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SIGNIFICANCE OF SHEAR WALL IN FLAT SLAB MULTI STORIED BUILDING - A REVIEW

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Abstract **-** *Modern trends towards high rise buildings increases recently due to the high increase in the number of tall buildings, both residential and commercial. In every parts of the world flat slab construction are widely used in reinforced concrete structures because; this system reduces the costs of form work and construction time and easy installation. Without beams floor slab system directly supports columns. In comparison with earlier high rise buildings, today's tall buildings are becoming more and more slender and leading to the possibility of more sway. From lateral loads such as wind, seismic loads shear walls provide the stability to the structure. These shear walls transfer the lateral loads to the foundation by their shearing resistance and resistance to overturning. In the present work, summarized the importance of flat slab construction and revealed the relevance of shear wall in a flat slab multi-storied building.*

Key Words: Flat slab, Shear wall, Linear dynamic analysis, Base shear, Time period, Story drift, Storey displacement

1 INTRODUCTION

From last two decades there is a high increase in the high rise buildings and modern trend is towards high rise structures. In tall buildings with increase in height lateral loads have prime consideration. From the effect of gravity resulting most common loads are dead load, live load and snow load. Buildings are also subjected to lateral loads caused by wind and earthquake. Due to the lateral loads develop high stresses, produce sway movement or vibrations. Flat slab is mostly used system to avoid the beam-column clogging, and it is very economical. Flat slabs directly transfer the loads to columns without beams. But flat slabs are not efficient in transfer the lateral loads. Punching shear strength around the column-slab connections always possess a problem. Punching shear is a type of failure of reinforced concrete slabs subjected to high localized forces. When the total shear force exceeds the shear resistance of the slab, the slab will be pushed down around the column is termed as punching shear in flat slabs. This results in the column breaking through the portion of the surrounding slab. As a solution of seismic load resistance, time and cost effective construction shear walls are most effective one method.

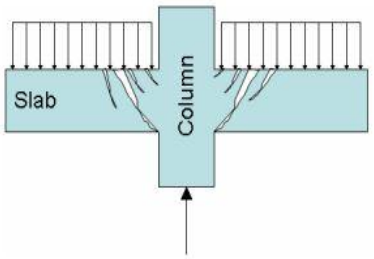

Fig 1 Punching shear failure in flat slab

Fig 2 Building collapse due to punching shear in flat slab

2 THEORETICAL BACKGROUND

Flat plate construction is widely used in residential, office and industrial buildings in many parts of the world. The main advantage of this construction is the faster construction compared to mushroom and ribbed slabs. Generally, slabs are supported by beams and these beams are supported by columns. Beam reduces available net clear ceiling height. Sometimes beams are avoided and slabs are directly supported by columns. This type of construction provides aesthetical appearance also. Those slabs which are directly supported by columns are called as flat slabs. Flat slab also referred as beamless slab, it is the directly connected by columns without beams. Due to the advantages

of flat slabs over other reinforced concrete floor system engineers are mostly used in construction works.

The main disadvantages of flat slab systems are; they are not suitable for supporting brittle (masonry) partitions, higher slab thickness, Chance for progressive collapse is more in flat slab due to the punching shear failure, in flat slabs, the middle strip deflection may be critical.

Fig 3 Flat slab construction

These practical difficulties call for the introduction of flat slabs in high rise buildings. Flat slabs are easy to construct and cost effective as a remedial measure beam-column clogging of joints and flat slabs less efficiency, shear wall is one of the effective bracing method for multi-storied buildings to resist both lateral and gravity loads in the structure.

2.1 Shear wall as a bracing method

Shear walls are the vertical elements to resist the horizontal force in s structure. Shear walls directly resist the lateral force along the length of the wall. By properly detailed longitudinal and transverse reinforcement can achieve the necessary strength to avoid the structural damage under earthquakes. Lateral forces are derived from winds and earthquakes that are applied horizontally to the building.

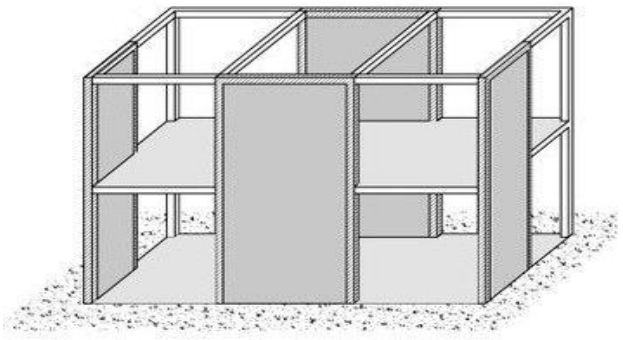

Fig 4 Building with shear wall

2.2 Analysis

Linear dynamic approach permits the multiple modes of response of building to be taken into account. A combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics" is called as the response of a structure. Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and modal mass, and they are then combined to provide an estimate of the total response of the structure. When a structure subjected to certain ground motion demands, the dynamic response estimate by the linear dynamic procedure. In linear dynamic analysis can calculate the magnitude of forces in all directions i.e. X, Y& Z and then observe the effects on the building.

3 LITERATURE REVIEW

Literature survey was performed using various relevant books and journal papers dealing with performance based design, study on flat slab systems and seismic retrofitting using shear wall for RC building. This also includes review of previous research related to the above areas. Various literature collected are briefly described below.

Lan N Robertson (1997) done analysis of flat slab structures subjected to combined lateral and gravity loads. Using a three dimensional model, analysis of a flat slab building can have done when it subjected to vertical and lateral loads which includes both slab-column frame elements and the lateral framing system (shear wall) if present. This study reviews two structural analysis models and compares them to experimental test results. A two-beam analytical model more accurately predicts the test results with respect to slab moment distribution and lateral drift. Three dimensional analysis done by ETABS computer program. These models assume a uniform slab effective width coefficient and constant cracking factor for an entire span. The analytical models were unable to reproduce the slab flexural moment distribution observed in test specimen at either 0.5 or 1.5 % drift levels. By replacing the single beam element with two-beam elements connected at the point of contra flexure, the difference between cracking in the positive and negative moment regions was incorporated in to the mode.

M A Rahman (2012) conducted a study on effect of openings in shear wall on seismic response of structures. In this paper, finite element modeling in analyzing and exploring the behaviour of shear wall with opening under seismic load actions, an attempt is made to apply the finite element modeling. A shear wall in a building contains many openings due to functional requirements such as doors, windows and other openings. This study is carried out using linear elastic analysis with the help of software ETABS under the earthquake loads in equivalent static analysis. This study reveals that, the size of the openings as well as their

locations in shear walls, if will affect the stiffness as well as seismic responses of structure. If the area of openings more, the displacement increases with increasing storey level. Thickening wall around the door openings are more effective than that of window opening as far as displacements in concerned at top most storey level.

Navyashree K (2014) introduced use of flat slabs in multi-storey commercial building situated in high seismic zone. The proposed work compared the behavior of multi-story commercial buildings having two way slabs with beams and with that of having conventional RC frame and flat slabs, then studied the effect of height of the building. Modeling and analysis are done by ETABS V 9.7.4. For the analysis and design total six models were considered. Three building heights (G+3, G+8, G+12) were considered. Two models created for each building height one with RC frame and other with flat slab. Maximum column moment obtained at first and terrace level. Base shear maximum at plinth level, after plinth level as height increases base shear decreases. That is, base shear of flat slab building less than conventional RC building. Lateral displacement maximum obtained at terrace level. As storey level increases lateral displacement also increases. Lateral displacement higher in flat plate building. Time period higher for flat slab building compared to conventional building. As height increases storey drift drastically increases. Storey drifts more in flat slab building.

M Santhosh (2014) has conducted the seismic analysis of multi-story building with non-parallel shear wall system. The use of non-parallel shear wall system is mainly for irregular shape of structures. Five storied building is selected in seismic zone v. Modeling done with ETABS V 9.6 and SAFE V 12.1.1. Response spectrum analysis is carried out. Three models are created for the analysis. Model one is the building without shear wall. Second is the building with shear wall. Third one is the building with non-parallel shear wall. Shear force, bending moment, base shear, time period, story drift and displacement were computed in three models and location of shear wall established. As a result of analysis it seems that stiffness of the bare frame and bare frame with shear wall are different. Depends on the lateral dimensions of the structure the time period values changed. Depends on the weight acting on the structure base shear is varying. Parallel shear wall is suited for the base shear during earthquake. Maximum story drift is for without shear wall.

G S Hiremath (2014) considered the effect of change in shear wall location with uniform and varying thickness in high rise buildings. Twenty-five stories building in seismic zone IV is considered. Total four models were considered in the analysis. Analysis is done by ETABS V 9.7.1 using non-linear static method. One is the building with shear wall at corner. Second is the building with shear wall at mid span. Third is the building with shear wall. Fourth is the model with shear at middle with mid span wall at middle span channel type. Push over method is used to analyze the model. Model with shear wall at mid span having varying thickness achieves highest reduction in displacement with base shear.

Lakshmi K O (2014) find the effect of shear wall location in buildings subjected to seismic loads. A symmetric sixteen story residential building considered for the analysis. The finite element analysis software ETABS is used to create the 3-D model and run the analysis by pushover method. Eight different models were considered. Due to the seismic ground motion at the base of the structure base shear is maximum. Maximum reduction in displacement is obtained for frame with core and corner shear wall.

Pooja Hedge (2014) has completed the study on effect of base opening in reinforced concrete shear wall. In high rise buildings, to provide basement parking which leads to the provision of openings at the base of shear walls. Software ANSYS-13 is used for the analysis. Non-linear static analysis (Push over method) is used for the study. The results obtained as for shear wall without opening, load carrying capacity is higher. Eccentric opening avoids as far as possible. Load carrying capacity decreases as base opening area increases. If the base opening greater than 50% of solid shear wall avoid solid shear wall.

Aarthi Harini T (2015) has done a study on behavior of shear wall with staggered openings under seismic loads. This study is carried out an a seven storey shear wall building, using linear elastic analysis, with software ETABS, using response spectrum method. Around the openings stress distribution depends on the time period, displacement, base shear. This study reveals that the time period, displacement, drift, base shear, stress distribution is affected by the location of openings in shear wall. Staggered openings found to provide better lateral resistance than shear wall with vertical openings. When compared to vertical arrangements of openings stress is small in staggered openings. Drift and displacements in staggered openings more than vertical openings. Staggered openings with shear walls needed much less reinforcement than shear wall with vertical openings.

Sachin P Dyavappanavar (2015) has done seismic analysis of RC multi-storied structures with shear walls at different locations. For the investigation of the structure twenty storied building is considered. Building assumed to be situated in zone IV. Analysis has done by changing the positions of shear walls symmetrically by considering different shape and locations of shear walls in buildings. Equivalent static method, Response spectrum method and time history methods are adopted for the analysis purpose, using the software ETABS V 9.7.1. Bare frame model, shear wall at exterior corner, shear wall at interior corner, shear wall at mid frame, a shear wall at center of building like five models were created for the analysis. In bare frame observed more lateral displacement. And as the level of the storey increased the lateral displacement also goes on increases. At exterior corner building with shear wall exhibit extreme base shear. Better location of shear wall found at exterior corner.

Aneeket T Patil (2016) compared the different configuration of shear wall under the effect of wind and earthquake. For a structure arrangement of plan by coinciding centroid and mass center of the building is the ideal configuration. So symmetric placing of shear wall provides to avoid torsional movement in building. He revealed the non-linear dynamic method is time consuming process and additional input related to mass of structure. For the comparison four models were considered. Modeling and analysis carried out by ETABS 2015. Model one for framed building. Model two for building with shear walls at corners. Third model is the building with shear walls at periphery. Fourth model is for building with shear wall at center. Response spectrum Push over analysis is used to analyze the model. From the analysis he concluded that location of shear wall at the core of the building can reduce the displacement to much greater extent.

K G Patwari (2016) has done a comparative study of flat slab building with and without shear wall to earthquake performance. The work deals, with or without shear wall of flat slab building on the seismic behaviour of high rise building with different position of shear wall. For the analysis fifteen storey model is selected. Time history analysis in software ETABs is carried out to study the effect of different location of shear wall on high rise structure. Time period, base shear, storey displacement and storey drift like seismic parameters are checked out. Storey displacement seemed more for structures without shear wall. Storey drift values found to be not more than 0.004 times to storey height according to IS 1893:2002 (Part 1). Because of considerable difference in storey displacement, time period, base shear and storey drift building with shear wall is preferred.

M. D. Rizwan (2016) has completed a comparative study of linear and non-linear seismic response of RC structure situated in different seismic zones of India. For the analysis soft soil, medium soil and hard soil were considered. Modeling and analysis carried out by using ETABS V 9.7.4. Equivalent static and push over methods are used to study the seismic behaviour. Base shear, displacement and storey drift were studied in both methods. After the analysis it is observed that the lateral deformation capacity is increasing, the symmetry of the structure decreasing. From bottom to middle storey, and from middle storey it gradually decreasing to top storey. In loose soil building shows less performance.

M K Devtale (2016) compared the seismic response between flat slab building and regular frame building. Seismic behavior of flat slab building has been carried out in the present study. Regular framed structure building and linear analysis of flat slab building has been carried out for this purpose. Linear analysis of flat slab building with shear wall and regular framed structure building with shear wall also had been carried out. Analysis is carried out using SAP 2000 by the method of equivalent lateral force analysis. After the analysis it is concluded that regular frame building performed better than flat slab building with use of shear wall, the performance of flat slab building improves much more.

Anand S Attal (2016) has done a study on effect of opening in shear wall. The main objectives of the study were analysis of building with shear wall opening and without opening, check the deflection of shear wall with respect to percentage of opening, effect of change in position of opening in shear wall with respect to deflection and the effect of size of opening and position of opening on stresses. Analytical study was done using software ANSYS-12. Lateral load calculated by seismic coefficient method. After the analysis it is seemed that the variation of deflection of shear wall with no opening and with single opening is very less when width of opening is less. The deflection in the wall increased when the number of openings increases. If the horizontal distance between the openings of floor becomes less, the deflection of shear wall is less.

4 SUMMARY AND CONCLUSION

The above literature review shows that various analytical and experimental studies are going on the field of high rise building construction as a lateral load stiffening method. Flat slab is one of the effective method to construct in cost and time. But its lack of structural stability against lateral loads promotes the idea of shear walls. Shear walls are the vertical element providing foundation to top of the building. These two structural elements help to the building system more stable in wind and earthquake loads. From the studies it is concluding that

- The base shear of flat slab building less than conventional RC building.
- Storey drifts more in flat slab building. Maximum reduction in displacement is obtained for frame with core and corner shear wall.
- In conventional RC building for shear wall without opening, load carrying capacity is higher. Eccentric opening avoids as far as possible.
- Load carrying capacity decreases as base opening area increases. Staggered openings found to provide better lateral resistance than shear wall with vertical openings.
- When compared to vertical arrangements of openings stress is small in staggered openings. There is a future scope for further study in this area.

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