Review on Performance and Optimum Position of Shear Wall in High Rise Building

Dipika N. Khandelwal[1*] & Monica Mhetre[2]

[1]PG Student, Department of Civil Engineering, Deogiri Institute of Engineering and Management Studies, Aurangabad, India
Corresponding Author E-mail: *khandelwaldipika2@gmail.com*

[2]Assistant Professor, Department of Civil Engineering, Deogiri Institute of Engineering and Management Studies, Aurangabad, India

Abstract: Due to increase in population in urban areas of India, there is a vast increase in demands of high rise buildings. The most important component to design a safe and durable structure is the shear wall system provided. It is a structural element used to resist horizontal forces which acts parallel to the plane of the wall. Shear wall has high plane stiffness and strength which counter the effect of large horizontal loads such as seismic forces, wind load and support gravity loads. The present paper work was made in the interest of studying various research works involved in some investigations made to analyzed by changing various location of shear wall to find optimum position and the performance for determining storey drift, storey shear and displacement by using standard package ETAB' s software. As shear walls resists major portions of lateral loads in the lower portion of the buildings and the frame supports the lateral loads in the upper portions of building which is suited for soft storey high rise building, as in India base floors are used for parking and garages or officers and upper floors are used for residential purposes.

Keywords: Shear wall, Story drift, Story shear, Seismic forces, ETABS, High rise building

I. INTRODUCTION

In structural engineering, shear walls are specially designed structural members to resist horizontal forces induced in the plane of the wall due to wind, earthquake and other lateral forces. Core walls are mainly flexural members and usually provided in high rise buildings to avoid the total collapse of buildings under seismic loads. Tall buildings are becoming as slender as possible, leading to the possibility of more sway in comparison with earlier high-rise buildings in Urban areas of India. Improvement of the structural systems of tall buildings can control their dynamic response is done by more appropriate structural forms such as shear walls and tube structures and improved material properties. The general design concept of the bearing wall system depends upon the combined structural action of the floor and roof systems with the walls. The floor system carries vertical loads and, acting as a diaphragm, lateral loads such as wind and earthquake loads are transferred to the walls and to the foundation. These shear walls have main function of shearing resistance and resistance to overturning. In the present study, various researches were discussed on performance of shear wall based on its location, orientation and materials used for construction.

II. LITERATURE REVIEW

Lin and Kuo, conducted experimental work and also performed Finite element analysis to study ultimate strength of shear wall with opening under lateral load. From the results it was concluded that the shear strength contributed by diagonal reinforcement around opening reached 40% of its yield strength, while the shear strength contributed by the rectangular arrangement reached 20% of its yield strength. The shear strength predicted by ACI EQ A-7 provided that the center to center of boundary elements was considered as the effective depth of the wall structure in the *high-rise* buildings. Consistent correlation between the results of finite element analysis and experiment was observed by properly releasing the tensile stresses in concrete after section cracked.

Sardar et.al, Conducted seismic analysis of a model with 25 storey building in zone V is presented with some investigation, by changing various location of shear wall for determining parameters such as storey drift, base shear and lateral displacement is done by using standard package ETAB. The study included creation of 3D building model for both linear static and linear dynamic method of analysis and influence of concrete core wall provided at the center of the building. From this study it was concluded that in when shear wall placed at center and four shear ***walls*** placed at outer edge parallel to X and Y direction is subjected to lesser displacement against the structure with shear wall at Centre of the structure.

Gong et.al, simplified the mechanical model and numerical simulation researches on shear wall with opening were reviewed, the research findings on shear wall with opening at home and abroad were summarized by applying seismic behaviors. The researchers concluded ***that,*** (1) shear capacity and lateral stiffness of the shear wall are reduced because of the openings, the ductility and energy-dissipation capacity can be improved also the seismic behaviors of the shear wall will be influenced by the frame constraint, the size and the location of opening. (2) Compared with common shear wall, the researches on prefabricated composite shear wall with boundary frames and openings are relatively less.

Hiremath et.al., worked on effect of addition of shear wall at different location and configuration, also studied varying thickness of shear wall. The results are tabulated by performing pushover analysis using ETABS v 9.7.1 in the form of displacements and storey drift. The graphical representation from the results shows that there has been steady increase in the amount of displacement of stories over the height. According to the analysis made in this paper, the reduction of displacement of stories is due to increase of stiffness of structure as well as decrease of velocity and acceleration of structure. After observing all the graphs, it can be concluded that drift ratio in upper storey is generally more, lesser in lower stories and maximum in the middle storey of the high rise building. It was concluded that providing shear walls at adequate locations substantially reduces the displacements due to earthquake, percentage of lateral drift and displacement both depends on the location of shear wall and its thickness. Model with shear wall at mid span having varying thickness achieves highest reduction in displacement with base shear in elastic region, so that the building acts well within the elastic region of it. On Observing, storey drift ratio is very low in bottom stories, very high at the middle stories and finally decreases towards the upper stories.

Marsono et.al., evaluated the coupling beams behavior of concrete shear wall with rectangular and octagonal openings .In this paper researchers suggests that addition of haunches to the corners of rectangular openings and to form octagonal openings to increase the strength of coupling beams. The experimental results of shear wall with Single band of rectangular and octagonal openings were compared in terms of behavior of coupling beams under cyclic load which demonstrate that the coupling beams in shear wall with octagonal openings were stronger than coupling beams in shear wall with rectangular openings.

Varsha Harne, analyzed a six storey RCC building which is subjected to Earthquake loading in zone II to determine the strength of RC wall by changing the location of shear wall in a high rise building using STAAD.Pro. In this paper seismic coefficient method is used to calculate the earthquake load as per IS 1893 – 2002 (Part I). Four different models like structure without shear wall, structure with L type shear wall, structure with shear wall along periphery, structure with cross type shear wall were analyzed. It was concluded from the results obtained that comparing to other models the shear force and bending moment, for structure with shear wall along the periphery is found to be maximum at the ground level and roof level respectively. Hence the shear wall provided along the periphery of the structure is found to be more efficient than all other types of shear wall locations in the high rise building.

Dadayan and Roudi, developed FEM (Finite Element Method) models were analyzed for stress-strain state of RC wall-frame buildings with various openings in the walls under action of seismic forces. Limitation of size and position of openings were considered taking into account of Building Code of Armenia (BCA). Eight different types of openings in shear wall were considered during practice. Some numerical analysis were performed to show that in RC walls where the length of the openings exceed their length more than 50 %, substantial increase of stresses occur both in walls and in columns.

Suresh et.al., studied to find the effective, efficient and optimum location of shear walls in high rise irregular RC building. In this paper the optimum location of shear wall has been investigated with the help of three different models. Model 1 is frame structural system and other two models are dual type structural system with central core wall and corner shear wall. An earthquake load calculations are based on IS 1893(PART-1)-2002 and applied to (G+20) storey R.C building in zone-2 and zone-5. The analysis is performed using ETABS 9.7.4 Software package. The conclusion was made that plan without shear wall gives more displacement and more drift compare to plan with shear wall along four edges. Hence by providing shear wall along four edges storey displacement, storey drift, storey shear can be reduced and also there is increase strength and stiffness of the structure. Hence it was concluded that by providing shear wall along four edges is found to be optimum position of shear wall.

Muthukumar et.al, studied the dynamic behavior of shear wall was studied under various opening locations using nonlinear finite element analysis (using degenerated shell element) by assuming strain approach and the material nonlinearity has been considered using plasticity approach. A 5-parameter Willam-Warnke failure criterion is considered to state the yielding crushing of the concrete with tensile cutoff. From the results obtained the time history responses have been plotted for all opening cases with and without ductile detailing. The analysis has been done for different damping ratios and observed that the large number of small openings resulted in better displacement response.

Ali et.al, considered important aspects concerning design of shear walls were its placement in structure and the cross section (i.e. width to thickness ratio) keeping check on torsional stresses, economy and ductility of structure. A comparative study has been carried out using ETABS software by varying location and cross section of shear wall for Stock Exchange Building, Islamabad. Maximum lateral drift, storey drift, base shear forces and time period of structure were important parameters considered. Comparison is made for response spectrum analysis between 4 cases depending upon location of shear wall and best possible case and the actual building. From the results obtained it had been concluded that original location with 6 inch thick shear wall would be more economical and ductile than existing 12 inch thick wall keeping in view the allowable lateral drift and base shear forces.

Surana et.al., focus was given on estimation of seismic performance of shear-walls and shear-wall core buildings designed as per Indian codes using non-linear pushover analysis. Modeling of shear-walls was carried out by wide column model and shell element model which were validated through the experimental results presented in other reviews of literature. Also it' s stated that the stiffness obtained from moment-curvature analysis was in close agreement with the experimental results while the shell element model predicts high initial stiffness and after cracking it reduces and matches with experimental results. These validated models were implemented for performance evaluation of " Dual Systems" designed according to Indian code. It was concluded that buildings with shear-walls placed at periphery had better performance than buildings with centrally placed shear-wall core.

Chandurkar and Pajgade, presented a study towards the solution for shear wall location in multi-storey building. Effectiveness of shear wall had been studied with the help of four different +models. Model one was bare frame structural system and other three models were dual type structural system. An earthquake load was applied to a building of ten stories located in zone II, zone III, zone IV and zone V. Parameters like Lateral displacement and story drift whereas total cost required for ground floor were calculated in both the cases replacing column with shear wall.

Karnale et.al., presented different configurations of shear walls for 6 (Low Rise) and 14 storey (High Rise) building and also stated functions and advantages of RCC shear wall. A comparative analytical study was made for 6 models having 6 and 14 storied building each with different combinations of placement of shear wall were analyzed by using ETABS software. The results compared by applying lateral loading on the basis of effect observed due to height of structure having shear wall. Results obtained from analysis which gives topically base shear, deflection and storey drift plotted to compare and to observe behavior of RCC framed structures with shear walls. In this paper it was concluded that the use of shear wall in high rise structure is more effective than use in low rise building

Lova Raju et.al., studied non-linear analysis of frames to find the effective position of shear wall in multi storey building. An earthquake load was applied to an eight storey structure of four models with shear wall at different location in all seismic zones using the software ETABS. Push over graphical curves were analyzed and observed that the structure with shear wall at appropriate location is more important while considering displacement and base shear.

III. CONCLUSION:

In the recent era researchers are more likely to use shear walls in construction of tall building structures. The conclusions drawn from the literature survey made in this paper is as follows, the high-rise structure without shear wall gives more displacement and more drift compare to plan with shear wall along four edges. Hence it can be concluded that, by providing shear wall along four edges we can reduce storey displacement, storey drift, story shear and, we can increase strength and stiffness of the structure. Structure with shear wall at optimum location is more important while considering displacement and base shear of any high-rise building. Also Shear walls with openings experienced a decrease in structural strength whereas diagonal shear wall found to be effective for high rise structures located in earthquake prone areas. Rising of shear wall up to the entire height of building is not necessary but it is sufficient to raise the shear wall up to mid height of high rise building structure.

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical statement: The authors declare that they have followed ethical responsibilities.

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