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Review on Behavior of Composite Column and Post-Tension Flat Slab in High Rise Building

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Abstract - *The development of multistorey structures has progressed very rapidly in metropolitan cities of developing countries, mainly to evaluate solution for housing shortage problem due to rapid growth of population. As the height of superstructure increases, wind load and seismic load intensity also increases. A structural component like column plays an important role in lateral loading. Composite column of concrete encased I-shape steel has positive aspects like high ductility, high strength and corrosion resistance. The composite column system is commonly used to effectively control storey drift, displacement, base shear due to lateral load. Structural and non-structural damage risk can be minimized during small or medium lateral load by the use of composite column. The zones where seismic and wind load intensity plays a dominant role there use of composite column is may be a good obtion. As the dead weight of structure reduces then, resistance against lateral loading increases. RC beam and slab having more dead weight as compare to PT flat slab. PT flat slab having tremendous demand now a day, for its good flexural strength, economy and stiffness, provides more floor to floor clearance.*

The objective of this paper is to study, the behavior of composite column structures and PT flat slab structures in multistorey RC structures subjected to wind and earthquake load through literature review.

Key Words: Composite column, Post-Tension flat slab, Lateral load resisting system, Earthquake responses.

1.INTRODUCTION

The mankind has always been attracted by the heights of buildings since historical times. From the construction of ancient pyramids to the present-day modern high rise structures, the wealth and power of civilizations has found to be repeatedly got expressed through the spectacular and monumental structures. Today, high rise tall structures are considered as symbols of economic power and leadership. As the height of buildings increases, the wind and seismic forces introduces lateral displacement and storey drift in the structure, thus creating complexities in meeting serviceability requirements while minimizing the architectural impact of the structure. Steel may be used to induce ductility an important criteria for tall building, while corrosion protection and thermal insulation can be done by concrete. Similarly buckling of steel can also be restrained by concrete. In order, to derive the optimum benefits from both materials composite construction is widely preferred.
Post-tensioned slabs are a preferred method for industrial, commercial and residential floor slab construction. The increasingly extensive use of this method is due to its advantages and its nature of easy application to a wide variety of structure geometry and design solutions. The use of posttensioned floor slabs has become increasingly popular in high-rise construction. As the floor system plays an important role in the overall cost of a building, a post-tensioned floor system is invented which reduces the time for the construction and finally the cost of the structure. In some countries, including the U.S., Australia, South Africa, Thailand and India, a great number of large buildings have been successfully constructed using post-tensioned floors. The reason for this lies in its decisive technical and economic advantages.

The present paper focuses on the concept and working principle of various configurations of composite columns and post-tension flat slab; and also on the studies carried out by several researchers for understanding the behavior of composite building and post-tension flat slab due to the effect of seismic and load condition.

1.1 Composite column

Composite columns are a combination of two traditional structural forms: structural steel and structural concrete. As composite columns were generally developed after steel columns and reinforced concrete columns, their design approach could have been based on either steel or concrete design methods. However, steel column design methods have differed from concrete design methods in a number of fundamental ways. Despite this, both design approach can be used as the basis for developing a design method for composite columns and this can be seen in the different methods currently used in Europe and the USA for composite columns. While the design approaches appear fundamentally different, the end results can be surprisingly similar. By understanding the design philosophies, designers can take full advantage of each approach for the effective use and economy of composite columns.

1.2 Advantages of Composite Column

1. Composite column gives more floor space area for given strength.
2. In concrete encase steel tubes, concrete has good corrosion and fire resistance property which helps to protect steel.
3. Due to constant periphery of coumn helps architectural detailing and easy construction
4. No needs to additional reinforcing steel in case of composite concrete filled tubular sections provide. That's why Formwork avoidable for CFST columns. For large constructions, bridges, industrial workshops, etc.
5. A composite member provides lesser Drying shrinkage and creep than ordinary conventional reinforced concrete.

1.3 Post-tension flat slab

Post-tensioned slabs are a preferred method for industrial, commercial and residential floor slab construction. The increasingly extensive use of this method is due to its advantages and its nature of easy application to a wide variety of structure geometry and design solutions. The use of posttensioned floor slabs has become increasingly popular in high-rise construction. As the floor system plays an important role in the overall cost of a building, a post-tensioned floor system is invented which reduces the time for the construction and finally the cost of the structure. In some countries, including the U.S., Australia, South Africa, Thailand and India, a great number of large buildings have been successfully constructed using post-tensioned floors. The reason for this lies in its decisive technical and economic advantages

1.2 Advantage of Post-Tension Flat Slab

1. As post tensioning reduces or nearly eliminates shrinkage cracking, hence fewer or no joints are required.
2. Cracks developed are tightly held together by means of tensioned tendons.
3. The post-tensioned slabs are suitable for the expansive soil conditions.
4. It has a benefit in reduced sectional dimension, catering resistance to higher loads.

2. LITERATURE REVIEW

Several researchers have studied the behavior and performance of the composite column system and post-tension flat slab system in multistorey structures, especially in wind and earthquake load active regions. The present theories and practices published by various researchers related to the behavior of composite column buildings using concrete encased steel system and PT flat slab is presented in the following section.

Kamal Padhiar, Dr. C.D. Modhera, Dr. A. K. Desai, [1] (2017) Have carried out research work on the flat slab with and without drop panel by changing grade of concrete to study the effect of punching shear, factored moment and post-tension quantity. Different Four spans are analyzing using ADAPT-PT software by varying grade from M35 to M50 for two different spans to depth ratio. All loading are considered as per ACI code and equivalent frame method is used for analyze. The results shows that the as the grade increase M35 to M50 there is 20% reduction in deflection for all span. Also flat plate slab above than 8m and flat slab with drop panel more than 13m fails in punching shear criteria. Hence researcher concluded that the flat slab with drop panel have more flexural strength and economical than flat plate slab for span above 8m. In addition, as the grade of concrete increases the PT quantity reduces by 5-8%.

Boskey Bahoria, Prof. R. S. Deotale, Dr. D K Parbat, [2] (2010) Have carried out design of G+4 office building by four different cases namely the post-tensioned flat slab (PT flat slab), post-tensioned beams with the R.C.C. slab, only R.C.C. flat slab and the R.C.C. slab with R.C.C. beams. Also the parametric study of the post-tensioned flat slab by varying the span by 0.5m interval is done and results of the different cases obtain with respect to economy. From the economic point of view the post-tensioned flat slab is the most economical i.e. 12.5%, 23% , 27 % than the PT slab with RCC beam, RCC flat slab, RCC slab with beam system respectively. In addition to that PT flat slab require 12% less thickness than R.C.C. flat slab also floor to floor distance and speed of construction is more in PT flat slab than other three systems. Hence it is concluded that PT flat slab gives more flexibility, economy and speed in construction than other three systems.

Duarte M.V. Faria, Valter J.G. Lucio, A. Pinho Ramos, [3] (2011) Have carried out research work on new strengthening technique for flat slab. In this technique flat slab strengthen by using post-tensioning in which anchorages are bonded with epoxy adhesive. This technique is tested on 7 lab models and result shows that this technique decreases the slabs deflections at service loads up to 70% as compared with un-strengthened slabs, and reduced crack widths significantly. It can also increase punching load capacity up to 51% as compared to non-strengthened slabs. The research carried out also shows that there was a reduction in the average strains of the reinforcing bars, mainly in the bi-directional strengthened slab. It is shows that this technique is very effective at ultimate and serviceability stage.

R. K. Jnanesh Reddy, A. R. Pradeep, [4] (2017) Have carried out comparative study on post-tension and RCC flat slab to estimate a cheaper one structure from the study. Both post-tensioned flat slab and RCC flat slab are analyze by using finite element software like ETABS and RAPT and are designed by equivalent frame method and load balancing method. For validation design of slab done in ETABS and software pre-stressing is done in RAPT. The results shows that concrete used in RCC flat slab is 25% more than that of post-tension flat slab with drop and whereas, steel used in RCC flat slab is 12% more than that of post-tension flat slab. Hence the researcher concluded that the post-tension flat slab with drop is cheaper than RCC flat slab.

H. S. Mohana, M. R. Kavan, [5] (2015) Have carried out a comparative study on flat slab and conventional slab structure for different seismic zones of India to study parameters like storey drift, storey displacement, base shear and axial force. Manually direct design method for flat slab is adopted to calculate punching shear values also and letter on can be checked by using finite element software like ETABS. The result shows that earthquake zones II, III, IV, V are changing, there is 5% decrement of storey shear of conventional slab structure than flat slab, 6% decrement of axial forces on conventional slab structure than flat slab and storey of flat slab is 4mm less displaced than conventional slab structure. Hence researcher proves that flat slab is more convenient for different earthquake zones in India than conventional slab structure.

V. G. Mutalik Desai, Mohammad J. Shaikh, [6] (2016) Have carried out a comparative study on flat slab and post-tension flab by changing the position of columns and orientation of column drop to study the effects like punching, deflection, moment , stresses and cost comparison also done here. There are three main cases I, II, III indicates disposition of columns and three sub cases A, B, C indicates the orientation of column drop along X, Y and both directions respectively. Modelling and analysis of all cases done by using SAFE . The result shows that, 55% to 90% reduction in deflection of post-tension flat slab than flat slab, The punching shear capacity ratio is within permissible limit for all cases, 50% to 85% reduction in positive and negative moments of post-tension flat slab than flat slab, The stresses of both post-tension flat slab and flat slab are within permissible limits according to IS 1343:1980 and there is a 7% to 8.5% reduction in cost of post-tension flat slab than flat slab. Hence, researcher proves that post-tension flat slab is better option than flat slab.

P. M. Darsana, B. S. Bhavya, [7] (2018) Have carried out a comparative behavior of different cases under seismic effect. The four different cases are conventional structure, RCC flat slabs, post-tensioned flat slabs and also post-tensionn flat slab structure with and without shear walls. A 15 Storey building is studied for earthquake zone IV by using a finite element software ETABS 2016 for different cases. A conventional structure is compare with RCC flat slab and post-tension flat slab for the parameters like storey drift, displacement and base shear. A post-tension flat slab structure with and without shear wall have been analyze by using ETABS 2016. The result shows that the storey drift of post-tension flat slab is increased by 8% to 73% than RCC flat slab and conventional structure respectively. Displacement of post-tension flat slab is increased by 8% to 68% than RCC flat slab and conventional structure respectively. Base shear of conventional structure is increased by 23% to 31% than RCC flat slab and post-tension flat slab respectively. From above result researcher concludes that conventional structure is stiffer than RCC flat slabs i.e. having less resistance against the lateral loads whereas conventional structure having maximum base shear than that of both flat slab structures. Post-tension flat slab with shear wall have a decrement of 83% to 84% in storey drift displacement respectively than post-tension flat slab without shear wall structure. A structure with shear wall having 14% more base shear than without shear wall structure. Hence, Researcher concludes that a post-tension flat slab having shear wall of 'L' shape at corners is capable to resist lateral loads and having more base shear and less storey drift and displacement.

S. S. Vivek, D. Anjali, and G. Dhinakaran [8] (2015) Have carried out an experimental study to check behavior under axial compression load of short columns made up of concrete encase I-shape steel. Two different specimens have been consider here, Conventional vibrated reinforcement concrete short coumn and reinforcement self-compacting concrete short column with 15% cement replace by metakaolin admixture, Both having M60 grade. The result shows that the CVC composite short column have 7 times less strength than SCC composite short column. CVC composite short column have only 20% axial load carrying capacity of SCC composite short column. Hence, Researcher concluded that SCC composite short column is better option for composite steel column.

Varsha Patil, Shilpa Kewate [9] (2015) Have carried out research work on RCC, Steel and composite structures for earthquake zone III of G+5 storey commercial building by considering IS 1893 (part I) provisions. A modelling and analysis of RCC, steel and composite structures done by using finite element software ETABS 2013 to study the effect of displacement, base shear, time period, frequency and lateral force distribution. The result shows that the displacement of composite building is 25% and 1.5% less than RCC and steel building respectively, base shear of composite building is 2% and 30% less than steel and RCC structures respectively, stiffness of composite building is more hence time period is less than steel and RCC structures, Whereas frequency of composite building is 7% to 14% more than steel and RCC building for lateral resistance composite building is less susceptible than RCC and steel building. Hence researcher concludes that composite building gives better results against base shear, storey drift, and time period, frequency, lateral forces than RCC and steel building.

Mahesh Suresh Kumawat and L. G. Kalurkar [10] (2014) Have carried out research work on the steel concrete composite building and RCC conventional building for earthquake zone III to study the effect of stiffness, lateral displacement, storey drift, axial force, shear force in composite column, shear force in response spectrum analysis, twisting moment, frequency by using SAP 2000, the modelling and analysis of both composite and RCC building is done by considering IS 1893 (part I)-2002 provisions. The results shows that the stiffness, lateral displacement, storey drift, axial force, shear force in composite column, shear force in response spectrum analysis, twisting moment, frequency of composite building is 15%, 50%, 42.5%, 25%, 37%, 40%, 55%, 13% less than RCC conventional building respectively. Hence, researcher concluded that the steel concrete composite building gives better result in earthquake loading conditions.

3. SUMMARY

From the literature survey, it is observed that composite column system have better result against base shear, storey drift, displacement, stiffness, resistance against lateral loading, axial force, shear force in spectrum analysis, time period, frequency, twisting moment, etc than conventional RCC building.

From the literature survey, it is observed that post-tension flat system have good flexural strength, economy and speed in construction as compare to RCC flat slab structure and RCC conventional structure. Post-tension flat slab gives more floor to floor clearance, good stiffness and less dead weight of structure.

3.1 Scope of further study

From the literature survey, it is observed that no research has been yet carried out for analysis and design of multistorey composite column building with post-tension flat slab under seismic loading condition. Further, study of composite column building with post-tension flat slab in combination of dampers and base isolation for carrying out seismic analysis of high rise buildings could be a future research area. Also, more scope is seen for the investigation of multi-outrigger system in vertically symmetrical and unsymmetrical high rise buildings.

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