A Review on Effect of the Positioning of Shear Wall for Earthquake Resistance Multi-Story Building

Mohammad Haroon Mohammadi and Pankaj Kumar

March 29, 2022

A review on Effect of the positioning of Shear Wall for Earthquake Resistance Multi-story building

Mohammad Haroon Mohammadi[1] Pankaj Kumar[2]

[1] Post Graduate student, Department of Civil Engineering, Chandigarh University Punjab, 140413

[2] Assistant Professor, Department of Civil Engineering, Chandigarh University Punjab, 140413

Abstract:

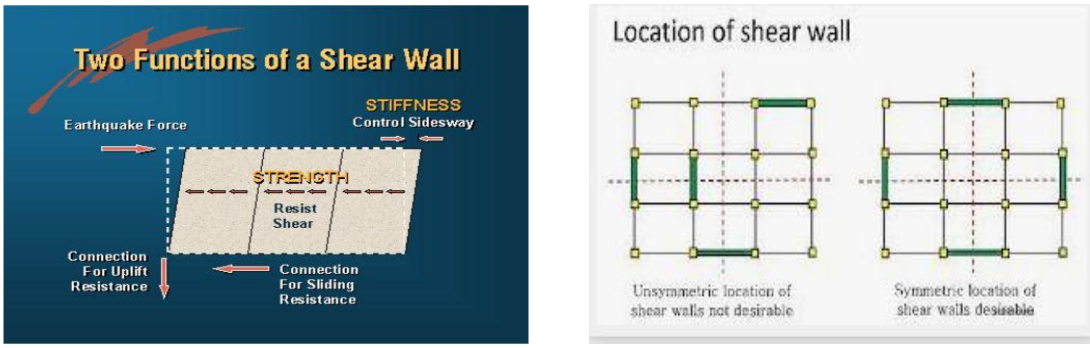
Earthquake is one of the major natural disasters in the world. It considered that. The damage caused due to the collapse of buildings during the earthquake is huge. The main reason for this calamity is the extirpation of manmade structures. The structure's lack of lateral rigidity is the first reason for its destruction during an earthquake .multi-story buildings need a seismic motion for their stability. Some endeavors have been done for finding the best method to make multi-story buildings strong and stable against earthquake forces. Provision of shear wall is one of the main options to provide diaphragm, which provides lateral strength for high-rise and multi-story structures. Shear walls have proper characteristics such as stiffness and strength, which can support building to resist high lateral and vertical loads. This paper aimed to find out the optimum positioning of the shear wall in a multi-story building on the sloped ground. A reinforced concrete (RC) framed building of $(G + 5)$ story on sloping area subjected to earthquake loading in zone V is considered. The analyses and design

comparison is carried out using STAAD Pro structural design software. Different cases of the shear wall at various locations of the considered building have been analyzed.
Keywords: Shear Wall, Dynamic Analysis, Story Drift, Lateral Story Stiffness, Staad Pro, Response Spectrum Analysis.

1. INTRODUCTION

In the present era of development, people are more enthusiastic and eager to move from rural to urban areas to avail more facilities and improvement, the prosperity of their life. Due to urbanization, there will be scarcity and shortage of land; even if it is available, the cost of land is not affordable for common middle-class people. Therefore, it is the need of time to construct the multi-story building. As per engineering knowledge whenever it is required to construct a building that is going vertically up, the impact of lateral load increase drastically and creates a big challenge for their stability. The lateral forces on the tall structure play a significant role at the top of the structure. The lateral forces acting on the building caused story drift and even lead to uplifting the column.

Among different lateral load resisting systems such as shear wall system, braced tube system, outrigger system, tuber system used in RCC framed structures, shear wall system is more common. After critical evaluation of the damage of the buildings in past earthquakes, reveals that the building having shear wall system suffer not much damage and shows good ductility as observed to those without having shear wall system. One of the most popular lateral earthquake resisting systems in multi-building is shear wall, which has stems to withstand to traction.



(a) Functionality of shear wall (b) Positioning of shear wall

Fig. 1 Shear wall in RC framed structure

The buildings having both vertical and horizontal irregularities are highly prone to damage due to earthquakes. Due to the scarcity of plain areas in the hilly ground, it is a compulsion for an engineer to construct the building on hilly slopes. Because the formation of the hilly area to plain area need more, cost and time consuming even in some cases not possible. On the side with demolition or excavation of hilly area to plain area, it will destroy the beauty and landscape of nature. Due to the land, improvement in the hilly area improves in financial, urbanization, as the result population concentrate has increased numerously, and an unbalanced ratio of accessibility to the land requirement is considering in the hilly area. While designing of multi-story building it will have considered that the design of the building in-the-plane area is very different in sloped ground area.

2. Objective and scope of the research

In this paper, a comparative study of the shear wall location of RC framed buildings for earthquake resistance construction is investigated. The objectives of this paper are as follows:

- Analyze the effect of optimum placing shear wall for a building, which is resting on the inclined ground.
- Analyze the effect of different story building which is located on the sloping ground area. And study different parameters like story drift, story displacement. Base shear
- Evaluate the ductility of the structure, which is resting on the sloped ground area with shear wall with consideration of horizontal force.
- To assess the different parameters like base shear, story displacement, and reduction factor for different positions of shear wall considered and suggested the best place for the shear wall in the building.
- Draw comparative graphs for building with and without a shear wall**.**

3. Application of Shear Wall for Earthquake Resistance Constructions

Estimation of earthquake load by considering the story drift, story displacement, and story shear for various positioning of the shear wall done. The high value of story displacement, story shear, and story drift was observed for the various positioning of the shear wall. The analysis will have done on G+15 concerning codal provision and all elements of building with normal beam, slab, and column (Ishant, 2016).

The behavior of a G+20 story residential building with shear walls in a different location was investigated and studied under seismic forces using the response spectrum method. The building is evaluated for story displacement, base shear with maximum permissible sideway, and torsional irregularity. The modeling and seismic analysis are done by ETABS 2015 with considering all zone of India. The dynamic analysis will consider by observing building irregularity in the plan. It concluded that the building with the shear wall, which is placed symmetrically, has a satisfactory result than the building without a shear wall. The maximum story displacement, story drift, and base shear are found to be more for zone five compare to another zone. It found that the placement of shear wall in the four-corner side has better results in terms of high displacement, story drift, and base shear and concluded that the building with uniform stiffness has better performance (Ahamad and Pratap, 2020).

The authors investigated the response of building under the action of earthquake and wind load, observed that its effect is crucial, and considered while designing. The effect of earthquake and wind load on the response on high-rise building signs increases with the height of the structure. The author considered two cases viz. with and with an out shear wall in a G+story RC framed building and analyzed in ETABS. Due to changes, the position of the shear wall in the building story drift and base shear compared. It is finalized that the correct placement of shear wall in the building can minimize the story displacement, story drift, and base shear and hence minimize the damage caused due to earthquake load and wind load (Tejas and Anirudhha, 2016),

The effect of lateral load in the building while considering the different positions of the shear wall with various heights in the G+5 story building for zone 3 is evaluated. For this, twelve different models will considered and analyzed for lateral load with the STAAD Pro software. (Yadav and Joshi, 2019).

The best position of the shear wall in the building investigated for a regular and irregular plan of the structure with the comparison with the positioning of the shear wall. In this study, G+ 10-story building was considered for zone II and IV. It observed that an irregular structure with a shear wall at the corner is the best choice as it decreases reinforcement and an irregular structure without a shear wall is more critical (Gupta, 2016).

In this study, the authors analyzed a multi-story building with a shear wall and try to find out the optimum placement of the shear wall that results in maximum strength against lateral forces and minimizes displacement of the multi-story structure. In this investigation, a G+ 7-story building of 15 m ×20 m in a flat area has been selected and modeled with ETABS. The prepared model was evaluated by calculating manually and the finding was validated in ETABS. Four different plans were modeled in ETABS placed in a similar seismic zone area. The new plans with shear wall concepts are executed on the structure at four various locations. Earthquake, vibration, and response spectrum analyses were performed on these buildings. Some basic parameters like story drift, story displacement, and story stiffness were calculated with the ETABS model. The obtained results compared with that of the rigid frame having no shear walls. With a comparison between the results found at different shear wall positions, the optimum plan with the shear wall having minimum lateral story displacement and maximum stiffness is suggested (Gajagantarao et al., 2021)

The author analyzed a G+ 9-story building with the location of the shear wall, braced system at the corner of the building, and evaluated the maximum displacement, maximum shear story, story drift. It concluded that the structure with the dual systems (sum of shear wall and bracings) at the corner (four edges of structure) shows minimum lateral displacement and story drift compared to a normal building. Sway displacement decreased by about 86% in the horizontal direction for both the shear wall and braced system compared to a normal structure. Maximum shear force and maximum bending moment reduced considerably due to both duel systems thus compared to normal biding (Sreeram et al., 2017).

In this study, the application of shear walls at various locations of structure and the behavior of structure due to changing the position of the shear wall shows a reduction of the maximum displacement, story drift, and story shear observed. Four different scenarios of shear wall location for G+10 story building with accurate consideration of zero eccentricity between the center of mass and hardness center have been analyzed and designed as a rigid frame system by computer application software ETABS. The rigid frame structure is subjected to horizontal load and vertical load by IS provision and the results are evaluated and considered to find the best placing of the shear wall. Due to the changing of the zone, the seismic severity will also change. In such cases, the use of shear walls becomes crucial for achieving safety in design (Vivek and Mitali, 2019).

The author explained the effect of the location of the shear wall for G+9 RC framed building with consideration of different lateral loads, twists of the building. Response spectrum method for various types of buildings, like symmetric building, unsymmetrical building, and plan irregularity with finding the shear walls at specific positions. The shear wall at the core of the model, shear wall at the periphery, and shear wall at the four corner edges for all of the structures with the observation of the different parameters like maximum story displacements and maximum story drifts, maximum base shear researched. This study used ETABS-2013 software. After analyzing G+9 the author concluded that, for symmetric building reduction in displacement in x and y direction for placement of L shape shear wall at corner edge. For irregular plan building placing of L shape at the corner has good performance and considerable reduction in both direction X and Y (Poornima et al., 2017).

The impact of shear walls in irregular multi-story structures was investigated. A fixed plan irregularity was selected to see the difference in both conditions with and without shear wall considering that shear wall has various shapes but has a constant area. The whole study focus on analyzing the impact of shear wall in irregular multi-story structures with considering the effective parameters. After analysis, it concluded from the analysis that the displacement in the x-axis and y-axis considered in the first model (which is with and without a shear wall in the building) shows maximum displacement concerning the remaining models having a shear wall at various locations. It considered that the minimum displacement and story drift has occurred in Model-7 and Model-8. As the Shape of the shear wall is as I-Section for model-7 at the center and corners. Wall By providing a shear wall, the stability of the f model increased against lateral loading. Therefore, the displacement and story drift are reduced if the shear wall is provided at the center of corresponding corners (Pandey, 2021). It suggested that avoiding heavy elements such as beam, column, etc. due to economic while due to seismic and wind load it is useful to provide shear walls to accommodate enough stiffness and rigidity to the building. After placing of shear wall and analyzing different parts of the building, it concluded that the shear wall at the corner has good performance due to seismic forces because the corners are more critical under seismic vibration (Chandiwala1, 2015).

A 13-story building selected and modeled by ETABS with various shear wall locations. Both static and dynamic analysis due to seismic forces did on the building by using ETABS with the equivalent static method and response spectrum method. Various kinds of models have been considered by placing the shear wall at various locations. Shear walls placed at the core (inside of the building) at the periphery along the X-axis and along the Y-axis (outside of the building) shear wall in L shape positioned at the corner, I shape shear wall positioned at the core of the frame by observing the one side opening and dual type of L shape shear wall placed at the internal frame. The comparison of the various shear wall models is investigated in this work against the different aspects like period, shear force, bending moment, displacement, story drift. Based on the story displacement and story drift values comparison it has been identified that the shear wall placed at the corner of the frame with L shape of the shear wall has a great advantage over other models (Sankar, 2017).

The author studied the behavior of multi-story G + 14 building having an asymmetric shape (square RCC shape) for various locations of the shear wall under the effect of an earthquake by considering the response spectrum method through to using STAAD Pro and good placing of shear wall on basis of some parameter like period, Story drift, fluency peak story shear, and maximum joint displacement. After a complete analysis of G + 14 story building, it is observed that increases in the lateral strength and sway motion with adding of shear walls to a multi-story building. After the above study, it is considered that for the good behavior of shear walls it should be specially designed for their best location, and from all mentioned models we found that the shear wall at the center (at the core) shows good results for a square plan which is made symmetrically. Furthermore, the shear wall, which is positioned asymmetrically, does not consist properly in the multi-story building and proves to be irrelevant sometimes (Bhattacharjee and Ankit, 2017).

The author performed a study on a damaged previous structure that found in past damaged building the design has not been considered according to modern IS code. Due to that more structures are prone to brittle types of shear failure while high seismic occur. After the survey and their assessment, find a reliable and more resisting element against lateral load, which is a shear wall. Furthermore, shear walls have a significant role in providing strength and stability against the lateral loading produced by seismic and wind loads. The majority of buildings have been designed to withstand strong earthquakes successfully due to the providing of shear walls. Moreover, the positioning of shear walls in a building plays a crucial role and considerably impacts their effectiveness, which is why the necessity is addressed. After analyzing 8-story frames using IDARC software. Two parameters considered for the design of building like reinforcement with detail and effective placing of shear wall.it concluded that, providing shear walls in such an optimum placement to withstand severe earthquakes effectively and efficiently. Shear walls in the building must be equal in length and positioned symmetrically on all four outside exterior walls and inside of the building (Raja, 2015).

The authors proposed the optimum placing of shear wall concerning store drift in X and Y direction. This study has carried out by the response spectrum method. After analysis, it concluded that the use of a shear wall could support the building by increasing the stiffness of the structure while decreasing the natural period. Sway displacement and story-drift significantly play the role. It is found that the best placing for the shear wall is at the core symmetrically (Tarigan et al., 2017).

The base shear is due to lateral load with ETABS V8i software. In this paper, the effect of seismic forces on the multi-story building while considering shear wall at the various position and trying to find the economical and the best location of shear wall. The analyses have been done for different locations like at the center of the building inside of structure at periphery of the building at the corner, between two corners and find the optimum placement of shear wall in the base of maximum shear wall moments and maximum deflection considered. For this analysis, five models are prepared. It considered that the placement of the shear wall in a significant way increases the capacity of the building to resist the lateral load. The columns, which be in failure condition before adding shear wall become safe after adding a shear wall. In addition, the problem of the soft story becomes solved after using the shear wall (Paul et al., 2020).

In this study, the author investigated the best configuration of structure using a shear wall by changing the thickness of the shear wall. In this study, a multi-story building having a G+15 story with various positioning of the shear wall has been done using ETABS software with IS provision. After analyzing it is found that the lateral loads are decreasing when the shear wall is added in optimum place, also shear wall can reduce the effect of torsion in the building, Steel plate provides more stiffness and strength to the building (Rahul et al., 2020).

The author of this paper focuses on the placing of shear wall in a way to reduce the distance between the mass center and hardness center and try to make this condition satisfied, for achieving the above condition considered different cases like placing the shear wall at the center or core, placing of the shear wall at the middle of the structure and placing of a shear wall along the periphery of the building, each case is investigated and compared to the other cases in the base of this basic parameter like lateral rigidity, diaphragm displacement, and story drift. This study used ETABS, software for analyzing different cases and models. The method is used for this analysis is the finite element method. After analysis, it is concluded that the best arrangement of shear wall in the plan of the building has an effective effect on the behavior of the building while earthquake occurring and best placement will change the stiffness in each story (Fares, 2019).

The effect on story stiffness, story drift due to the application of various shapes of shear wall-like, L shape, I shape, rectangular shape and C shape investigated. The author considered three cases of G+6, G+16, and G+25-story buildings, and analysis has been carried out using ETABS-2016 software. The author concluded in this study that, placing I shape shear wall in the center of the building has the best performance than all other shapes of the shear wall (Gupta and Bano, 2019).

The importance of a shear wall for a G+12 story building on performance is studied using two conditions. The response spectrum method is used with ETABS. Shear wall plays a vital role in the building to increase the rigidity of the building. Further, the shear wall increases the ductility and capacity of the building against lateral load and prevents the collapse of the building. With the use of a sheltering wall, we can solve a huge challenge that the design engineers faced with increasing the height of the building. The shear wall can absorb the external load due to its stiffness (Aman et al., 2020).

This paper described the various ways that the high rise structure can stand with a shear wall and can resist lateral load (Seismic and wind load) In this paper focused on constructing a cost-effective building in less time, a shear wall is used in the structure to resist not only vertically but resist against lateral load as well, a shear wall is used to resist against uplift load which caused by wind load. The key aim of the shear wall is to construct a safe tall building and aesthetic. Finally, the author concluded that the careful design and detailed structure with the shear wall have good behavior in past seismic motion. Therefore, a shear wall is so needful for that area that is prone to earthquakes (Tholkapiyan and Mohan, 2018).

Analysis of multi-story building with considering the different position of shear wall and evaluate the performance of the building according to that. Furthermore, consider the effect of different earthquake zone as per IS code. The method used in this analysis is the response spectrum method according to IS 1893. All analyses will have performed using ETABS. This analysis was done concerning story displacement, story drift & base shear along with the length and width of the building (Kumar, 2020).

The seismic coefficient method and response spectrum method are used for the investigation of asymmetric architectural configuration. Using ETABS software. This study was done in a comparative way to suggest the best suitable plan for both methods. It concluded that the seismic coefficient method is good for higher stories than the response spectrum method. Base shear obtained is more in the seismic coefficient method. (Prasanna et al., 2019)

4. Conclusion

In this paper, the effect of positioning of shear walls concerning earthquake resistance design is investigated. Different parameters like those that store story, base shear, story stiffness, etc. are considered while placing the shear wall at different locations of the RC building. In most cases, it observed that the efficiency of earthquake resistance design of building increases despite the location of the shear wall; however, in some cases, the lateral drift was found to be minimum. The best location observed for the placing of shear wall is centrally placing and with symmetrical way. In addition, the plan irregularity plays an important role while considering the building models for seismic analysis. In addition, a combination of shear walls and bracings may be a good choice for the earthquake resistance design of the structure.

References:

1. Akhil Ahamad S. and Pratap K. V. (2020), Dynamic analysis of G+20 multi-storied building by using shear walls in various locations for different seismic zones by using ETABS. Materials Today: Proceedings, 43, 1043. https://doi.org/10.1016/j.matpr.2020.08.014.
2. Basavalingappa M. and Anil Kumar, M. (2020), Analysis of High-Rise Building and its Behaviour Due to Shear Wall at Different Location and in Different Seismic Zones. www.ijert.org.
3. Bhattacharjee, J., Jain, P., & Gaurav, A. (2017). STUDY THE BEHAVIOUR OF HIGH-RISE BUILDINGS AT DIFFERENT POSITIONS OF SHEAR WALLS SUBJECTED TO SEISMIC LOADING. 7.
4. Dahat, I., & Autade, P. (2016). ANALYSIS OF LATERAL LOAD ON DIFFERENT ORIENTATION OF SHEAR WALL ISHANT DAHAT PG

Scholar: Department of civil engineering. In NOVATEUR PUBLICATIONS International Journal Of Research Publications In Engineering And Technology (Vol. 2).

5. Durga Prasanna, M., Rao, B. P., & Dean, P. (n.d.). A Comparative Study on Behaviour of High Rise Building with Shear Wall Under Seismic Analysis. www.ijert.org
6. Fares, A. M. (2019). The Effect of Shear Wall Positions on the Seismic Response of Frame-Wall Structures. https://www.researchgate.net/publication/340679778
7. Gupta, R. (2019). Performance Evaluation of Various Shapes of Shear Wall using Response Spectrum Analysis. In International Journal of Recent Technology and Engineering (IJRTE) (Issue 8).
8. Gupta, S., Akhtar, S., Hussain, A., Tech scholar, M., & Professor, A. (2016). Effect of Shear Wall Location on Bending Moment and Shear Force of Multistory Building Subjected to Earthquake Loading. In International Journal of Computer and Advanced Engineering Research (IJCAER): Vols. III-Issue II.
9. Journal, I., Shaha, T., & Banhatti, A. (2016). Earthquake Behavior of RCC Building for Various Shear Wall Configurations. International Research Journal of Engineering and Technology. www.irjet.net
10. Kulkarni, A., & Dabir, V. (2016). || Volume, 06 || Issue. In International Journal of Computational Engineering Research. www.ijceronline.com
11. Munde, G. M., & Meshram, K. (n.d.). Seismic Analysis of Shear Wall at Different Location on Multi-storey RCC Building. In International Journal of Interdisciplinary Innovative Research & Development.
12. Pandey, N. (2021). Stability Analysis of Shear Wall At Different Locations In Multi-Storeyed Geometrically Irregular Building Using ETABS. In International Journal of Engineering Research in Current Trends (IJERCT) (Issue 4).
13. Paul, A. A., Dhawale, P. G. D., & Kalmegh, P. V. A. (2020). Effect of the earthquake on high rise building in different positions of the shear wall using staad

pro. International Journal of Research and Analytical Reviews, 7(3). www.ijrar.org

14. Rahul, L., Akbar, M., & Sriraman, M. (n.d.). Design Optimization and Earthquake Analysis of Shear Wall in High Rise Building.
15. Raja Ganai, W. (2014). The Effect of Change in the Seismic Stability of Tall RC Buildings by Changing the Position of Shear Walls. In International Journal of Civil and Structural Engineering Research (Vol. 2). Online. www.researchpublish.com
16. Sanjay S J Assistant Professor Assistant Professor, P. D., & M Assistant Professor, Y. H. (2017). Seismic Analysis of RC Residential Multi-Storey Building for Different Locations of Shear Wall. In IJSTE-International Journal of Science Technology & Engineering | (Vol. 3, Issue 11). www.ijste.org
17. Shafy, Y. A. (n.d.). The Methodology of mitigation response of the high rise building by using outrigger system. https://doi.org/10.7537/marslsj170620.06
18. Siva Sankar, P., Kodanda, P., & Rao, R. (2017). STATIC AND DYNAMIC ANALYSIS OF A MULTI-STORIED BUILDING WITH SHEAR WALLS AT DIFFERENT LOCATIONS Master of Technology in Structural Engineering.
19. Sreeram, K. V. G. M., Singh, R. P., Siva, S., & Sai Kumar, B. (2017). EFFECTIVE LOCATION OF SHEAR WALLS AND BRACINGS FOR MULTISTORIED BUILDING. International Research Journal of Engineering and Technology. www.irjet.net
20. Sungaria, V., & Shrivastava, M. (n.d.-a). EVALUATING DIFFERENT SHEAR WALL PLACEMENTS IN MULTI-STOREYED STRUCTURES.
21. Sungaria, V., & Shrivastava, M. (n.d.-b). MITIGATING LATERAL DRIFT IN MULTISTOREY-BUILDINGS BY OPTIMUM POSITIONING OF SHEAR WALLS.

22. Tarigan, J., Manggala, J., & Sitorus, T. (2018). The effect of shear wall location in resisting earthquake. IOP Conference Series: Materials Science and Engineering, 309(1). https://doi.org/10.1088/1757-899X/309/1/012077
23. Tholkapiyan, M., & Mohan, A. (2018). Online) Available online atwww. In ijartet.com International Journal of Advanced Research Trends in Engineering and Technology (IJARTET) (Vol. 5). www.ijartet.com
24. Yadav, P., & Joshi, R. (2019). Effect of height and position of shear wall on G+5 multi-story building for zone III. International Journal of Recent Technology and Engineering, 8(3), 5452–5456. https://doi.org/10.35940/ijrte.C4609.098319