Review on Optimization of Post tension of Concrete Floor Slab

Ashish L. Jadhav[1], Rahul D. Patil[2]

[1]*PG Student, Dept. of Civil Engineering, Rajarambapu Institute of Technology, Maharashtra, India*
[2]*Associate Professor, Dept. of Civil Engineering, Rajarambapu Institute of Technology, Maharashtra, India*

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Abstract - *With the increased innovation of concrete and prestressed members, the entire building industry is entering a new era. Prestressed concrete is frequently used in the construction of structures such as buildings, sanitary, hydraulic, roadway, nuclear, and marine structures. Post-tensioning is a good way to improve the structural behavior of masonry elements. This paper aims to optimization of post tension of concrete floor slab to determine the post-tensioning slab thickness and weight of slab may be reduced.*

Key Words: Prestressed, post-tensioning, behaviour of post tensioned slab.

1.INTRODUCTION

Post-tensioning is a technique for reinforcing concrete or other materials with high-strength steel strands or bars known as tendons. Post-tensioning is only a process of fabricating prestressed concrete and other structural parts. The word prestressing refers to the technique of putting internal forces (or stress) into a concrete during the construction process to counteract the external loads delivered after the structure is put into operation (known as service loads). Internal forces are applied by tensioning high-strength steel either before or after the concrete is placed. The process of tensioning steel before to the placement of concrete is known as pre-tensioning. Post-tensioning is the process of tensioning steel after it has been placed in concrete. On-site post-tensioning is accomplished by inserting post-tensioning tendons into the concrete formwork in the same manner as rebar is inserted. (11)

The tendons are tensioned after the concrete surrounding the strands and rebar dries to a specific strength. Post-tensioning is similar to "pre-tensioning," in which the tendons are stressed prior to pouring the concrete and then released after it has cured. Post-tensioned slabs are a good example since they allow for a significant reduction in slab thickness by maximising spans and assisting in raising the number of floors, which is very crucial in high-rise buildings.(03)

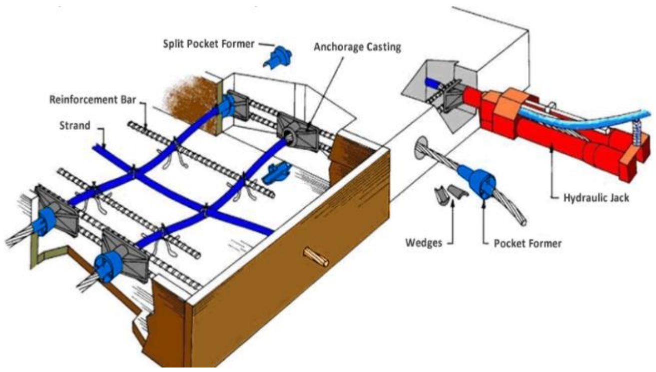

Fig 1: Schematic layout for post tension system

1.1 Advantages of prestressed concrete:

- Prestress concrete members provide better resistance to shearing forces due to effect of compressive stresses developed by prestressing the tendons.
- Dead load is counter balanced by eccentric prestressing in prestressed concrete member whereas in RCC dead load are of great importance.
- Use of high strength materials reduces cracks and improve durability under aggressive environmental condition.
- Long span structures are achievable in prestressed concrete, resulting in significant material savings, whereas RCC requires relatively heavy sections.
- It only requires a minimal amount of construction materials.
- The joints are the primary source of weakness in concrete buildings, fewer joints result in cheaper maintenance costs during the structure's design life.

1.2 Prestressing Systems

Pre-tensioning

During steel binding, prestressing tendons are placed into the mould or assembly. Before pouring concrete, these tendons are tensioned with hydraulic jack. When desired strength is reached after casting, the extra tendons are separated and both sides are grouted.

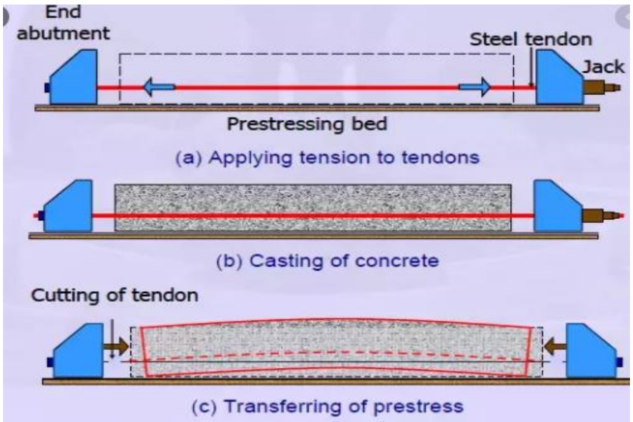

Fig 2: Pre-tensioning

Post-tensioning

Tensioning is done after the concrete has been poured in this manner. During the casting process, ducts are left behind that are used by the tendon that runs through them. When the concrete is ready for stress, the tendons are stressed in the same way as pre-tensioning is done, and then grouting is finished.

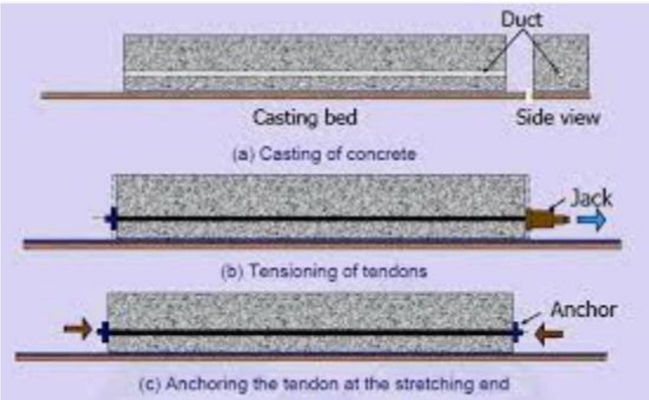

Fig 3: Post-tensioning

2. LITERATURE REVIEW

Numerous studies have been carried out on flexural behavior of post tensioned slab with various parameters like slab size, use of admixtures, bonded or unbonded tendons etc. The present theories published by researchers related to optimization of slab thickness by post tension design is presented in the following section.

Torok I. et al. (2019), The main purpose of this paper is to describe the post-tensioning methods possible to use for flat slabs of public buildings. The analysis follows the process of the structural design, considering in the analysis the advantages the method might present in future of the analyzed constructions, with all the advantages the method might present. This method can be efficiently used for buildings with spans larger than 7 meters, where the relative openings do not present major variation. Although post-tensioning of flat slabs is common in other countries, it is still avoided in the realization of reinforced concrete slabs in Romania due to a lack of understanding in the design and execution of post-tensioned slabs.(12)

Abd-El-Mottaleb H. E. and Mohamed H. A. (2018), Post tension floors (PT) are one of the most widely used system which are very effective method regarding ultimate and serviceability limit states. RAM software is used to examine a numerical model for discretized two-way reinforced concrete flat slab with diverse systems. The effects of different parameters are investigated in this study. Concrete strength, flat slab thickness, varied values of jacking force (P) / area of strand (A), and also examine the flat slab with opening by varying the values of P/A are among the parameters investigated. The results showed that the PT system had a substantial influence on the flat slab by reducing deflection. Also, the magnitude of the bending moment is reversed at one internal column by increasing the value of P/A for large thickness.(02)

Hymans M. et al. (2018), A case study is provided that is currently under construction and uses some of the methodologies addressed in this research to demonstrate its practical use. Through a numerical comparison, material quantity savings are demonstrated when compared to conventional design methods. This research is presented as an extension of previously developed methods and intends to explore new opportunities for enhancement both in the identification of vertical tendon profiles for tendon plan layouts and the rapid assessment of rebar requirements when designing post-tensioned systems.(05)

Bednarz K. (2018), The paper presents the results of the computational analysis of several types of cross-sections (full, with internal relieving inserts and ribbed) in the application to a post-tensioned slab with a span of 15.0m. Based on the results presented, appropriate conclusions were drawn.(03)

Imran M. et al. (2017), In the present study the regular Block type layout of plan is taken into consideration with two types of slab system i.e. A flat slab and a post tensioned slab are compared. Considering earthquake zones 2 and 3 according to Indian codes Buildings with G+9, G+11, G+14, G+19, and G+24 stories are considered, with differences in geometrical and material features. The method used for analyzing the model is Linear Time history analysis considering Locc-North seismic condition using software namely ETABS 2015. And conclusions are formed from many elements about each structural member's behaviour during the action of forces on them, with differences highlighted.(06)

Mohammed, A. H. et al. (2017), Optimization approaches may be useful in identifying alternative designs for posttensioned slabs in order to enhance their mechanical performance, notably in lowering bending moments. Post-tensioned (PT) concrete one-way slabs are one of the most commonly utilised slabs due to its high performance and low cost when compared to other slab types. The interface between PT tendon and the surrounding concretes was also modelled, allowing the tendon to keep its shape during slab deformation. The design variables are the area of the PT tendons, the starting stress in the tendons, and the eccentricity of the tendon profile, whereas the constraints are the normal stress in concrete, the stress in steel tendons, the shear stress in concrete, and the displacement at the slab's mid-span. The optimization results indicate that the area of PT tendons may be reduced by approximately 38% using an appropriate optimization algorithm. We conclude that optimizing the area of the PT tendons of the post tensioned slab is critical because it allows us to identify the optimal area of the PT tendon at a reasonable cost and under adequate service circumstances. (07)

Sarkisian, M. et al. (2017), Topology optimization is an optimization method which determines optimal load paths in a finite element continuum. Thus, it has been demonstrated that by orienting PT tendons along the ideal load routes recommended by topology optimization, PT quantities can be lowered by 25% or more while maintaining the same mild steel reinforcement. Many of the observed layouts do not adhere to standard uniform/banded patterns. Furthermore, deflection performance is substantially more consistent because tendons resist stress in a manner compatible with load needs. This can help to mitigate frequent concerns with thin flat-plate gravity systems, such as uneven floor flatness caused by PT system warping and inconsistent deflection at the external wall. For efficient application, this innovative design process was implemented to three buildings and coordinated with construction teams.(10)

Szydlowski, R and Barbara Labuzek, B. (2017), Slabs prestressed by unbounded tendons are successfully used worldwide for several decades. Many recommendations about geometry and prestressing, dimensioning, and erection technology were given at the time. In recent years, prestressed slabs with span and slenderness significantly surpassing specified limits have been successfully constructed and installed in Poland. During the slab's erection and in two years of their using, the deflection of three oversized slabs were monitoring. Despite the fact that the slabs were built to be substantially larger and slender than the specified maximum value of span and span to depth ratio, the deflection of the slabs is clearly far from the limit value. The study illustrates the geometry, characteristics, and deflection of built slabs, as well as the conclusion. This study presents a description of a very big span slab (21.3m) that was designed based on information received from the previous realization.(11)

Reddy, R. K. and Pradeep A. R. (2017), The current study compares the economic effectiveness of post-tensioned flat slab systems to that of reinforced concrete flat slab systems. Based on the design methodology, both systems are assessed using RAPT and ETABS, respectively. The results show that post-tensioned flat slabs are less expensive than RCC slab systems.(08)

Desai, M. V. G. and Shaikh M. J. (2016), This thesis investigates the analysis and behaviour of post-tensioned flat slabs. Modelling and analysis of flat slab and PT flat slab is done using SAFE. In assessing the PT slab, 12.7 dia and 9.5 dia 7 ply high tensile steel strands are employed for post-tensioning. Slab panel of 8m by 12m is modeled for different cases and respective properties are assigned. The slab is separated into two sections: the column strip and the middle strip. Drops are provided along column strip in flat slab and PT flat slab. Results are compared with flat slab and PT flat slab with respect to deflection, punching, moment and stresses. The quantities of reinforcing steel, post-tensioning steel, concrete required for the slab is calculated for the same and cost per square meter are presented in graphical form. Overall study on PT flat slab proves that PT flat slab could be a better option compared to flat slab, in respect of cost of project.(04)

Aalami, B. O. and Jurgens J. D. (2003), This article presents a set of guidelines intended to assist designers in routine post-tensioning design, begins with a discussion of the preliminary decisions that must be made in order to construct post-tensioned floor members. We then present a series of recommendations based on industry practise that have resulted in cost-effective designs with good in-service performance. We based the guidelines on ACI 318-02 and IBC 2000 when applicable. We have assumed for the purposes of this article that the design engineer is familiar with the concept and application of post-tensioning. There are several useful references on the subject of post-tensioning. 3-5 We have further assumed that the design engineer knows both the geometry of the structure and the loading; this article discusses the design process that follows the determination of the structure's geometry and loading.(01)

3. METHODOLOGY

Four specimens are considered in this research, 2 of RC and 2 prestressed. The beams are designed as per IS 456: 2000 and IS 1343: 2012. The concrete mix of M30 grade is designed as per IS 10262: 2019.

Notation	Clear span (m)	Total span (m)	Beam size (m x m)
Slab 1	1.6	2.0	0.6 X 0.075
Slab 2	1.6	2.0	0.6 X 0.1

Analysis of beams is done based on finite element-based software tool, Etabs 18.
Experimental testing of beams is done using two-point loading test setup.

4. CONCLUSIONS

From the literature review, following conclusions can be drawn:

i. Stressing improves the flexural strength of the slab significantly. The tensile stress created in the slab balances the structure's loads and keeps it strong.
ii. Due to large spans utilized in the slab, which require considerable steel reinforcement to save the deflection in the slab, the usage of post tension in the slab for improving the function of the slab is increasing nowadays.
iii. As compared to reinforced concrete, prestress concrete structures are more economical of material usage and economic span range.
iv. Most researches have used admixture usage criteria and software analysis for comparison, which provides us with a method to optimize post tension of concrete floor slab to identify the post-tensioning slab thickness and weight of slab may be minimized.
v. The stiffness and strength of a concrete structure, using PT Slab will be greater than that of a structure made with R.C.C Slab.

ACKNOWLEDGEMENT

The authors are very grateful to Dr. Mrs. Sushma S. Kulkarni, Director of RIT and Dr. Pandurang S. Patil for allowing to utilize the library facilities and for their motivation.

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