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Review on Analysis and Design of RCC Shear Walls with and Without Openings

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ABSTRACT
Shear wall is a structural element which provides stability to structure from lateral loads like wind load and seismic loads. The stiffness and strength of wall may decreased by the reduction in the concrete area and the discontinuity of the reinforcement due to opening. To know the responses of providing openings and the behavior of shear wall without openings is the aim of the given study. Hence, it is necessary to demonstrate work on the analysis, design and post effects of shear walls when seismic forces are applied. In this paper, a review is taken out over the analysis and design of RCC shear walls with and without openings to study more detail analytical results and conclusions.

Keywords: Analysis, ETABs, High Rise, Openings, RCC Shear Wall, Seismic Performance

I. INTRODUCTION

This study investigates the analytical results and designing provisions for the shear walls with and without openings, obtained from available literature. In the seismic design of buildings, reinforced concrete structural walls or shear walls, act as major earthquake resisting members. Structural walls provide an efficient bracing system and offer great potential for lateral load resistance. The properties of these seismic shear walls dominate the response of the buildings, and therefore, it is important to evaluate the seismic response of the walls appropriately. Shear walls are commonly used in reinforced concrete construction to resist the shear force induced by earthquake. The size and location of opening may play a significant role in the response of shear walls. Though it is a well known fact that size of openings affects the structural response of shear walls significantly, there is no clear consensus on the behavior of shear walls under different opening locations. Shear walls situated in advantageous positions in the building, they can form an efficient lateral force resisting system.

As shown in the Fig. 1(a) and Fig. 1(b), shear walls with and without openings are placed around the periphery of plan of structure. The given study also focuses for the results obtained in an analytical and designing manner, if the combination of shear walls with and without openings Fig.1(c) is established in a single structure.

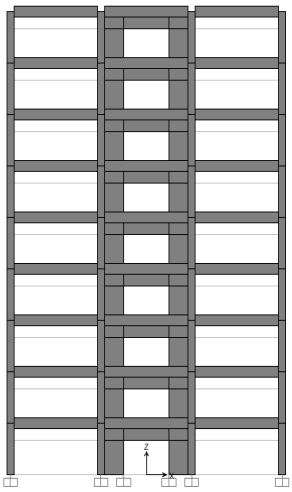

Fig.1(a): Elevation of shear wall with opeings in high rise structure.

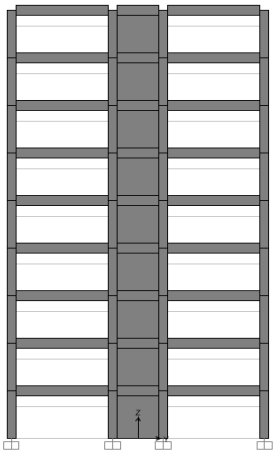

Fig.1(b): Elevation of shear wall without opeings in high rise structure.

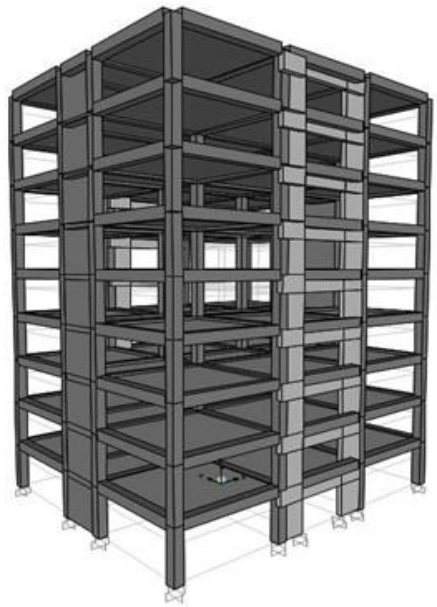

Fig.1(c): Isometric view of combination of shear walls with and without openings in high rise structure.

II. REVIEW OF LITERATURE

[1] J. Ali, A. Bhatti, M. Khalid, J. Waheed and S. Zuberi, In this paper, important aspects concerning design of shear walls were its placement in structure and the cross section (i.e. width to thickness ratio) keeping in view torsional stresses, economy and ductility of structure. A comparative study 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. Response spectrum analysis had been carried out on 4 cases depending upon location of shear wall and best possible case, selected which was finally compared with actual building. It had been concluded that original location with 6 inch thick shear wall could had been more economical and ductile than existing 12 inch thick wall keeping in view the allowable lateral drift and base shear forces. This also suggested an informative revision in Building Code of Pakistan (BCP) in part of the building height limits for building systems in seismic zone 2.

[2] P. P. Chandurkar and Dr. P. S. Pajgade, This paper 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, story drift and total cost required for ground floor were calculated in both the cases replacing column with shear wall.

[3] A. B. Karnale and Dr. D. N. Shinde, **'**In this paper, researchers presented the results for different configurations of shear walls for 6 (Low Rise) and 14 storey (High Rise) building. They also defined the functions and advantages of RCC shear wall. A comparative analytical study was given by using ETABs software in which 6 models for 6 and 14 storied building each with different combinations of placement of shear wall were analyzed. The results compared on the basis of effect observed due to height of structure having shear wall. In this dissertation the analysis was done for lateral loading. Loads used were equivalent static load as earthquake load. Results obtained from analysis which gives topically base shear, deflection and storey drift plotted to compare and to have knowledge of behavior of RCC framed structures with shear walls. The use of shear wall in high rise structure is more effective than use in low rise building.

[4] M. Surana, Y. Singh and D. H. Lang, The given study focuses 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 were validated through the experimental results available in other reviews of literature. It was also observed 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 had been observed that buildings with shear-walls placed at periphery had better performance than buildings with centrally placed shear-wall core.

[5] M. Mosoarca, The paper presented the results of the theoretical and experimental tests on failure modes of three types of reinforced concrete shear walls with staggered openings which were compared to those obtained from walls with vertical ordered openings as far as the seismic response was concerned. The failure modes of the structural walls under seismic stress had been identified using calculus programs and cyclic alternated experimental tests.

[6] G. Muthukumar and Manoj Kumar, in this research paper, the dynamic behavior of shear wall was studied under various opening locations using nonlinear finite element analysis (using degenerated shell element) with assumed strain approach. Only material nonlinearity has been considered using plasticity approach. A five-

parameter Willam-Warnke failure criterion is considered to define the yielding crushing of the concrete with tensile cutoff. 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. It has been observed that the large number of small openings resulted in better displacement response.

[7] A. K. Marsono and S. Hatami, This paper gave the evaluation of coupling beams behavior of concrete shear wall with rectangular and octagonal openings. This research suggests 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. The results demonstrate that the coupling beams in shear wall with octagonal openings were stronger than coupling beams in shear wall with rectangular openings.

[8] C Y Lin and C L Kuo, in this paper, Finite element analysis and experimental work were conducted to study ultimate strength of shear wall with opening under lateral load. The test results indicated 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. Consistent correlation between the results of finite element analysis and experiment was observed provided that the tensile stresses in concrete were properly released after section cracked.

[9] S. M. Yarnal, S. S. Allagi, P. M. Topalakatti and A. A. Mulla, in this research paper seismic analysis of shear wall building in zone III (IS 1893: Part 1, 2002) and study for shear walls with various percentages of openings were done. Analytical results obtained for fundamental frequency, base shear, storey drift, shear forces and stiffness. The performance of shear wall was compared with various percentages of openings of shear wall area. In this project ETABS 2013 tool was used for analysis of the structure. The conclusions derived as, storey drift of building provided with openings in shear wall is greater than shear wall without openings. Time period is directly proportional to the openings in shear wall i.e. as area of openings increases in shear wall, time period also increases. Base shear is relatively less for shear walls with openings than shear walls without openings.

[10] T. Dadayan and E. Roudi, In given research work, FEM (Finite Element Method) models were used for investigation of 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 in the paper taking into account of Building Code of Armenia (BCA). Eight types of different schemes of openings in shear wall were considered during practice. Some numerical analysis were done 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.

[11] L. Gong, J. Chen and Y. Su, gave establishment of simplified 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, and the seismic behaviors were induced and analyzed. The researchers found some problems which tend to solve as, (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. And 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.

[12] S. K. Mutwalli and Dr. S, Azam, This study presented the procedure for seismic performance estimation of high-rise buildings based on a concept of the capacity spectrum method. 3D thirty storied buildings Modeled and analyzed using structural analysis tool ETABS. The analytical model of the building includes all important components that influence the mass, strength, stiffness and deformability of the structure. To study the effect of concrete core wall & shear wall at different positions during earthquake, seismic analysis using both linear static, linear dynamic and non-linear static procedure had been performed. The deflections at each storey level had been compared by performing Equivalent static response spectrum method as well as pushover method had also been performed to determine capacity, demand and performance level of the considered building models. It had been observed that non-linear pushover analysis provide good estimate of global as well as local inelastic deformation demands and also reveals design weakness that may remain hidden in an elastic analysis and also the performance level of the structure. Storey drifts were found within the limit as specified by code (IS: 1893-2002) in Equivalent static, linear dynamic & non-linear static analysis.

III. CONCLUSION

From the study of literature presented in this paper, conclusions are drawn out on the responses of shear walls with and without openings in multi storey buildings as,

i. Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position.
ii. If the dimensions of shear wall are large then major amount of horizontal forces are taken by shear wall.
iii. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake.
iv. Although shear capacity and lateral stiffness of the shear wall are reduced because of the openings, the ductility and energy-dissipation capacity can be improved and the seismic behaviors of the shear wall influenced by the frame constraint, the size, the location of opening etc.
v. The shear wall located at core of building gives deflection in permissible limit but maximum base shear. So, it is more vulnerable to earthquake.
vi. Storey drift of building provided with openings in shear wall is greater than shear wall without openings.
vii. Time period is directly proportional to the openings in shear wall. As area of openings increases in shear wall, time period is also increases.
viii. Frequency decreases with increase in openings.
ix. Base shear is relatively less for shear walls with openings than shear walls without openings.
x. The ductility and shear strength of the shear wall with openings is highly affected by reinforcement provided around openings.
xi. Compared with common shear wall, the researches on prefabricated composite shear wall with boundary frames and openings are relatively less.

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