Review on Comparative Study of Flexural Behaviour of RCC and Post Tensioned Beams with Varying Span to Depth Ratios

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Abstract - *With increase in the innovation of concrete and prestressed members, the whole construction industry is heading towards a new era. Prestressed concrete is often preferred in the construction of building, sanitary, hydraulic, highway, nuclear and marine structures. As a result, it is a very useful tool for structural engineers. Post-tensioning is an effective technique for improving the structural behaviour of masonry members. The objective of this paper is to provide a comprehensive brief review on the latest efforts and researches related to flexural behaviour of post-tensioned beams.*

***Key Words*:** Prestressed, post-tensioning, span to depth ratio, flexural strength.

1. INTRODUCTION

Concrete is the most widely utilized structural material in modern society due to its great economic value and durability. (8) Nowadays, some of the concrete structures those are built in the past years were inadequate to carry service loads. Poor maintenance, an increase in the legal load limit, insufficient reinforcing, excessive deflections, structural damages, or steel corrosion, which leads to cracks, have all contributed to this insufficient load bearing capability.(6)

The present state of development in the field of prestressed concrete is due to the continuous research done by engineers and researchers during the last 90 years. Prestressed concrete is simply concrete that has been subjected to internal stresses of a sufficient magnitude and distribution in order to counteract the stresses caused by external loads to a desired degree. Tensioning the steel reinforcement is a common method of introducing prestress in reinforced concrete members. (9)

Post-Tensioning techniques are one of a number of methods used to improve the behaviour of beams and to repair it to carry additional loads and enhance serviceability limits. It also improves the load bearing strength of the concrete. (6) During service, the reinforcing steel is subjected to tensile forces. As a result, before the concrete is poured around it, it is placed under tension. The tension on the reinforcing steel is released once the concrete gets hardened, hence, a built-in compressive force on the concrete. This aids in the absorption of more stress and the reduction of compressive force on the concrete. As the concrete will be under compression, it is less subjected to failure or cracking. (10) .

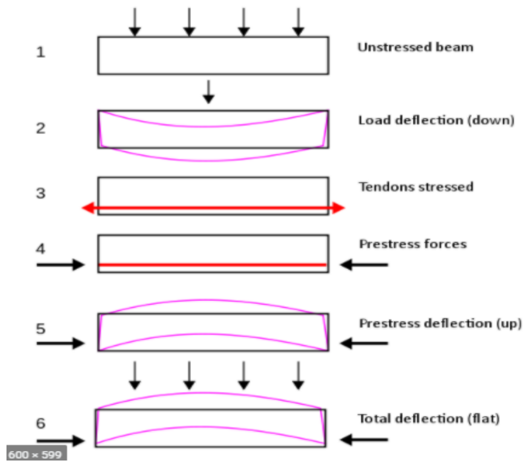

Fig 1: Effect of prestressing

1.1 Advantages of prestressed concrete:

- Cross-section of member is more effectively utilised as compared to RCC
- A permanent dead load is counteracted by increasing eccentricity of prestressing force which saves the excessive use of concrete.
- It helps to improve resistance to shear force which is developed near the supports, particularly in long span members.
- Durability of the structure is improved by its high strength and crack resistance when exposed to harsh weather conditions.
- Due to prestressing, energy absorption under impact load and resistance to repeated working loads are well established.
- In the long run, prestressed concrete is less expensive than RCC. (9)

1.2 Prestressing Systems

Pre-tensioning

Prestressing tendons are inserted in the mould or assembly during steel binding. These tendons are tensioned using hydraulic Jack before pouring of concrete. After casting when the desired strength is achieved, excessive tendons are separated and grouting is done on both sides. (9)

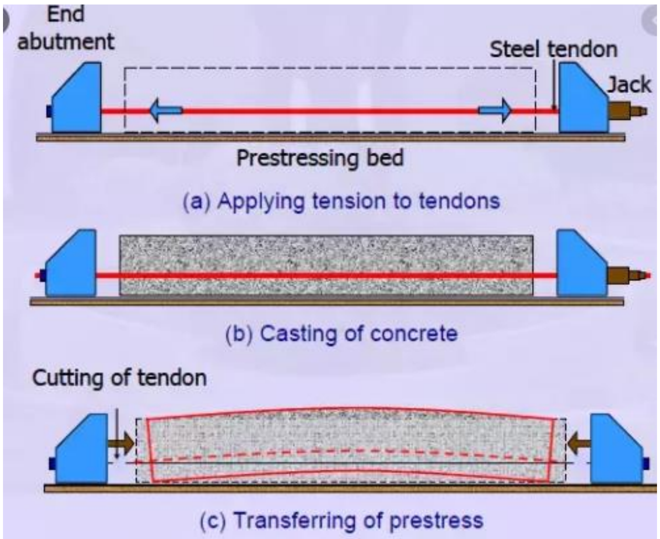

Fig 2: Pre-tensioning

Post-tensioning

In this method tensioning is done post-pouring of concrete. While casting, ducts are left which are used for tendon passing through it. When the concrete is ready to be stressed, the tendons are tensioned in the same way as pre-tensioning is done, and then the grouting is finished. (9)

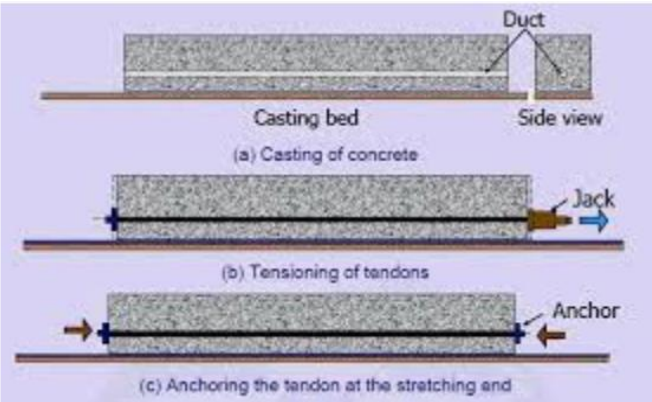

Fig 3: Post-tensioning

2. LITERATURE REVIEW

Numerous studies have been carried out on flexural behaviour of post-tensioned beams with various parameters like beam size, use of admixtures, bonded/unbounded tendons etc. The present theories published by researchers related to the flexural behaviour of post-tensioned beams are presented in the following section.

Min Sook Kim and Young Hak Lee (2020), assessed the applicability of high-strength strands to current design codes and various existing equations. . Test variables included the tensile strength of strands, the number of strands, the cross-section shape, and anchorage zone reinforcement details. Test results were compared with ACI 318-19, AASHTO. A flexural experiment was conducted on eleven specimens to investigate the flexural performance of posttensioned concrete components with Grade 2400 strands. Grade 1860 strand specimens have deeper cracks than grade 2400 strand specimens. Fe2400 specimens have a 14.5 percent better flexural strength than Fe1860 specimens. Flexural cracks in specimens with high-strength strands widened and penetrated deeper into the compressive zone. In the specimen whose anchorage zone was reinforced by stirrups, the concrete in the anchorage zone could not resist the increased compressive stress due to the increased bending moment [7].

Ankith M. K. et al. (2020), An experimental examination of the flexural behaviour of a post-tensioned beam is presented in this paper. The primary goal of this research was to investigate the beam's deflection, initial load carrying capacity, final load carrying capacity, and flexural behaviour. Since ancient times, several additives such as GGBS, Silica Fume, and Fly Ash have been employed in concrete. For this study, M60 concrete was used to cast three beams. In that Type-1 is the Conventional Concrete, Type-2 is replacement of 20 % of cement with GGBS and Type-3 is replacement of 5 % of cement with Silica Fume. According to the Design, all three beams are post tensioned with the requisite prestressing force. The beam dimension is 400 mm width, 300mm depth and 2000mm length. When compared to conventional concrete beams, the inclusion of 20% GGBS with cement replacement and 5% cement replacement enhances the Compressive Strength by 3% and 5%, respectively. The result shows an increase in the compressive strength of the 6 mixes with addition of admixture. From the results of split tensile test we can conclude that use of Silica Fume with 5% replacement of cement in Post tensioned on M60 grade of concrete is the most efficient mix as compared with other mixes. Flexural strength results show a significant increase with the addition of admixtures with replacement of cement in Post tensioned beam. The strength increases by 50% with addition of GGBS and 80% with addition of Silica Fume when compared to Conventional concrete beam [1].

Swoo-Heon Lee et al. (2018), For flexural strengthening, a post-tensioning approach using externally unbonded steel rods was used on pre-damaged reinforced concrete beams in this investigation. Three-point bending was performed on nine simply supported beams, three reference beams, and six post-tensioned beams. The post-tensioning technology improved load-carrying capacity and flexural stiffness by 40–112% and 28–73%, respectively. The rehabilitation or strengthening of the beams with external unbonded post-tensioning steel rods resulted in stiffness and strength improvements of more than 28% and 40%, respectively. [8].

Deng Fangqian et al. (2016), studied the flexural behaviour of externally prestressed carbon fibre reinforced plastic (CFRP) tendons enhanced T shaped section reinforced concrete (RC) beams subjected to static loads using a new external prestressing method. The influences of concrete strength, reinforcement ratio of the non-prestressed tensile steel bars and the tension control stress of the CFRP tendons on the flexural behaviour in terms of bearing capacity and ductility were examined. The test results revealed that, as compared with unstrengthened RC beams, the specimens externally strengthened with prestressed CFRP tendons showed a better performance in the flexural capacity, as well as overall stiffness and ductility. A total of seven T-shaped simply supported RC beams including a beam unstrengthened with CFRP tendons were prepared in the experimental program. Three factors were considered here, i.e., the concrete strength grade, the tension control stress of CFRP tendons and the reinforcement ratio. The ductility behaviour on the strengthened RC beams exhibits opposite than on the ordinary ones [3].

Ghanem, G. et al. (2016), presented a study on the flexural behaviour of strengthened RC beams using external posttensioning technique under the effect of cyclic loads. In the experimental study, the impacts of varied percentages of shear reinforcement were also studied, which included the use of GFRP bars, and prestressing steel bars. Finally, the results of the experimental work were compared to theoretical analysis by simulating the tested beams in finite element software (ANSYS). The ultimate load of strengthened beams was more than ultimate load of non-strengthened beam by 7%. The cracks propagated to nearby the top of strengthened beams. There is no yield or rupture observed for the external prestressing bars for all the beams studied [6].

Sudhir P. Patil and Keshav K. Sangle (2016) reported a study in which 20 percent fly ash (class-C) was used as a binder replacement and 1.5 percent steel fibres were added to the concrete weight. The load carrying capacity of steel fibre increases by 30–50% over the plain beam for non-prestressed beam. The load carrying capacity is increased approximately by 30– 90% than the plain prestressed concrete beam. Crack width was not more than 6 mm and 3 mm in case of the non-prestressed and prestressed steel fibre reinforced concrete beams respectively [10].

Assaad Taoum et al. (2015), looked into the behaviour of post-tensioned reinforced concrete beams that were post-tensioned. Four concrete beams were post-tensioned and tested on the spot. AS3600-2009 was used to make theoretical predictions. It was found that the approach adopted in AS3600- 2009 to predict the cracking moment was not applicable for post-tensioned beams, since the forces involved in this process were not included. The local post-tensioning is applied only in critical areas where the bending moments reach the maximum values, e.g. at a support area or mid-span [11].

R. Balamuralikrishnan (2015), presented the result of experimental studies concerning the flexural behaviour of post tensioned geopolymer concrete beams. The fly-ash-based geopolymer concrete mix design for M50 grade was obtained in this investigation. The ratio of fluid to fly ash was set at 0.45. A total of four beams of size 125 × 250 × 3200 mm were cast and tested in the laboratory. Two of the beams are made of geopolymer concrete, while the other two are made of traditional concrete. The geopolymer concrete beam deflects more than the ordinary concrete, nearly 18% more deflection at given load level. Geopolymer concrete is 25% economically beneficial than ordinary concrete. The cracks of the concrete beams occurs at the center are well distributed in flexure zone only [2].

3. CONCLUSIONS

From the literature review, following conclusions can be drawn:

i. Flexural strength of beam is improved effectively due to stressing. The tensile stress induced in the beam counteracts the loads on the structure and makes it stable.
ii. Grade of steel and concrete makes a large difference in the flexural behaviour of the beam.
iii. Concrete with fly ash, polymers, silica fume perform better than conventional concrete. It also improves load bearing capacity of the beam.
iv. Use of GFRP bars strengthens the concrete as compared to concrete with prestressing bars. It also helps to upgrade the crack pattern.
v. Study made on Flexural behaviour of RCC and Post-tensioned beams helps in understanding the concepts when it is used in construction.

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