Study on the effect of special shear walls on seismic behaviour of multi-storey reinforced concrete building: A review

Shubham J. Mahadik[1], H. S. Jadhav[2]

[1]*P.G. Student, Dept. of Civil Engineering, Rajarambapu Institute of Technology, Islampur, Maharashtra, India.*
[2]*SProfessor, Dept. of Civil Engineering, Rajarambapu Institute of Technology, Islampur, Maharashtra, India.*

---***---

Abstract - *Tall buildings are the need of the hour for affordable housing initiatives in India. Strength and stiffness are typically provided to tall buildings by the wall system, which contains shear walls. In multi-story reinforced concrete structures, shear walls are the best structural element for resisting lateral loads. The basis for modern seismic design is the structure's ductile response. With this premise, the majority of current seismic codes include a set of provisions to ensure the member's flexural behaviour and achieve sufficient ductility levels. To make sure that the special shear wall has adequate ductility, a ductility check is covered in IS 13920:2016. The shear wall system needs to be effective with wind loads and earthquake loads, if not it'll result in catastrophic failure. Shapes and location of shear wall play a crucial role in minimizing the effect of the lateral loads and maintaining the economical aspect of the structure. In this paper, a brief review of various shapes of special shear walls and their behaviour under various loading conditions are discussed.*

Key Words: shear wall, seismic performance, lateral loads, ductility, stiffness, storey displacement.

1. INTRODUCTION

As mass increases, we have to go for even heavier sections to counter these seismic forces that in turn will increase the mass of the structure resulting in more seismic forces. Structures are made ductile to manage this so they can yield and dissipate seismic forces. In a framed structure, ductility can be easily added through proper reinforcement detailing, but once the structure crosses a certain height, it becomes impractical due to the need for large section sizes to resist forces. Shear walls are added as a response to this development. Shear walls bend in-plane to give the building frame the desired stiffness; however, when shear walls are used more frequently, the structure becomes stiffer. For the safe and efficient design of high-rise structures, a balance between the number of shear walls & frame components in a structure should be maintained. Shear walls can be built at a low cost to reinforce buildings and reduce damage. Shear walls are inherently less ductile and shear is likely the main mode of failure, so for a well-designed shear wall to perform well, the structure must be designed to be more resistant to lateral loads than a ductile reinforced concrete frame with similar properties. However, shear walls' excellent performance is compromised when their height-to-length ratio is high enough to cause an overturning issue and when they have an excessive number of openings.

2. LITERATURE REVIEW

Chouksey, Palkesh, et al. [1] modelled 12 models with the thickness of the shear wall provided corners from 0.130m to 0.150m thickness. The building consists of a 5 m separation of the 6-bar grid on both major routes. The plan area is taken 30mx30m (900 m2) and is located in seismic zone III. The project concluded that the stability of the structure increases with the increasing stiffness of the barber wall. The lateral load capacity in the shear wall structure is much higher and the elevation in it also increases. Finally, the best structures recognized in terms of sustainability in terms of outcome parameters are OSW10 (shear wall with 0.148m thickness) & 11(shear wall with 0.150m thickness).

Vanshaj, Kumar, et al. [2] studied a G+15 storey RCC building subjected to earthquake loading in Zone 4 on medium soil. Analysis was performed using STAAD Pro software. Here, the study has been done to compare storey drift, base shear, and storey displacement of building with and without a shear wall. When compared, the maximum value of Storey displacement is for the structure without a shear wall as compared to a building with a shear wall. The maximum value of Base Shear is for the structure without a shear wall as compared to a building with a Shear wall. The maximum value of Base Shear is for structures without shear walls as compared to building with Shear walls.

Firdose, HM Arshiya, et al. [3] carried out work to find the optimum location of the shear walls in plan irregular structures with shear walls such as in I -frame, L -frame, and T- frame for different zones in G+17 stories with each storey height of 3.2 m. Shear walls are given at the corners and periphery of the building. The seismic analysis performed is a linear dynamic response spectrum analysis utilizing the well-known analysis and design software ETABS 18. Seismic performance of the building has been examined based on specifications such as storey displacement, Storey drift, Storey Shear, Base shear, and Time period of modes. After analysis shear walls at corners are found as the best optimum location and positioning of shear walls.

Mahmoud, Sayed, and Alaa Salmana [4] examined the seismic response of RC shear wall buildings of 5, 6, 7, 8, 9, and 10-storey designed as conventional and ductile and located in a moderate seismic zone in Saudi Arabia under the seismic provisions of the American code ASCE-7-16 using linear dynamic analysis. The seismic responses of several design variations are evaluated in terms of storey displacements, drift, shear and moments of both conventional and ductile building models as performance measures and presented comparatively. Additionally, Pushover analysis is also performed for the lowest and highest building models. The cost estimate of ductile and conventional walls is evaluated and compared to each other in terms of the weight of reinforcement bars. In addition, due to the complexity of the design and installation of ductile shear walls, sensitivity analysis is performed as well. Finally, it is observed that conventional design considerably increases cost and induced seismic responses compared to ductile one.

Gaikwad, Aditya P., and R. M. Desai [5] studied the analysis of structures with shear walls at different locations and their effect on the structure. A 10-storied flat slab structure is modelled on Etabs software and response spectrum analysis and pushover analysis are performed. Seismic parameters like storey displacement, storey drift, base shear and time period are considered. It is observed that L shape shear wall at the corner is the optimum location of the wall where the structure gives good performance under seismic conditions.

Mandloi Shubham and Rahul Sharma [6] examined and critically evaluates and critically assesses the effects of various sizes of openings in shear walls on the responses and behaviours of multi-storey buildings also the Opening Area Effect of Core Type Shear Wall in Hospital building with the Highest Importance Factor. A number of G+20 storey prototype buildings with different types of openings in shear walls with and without incorporating the volume of shear wall reduced in the boundary elements are analysed using software Staad-Pro using the Response spectrum method (1893-2016). Overall analysis shows that the most efficient case for this study has been HIF5 (shear wall with 25% opening). The hospital building can be survived with the highest importance with the value of I = 1.5 as per IS 1893:2016 for opening area effect of core type shear wall. It can also be recommended that up to 25% opening will be possible without any seismic damage.

Prathama, A. H., et al. [7] presented the structural response comparison of buildings against variations in the profile and layout of shear walls subjected to earthquake loads. Force Based Design method is used using SAP200 software. The response spectrum approach is used for the analysis. Six structural models comprise a frame without shear walls, three L-profile shear walls, and two I-profile (straight) shear walls. The simulation results of the overall structural models show that the profile and layout configuration of shear walls in the frame structure of a multi-storey building correlates directly to the performance of base shear, drift ratio, and storey drift with relatively comparative conditions.

Duduskar, Rohan, et al. [8] analysed the behaviour of structures and compared the parameters like storey displacements, storey drift, storey shear, and time period. Four models of G+20 storey building were considered, Model I considered the normal structure, model II considered the floating columns structure, model III considered the shear wall structure and model IV considered both floating columns and shear wall structure. The seismic analysis of G+20 storey structures is analyzed by both equivalent static and response spectrum methods using Indian Standard code IS 1893 (Part1) 2002 and ETABS-2018 software. Storey displacements, storey shear, storey drift, and time period for seismic zone IV were studied. The storey drift compared to normal structure increased drifts in model II and decreased in model III, and IV. The storey shear compared to normal structure decreased shears in model II and increased in model III, and IV. Within all four models the time period of floating column structure i.e., model II is greater. Model III (shear wall at the corner of the building) structure is better performance with lesser displacements, and more strength compared with all four models.

Jiang, Huanjun, et al. [9] examined the influence of vertical setback on its seismic performance through elastoplastic time history analysis on three groups of models under different levels of earthquake excitation. The studied variables include setback percentage, local lateral stiffness ratio and setback position, which cause vertical irregularity in the structure. It is confirmed that the existence of a setback increases the inter-storey drift ratio at the setback position due to the sudden change of lateral stiffness thereby. Compared to the structure without a setback but having a similar local lateral stiffness, the maximum inter-storey drift ratio is smaller due to the reduced mass associated with the existence of a setback. To quantify vertical irregularity, limitations on the local lateral stiffness ratio can be relaxed to some extent for structures with setbacks. Along the height, the setback at the middle height gives a larger inter-storey drift ratio and seismic force. Overall, it was observed that setback at the middle height should be avoided.

Thakre, Prafoolla, et al. [10] studied the effect of the reduction in shear wall area in a multistorey building (G+19) to reduce cost. Total 5 buildings framed in Staad pro software abbreviated as SA, SB, SC, SD, and SE are supposed to be situated at Seismic Zone III. Post-parametric analysis results show that the reduction in shear wall area should be adapted to a certain limit of up to 20 % for cost-cutting.

Yadav, Gagan, and Sagar Jamle [11] performed the study work in two stages. The former one is building with a single shear wall core and the latter one is building with a dual-core shear wall; the entire work has been performed in four different phases. In the first phase total of 5 buildings are modelled with different openings in single-core type shear walls and then the second phase performs the analysis procedures of the same. The third phases have a total of 6 buildings that are modelled with different openings in dual-core type shear wall and the fourth phase performs the analysis procedures of the same. Building with 25% opening area in single-core type shear wall and 50% opening area in dual-core type shear wall performs well to reduce the cost of the project.

Patidar, Manoj, and Sagar Jamle [12] provided a study on the optimization of stability of multistoried structure by changing grades of concrete in shear wall member. The work demonstrates the devastating impact of the earthquake on a multistoried building. For this, a total of 12 shear wall stability case residential apartment building models are prepared and assumed to be located at seismic zone III with a shear wall at its core. These models have different shear wall thicknesses viz. 0.140m, 0.160m, 0.180m and 0.200m along with M20, M30 and M35 grades of concrete. According to all the parameters (base shear, maximum displacement, axial forces, shear forces, bending moment, principal stresses, and Von Mises stresses), thicker shear wall members made of higher-grade concrete are required to increase the stability of the multistory building.

Vijayan, Vineeth, et al. [13] studied the seismic performance of high-rise buildings with different types of shear walls. In Different shear wall types—concrete, silica fume concrete, steel plate, and steel silica fume concrete composite are taken into consideration for elevator walls in tall buildings that are 22 and 52 stories high. ETABS is used to analyse the seismic performance of these structures using the response spectrum method. Storey displacement, storey drift, and storey shear are studied as factors. When compared to the traditional shear wall, it is seen that there is a sizable reduction. When compared to a typical shear wall, it is seen that a composite shear wall can lessen the seismic effect to a greater extent because it results in a nearly 60% reduction in displacement. Finally, it is observed that the composite shear wall plays a significant part in the decrease of storey shear.

Patel, Neeraj, and Sagar Jamle [14] conducted a study on the use of shear wall belt at optimum height to increase lateral load handling capacity in a multistorey building on a 25-storied high-rise residential building. A standard floor plan with a plinth area of 825 m2 was used in this work. Different cases are created with the shear belt on different floors. Response spectrum method with SRSS (Square Root of Sum of Square) combinations used to determine various parameters such as base shear, maximum nodal displacement in the longitudinal and transverse direction, drift values and load cases that creates maximum drift. This paper presents the criteria for the provision of the shear belt at different heights with the use of Staad pro software. The optimum height for placing a shear wall belt to increase lateral load handling capacity was found to be on the 12th floor.

Joshi, Yash, et al. [15] studied the effect of the curtailed shear wall on RC buildings. Five cases of shear walls in multi-storey buildings are considered. Variation in shear wall thickness (250 mm, 200 mm, 150mm) and curtailment at different storey levels have been analyzed for seismic zone 3 and zone 5 are considered for 20 storey building. Dead load and gravity loads are applied to the building as per IS codes and the response spectrum method of dynamic analysis is carried out. Responses of models are compared for seismic parameters like displacement, time period, and axial force in columns. Better stability was observed in building with the full shear wall without curtailment as compared to remaining structures.

Suwalka, Vivek, et al. [16] carried out a study to find the prime location of the shear wall and then investigate the effectiveness of the best shear wall in a bare frame system. The structure is analyzed for earthquakes in the types of the structural system i.e., bare frame system. The building is located in Zone-IV according to IS 1893: 2002. Analysis of the 3 D building model is done by linear static method, response spectrum and surface messing are done to a model shear wall. In this study, Etabs software is used. A comparison of these models for different parameters like Lateral displacement in X & Y Direction, storey drift and axial force in columns was carried out. It was observed that the provision of a shear wall Model in Location 1 & 5 influences the seismic performance of the structure concerning lateral displacement and the results indicates that this configuration gives the least lateral displacement under seismic loads. The provision of a shear wall with an appropriate location is advantageous and the structure performs better if the optimum configuration and its footprint are identified before the design of the entire structure.

Reslan, N., et al. [17] compared the performance of reinforced-concrete shear walls (RCSW) to composite shear walls as a lateral-load resisting system. Buildings with RCSW or composite shear walls (CSW) with variable heights (8-storey, 14-storey, 20-storey) are the subject of the investigation. Etabs software is used for the 3D modelling of structures. Buildings are examined for static lateral forces using the equivalent static load method. Dynamic time-history analyses and response spectra dynamic analyses use the IZMIT earthquake record. In this study, it was found that installing composite shear walls in place of RC shear walls is a very effective and attractive structural choice to be made in earthquake-prone areas. A significant decrease in the building's overall dead load as a result of the steel wall's thinner thickness when compared to the RC shear wall.

Because of the rigidity of steel walls (EI), which is greater than that of RC walls due to cracking and a lower modulus of elasticity, the stiffness of the building with composite shear walls is higher. A fundamental requirement for seismic design is that composite shear walls have higher ductility than RC shear walls and higher energy of dissipation.

El-Sokkary, Hossam, and Khaled Galal [18] examined the effect of the wall's selected ductility level on the rebar detailing and the quantities of its constituent materials. For the study, 4 multi-storey RC shear wall buildings with different heights were located in three different cities in Canada; Toronto (low seismic hazard zone), Montreal (medium seismic hazard zone), and Vancouver (high seismic hazard zone) are used. The walls are designed using the dynamic analysis procedure of the National Building Code of Canada to reach different ductility levels. The construction material quantity estimates and the effect of ductility level on the bar detailing were evaluated and compared to a reference case for each building height, seismic hazard, and ductility level. The results show that conventional construction design required the least rebar work for RC shear wall buildings located in low and medium seismic hazard zones when conventional construction design is permitted by the code. However, in zones with high seismic hazards, the ductile wall design showed the lowest rebar work.

Swetha, K. S., and P. A. Akhil. [19] carried out a study on a 7-storey frame shear wall building, using linear elastic analysis. Etabs software is used to carry out the time history method. On a shear wall with openings arranged vertically, horizontally, and zigzag, and by varying the percentage of openings in a zigzag pattern, various parameters, including time period, displacement, base shear, storey drift, and storey acceleration, were studied. The findings demonstrated that the placement of openings affects time, displacement, base shear, storey drift, and storey acceleration. It is advised to use the zigzag arrangement of openings in shear walls because it performs comparatively 4% better than other arrangements of opening. Additionally, it has been found that a structure with a shear wall and openings arranged in a zigzag pattern that has an opening area of less than 16.67 % of the shear wall area performs about 4% better in terms of base shear, time, storey drift, storey displacement, and storey acceleration than a structure with an opening area greater than 16.67 % of the shear wall area.

AlHamaydeh M, et al. [20] studied the effects of Dubai's high and moderate seismicity estimates on seismic performance and construction and maintenance costs for structures with 6, 9, and 12 stories. The seismic force-resisting system of the reference buildings consists of special shear walls made of reinforced concrete. Nonlinear static and incremental dynamic analyses are used to examine seismic performance. To determine the impact, construction and repair costs related to earthquake damage are evaluated. The findings demonstrated that designing for higher seismicity significantly improves overall structural performance. Additionally, the increased seismicity estimate led to a slight increase in the price of initial construction. A reduction in earthquake damages and a significant improvement in seismic performance, however, more than offset the increase in initial investment. When repair and downtime costs are taken into account, this led to overall cost savings.

Vetr, M. G., et al. [21] examined the work on the construction behaviour at the interface of the composite column, shear wall elements, and concrete wall. Ten test specimens with different interface connections numbered HSW 1 to HSW 10, were tested to analyse the force-slip behaviour between Concrete Filled Steel Tubular (CFST) columns and Reinforced Concrete (RC) Shear Walls. When specimens were placed out diagonally during testing, the expansion of cracks at the IFC region was restrained, and failure occurred in the central region of the RC panel. The experimental force-displacement curves were normalised at load FR and slip SR to assess the non-linear static and dynamic response of Hybrid Shear Wall (HSW) under lateral loading and to establish a force-slip relationship at IFC. The effectiveness of various interfaces was evaluated, and it was found that straight anchor bars respond less effectively than those with diagonal bars. The HSW10 interface solution, which is arranged diagonally with 6 mm anchoring bars spaced at 50 mm from CFST penetration, is the best interface solution identified from the results. Straight anchorage bars exhibited significant slippage along the column-wall interface, as demonstrated by the force-slip results.

Christidis, Konstantinos I., et al. [22] examined 5 medium-rise shear walls with a shear ratio of 2.0 and designed and tested them as cantilevers under static cyclic loading. There was 1 reference wall and 4 strengthened walls. Four different configurations were included in the strengthened specimens, each of which aimed to limit the phenomenon of reinforcing bars buckling under compression and control the cracking width along the web. The four strengthening configurations are as follows: only horizontal straps along the height; only horizontal straps and corner angles along the height; only horizontal straps and corner angles in the lower part; and finally, the combination of horizontal straps and corner angles in the lower part with an X-shaped configuration in the rest of the web. According to this study, buckling of the compressive longitudinal reinforcement rebars, which frequently results in an early loss of all bearing capacity and consequently poor ductility levels, is the primary factor that determines the bearing capacity of existing non-conforming shear walls. The maximum measured load (capacity), on the other hand, does not appear to be affected by the low ratio of shear reinforcement (shear strength lower than the flexural one), but it is important in managing the cracking pattern along the wall web.

Wang, M., et al. [23] examined the seismic behaviour of unstiffened steel plate shear wall specimens with a 1:3 ratio under cyclic load. The test is carried out on a four-three storey unstiffened steel plate shear wall which exhibited high strength, good energy dissipation capacity and good ductility with no more than 5% strength degradation. For the experimental approach, the span to height ratio is put L/h=1.5 to 2.0 and a steel plate shear wall specimen with a 1:3 ratio is designed. During loading at an inter-drift angle of 1/50 of the specimen, the strength degradation is no more than 5% which indicates that the structure is good in seismic behaviour. Results of this study found a column stiffness ratio of more than 0.2, which is the best for post-buckling strength of steel plate shear wall and stiffness of edge column provides a great lateral load capacity of shear wall. As the ratio increases the specimen shows good ductility i.e., the ductility coefficient reached more than 3.0 of the first specimen which spans to a height ratio is 1.5. The experimental studies also indicate that residual stresses had little effect on behaviours of steel plate shear wall which cannot be considered for numerical analysis.

Walvekar, Anuja, and H. S. Jadhav. [24] examined how shear walls in various positions affected the seismic behaviour of high-rise buildings with flat slabs. The 15-story model is chosen for that. The software ETABs performs a linear dynamic analysis (Response spectrum analysis) to examine the impact of various shear wall placements on high-rise structures. The examination of seismic parameters includes time period, base shear, storey displacement, and storey drift. Base shear in X and Y directions for structures with shear walls is found to be 3.08% greater than for structures without shear walls, and storey displacement without a shear wall along EQX and EQY is found to be 48.52% and 53.36% greater than displacement with a shear wall, respectively. Storey displacement is minimal for a structure with a shear wall along the periphery. Compared to structures with L-type shear walls and structures with non-parallel shear walls along the periphery, it is respectively 29.13% and 10.06% less for structures with a shear wall along the perimeter.

3. CONCLUSIONS

From the above study, it can be concluded that different researchers had studied different types of problems related to earthquakes and addressed that shear walls are more prominent to resist lateral force due to earthquakes. Analysis by software such as STAAD Pro, ETABS etc. is also combined along with manual studies. Models are generated and shear walls are located at different positions in the building to find the least displacement of the structure. Moreover, some research stated that changes in positions of shear walls affect the attraction of forces. The location of the shear wall in any building substantially reduces displacements and reduces impacts on the structure. For irregular RC framed structures, it was found that shear walls at corners are the best optimum location and positioning of shear walls (Firdose, et al. 2022). For 10 storied structures with flat slabs, it is observed that L shape shear wall at the corner is the optimum location of the wall where the structure gives good performance under seismic conditions (Gaikwad, et al. 2021).

Openings in the shear wall are also an issue of concern in the study of shear wall buildings. For a hospital building with an importance factor, I =1.5 it is recommended that up to 25% opening will be possible without any seismic damage (Shubham Mandloi, et al 2021). It is observed that a building with a 25% opening area in a single-core type shear wall and a 50% opening area in a dual-core type shear wall performs well to reduce the cost of the project (Yadav Gagan, et al. 2020). Also, a structure (7-storey) with a shear wall having openings arranged in a zigzag manner having an opening area of less than 16.67% as compared to a shear wall area is founded to be approximately 4% better performance in the base shear, storey displacement, time period, storey drift and storey acceleration than opening area greater than 16.67% as compared to shear wall area (Swetha, et al. 2017). Generally, openings provided in shear walls increase displacement in the building. Thus, building without a shear wall is a subject of concern and needs to be retrofitted in places of the high earthquake and wind impact. Analyses and design results showed that conventional construction design required the least rebar work for RC shear wall buildings located in low and medium seismicity zones when conventional construction design is permitted by the code, however for high seismicity zones, the ductile wall design showed the least rebar work (El-Sokkary, et al. 2018).

Building without a shear wall is a subject of concern and needs to be retrofitted in places of the high earthquake and wind impact. The location of the shear wall in any building substantially reduces displacements and reduces the impact on the structure. The effect of various shapes of shear walls on the building can be studied. Comparison can be made with a building with various shapes of shear walls. Moreover, the placement of shear walls at different locations is an essential aspect to be thought of for further study.

REFERENCES

[1] Chouksey, Palkesh, et al. "Analysis of Uniform Concrete Grade for Increment of Stability of Building by Changing Thickness of Shear Wall at Corners." International Research Journal of Modernization in Engineering Technology and Science, vol. 04, no. 03, 2022.

[2] Vanshaj, Kumar, et al. "COMPARATIVE STUDY OF MULTISTOREY RC BUILDING WITH AND WITHOUT

SHEAR WALL." International Research Journal of Modernization in Engineering Technology and Science, vol. 04, no. 03, 2022.

[3] Arshiya Firdose, H. M., et al. "Study on Dynamic Behaviour of Irregular R.C Framed Structures with Different Location of Shear Walls." IOP Conference Series: Earth and Environmental Science, vol. 982, no. 1, 2022.

[4] Mahmoud, Sayed, and Alaa Salmana. "Impact of shear wall design on performance and cost of RC buildings in moderate seismic regions." EARTHQUAKES AND STRUCTURES, vol. 21, no. 05, 2021, pp. 489-503.

[5] Gaikwad, Aditya P., and R. M. Desai. "Seismic Analysis of Flat Slab Structure with Shear Wall at Different Locations." International Research Journal of Engineering and Technology (IRJET), vol. 08, no. 01, 2021.

[6] Mandloi, Shubham, and Rahul Sharma. "Opening Area Effect of Core Type Shear Wall in Hospital Building with Highest Importance Factor." International Journal for Research in Applied Science & Engineering Technology (IJRASET), vol. 9, no. 11, 2021.

[7] Prathama, A. H., et al. "Response Analysis of a Multi-Story Building Structure with a Variety of Horizontal Irregularities and Shear Wall Geometries." IOP Conference Series: Earth and Environmental Science, vol. 933, no. 1, 2021.

[8] Duduskar, Rohan, et al. "Seismic Analysis of Multi-Storey Building with and without Floating Column and Shear Wall." International Journal of Engineering Research & Technology (IJERT), vol. 10, no. 07, 2021.

[9] Jiang, Huanjun, et al. "Seismic Performance of RC Frame-Shear Wall Structures with Vertical Setback." Structures, vol. 33, 2021.

[10] Thakre, Prafoolla, et al. "Opening Area Effect of Shear Wall in Multistorey Building under Seismic Loading." International Journal of Advanced Engineering Research and Science (IJAERS), vol. 07, no. 02, 2020.

[11] Yadav, Gagan, and Sagar Jamle. "Opening Effect of Core Type Shear Wall Used in Multistoried Structures: A Technical Approach in Structural Engineering." International Journal of Advanced Engineering Research and Science, vol. 7, no. 3, 2020, pp. 344–351.

[12] Patidar, Manoj, and Sagar Jamle. "Optimization of Stability of Multistoried Structure by Changing Grades of Concrete in Shear Wall Member." Journal of Xi'an University of Architecture & Technology, vol. 12, 2020.

[13] Vijayan, Vineeth, et al. "Seismic Performance of High Rise Buildings with Different Types of Shear Wall." IOP Conference Series: Materials Science and Engineering, vol. 936, no. 1, 2020, p. 012055.

[14] Patel, Neeraj, and Sagar Jamle. "Use of Shear Wall Belt at Optimum Height to Increase Lateral Load Handling Capacity in Multistory Building." International Journal for Research in Engineering Application & Management, vol. 04, no. 10, 2019, pp. 596-603.

[15] Joshi, Yash, Sagar Jamle, and Kundan Meshram. "Effect of Curtailed Shear Wall on Dynamic Analysis of RC Building." International Journal of Management, Technology And Engineering, vol. 9, no. 07, 2019, pp. 223-230.

[16] Suwalka, Vivek, et al. "Comparative Study and Modelling of Framed Structure with Shear Wall & Without Shear Wall by Using ETABS." International research journal of engineering and technology (IRJET), vol. 5, 2018.

[17] N, Reslan, et al. "Composite Shear Walls an Efficient Seismic Resistant System for Multi-Story Buildings." Journal of Steel Structures & Construction, vol. 04, no. 01, 2018.

[18] El-Sokkary, Hossam, and Khaled Galal. "Effect of Preliminary Selection of RC Shear Walls' Ductility Level on Material Quantities." International Journal of Concrete Structures and Materials, vol. 12, no. 1, 2018.

[19] Swetha, K. S., and P. A. Akhil. "Effect of Openings in Shear Wall." International Research Journal of Engineering and Technology (IRJET), vol. 04, 2017.

[20] AlHamaydeh, Mohammad, et al. "Impact of Seismicity on Performance and Cost of RC Shear Wall Buildings in Dubai, United Arab Emirates." Journal of Performance of Constructed Facilities, vol. 31, no. 5, 2017.

[21] Vetr, Mohamad-Ghasem, et al. "Seismic Resistance of Hybrid Shear Wall (HSW) Systems." Journal of Constructional Steel Research, vol. 116, 2016, pp. 247–270.

[22] Christidis, Konstantinos I., et al. "Strengthening of Non-Conforming RC Shear Walls Using Different

Steel Configurations.” Engineering Structures, vol. 124, 2016, pp. 258–268.

[23] Wang, Meng, et al. “Experimental and Numerical Study of Unstiffened Steel Plate Shear Wall Structures.” Journal of Constructional Steel Research, vol. 112, 2015, pp. 373–386.

[24] Walvekar, Anuja, and H. S. Jadhav. "Parametric study of flat slab building with and without shear wall to seismic performance." International journal of research in Engineering and Technology, vol. 04, no. 04, 2015, pp. 601-607.

[25] Bureau of Indian Standards: IS-1893, part 1 (2016), “Criteria for Earthquake Resistant Design of Structures: Part 1 General provisions and Buildings”, New Delhi, India.

[26] Bureau of Indian Standards: IS-13920 (2016), “Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces - Code of Practice”, New Delhi, India.