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Behaviour Of Multi-Storied Flat Slab Building Considering Shear Walls: A Review

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ABSTRACT

Recently there has been a considerable increase in the number of tall buildings, both residential and commercial, and modern trend is towards taller structures. Flat slab is most widely used systems in reinforced concrete construction. Flat-slab building structures possesses major advantages over traditional slab-beam-column structures taking a advantages of reduced floor height, shorter construction time, architectural –functional and economical aspects. But in flat slab building columns are directly provides supports to slab with eliminating beams so there is requirement of provision of shear walls to increase the stiffness of building against lateral forces. Shear wall system are one of the most commonly used lateral load resisting in high rise building. Shear wall has high in plane stiffness and strength. The present paper reviews various research works carried out by several researchers on multi-storied buildings provided with flat slab and shear walls.

Keywords: Flat slab, Shear wall, Multistoried building, Seismic behaviour.

I. INTRODUCTION

A traditional common practice in construction is to support slab by beam and beam supported by column this may be called as beam slab load transfer construction technique [1]**.** Shear walls are specially designed structural walls which are incorporated in buildings to resist lateral forces that are produced in the plane of wall due to earthquake, wind and flexural members [2]. The behaviour of multi-storey buildings having flat slabs with drops with that of having two way slabs with beams and to study the effect of part shear walls on the performance of these two types of buildings under seismic forces [3]. Flat-slab building structures possesses major advantages over traditional slab-beam-column structures taking a advantages of reduced floor height , shorter construction time, architectural –functional and economical aspects [4,5]. It is necessary to analyze seismic behaviour of building for different heights to see what changes are going to occur if the height of conventional RC Frame building and flat slab building changes [6,7]. It may be possible to undertake construction without providing beams, in such a case the frame system would consist of slab and column without beams [8]. The present day Indian Standards Codes of Practice outline design procedures only for slabs with regular geometry and layout [9]**.** The comparison of the behaviour of multi-storey buildings having flat slabs with drops and without drop on theperformance of these two types of buildings under seismic forces [10]. Experience in the past earthquake has shown that a building with discontinuity in the stiffness and mass subjected to concentration of forces and deformations at the point of discontinuity which may leads to the failure of members at the junction and collapse of building [11]. The FE model can predict the behaviour of the composite shear walls with reasonable precision [12].

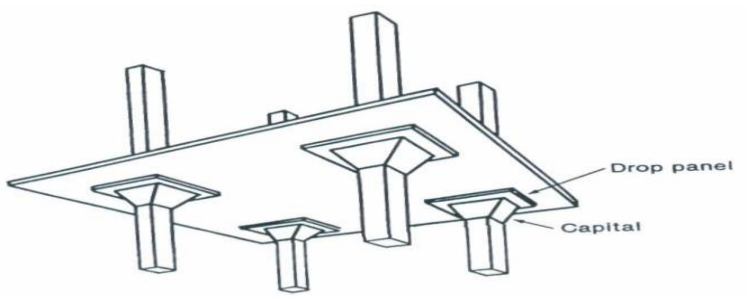

Fig. 3 Flat slab with drop panels

II. PRESENT STUDIES

There are many researches have been carried out to know seismic behaviour of flat slab building. This section summarizes some previous studies carried out on flat slab building.

SumitPahwa et al [1], studied comparative behavior of flat slab with old traditional two way slab. This parametric study comprised of maximum lateral displacement, storey drift and axial forces generated in the column. In this study models created of two-way slabs and flat slab without shear wall for each plan size of 16X24 m and 15X25 m, using Staad Pro. 2006 for seismic zones III, IV and V with varying height 21m, 27 m , 33 m and 39m. This investigation also told us about seismic behavior of heavy slab without end restrained.

Earthquake behavior of buildings with and without shear wall using STAAD.Pro software for 50 storied building with shear walls at different locations such as at periphery, central core and corner of building. From this analysis it is found that building with shear wall at core (square shape) shows better response against earthquake [2].

From analysis and design it is found that building having flat slab with drop results in increase in column reinforcement to resist lateral loads so that researcher suggested to use shear wall in flat slab building for better performance in an earthquake [3].

Flat slab system is very simple method for construction and provides minimum building height. Dynamic analysis of flat slab and conventional two way slab for seismic excitation by considering diffrent seismic zones were carried out. From this research it is found that story displacement and bending moment is more for a building provided with flat slab as compared to conventional two way slab [4,5].

Analysis carried on structural efficiency of building with and without provision of flat considering six number of conventional RC frame and Flat Slab buildings of G+3, G+8, and G+12 storey building models. The performance of flat slab and the vulnerability of purely frame and purely flat slab models under different load conditions were studied for seismic zone IV using ETABS software. From the study it is found that the time period and storey drift is more for flat slab building than conventional building. Shear wall can be used to improve the performance of flat slab [6,7].

Natural time period of building is important parameter while analysing dynamic response of building. Dynamic response of Flat slab with drop and without drop and Conventional Reinforced Concrete Framed Structures for different height with and without masonry infill wall shows that natural period and displacement values are more in case of masonry infill compared to without masonry infill wall. They also found that base shear is less in masonry infill wall [8].

In analysis of 9 storied special moment resisting frame building with flat slab and grid slab using ETABS shows that building with flat slab experience maximum shear force, as compared to grid slab. Shear force experienced by flat slab is 14 % higher than that of the grid slab. By providing drop shear strength of flat slab can be improved [9].

Seismic behaviour of 6 storied building considering flat slab with and without drop using ETABS were analysed. Study is carried out considering different types of zones and different type of soils condition as per IS code provision. This study shows that the behaviour of flat slab building can be improved by providing drops.This work provides a good source of information on the parameters storey shear, base shear, storey drift, and maximum bending moment of columns [10].

R. V. Surve et al [11], they studied performance of a building with soft storey at different level along with at GL using nonlinear static pushover analysis. From analysis they found that plastic hinges are developed in columns of ground level soft storey which is not acceptable criteria for safe design. They suggested retrofitting with shear wall for safe performance of building. They also found that after retrofitting the base shear carrying capacity is increased by 19.22 % to 34.64%.

The deformation capacity of Steel Reinforced Concrete–RC walls is sufficient, and the SRC–RC walls might be applicable as a favourable lateral resistance system for buildings located in earthquake-proneregions. The ductility of SRC-RC wall is more than that of RC wall. SRC boundry column resist more overturning moment at peak load [12].

By adding steel fiber ductility and tensile properties of concrete can increased. Experimental research on shear walls with steel fibers, showed that steel fibers can simultaneously improve the crack resistance, ultimate capacity, ductility and energy dissipation capacity of reinforced concrete shear walls [13,14].

Dissipation of energy is very important in case of seismic loading. Composite steel- concrete shear wall can be used where energy dissipation is very important. Connecters are required for better bonding between steel and concrete. For better energy dissipation high grade concrete is recommended [15].

Squat reinforced concrete shear walls with a height *hw* to length *lw* ratio of less than 2 are commonly used in low-rise building. They show good performance in lateral load resistance and drift control. Recycled concrete can be used in sqat reinforced concrete shear wall. In this type of shear wall drift capacity can be increased by increasing horizontal web reinforcement [16].

In flat slab, slab is supported by column. Flat slab and conventional two way slab buildings were analysed for seismic excitation by considering 7 storied building in seismic zone V. From this research they conclude that story displacement and bending moment is more for a building provided with flat slab as compared to conventional two way slab [17,18].

The column loss event is inherently dynamic. The ability of flat slab structures to efficiently span in two directions provides effective alternative load paths after a single column loss. When damage occurs the dissipation of energy affects the peak displacement and level of damping, as well as reducing the stiffness, and therefore natural frequency. There is increase in maximum displacement upto 50% than static case [19].

Strengthening of flat slabs with post-tensioning using anchorages by bonding can be done. It improves asthetic look and not require external anchorage. This technique reduced the slabs' deflections at service loads up to 70% as compared with unstrengthened slabs. Load carrying capacity of strengthened slab can be increased upto 34- 54% than the unstrengthened slab [20].

Concrete-filled steel tube-enhanced steel plate-reinforced concrete (CFST-SPRC) shear walls have been proposed for use in super high-rise buildings. Failure of CFST-SPRC is from web cracking under constant axial force and reversed cyclic loading. These walls are capable to dissipate significant seismic energy. For CFST-SPRC ultimate drift ratios were around 1.7% [21].

In lightly reinforced shear wall damage due to reversed static cyclic loading accumulates near the base of the wall. Because of damage at base of wall, wall may slide under static loading. Shear wall designed only for gravity load have 1% more drift capacity. In squat shear wall drift capacity is depends upon axial force ratio and vertical reinforcement arrangement. Brittle failure may occur in case of shear wall fixed at top and bottom as compared to cantilever wall. Large lightly reinforced shear wall along the periphery reduces the seismic effect o column considerably [22,23].

Under seismic load flat slab deforms as a part of building or as a part of moment resisting frame. As height increases deformation also increases. To reduce deformation in flat slab resulting from lateral loading shear wall can be used [24].

Glass-fiber-reinforced polymer (GFRP) reinforced shear wall gives acceptable drift values. Behaviour of GFRP bar is elastic. Due to elastic behaviour of GFRP, GFRP- reinforced wall significantly controls shear damage in the wall. Hence, GFRP reinforcement can be used in shear wall to resist seismic load [25].

Actual flexural capacity of flat slab is different than that of isolated test specimen. Flexural capacity of continuous specimen is more than that of isolated specimen. Deflection is less in continuous flat slab as compared to isolated specimen. Hence while assessing existing structure these parameters should be considered to avoid unnecessary strengthening [26].

In flat slab unbalanced moment created due to horizontal cyclic loading are transferred to the columns. For analysis of punching shear of flat slab for vertical and horizontal load 4.25x1.85x0.15m3 size slab and column 0.25x0.25m2 were analyzed. From analysis it is found that cyclic horizontal loading is very harmful to slab column joint connection. Stiffness of slab column connection gets reduced due to horizontal loading resulting in low energy dissipation and drift capacity. Infill material can reduce lateral drift and unbalanced moment [27,28].

In flat slab, slab is supported by column grid. Shear reinforcement is provided to resist punching shear of in flat slab construction. It resists the shear due to vertical load. In case of fire this reinforcement is unable to resist premature punching failure of flat slab-column connections exposed to fire [29].

The main advantage of performance based design is the predictable seismic performance with uniform risk. The reliability of this approach may ultimately depends on the development of explisit and quantifiable performance criteria that can be related to the calculated response parameters such as stress, strain, displacement, acceleration [30].

To reduce the selaf weight of structure Ultra-lightweight cement composite (ULCC) has been developed. This ULCC can be used in flat slab also. Fibers are added to resist shear stress [31].

III. CONCLUSIONS

Based on the studies so far carried out by several researchers following conclusions can be drawn.

1) The flat slab building shoes poor seismic response as compare to conventional building due less lateral stiffness.
2) Seismic response of building is also affected by the location of shear walls in building.

3) As shear walls provide better resistance to lateral load, hence it is important to find behaviour of flat slab building provided with shears walls and its effective positions in building.

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