Experimental behavior of retrofitting of prestressed concrete Beam with FRP laminates

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ABSTRACT

Pre-stressed concrete structures showed a higher strength and effective usage than the RCC. But due to aging and deterioration due to environmental exposures, the structures reduced its life span and hence it doesn't provide the affordable strength then it has to replace with new member or to strengthen the existing member with various traditional strengthening methods. But such traditional method has its own demerits. Fibre Reinforced Polymer (FRP) is used in the current generation because of higher modular ratio ,strength and ductility .This project presents an experimental program conducted to study the behavior of pre-stressed beams and the pre-stressed beams strengthened with various composites of FRP sheets .The program consists of a total of five beams; one specimen is a control beam of normal pre-stressed concrete, two specimens were strengthened using Carbon fiber Reinforced Polymer and remaining two specimen were strengthened with Unidirectional Cloth of Glass fiber reinforced concrete. The entire 5 specimen were a partially pre-stressed and unbounded type of pre-stressed concrete beam. The overall dimensions of the beams are 150 x 250 x 3000 mm. The beams were tested under a static gradual loading up to failure to examine its flexural behavior. Some various criteria of the beams were compared with each other with respect to Ultimate load, Deflection, Ductility, Strain and Crack patterns. There is maximum increase of 35% with the ultimate loads between the beams with and without FRP. The UDC GFRP show more ductility compared with other beam specimens and Carbon fibres are some stiffener than the other samples.

KEY WORDS: Cement Concrete, Pre-stressing, flexure test.

1. INTRODUCTION

The technique of inducing permanent stresses in concrete, of a type opposite to these which the loads will cause, has been developed and extensively used. The unique characteristics of pre-stressed concrete allow predetermined, engineering stresses to be placed in members to counter-act stresses that occur when the unit is subjected to service loads. This is accomplished by combining the best properties of two quality materials: high strength concrete having compressive stresses equal to 100 to 150kg/sq.cm for compression and high tensile strength steel strands which can take stress up to 9000 to12000 kg/sq.cm for tension. Actually, pre-stressing is simple. High tensile strands are stretched between abutments at each end of long casting beds. Concrete is then poured into the forms encasing the strands. As the concrete sets, it bonds to the tensioned steel. When the concrete reaches a specific strength, the strands are released from the abutments. This compresses the concrete, arches the member, and creates a built in resistance to service loads.

2. MATERIALS AND METHODS

Cement: Ordinary Portland cement of 43 grades conforming to IS 8112-1989 was used.
Fine Aggregate: Natural fine aggregate (conforming to grading zone II of IS 383-1970) available in local market having specific gravity 2.60 was used.
Coarse Aggregate: Normal coarse aggregate of size 12 mm, having specific gravity 2.76 was used.
Water: Fresh, colourless, odourless and tasteless potable water having pH value ranging between 6 to 8 was used.

Table.1. Mix proportions

Water	Cement	Fine aggregate	Coarse aggregate
183	405 kg	585 kg	1180kg
0.45	1	1.44	2.90

Reinforcement details: The size of the pre-stressed concrete beam is decided as 150 mm x 20 mm cross-section and the span is 3000 mm. The beams were reinforced with two bars of 10mm diameter at the compression face and two bars of 12mm diameter at the tension face. Shear reinforcement consist of 8mm diameter stirrups at 150 mm spacing. The aluminum duct is placed at an eccentricity of 25 mm from the neutral axis of the beam and spacing between the pre-stressing wires is 50 mm the eccentricity 25 mm is adopted from the minimum eccentricity value.
Fiber reinforced polymer: In this study we have used two types of fibers for the purpose of strengthening of the Pre-stressing beams they are Glass fiber reinforced polymer (GFRP) in which the orientation is Uni-directional cloth (UDC) of 3mm and 5mm thickness and carbon fiber reinforced polymer (CFRP) in 1 layer and 2 layers.
Lamination of FRP: Once after the pre-stressing of the beams is over the beams are reversed to show the tension face upwards before the lamination of the FRP sheets the surface is well cleaned and grained using the hand machine.

This makes the surface well smooth finished without any undulations, epoxy resins were used for the purpose of pasting the FRP sheets the initial setting time for the fibers is 4 hours and complete setting time is 24 hours and dry curing should be allowed for 7 days for the proper bonding of the FRP with the specimen. This epoxy resin is prepared with a various combination of mix in various proportions which gives rise to perfect bonding of the FRP plates with Beams.

Prestressing wires: The pre-stressing wires are very high strength wire, there are various types of wire in the HTS wire the type we used here for the beam specimen is of 7mm diameter plain hard drawn wires the Ultimate tensile strength of the wire is 1532 N/mm2 .the breaking load is 59.1 kN.% of elongation is 4.0 average. This is as per IS 1785 part 1.

3. RESULTS

While the load is given gradually in the system the whole system is watched carefully to avoid any important behavior and faulty proceedings of the testing .The values of load deflection and various strains measurements are clearly recorded for every second in a personal computer connected with the data logger. The beam is tested for its ultimate load so once the load is reversed it advice able to remove the load in order to avoid collapse of the beam which may affect the measuring instruments.

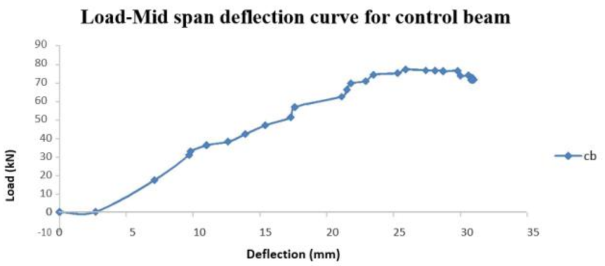

Figure.1. Load-Mid span deflection curve for PSC control beam

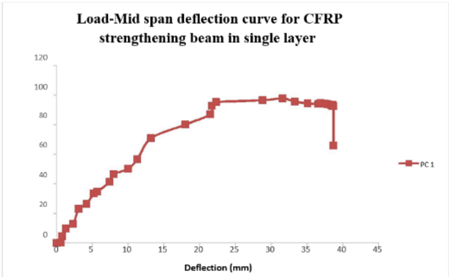

Figure.2. Load-Mid span deflection curve for CFRP strengthening beam in single layer

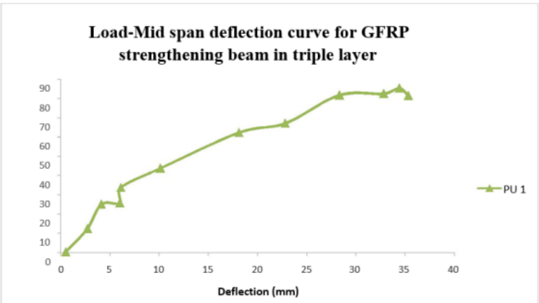

Figure.3.Load-Mid span deflection curve for GFRP strengthening beam in triple layer

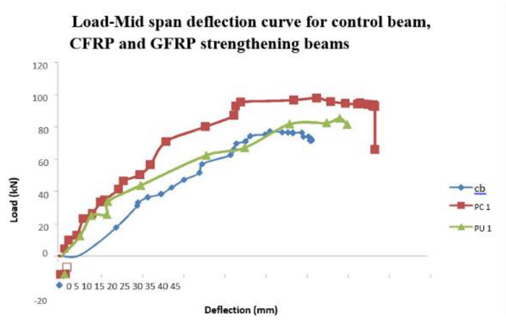

Figure.4.Load-Mid span deflection curve for control beam, CFRP and GPRP strengthening beams

Table.2. Deflection at various stages of loading

S.No	Specimen details	Deflection at initial crack (mm)	Deflection at Yield Strength (mm)	Deflection at Ultimate Strength(mm)
1	CB	8.1	9.8	25.9
2	PC 1	5.2	8	37.5
3	PU 1	5	6.1	34.4

Load – Mid span Strain UDC Strengthening Beam

Table.3. Load –Mid span Strain

UDC GFRP strengthening BEAM	
Load (kn)	Strain
0	0
7.42	3
13.44	14
18.34	45
29.26	57

Table.4. Load –Mid span Strain CFRP Strengthening Beam

CFRP strengthening beam	
Load (kn)	Strain
0	0
13	14.2
30	9.52
45	12.46
106	18.48
328	21.28
590	25.2

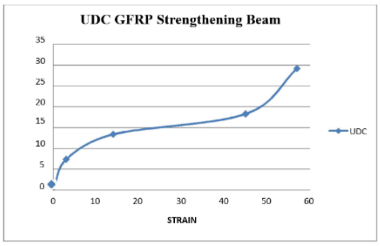

Fig.5. Load-Strain curve for UDC GFRP strengthening beam

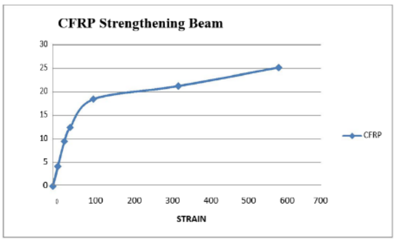

Fig.6. Load-Strain curve for CFRP strengthening beam

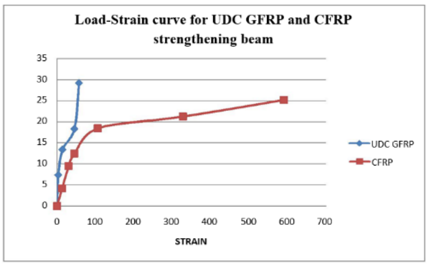

Fig.7. Load-Strain curve for UDC GFRP and CFRP strengthening beam

Table.5.Comparison of the Ultimate loads

S.No	Details of beam	Ultimate load in (KN) (Experimental)
1	Control PSC beam	45.25
2	UDC GFRP Strengthening beam	65.82
3	CFRP strengthening beam	90.57

4. CONCLUSIONS

- Strengthened PSC beam showed a significant increase in load carrying capacity by 36 % over the control beam.
- GFRP strengthened PSC beam showed a increase in ultimate deflection by 18% than the control beam.
- From the experimental investigation it revealed that energy absorption capacity was than that of the other beams.
- From the tested beams, it was observed that the FRP strengthened PSC beams increased the ductility in the range of 77% to 246 %.
- Failure of the specimens occurred by concrete crushing within the constant moment region, FRP de-bonding, FRP rupture, or a combination of these modes. [22-23]

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