

**2.11** Rahul T. Pardeshi, 2017[11], analysed an uneven multi-storey building accompanying and outside cut wall that were completed activity to accept the lateral loads and dislocation cut belongings. It is relevant that multi-storey houses are growing continually, hence, this study was essential for the growth of viewpoint. STAAD Pro V8i was used for the analysis the sure irregular elevated construction by changeful the location of clip obstruction and visualise what the effects on makeup were. The work was held the exploratory investigation on uneven shape construction for capably location shear obstruction at variable places. A study on an uneven high-rise construction accompanying cut walls and outside cut divider was conducted to think the effect on balance of construction and other determinants as dislocation, turning importance and axial force.

**2.12** Devendra Kumar Somwanshi, 2023[12], determined a inclusive study of shear obstruction sites in multi-storey houses for seismic fighting. The basaltic reasoning was carried out utilising STAAD Pro V8i spreadsheet, employing the Response Spectrum Analysis plan. A G+10 multi-storey structure located in seismic zone V was devised in accordance with IS 1893:2002, with three various models including clip walls at miscellaneous neighbourhoods. The efficiency of these models was evaluated in agreements of main limits to a degree lateral dislocation, labyrinth, turning moment, and principal force. By combining the verdicts from the reviewed documents and the reasoning of various shear obstruction areas, this study determined valuable insights for engineers and scientists in optimizing the tectonic act of multi-storey constructions. The maximum axial force and labyrinth was noticed in double be on the edge shear obstruction.

## III. CONCLUSIONS:

- Optimising shear wall placement extends beyond structural concerns; it also aligns with principles of efficiency and sustainability. By reducing the quantity of materials used without compromising safety, engineers contribute to sustainable construction practices. Additionally, efficient shear wall placement can lead to cost savings during construction and throughout the building's life cycle. In conclusion, the optimal placement of shear walls in multi-storey buildings requires a multidisciplinary approach that integrates structural engineering, architecture and sustainability. Achieving the delicate balance between structural integrity, architectural design, and cost-efficiency is crucial for the success of any construction project.

- From the above studies, it was observed that the building with L type shear wall resulted in maximum displacement as compared to the building with core type shear wall. It was also observed that by providing shear wall as core type, the storey drift was reduced. The buildings with U-shape cross-sectional shear wall located as building's central core and Z-shape cross-section shear wall placed at corners gave better seismic behaviour. Furthermore, it was observed that high displacement value and base shear value were seen in buildings constructed on sloping ground gave as compared to building constructed on non-sloping ground. Thus, as advancements in technology and methodologies continue to evolve, the quest for shear wall placement remains an ongoing pursuit, shaping the future of safer and more sustainable urban landscapes.

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