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An Experimental Investigation of Post Tensioned Beams with BFRP Fabric

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Abstract:
The most commonly used material in Civil Engineering works is Reinforced Concrete, there should be enough strength and stiffness in the existing structures to withstand the external loads. Some of the Pre-stressed Concrete (PSC) is designed without suitable codal references so they provide insufficient structural performance, to get away from this they have to be advanced in order to increase the load carrying capacity. In this experimental work post-tensioned beams were strengthened by BFRP fabric. The aim of this work is to evaluate the stress strain behavior of post-tensioned beams. To achieve this post tensioned beams of size 1300mmX150mmX200mm were casted according to IS 1343-1980 regulations and tested less than two point loading. The beams were assigned as Control beam, Post Tensioned beam and Strengthen beam. The conclusion was discussed based on stress strain curve plotted. From experiment results, there were decrease in the strain values for strengthen beams. Beam strengthens with double layer BFRP have less strains compared to other beams.

Keywords: Post Tensioned beam, Strengthening, BFRP fabric.

I. INTRODUCTION

Numerous Pre-stressed concrete structures are unable to carry loads as an outcome due to poor constructions methods and materials used inadequacy in design standards, environmental loss and others. To achieve a better performance of structure the strength and stiffness plays a vital role. As a result, many existing structures are in necessity of strengthening, rehabilitation or repairing etc. Depending upon the importance of structure and its location complete replacement of structure is not possible; under such situations strengthening is best decision which can be done. Strengthening of PSC members is an important one which includes economy and other social aspects around the world. In fact, PSC members designed without proper code references leads to intolerable structural behavior due to loss of priestess in strands. The crucial regions in PSC beams are flexure and shear regions, these zones are strengthened with Fiber Reinforced Polymers (FRP).

II. RELATED WORKS

The initial FRP material used was glass fibers implanted in polymeric resins that were equipped by petrochemical industry. FRPs were first applied to reinforced concrete columns for providing supplementary confinement in Japan in 1980s. Suddenly there was drastic increases in use of FRP were witnessed in Japan after Hyogokn Nanbu earthquake in 1995. As a result research activities lead to FRPs material in many fields. The countries like Europe, Japan, Canada and United States in fields of retrofitting and rehabilitations project using FRPs as a construction material. FRP materials are now finding broader acceptance in the characteristically conservative infrastructure construction industry [1]. In 1980's the FRP's were first applied to RC columns as an additional confinement. The initial FRP materials used was glass fibers embedded with polymeric resins and it was made by petrochemical industry following World War II. Several researches have carried out numerous experiments in countries like Japan, Canada and Unites States in retrofitting of structures by means of FRP's [2]. In this work the post-tensioned beams were strengthened with natural fibers i.e sisal fiber. The beams were strengthen with natural occurring sisal laminate only for flexure zone and other beams were strengthen with sisal fibers laminate throughout the length of beams provided with the anchorages. The strengthen beam with anchorages carried more loads compared to beams strengthen in flexure zone. [5] In this experimental work the post-tension beam were strengthened with CFRP and GFRP. Here beams were wrapped with different patterns such as total length wrapping, bottom wrapping and full length wrapping. The load carrying capacity of beams for full length wrapping seems to be increased for both CFRP and GFRP compared to control beams [6]. In this experimental work the post tensioned beams are strengthened with BFRP and analysis is carried out to know their stress strain behavior under static loading. Where two beams are strengthen with single layer BFRP and other two with Double layer BFRP.

III. EXPERIMENTAL PROGRAM

The experimental study was conducted on Post Tensioned beams cast and they were tested under two point loading. This analysis is limited only for flexure failure, as the beams are designed to fail in flexure. The reinforcement provided was #2-10ϕ on compression and tension side with a stirrups spacing of 8ϕ@150mm c/c along length of beam. For post-tensioned beams along with actual reinforcement, 2 number of 7mm dia tendons are placed with an eccentricity of 50mm, stressed for a pre-stressing force of 48KN in each tendon individually. The clear cover of 40mm was provided from bottom of beam and 25mm cover from the sides.

The beams are divided into as,

- Control Beams. (CB)
- Post-Tensioned Beams. (PTB)
- Strengthen Beams. (SB)

All the specimens were strengthen with BFRP fabric and resin. Fabrics are attached to soffit of beams for full length.

A. Casting of Beam specimen

Post-tensioned beams were cast with the flexible rubber tube of 10mm diameter throughout the length of beam, during this high tensile steel tendons of 7mm dia of two numbers are introduced into the tube in order to avoid the firmness of tube during casting. Concrete of grade M40 was used and poured from height below 1m, with help of vibrator it was compacted uniformly. After initial setting of concrete the tendons are moved back and forth to confirm that there is no concrete in rubber pipe. After 24 hours the beam specimens are de-mould and they are cured for 28days and then the specimens were tested.

B. Pre-stressing of Beams

Two mild steel plates of size 150mmX100mmX10mm were used as end bearing plates. Two holes were punched in each end bearing plate for housing the tendons. High tensile tendons were placed through the holes in mild steel plates in particular ducts provided. At both the ends the barrels are first fixed and then two pieces of wedges were inserted into barrels for each tendons. The tendons were sealed at one end and at other end tendon was stressed by hand operated hydraulic jack up to designed pre-stressing force and the elongation of tendons were measured. Each tendon of 7mm diameter were pre-stressed individually with hydraulic jack of 7-metric ton capacity with least count of 1KNas shown in figure – 1. In this work Gifford – Udall system is referred.

Figure.1. Post-tensioning of beams

C. Strengthening of Beams with BFRP fabric

In this experimental work the post-tensioned beams were strengthened with Single layer (SBSL) and Double layer (SBDL) BFRP. The bottom surface of post-tensioned beam should be free from oils, excess concrete and other materials. Lapox L-12 epoxy resin is applied over the soffit of beam, BFRP should be cut to required shapes and size and then it is pressed with roller to get rid of air bubbles and to gain proper bonding. Once the strengthening work is done then it is allowed for drying up to four days to get proper bonding.

IV. TEST SETUP

The beam specimens were tested under 500KN capacity loading frame and all beams was tested under static loading as shown in figure – 2. The loading were applied at an interval of 10KN increments till the failure of beam i.e ultimate load. Strains were measured with the help of pilletsat mid region of the beam, for each loading the strains were recorded along the top and bottom zones using demac gauge.

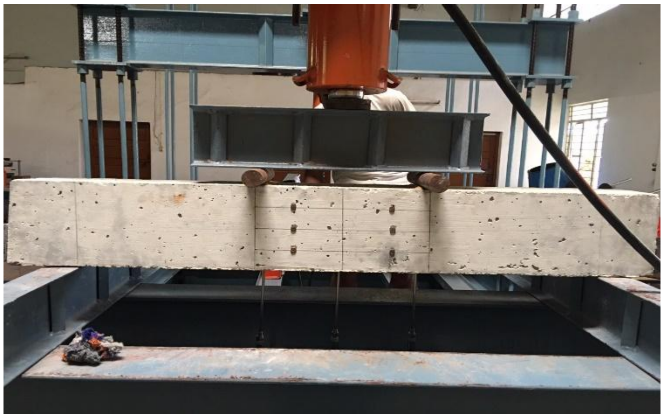

Figure. 2. Test setup

V. RESULTS AND DISCUSSION

The beams of size 1300X150X200mm were subjected for loading at 10KN intervals and strains were measured at mid-span region of the beam using demac gauge and results are plotted as stress v/s strain curve and the same is shown in figure – 3 ,

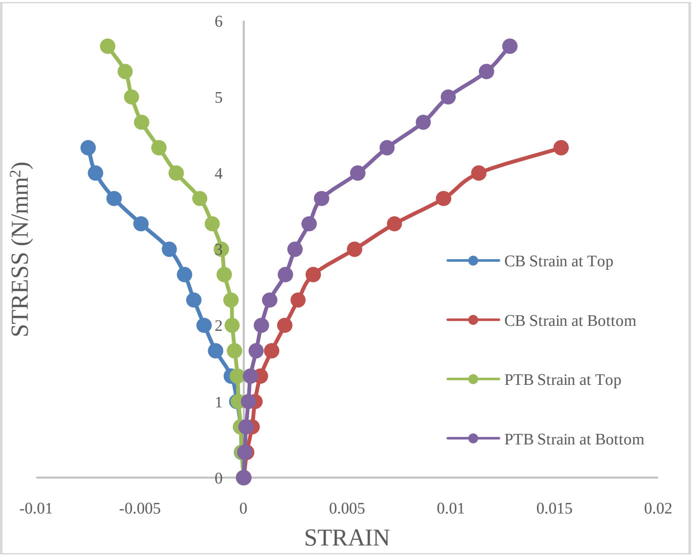

Figure.3. Stress v/s Strain for CB and PTB

Figure – 3, represents stress v/s strain curve for control beam and post-tensioned beam. It can be observed that, as load increases the strain in the top zone of the beam reduces i.e compression and the strain in bottom zone increases i.e tension for both control beam and post-tensioned beam. It can also be seen that the maximum load carrying capacity is more in post tensioned beams compared to control beam i.e 170KN in post-tensioned beam and 130KN for control beam respectively. The strain values was reduced for post tensioned beams compared to control beams i.e -0.004085 at top and 0.00692 at bottom in post tensioned beams and -0.0075at top and 0.01533 at bottom for control beams at a load of 130KN respectively.

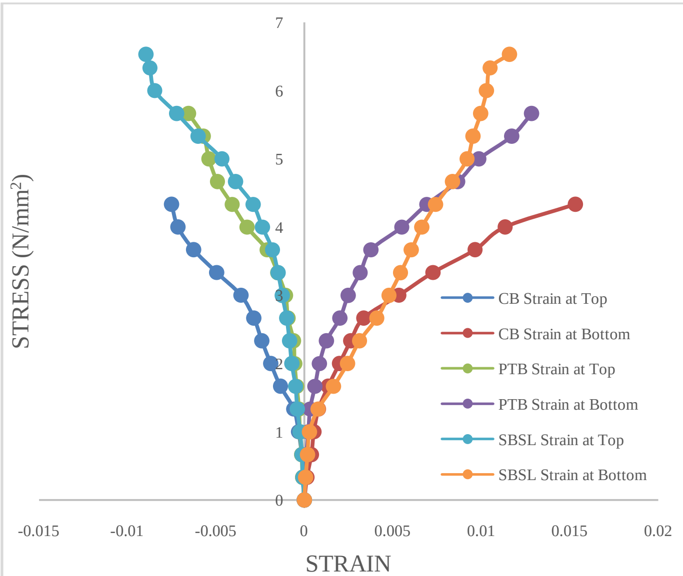

Figure.4. Stress v/s Strain for CB, PTB and SBSL

Figure – 4, represents stress v/s strain curve for control beam, post-tensioned beam and strengthen beam with single layer BFRP. It can be observed that, as load increases the strain in the top zone of the beam reduces i.e compression and the strain in bottom zone increases i.e tension for control beam, post-tensioned beam and strengthen single layer beam. It can also be seen that the maximum load carrying capacity is more in strengthen single layer beam compared to control beam and post tensioned beams i.e190KN in strengthen single layer beam, 130KN for control beam and170KN for post-tensioned beam respectively. The strain values was reduced for strengthen single layer beam compared to control beams and post tensioned beams i.e-0.0029 at top and 0.006103 at bottom in strengthen single layer beam, -0.0075 at top and 0.01533 at bottom for control beams and -0.004085 at top and 0.00692 at bottom in post tensioned beams at a load of 130KN respectively.

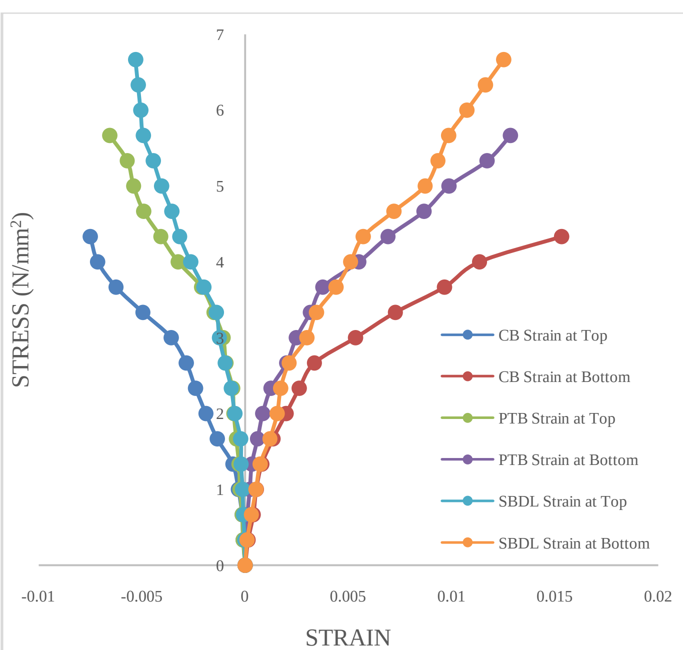

Figure. 5. Stress v/s Strain for CB, PTB and SBDL

Figure – 5, represents stress v/s strain curve for control beam, post-tensioned beam and strengthen beam with double layer BFRP. It can be observed that, as load increases the strain in the top zone of the beam reduces i.e compression and the strain in bottom zone increases i.e tension for control beam, post-tensioned beam and strengthen double layer beam. It can also be seen that the maximum load carrying capacity is more in strengthen double layer beam compared to control beam, post tensioned beams and strengthen single layer beami.e200KN in strengthen double layer beam, 130KN for control beam, 170KN for post-tensioned beam and 190KN for strengthen single layer beam respectively. The strain values was reduced for strengthen double layer beam compared to control beams, post tensioned beams and strengthen single layer beami.e-0.002775 at top and 0.005715 at bottom in strengthen double layer beam, -0.0075 at top and 0.01533 at bottom for control beams, -0.004085 at top and 0.00692 at bottom in post tensioned beams and -0.0029 at top and 0.006103 at bottom in strengthen single layer beam at a load of 130KN respectively.

VI. CONCLUSION

Based upon experimental study and observations the following conclusion were drawn,

- Post Tensioned beams shows better performance when compared with control beam.
- Post Tensioned beam strengthen with single and double layer BFRP wrapping reduces the deformation when compared to control beams.
- The strains of post-tensioned beam, strengthen beam with single layer BFRP and strengthen beam with double layer BFRP was reduced by 54%, 60% and 62.7% when compared to that of control beam respectively.

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