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Design and Analysis of a Building with and Without Shear Wall

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ABSTRACT

The present study aims to investigate the effectiveness of reinforced concrete shear wall in the buildings subjected to seismic loads. The shear wall is an alternate structural form for resisting the earthquake forces. In this study, (Base+ G+9) building seismic analysis is carried out with and without shear wall by using response spectrum method as per IS: 1893-2002 (Part I). The analysis is carried out using ETABS finite element analysis software. It is concluded that, presence of shear wall in the structure decreases percentage of reinforcement in the columns and increases the lateral stiffness of the building, thus performing effectively in resisting lateral forces induced by an earthquake.

1. INTRODUCTION

The walls, in a building, which resist lateral loads originating from wind or earthquakes, are known as shear walls. A large portion of the lateral load on a building, if not the whole amount, as well as the horizontal shear force resulting from the load, are often assigned to such structural elements made of RCC. These shear walls, may be added solely to resist horizontal force, or concrete walls enclosing stairways, elevated shafts, and utility cores may serve as shear walls. Shear walls not only have very large in-plane stiffness and therefore resist lateral load and control deflection very efficiently, but may also help to ensure development of all available plastic hinge locations throughout the structure prior to failure. The other way to resist such loads may be to have the rigid frame augmented by the combination of masonry walls.

The use of shear walls or their equivalent becomes imperative in certain high-rise buildings, if inter- storey deflections caused by lateral loadings are to be controlled. Well-designed shear walls not only provide adequate safety, but also give a great measure of protection against costly non-structural damage during moderate seismic disturbances. The term shear wall is actually a misnomer as far as high-rise buildings are concerned, since a slender shear wall when subjected to lateral force has predominantly moment deflections and only very insignificant shear distortions. High-rise structures have become taller and more slender, and with this trend the analysis of shear walls may emerge as a critical design element. More often than not, shear walls are pierced by numerous openings. Such shear walls are called coupled shear walls. The walls on both sides of the openings are interconnected by short, open deep, beams forming part of the wall, or floor slab, or both of these. The structural engineer is fortunate if these walls are arranged in a systematic pattern. The scope of the book limits the discussion to shear walls without any openings.

2. LITERATURE

Mr.K.LovaRaju(et.al) conducted non-linear analysis of frames to identify effective position of shear wall in multi storey building. An earthquake load was applied to a eight storey structure of four models with shear wall at different location in all seismic zones using ETABS. Push over curves were developed and has been found the structure with shear wall at appropriate location is more important while considering displacement and base shear.

Syed.M.Katami et.al presented the results of time history analysis which addressed the effect of openings in shear walls near- fault ground motions. A model of ten storey building with three different types of lateral load resisting system: Complete shear walls, shear walls with square opening in the centre and shear wall with opening at right end side were considered. From the results it was observed that shear walls with openings experienced a decrease in terms of strength. The maximum lateral displacement of complete shear wall is 17% less than that of shear walls with openings at centre whose displacement is found to be 8% less than that of shear walls with openings at right end.

Dr.B.Kameshwari et.al analysed the influence of drift and inter storey drift of the structure on various configuration of shear wall panels on high rise structures. The bare frame was compared with various configurations like i) Conventional shear wall ii) Alternate arrangement of shear wall iii) Diagonal arrangement of shear wall iv) Zig Zag arrangement of shear wall v) Influence of lift core shear wall. From the study it was found that Zig Zag shear wall enhanced the strength and stiffness of structure compared to other types. In earthquake prone areas diagonal shear wall was found to be effective for structures.

NanjmaNainanet.al conducted analytical study on dynamic response of seismic resistant building frames. The effects of change in height of shear wall on storey displacement in the dynamic response of building frames were obtained. From the study it was concluded that it is sufficient to raise the shear wall up to mid height of building frames instead of rising up to entire height of the building.

Shahzad Jamil Sardar et.al modeled a 25 storey building zone V and analysed by changing the location of shear wall to determine various parameters like storey drift, storey shear and displacement using ETABS. Both static and dynamic analysis was done to determine and compare the base shear. Compared to other models, when shear wall placed at centre and four shear wall placed at outer edge parallel to X and Y direction model showed lesser displacement and inter storey drift with maximum base shear in addition strength and stiffness of the structure has been increased.

Eshan Salimi Firoozabadet.al determined the shear wall configuration on seismic performance of building. The top storey displacements for different configurations were obtained using SAP 2000. From the study it was observed that the top storey drift can be reduced by changing the location of shear wall and it was suggested that the quantity of shear wall could not influence the seismic behavior of buildings.

Varsha.R.Harneconsidered 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 using STAAD Pro. 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 modeled for analysis. Compared 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.

Anuj Chandiwalastudied a 10 storey RC building located in seismic zone III which is on medium soil. The different building configurations were i) Shear wall at end of L section ii) L Shear wall at junction of 2 flange portion iii) Two parallel L shear wall at junction of 2 flange portion iv) Tube type shear wall at junction of 2 flange portion v) Two parallel shear wall at end of flange portion. From the analysis, it was observed that compared to other models shear wall placed at end of L section is best suited for base shear since end portion of the flange always oscillate more during earthquake.

Shahabodin. Zaregariziconducted comparative investigation on using shear wall and infill to improve seismic performance of existing buildings. Static nonlinear analysis was done to compare the effectiveness of both methods. From the results, it was observed that concrete infills have considerable strength while brick one showed lower strength. On the contrary, brick infills accepted large displacement than concrete ones. It was concluded that the combination of brick and concrete infills reduced the negative effects when they both used individually.

Mithesh Surana et al. focused on estimation of seismic performance of shear wall and shear wall core buildings designed for Indian codes. Non-linear pushover analysis was used in this study. For modeling the shear wall, the commonly used models like wide column model and shell element model were validated using experimental results available in earlier literature. Both the models showed identical strength for shear wall and shear wall cores. In case of ductility capacity of shear wall and shear wall cores, wide column model underestimates whereas the shell element model overestimates. It has been found that stiffness obtained from moment-curvature analysis is matched with experimental results. But shell element model showed high stiffness initially and later it is reduced due to cracking and finally matched with experimental results. To evaluate the performance of “Dual systems” which is designed as per Indian code, these models were implemented. It has been noted that buildings with shear walls placed at periphery showed excellent performance than buildings with centrally placed shear wall core.

Chun Ni et al. described the performance of shear walls with diagonal or transverse lumber sheathing. A total of 16 full-scale shear walls were tested to determine the effects of hold-owns, vertical load and width of lumber sheathing on in-plane shear capacity. The in-plane shear capacities of shear walls with double diagonal lumber sheathing are 2-3 times higher than that of shear walls with single diagonal lumber sheathing.

Michael R. Dupuis et al. analyzed seismic performance of shear wall buildings with gravity-induced lateral demands using OpenSees software. The inelastic response of concrete shear wall buildings was investigated. From the result, it was demonstrated that a seismic ratcheting effect can develop and amplify inelastic displacement demands. But the effect is more prevalent in coupled shear walls than cantilevered shear walls.

Wen-I Liao et al. conducted an experimental investigation on high seismic performance shear wall. The test results of four large-scale shear walls, (two shear walls under shake table tests and two shear walls under reversed cyclic loading) were presented. The response time histories for accelerations and displacements as well as the hysteretic loops were presented for the shear walls under dynamic loading induced by shake table. The force-displacement hysteretic loops were presented for the shear walls under reversed cyclic loading. From the experimental results, it was found that the tested high performance shear walls have better ductility than that of conventional shear walls.

3. METHODOLOGY

3.1. Earthquake analysis

The analysis of a structure can be performed by four different methods. They are

- Linear static analysis (Equivalent static method)

- Non-linear static analysis (Push over analysis)
- Linear dynamic analysis (Response spectrum analysis)
- Non-linear dynamic analysis (Time-history analysis)

4. EXPERIMENTAL RESULTS

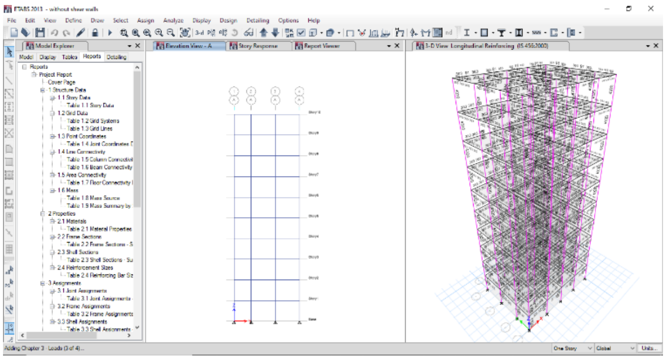

Figure 1. A building model without shear wall

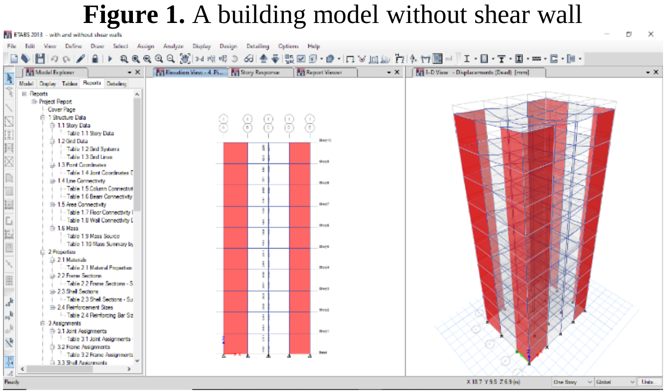

Figure 2. A building model with shear walls

5. CONCLUSION

The conclusions drawn from the analysis of a (BASE+ G+9) building with and without shear wall are as follows

- Fundamental frequencies of structure with shear wallis increasedby 20% as compared to that in structure without shear wall, so it's about increasing of stiffness byproviding shear walls.
- The storey shears of structure with shear walls is more as compared to structure without shear walls.
- Lateral seismic load distributions in structure with shear wall are greater than in the structure without shear wall.
- The storey shears and lateral loads for EQ X and EQ Y in the structure with shear wall are equal.
- The values of storey displacements, drifts, shears, stiffness and lateral loads for EQ X of structures are greater than EQ Y values.
- Parameters like storey displacements, story drifts are found to begradually decreasing in structure with shear wall as compared to structure without shear wall.
- The rebar percentage is found to be more in the model withoutshear wall, therefore comes with the concept of economy andstability adjacently.
- Provision of shear walls may not effective in reducingpunching shear on intermediate story's but effective in top andbottom story's as shear wall attracts lateral moments fromcolumns.

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