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Analysis of A Tall Structure Considering Opening Wall Conditions Using ETABS A Review

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ABSTRACT

Shear walls are structural systems which provide stability to structures from lateral loads like wind, seismic loads. An attempt is made to apply the finite element modelling in analyzing and exploring the behavior of shear wall with opening under seismic load actions. Shear walls are generally located at the sides of buildings or arranged in the form of core that houses stairs and lifts. 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 shear walls appropriately. Due to functional requirements such as doors, windows, and other openings, a shear wall in a building contains many openings

In this paper presenting review of past journals

Keywords : ETABS, Seismic behavior, Storey drift, Shear Wall, Staggered Openings, Seismic Loads, Finite Element Analysis and Response Spectrum Method.

I. INTRODUCTION

Shear walls are vertical structural elements for resisting the lateral loads that may be induced by the effect of wind and earthquakes. Shear wall is a structure considered to be one, whose resistance to horizontal loading is provided entirely by them. Introduction of shear walls in a building is a structurally efficient solution to stiffen the building because they provide the necessary lateral strength and stiffness to resist horizontal forces. Shear walls generally start at the foundation level and are continuous throughout the building height. They are generally provided along both length and width of the building and are located at the sides of the buildings or arranged in the form of core. Shear walls may have one or more openings for functional reasons.

The size and location of shear walls is extremely critical. They must be symmetrically located in plan to reduce the effect of twisting in buildings. Properly designed and detailed buildings with shear walls have shown good performance in past earthquakes. Also the strong earthquakes recorded worldwide in the past have shown that the damages and certain failure mechanisms of shear walls depend on a series of factors such as, the shape in plan, dimensions of the walls and openings, reinforcement and the openings layout, site condition, type of earthquake and strain rates. Even if failure modes have been extensively researched, there are still certain failure modes which have to be investigated further. One such is the case of shear walls with staggered openings.

Irregularity of Building

Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may subject to devastating earthquakes. In case, it is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. Structures experience lateral deflections under earthquake loads. Magnitude of these lateral deflections is related to many variables such as structural system, mass of the structure and mechanical properties of the structural materials. Reinforced concrete multi-storied buildings are very complex to model as structural systems for analysis. The current version of the IS: 1893 (part I) -2002 requires that practically all multistoried buildings be analyzed as three-dimensional systems. This is due to the irregularities in plan or elevation or in both. The paper discusses the performance evaluation of RC (Reinforced Concrete) Buildings with irregularity. Structural irregularities are important factors which decrease the seismic performance of the structures.

Types of Irregularity

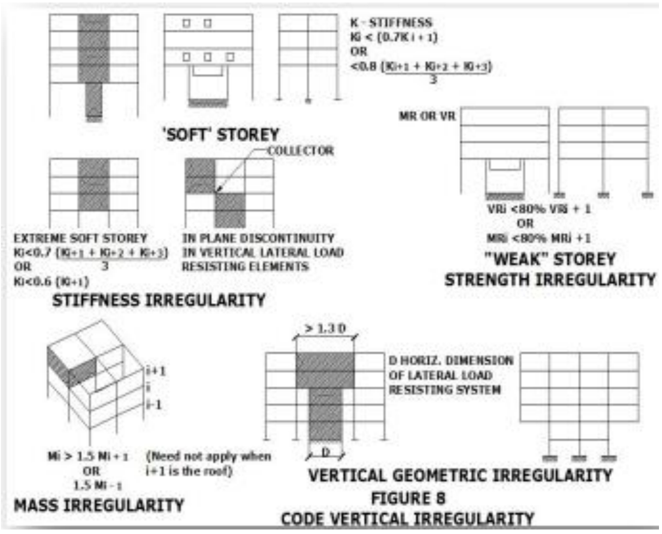

Fig 1: Vertical Irregularities

II. Review of Literature Survey

Akash Malika et.al (2023) objective of the research paper was to determine the seismic behaviour of staggered shear wall models and staggered X bracing models when subjected to historical earthquake data with the assistance of nonlinear time history analysis carried out by ETABS software.

Results stated that base shear of the structure with staggered X bracing is 37% lower than the base shear of the structure with staggered shear walls. When compared to staggered X bracing structures, staggered shear walls have a fundamental time period that is 62% shorter. However, because the values are lower, the structure with staggered shear walls is stiffer. Therefore, the structure with the staggered X bracing can perform better than the structure with the staggered shear wall because of the higher value of time period. When compared to the staggered X bracing structure, staggered shear walls have a frequency that is 62% higher. When compared to the structure with staggered X bracing, the overall dynamic performance of the structure that has staggered shear walls is superior.

Vinodkumar S A et.al (2023) objective of the research paper was to identify the optimum location of shear wall in irregular buildings with different irregular ratios by comparing structures with shear walls at various locations like, at the edges, at the corners and at both the corner and the edges. Further the dynamic analysis was carried out by considering optimum location of shear wall and replacing it with staggered shear wall. The effectiveness of staggered shear wall was analyzed by comparing the results with the shear wall structure having regular openings considering same percentage of openings in both the models using ETABS v18 software.

Model with shear wall at edges of the structure shows 70% less displacement in regular structure and up to 50% less displacements in irregular structure models. Staggered shear wall structure shows 1.5% variation in storey displacement and 2.8% variation in storey drift ratio in comparison with the structure having no openings in the shear wall. Shear wall structure having regular openings in shear wall shows 49 % variation in storey displacements and 40 % variation in storey drift ratio in comparison with the structure having no openings in the shear wall. Hence results confirmed that staggered shear walls are more effective than the shear walls with regular openings. Staggered shear wall performs very well under seismic activity without affecting the stiffness of the building largely.

Ahmed Saeed et.al (2022) in the research paper, author investigated a building of G + 13 stories with RC shear walls with and without openings using ETABS Software. The seismic analysis was carried out for the determination of parameters like shear forces, drift, base shear, and story displacement for numerous models. The regular and staggered openings of the shear wall were considered variables in the models and dynamic analysis was conducted.
Results stated that the seismic behaviour of the shear wall with regular openings provides a close result to the shear wall with staggered openings. At the roof, the displacement of the model with regular openings was 38.99 mm and approximately 39.163 mm for the model with staggered openings. However, the model without a shear wall experienced a displacement of about 56 mm at the roof. Results concluded that the openings have a substantial effect on the seismic behaviour of the shear wall, and that should be taken into consideration during the construction design. However, the type of opening (regular or staggered) has a slight effect on the behaviour of shear walls.

G.D. Pawar and V.B. Dawari (2022) author demonstrated effect of static and dynamic actions on 15 storey RC building having shear walls with openings. 32 building models were prepared in commercial software STAAD for various inline and staggered openings in shear walls. Seismic coefficient method and Response spectrum method was used for seismic analysis. The analysis was carried out for the seismic zones III and IV for hard and medium soil conditions. The research compared the response of these building models having shear wall with and without openings on parameters of time period, base shear, storey displacement, storey drifts and surface stress distribution.
Results stated that the Base Shear of structure reduced in Staggered Openings and In-Line Openings. The structure is found to be stiff, if opening percentages for used zones and soil conditions kept in specific range. Optimal opening percentage decreases as the zone and soil condition of the structure changes. It varied from 10.5% to 16%. The size of the openings in shear wall with gradually changing the percentage is controlled by the location of openings. It helps designer to take advantage of arranging locations conveniently.

Ika S. Nurahida et.al (2022) author investigated the nonlinear performance of RC shear walls with regular openings influenced by HSS. To verify the validity of the numerical model using 3DNLFEA, the numerical model was confirmed with the existing experimental test for shear walls with openings built with normal-strength steel. After the numerical model can reasonably predict the behavior of the modelled shear wall, modification of the shear wall reinforcement using HSS and a combination of HSS and NSS were presented.
The parametric studies by replacing the use of the NSS rebar with the HSS rebar showed that by utilizing the HSS rebar with the same reinforcement capacity and ratio is a decrease in the ability to accept lateral loads by 12.22%. In addition, the damage to the shear wall structure is smaller than that of the NSS configuration. For stress distribution

with the use of HSS, the stress that occurs is small, the distribution of compressive stress is small and the area of concrete that is experiencing crushing is also small. Then for the HSS configuration, the reinforcement has not melted, while for the NSS configuration and the combination of many reinforcements that have yielded.

Udit Yaduwanshi et.al (2022) research paper presented a comparison between a building with a shear wall that has no opening and a building with a shear wall that has different openings under seismic and gravitational loading, and the concept of different openings in shear walls in buildings was investigated. Different types of structural configurations considering G+9 structure are modelled for each case and analysed using ETABS software. Building parameters such as time period, storey displacement, storey drift, storey shear, and stress distribution were considered for comparison.

Results stated that shear wall structures with no opening, vertical opening, and staggered opening have time periods of 0.531, 0.585, and 0.591 seconds, respectively. By using the Equivalent Static Method, the storey displacement for a shear wall structure without opening, with vertical opening, and with staggered opening is 21.443 mm, 23.171 mm, and 23.169 mm, respectively. According to the Response Spectrum Method, the storey displacement for a shear wall structure without opening, with vertical opening, and with staggered opening is 18.196 mm, 20.161 mm, and 20.123 mm, respectively. Storey drift is higher for staggered openings than for vertical openings, but storey drift decreases toward the base for staggered openings than for vertical openings, according to both methods. By using the Equivalent Static Method, the Storey shear for a shear wall structure without opening, with vertical opening, and with staggered opening is 3684.0406 kN, 3227.3181 kN, and 3256.484 kN, respectively.

Priyanka N and S. kumar (2021) author investigated deformation, load carrying capacity and stresses that occur during loading for six RC shear wall models were subjected to lateral load using finite element analysis. Three Rc shear wall models, one with solid shear wall and other two with an ordered opening and a staggered opening were analyzed without any strengthening and other three strengthened with Basalt Fiber Reinforced-Concrete.

Results stated that the shear walls strengthened with basalt fibers show better seismic performance than the un strengthened shear wall. The load carrying capacity of Rc shear wall is greatly improved. The load carrying capacity of Rc shear wall is increased when basalt fiber is used as a strengthening material. The deformation in the Rc shear wall subjected to lateral loading is also decreased with the incorporation of basalt fiber. The deformation in the staggered opening shear wall is less when compared with the ordered opening shear wall. The load capacity of staggered opening is higher than the ordered opening.

Shobha Ram et.al (2021) in the research paper, analytical investigation was done to examine the performance of flanged, L-shaped and box-type shear walls with and without openings in high rise buildings under seismic excitation for regular and irregular reinforced concrete buildings. The models were designed on ETABS v.15 software and are analyzed by response spectrum method as per IS 1893 (Part 1): 2002 for various parameters like displacement, story drift, base shear and member forces. Two types of structures, regular and irregular plan shaped, were analyzed with three types of shear wall with and without openings.

Result shows that the presence of openings in shear wall affects the strength and rigidity of the shear wall depending upon the size of openings. The floor area increased in some parts due to the column reduction and shear wall application in the buildings.

Yagya Raj Khatri and Dr. Prasenjit Saha (2021) in the research paper, Irregular building with and without shear walls with different configurations was analyzed using the IS:456 2000 and seismic code IS:1893 2016. The earthquake loads was analyzed using static (Equivalent Static Method) and dynamic (Response Spectrum) methods as per IS:1893 2016 and the time history method using acceleration time history of Bhuj 2001. Five models were modelled and analyzed using ETABS 2018 considering similar loading conditions.

Results stated that the lateral stiffness of the buildings is enhanced by the introduction of shear walls at the building which leads to better performance against lateral loads. The configuration with shear wall at the lift core gives a good performance against lateral load in both the x and the y directions and the configuration with the shear wall along the y direction gives the best performance against lateral loads in y direction. The performance of any highrise buildings can be improved by providing shear wall of appropriate lengths at appropriate locations. The location should be such that the shear wall should help in decreasing eccentricity, and distributing gravity and lateral loads in best way possible.

Jyoti M.Chavan et.al (2020) in the research paper, the seismic behavior of the G+22 R.C. a building with conventional opening shear wall and staggered opening shear wall was analyzed by Static and dynamic analysis of the shear wall and the resultant parameters like displacement, time period, stiffness etc. was compared by using structural software ETABS.

Conclusion stated that it was better to provide opening in periphery instead of opening provided at the center. And in case of providing the opening we always have to go with staggered opening shear wall because it gives better performance against earthquakes in displacement, drift and base shear.

A. K. Yadav et.al (2019) in the research paper, A 3-D analysis of the frame structure with shear wall structure using ETABS for 70 story of building, located in seismic zone III as per IS 1893-2016 (Part2) was conducted using response spectrum method. The research covered the location and types of openings in shear walls and structural behavior was evaluated in terms of deflections, bending moment and shear force.

Results stated that deflection, Bending Moment, and Shear Force increases as the size of opening increases in Shear wall. The Deflection exceeds the permissible limits for wind in Across X direction. Results of analysis in Across X and Y direction is more than in Along X and Y. Results concluded that the opening in shear wall should be avoided or it should be of minimum size and number as the height of structure goes on increasing for tall structures.

Rajiv Banerjee and J.B. Srivastava (2019) author conducted comparative study to obtain the optimum position of shear wall in the structure considering irregular T shaped G+15 storey building modelled and analyzed using ETABS v. 2016. For optimization, the total length of the shear wall in the structure is kept constant. The comparative study was done on the basis of base shear, storey displacement and storey drift.

Results concluded that location of shear wall plays a very important role in increasing the resistance against the lateral forces. The location should be such that it should distribute the gravity loads and the lateral loads such that the building retains it centre of gravity in best way possible. Seismic forces increase in the buildings in terms of base shear. This indicates that buildings with shear walls are able to capture more seismic loads.

Nitin Vishwakarma and Hardik Tayal (2018) research paper dealt with the behavioral study of Steel Braced optimized Shear wall considering G+20 storey in Gurgaon, India (Seismic Zone IV) having Shear Wall system. Several cases were considered with Shear wall with different bracing pattern and performance of building was observed with different cases and compares with the performance of actual building. The modelling and analysis was done using analytical application ETABS.

Results stated that shear wall elements are very much effective in dropping lateral displacement of frame as drift and horizontal deflection induced in shear wall frame are much less than that induced in braced frame and plane frame. Steel bracing carryover lateral load by axial load mechanism and decreases shear and flexure demands on beam and column. In building frames, having an X type bracing system will have minimum probable bending moments as compared to other bracing. Total weight of building will not change extensively by the usage of bracing system and thereby reduces base shear of building. X type bracing reduces lateral displacement about 35 % to 45 % and reduced maximum displacement. Performance of buildings under seismic load can be studied by varying the position of steel braced shear wall.

Ram A. Prajapati and K. Singh (2018) objective of the research paper was to determine the effectiveness of shear wall with regular and staggered opening in regular building under earthquake loads with the help of time history method of analysis on ETABS software. The buildings are analysed for earthquake load (seismic zone IV).

Results concluded that for opening area < 20% of shear wall area, the stiffness of shear-wall structure is more affected by the size of openings than their arrangement in the shear walls. For opening area>20% of shear wall area, the stiffness of the system is significantly affected by the openings arrangement in shear walls. Presence of opening decreases strength and stiffness . In the economical point of view staggered opening is more preferred than vertical opening. Performance of the shear wall depends on the size and shape of the opening.

Abhija Mohan and Arathi S (2017) objective of the research paper was to determine effectiveness of shear wall with vertical opening and staggered opening in regular and irregular buildings under earthquake loads with the help of finite element software, ETABS. The G+10 storied rectangular, L, H and T shaped buildings with shear wall having vertical and staggered openings are analysed using response spectrum analysis.

Results concluded that regular building with shear wall having staggered opening shows better results in terms of displacement, storey drift and storey shear. In the case of irregular buildings (H shaped and T shaped) buildings with staggered opening shows better results in terms of displacement, storey drift and storey shear in both X and Y directions. But in case L shaped irregular building, building with shear wall having vertical openings shown good results in terms of displacement and base shear in Y direction.

Dr. Hadi Hosseini (2017) author analyzed a 20 story building with Shear walls with openings and without openings using dynamic analysis as per the Indian Standard code books. ETABS were used for the purpose of modelling and analysis of the structure considering similar loading conditions.

Results stated that with the provision of shear wall the shear force decreases and moment increases in the columns. No significant difference in shear force and moment provision of 20 % opening in the shear wall. With the provision of the shear wall the drift and displacement is increasing.

J.S.S.K. Vasa et.al (2017) research paper focused on the investigation of seismic performances of G+11 multi storey structures when retrofitted with shear wall and with staggered openings of shear wall under influence of two seismic zones (Zone-II, III). The analysis was done in both dynamic analysis (Response Spectrum Analysis) modelled using ETABS 2016.

Results stated that opening greatly influences the deformation characteristics of the shear wall structure. The solid shear walls absorb more energy than the slits shear walls in the structure. Deformation is delayed in the slit shear wall when compared to the solid shear wall. The decrease in the storey shear of the opening shear wall structure is lesser than the solid shear wall structure. The displacements of the opening shear wall slit variation, when compared to the solid shear wall structure. The increase in the stiffness of the opening shear wall structure is greater than the solid shear wall structure. The opening shear wall decreases the lateral load carrying capacity when compared to the solid shear wall.

M.S. Kodappana and P. Dilip P (2017) author analysed 16-storeyed (G+15) reinforced concrete structure with irregular plan shape "L", "T", and "I" with staggered and regular opened shear wall in Seismic Zone V using ETABS v 15. The shear wall having 10% opening compared to the area of wall in that storey.

Results stated that staggered opened shear wall structures have less displacement compared to regular opened shear wall structures, can reduce 4% of displacement compared to regular opened shear wall. The models with „T" shape plan perform better in controlling displacement value, with least storey drift when compared to other irregular models. By comparing the position of shear wall, the staggered opened shear wall at the corner can reduce 10% displacement compared to shear wall at periphery for all models. The base shear is found to be much lesser for shear wall with staggered openings compared to regular openings. The staggered openings in shear wall shows highly advantageous and they provide better lateral resistance strength to the structure compared to regular opened shear wall. The structure with irregularity when provided with shear wall, the overall performance is enhanced. The shear wall provided at the corner will perform better in resisting lateral load in high rise structures.

III. CONCLUSION

It is found that a lot of work is done in determining the position of shear wall in regular buildings. But, the input data or the test models for the comparison are very less and the calculations are very simple. In this manner, we are far away from the real challenges. In order to find the optimum position of shear wall, sufficient input data is required in form of test models. Apart from that, the surrounding condition should also be varied to obtain a relevant result. Thus, it is concluded that, optimum location of shear wall in such buildings can be more precisely determined by considering more no. of combination of configuration and surrounding data.

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