Strengthening Technique for RC Beam Using Carbon and Aramid Fiber

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Abstract- *This paper presents the flexural behavior of aramid and carbon fiber reinforced polymer (AFRP) strengthened reinforced concrete (RC) beams of M20 grade of concrete. The experimental program included strengthening and testing of simply supported rectangular cross section beam of size 1800mm x 100mm x 200 mm strengthened with aramid and carbon fiber polymer sheets. Total fifteen specimens were tested out of which three beam specimens were tested as control beams and remaining for number of layer of fiber. The effects of strengthening on load carrying capacity and effect of damage degree are discussed in detail. The results indicate that the load carrying capacity of beams was significantly increased as the number of layer increased. In order to study the flexural behavior of the beam, the specimens were only subjected to two point loading mechanism only. The beams were wrapped with AFRP and CFRP sheets in single layer and double layers along the length at the bottom face of the beam. The present work includes comparison between AFRP and CFRP by considering effect of number of layers. Thus it is a feasible method for strengthening and retrofitting of RC beams.*

Keywords- AFRP, CFRP, Strengthened beams, Flexural behavior.

I. INTRODUCTION

Fiber reinforced polymers (FRP) have been used for many years in the automotive and aerospace industries. In construction industry they can be used for cladding or for structural elements in a highly aggressive environment. Now a day's building are found to be damaged because of change in the function of building, exposure to environmental conditions and due to use of older codal provisions. Today deterioration of RC structure is one of the major problems in civil industry. Mostly large number of buildings are constructed as per older design codes in different parts of the world, thus are structurally unsafe according to present design codes, since replacement of such deteriorated structure takes plenty of money and time. Nowadays, it is necessary to find repair techniques suitable in terms of low costs and fast processing time. Much of our current infrastructure is constructed of concrete. As time passes, deterioration and change of use requirements facilitate the need for new structures. Demolition of existing and construction of new structures is a costly, time consuming and resource intensive operation.Externally bonded FRP sheet can be used to increase as flexural strength of reinforced concrete beams. Reinforced concrete beams externally reinforced with fibre reinforced polymer sheets is a good retrofitting technique. Aramid and carbon fiber composites play a major role in improving strength of structure and do so at significantly low cost than new structure construction cost.Fiber wrapping is the new technology for reinforced concrete structure It is used for strengthening of structural members without disturbance to other member as compared to other conventional methods. Externally wrapped fiber sheet can be used to increase the flexural strength of rectangular reinforced concrete beams. accuracy of the finite element model is checked with help of comparison its results with the experimental results. The load-deflection curves obtained from the holds good with the experimental results.

1.1 Aramid Fiber

Aramid Fiber is also known as keveler fiber. Aramid fiber is also high strength, tough and highly oriented organic fiber derived from polyamide incorporating into an aromatic ring structure. Keveler is used in bullets resistance jacket. This fiber is quite abrasive and under repeated loading they can abrade against each other by weakening the sheets. Aramid fiber is a family of synthetic products characterized by strength some five times stronger than steel on an equal weight basis and heat-resistance and high tensile strength. Physical properties of Aramid fiber are given in Table 1.

Table 1 Properties of Aramid fiber sheet

Property	Value
Weight of sheet per m^2	480gsm
Tensile Strength	2400to3600MPa
Modulus of Elasticity	127GPa
Density	1450g/cm^3
Color	Yellow
Dry fabric thickness	0.4mm

1.2 Carban fiber

Each carbon filament thread is a bundle of many thousand carbon filaments. A single such filament is a thin tube with a diameter of 5–8 micrometers and consists almost exclusively of carbon. The earliest generation of carbon fibers (e.g. T300, and AS4) had diameters of 7–8 micrometers. Later fibers (e.g. IM6) have diameters that are approximately 5 micrometers. Carbon fiber is an extremely lightweight reinforcing fiber derived from the element carbon.

Material properties of CFRP

Property	Value
Weight of sheet per m2	400
Tensile strength	5650MPa to531GPa
Modulus of elasticity	240kN/mm2
Density	1.7g/cm3
Ultimate strain %	1.55
Color	Black
Dry fabric thickness	0.117mm

II. EXPERIMENTAL PROGRAM

Total fifteen numbers of reinforced concrete rectangular beams were cast for the experimental study. Three is taken as controlled beam, three beam are strengthened with a single layer aramid fabric at tension side and other three for double layer. In second series three beams are strengthened with carbon fiber single layer and three for double layer. All these fifteen beams are testing under two point loading on a Universal Testing Machine of capacity 100kN.

2.1 Beam Specimen for testing.

The experimental programs consisted of a total twelve rectangular beams designed as under reinforced concrete. All beams were of the same geometry 100 mm x 200 mm x 1800 mm, 3Nos-8 mm diameter bars were used for tension reinforcement at the bottom of each beam, 2Nos-8 mm at the top of each beam as a anchor bar and 6 mm diameter shear reinforcement spaced 150 mm c/c. The reinforcement details of beam used for experiment has illustrated in the Fig. 1.Maximum size of aggregate are 20mm The beams was casted by using M20 grade concrete with OPC 53 grade cement. These beams were cured for 28 days in pure water were tested using two-point loading on a Universal Testing Machine of capacity 100 kN

2.2 Reinforcement detail

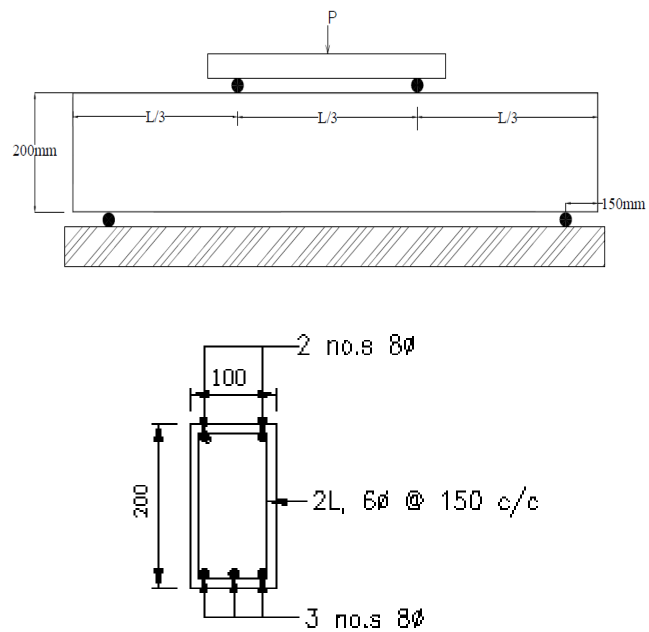

Fig.No1.Reinfocement detail of beam

2.3 Preparation of Test Specimen

The description of test specimens is summarized in Table 2. The tension surfaces of the beams were cleaned using polish paper to ensure a good bond between the AFRP, CFRP strip and concrete surface. Each of these beams was externally bonded with AFRP, CFRP strips and epoxy at the tension face of the beam as per the procedure given by the manufacturer.

Sr. No.	Type of beam	Beam Designation	No. of Specimen
I	Controlled Beam	CB	3
II	AramidSingle Layer fiber	ASL	3
III	AramidDouble Layer fiber	ADL	3
IV	CarbonSingle Layer fiber	CSL	3
V	CarbonDouble Layer fiber	CDL	3

Fig.No.2Applying fiber on beam specimen

2.4 Test set up

All specimens were tested under two point loading. The load was applied through Universal Testing Machine of capacity 100 kN. load will be gradually applied. During loading the mid span deflection was measured using dial gauge having a least count of 0.01 mm. Deflections and the applied load were recorded at every load increment. Cracks formed on the faces of the beams were marked and identified. All beam specimens were loaded and simply supported as shown in fig. 2

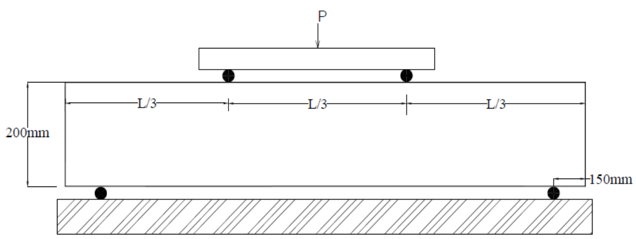

Fig.No.3 Loading condition for testing.

Fig.No.4 Test Setup

2.5 Crack pattern

In this the comparison of crack pattern was done of control beam and wrapped beam. It was seen that flexural and shear crack pattern in both the beams was same. The flexural cracks develop in vertical direction at pure bending and shear cracks are developed in inclined pattern at shear zone nearer to support. The number of cracks and crack width gets reduced after application of AFRP and CFRP sheet. The crack pattern of AFRP beam strengthened with single layer has been shown in fig.5.

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Fig .No.5:Flexural and Shear crack Pattern for control Beam

Fig.No.6: Flexural and Shear crack pattern for AFRP strengthened beam.

Fig.No.7: Flexural and Shear crack Pattern for CFRP strengthened beam

III. RESULTS AND DISCUSSION

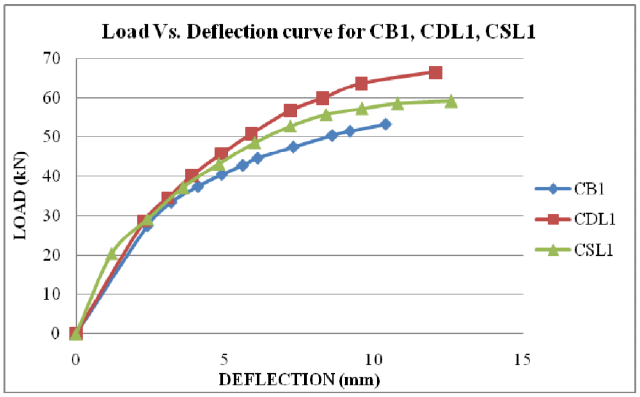


Fig.No.8Load vs. Deflection curve for CB1, CDL1 and CSL1.

Description: Average maximum load carried by CDL beam is 13.35% more as compare to CSL beam and 21.63% more as compare to CB

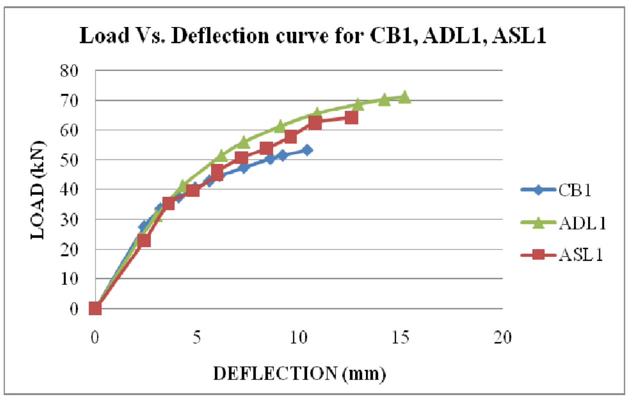


Fig. No.9:Load vs. Deflection curve for CB1, ADL1 and ASL1

Description: Average maximum load carried by ASL beam is 11.15% more as compare to ADL beam and 25.19% more as compare to CB

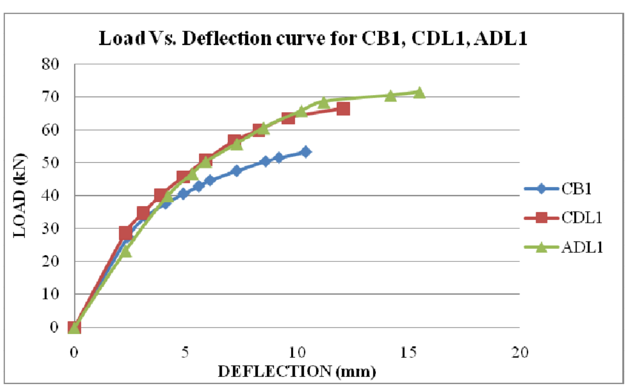


Fig.No.10:Load versus deflection curve for comparison of CB1, CDL1and ADL1.

Description: Average maximum load carried by ADL beam is 4.63% more as compare to CDL beam and 25.19% more as compare to CB

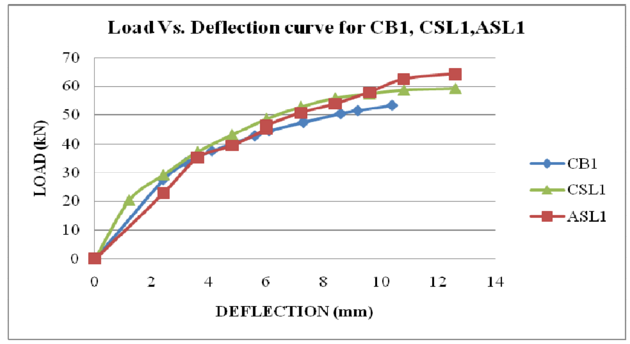
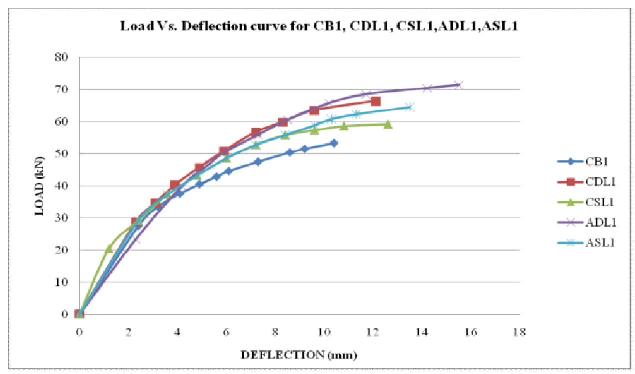


Fig.No.11:Load versus deflection curve for comparison of CB1, CSL1and ASL1.

Description: Average maximum load carried by ASL beam is 8.45% more as compare to CSL beam and 17.11% more as compare to CB



FigNo.12 Load versus deflection curve for comparison of CB1,CS1L, CDL1 ADL1,and ASL1.

Description: From e above graph it is conclude that beam wrapped with aramid fiber double layer carry higher load than other beam. So it is more effective to use aramid double layer fiber in strengthening for structural member of pump station.

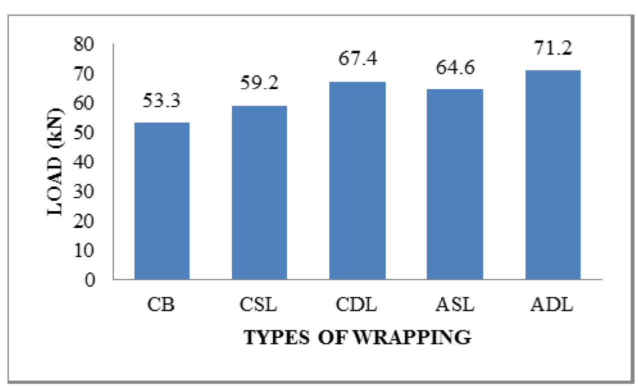


Fig.No.13: Load carried by types of wrapping fiber.

III. CONCLUSIONS

Following conclusions are drawn from the test result and values load and deflection

1. Average load carried by control beam is 53.2 kN.
2. Average maximum load carried by CDL beam is 13.35% more as compare to CSL beam and 21.63% more as compare to CB.
3. Average maximum load carried by ASL beam is 11.15% more as compare to ADL beam and 25.19% more as compare to CB.
4. Average maximum load carried by ADL beam is 4.63% more as compare to CDL beam and 25.19% more as compare to CB
5. Average maximum load carried by ASL beam is 8.45% more as compare to CSL beam and 17.11% more as compare to CB
6. The flexural capacity of all the strengthen beams were enhanced as compared to the control beam.
7. Reinforced concrete beams strengthened with aramid and carbon fiber sheets exhibited significant increase in their cracking and ultimate strength as well as ultimate bends deformations.
8. Initial cracks appear for higher loads in case of strengthened beams.
9. The load carrying capacity of the strengthened beam fully wrapped on tension side with armid and carbon fiber was found to be maximum than the controlled beams.
10. The load carrying capacity of the strengthened beam with wrapped with armid and carbon fiber strip was found to be greater than the controlled beams.
11. The strips are placed on tension side so that strength of normal beam increases.
12. We can use this technique for pump station of 32-village water supply scheme.

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