Experimental Investigation on the Behaviour of Flexural Strengthening of Beam Using Basalt Fiber

R Singaravadivelan, N Sakthieswaren and Dr.K.L Muthuramu

Abstract**—**Worldwide, a great deal of research is currently being conducted concerning the use of fiber reinforced plastic wraps, laminates and sheets in the repair and strengthening of reinforced concrete members. Basalt fiber reinforced polymer (BFRP) application is very effective ways to repair and strengthen structures that have become structurally weak over their life of the span.BFRP Repair systems provide an economically viable alternative to traditional repair systems and materials. Experimental investigations o the cube, cylinder & flexural RC beams strengthened using basalt fiber unidirectional cloth is carried out. Externally reinforced concrete beams with epoxy bonded cloth were tested to failure using a symmetrical one point concentrated static loading system. Seven beams weak in flexure were casted, out of which one is controlled beam and other beams were strengthened using basalt unidirectional cloth in flexure. The strengthening of the beam is done with different amount and configuration of BFRP cloth. Experimental data on load, deflection and failure modes of each of the beams were obtained. The detail procedure and application of BFRP cloth for strengthening of RC beams is also included. The effect of number of BFRP layers and its orientation on ultimate load carrying capacity and failure mode of the beams are investigated.

Keywords-- Concrete, BFRP cloth, epoxy resin,

I. INTRODUCTION

THE maintenance, rehabilitation and upgrading of structural members, is perhaps one of the most crucial problems in civil engineering applications.moreover,a large number of structures constructed in the past using the older design codes in different parts of the world are structurally unsafe according to the new design codes. Since replacement of such deficient elements of structures incurs a huge amount of public money and time, strengthening has become the acceptable way of improving their load carrying capacity and extending their service lives.

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Infrastructure decay caused by premature deterioration of buildings and structures has lead to the investigation of several processes for repairing or strengthening purpose.

One of the challenges in strengthening of concrete structures is selection of a strengthening method that will enhance the strength and serviceability of the structure while addressing limitation such as constructability, building operations and budget. Structural strengthening may be required due to many different situations.

Basalt fibers

Basalt is a natural, hard, dense, dark brown to black volcanic igneous rock originating at a depth of hundreds of kilometers beneath the earth and resulting the surface as molten magma. And its gray, dark in colour, formed from the molten lava after solidification. The production of basalt fiber consists of melt preparation, extrusion, fiber formation, application of lubricates and finally winding. This method is also known as spinning. A fiber is a material made into a long filament with a density generally in the order of 300g/cm2 of 50cm.

The aspect ratio of length and diameter can be ranging from thousand to infinity in continuous fibers. It is donot undergo any toxic reaction with water and donot pollute air also. The main functions of the fibers are to carry the load and provide stiffness, strength, thermal stability and other structural properties in the BFRP.

II.EXPERIMENTAL PROGRAM

The main objectives of the experimental program were (a) to investigate the effectiveness of confinement based on the basalt fibers preimpregnated with epoxy resin and the bonded with concrete (b) to compare the performance (in terms of strength)of different confinement techniques. This investigation was carried out on concrete 15 nos.cubes,(150mm x150mm x150mm)her finding compressive strength,23 nos.cylinder (150mm x300mm) for compression as well as tension test &12 nos prism(700mm x150mm x150mm) moulds are taken for finding flexural strength were cast.

Each specimen shall be taken IS procedure preferred. After casting the test M-20 grade specimen were demoulded after 24 hours and were kept in the curing tank until the time of test.

Fig .1 concrete elements

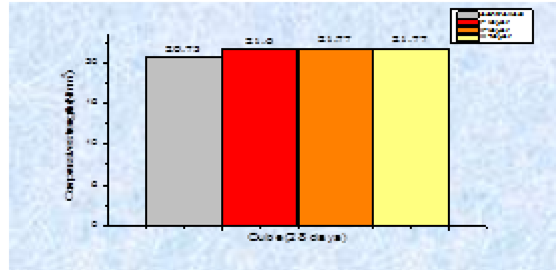
Test on concrete

The compressive strength and flexural strength of concrete was tested at 28 days in accordance with IS:516-1999.The values of compressive strength and flexural of mixes at 28 days as shown in graph. 1, 2, 3 and 4.The split tensile strength of concrete was determined at 28 days in accordance with IS5816:1999.

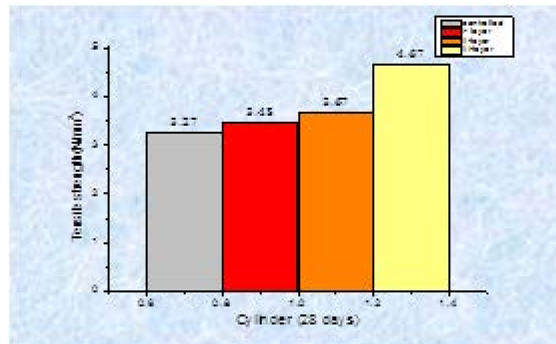
TABLE.1
MIX DESIGN

cement	Fine aggregate	Coarse aggregate	water
394kg	699.48kg	1085.40kg	197.16 liter

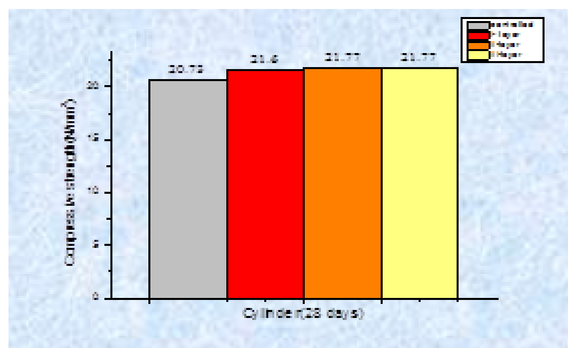
Fig. 2 Testing of concrete elements



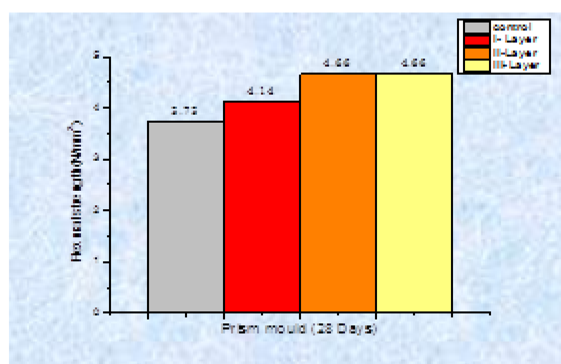
Graph.1 Compressive strength of concrete in cubes.



Graph.2 Split- tension test of concrete in cylinder.



Graph.3 Compressive strength of concrete in cylinder.



Graph.4 Flexure test on concrete in prism.

Strengthening of beam

The aim of the present research is limited to small-scale beams of the particular size of 150mm x 200mm x2100mm length rectangular beam for strengthening purpose. The two point loading pattern is used to achieve the pure bending. The external bonding is made for full length of the beam and it covers three faces of it.(U-wrapping).

Procedure to bond BFRP

The surface was first cleaned to remove any dust particles. Then the surface was applied with the mixed solution of epoxy resin, then the properly cut basalt unidirectional cloth was placed over the surface and another coating of the mix was applied and the specimen was left to dry for 24 hours before testing.

Testing procedure

The beam specimen is setup as shown in the figure.1 loading jack is kept in position and its loading end is connected with the beam using the frame. The instruments are then mounted after dial gauges are noted.

III. Evaluation Of Results

The specimens A0, A1, A2, and A3 were tested. Accordingly, the beam failed by the yielding of steel reinforcement followed by compression failure of concrete at mid-span.

The specimen A0 was control specimen. It was tested accordingly, the deflection at mid span and under the points of application of load were noticed throughout the steel. The ultimate load of control specimen was 1.6T.

Fig.4 Testing of beam without BFRP cloth-A0

Fig.5 Testing of beam with I-layer of BFRP cloth-A1

Specimen A1 was wrapped with one layer of fiber. The beam was failed at a load of 4.9T due to the yielding of steel reinforcement and external reinforcement. it is termed as conventional flexural tensile failure. There was an increment of 60% in the total load carrying capacity of the member compared with control specimen.

Specimen A2 was wrapped, with two layers of fiber. The ultimate load carrying capacity was found to be 4.95T;the is around 62%enlargement in the load carried by the specimen. The mode of failure is longitudinal failure.

The specimen A3 was strengthened with three layers basalt unidirectional cloth. The ultimate load was found 6.1T, which shows an increment of 70% in the load carrying capacity. The failure of the beam was diagonal failure.

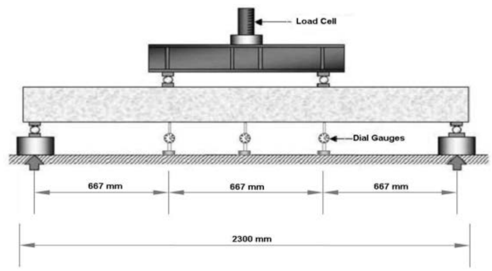


Fig.3 Two Point Loading System

Fig.6 Testing of beam with II-layer of BFRP cloth- A2

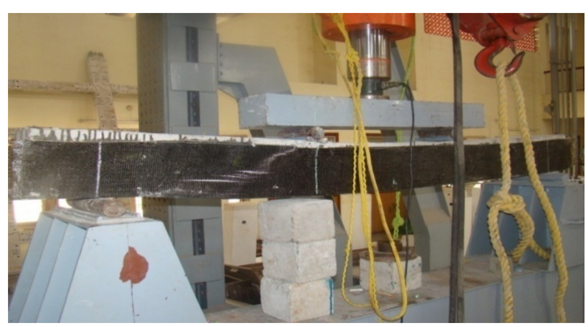
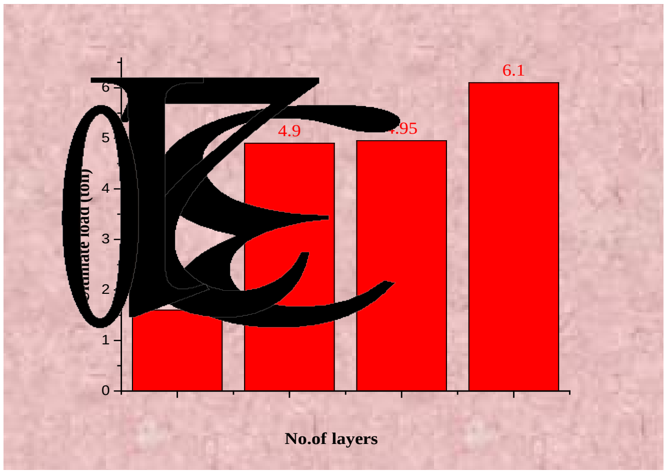
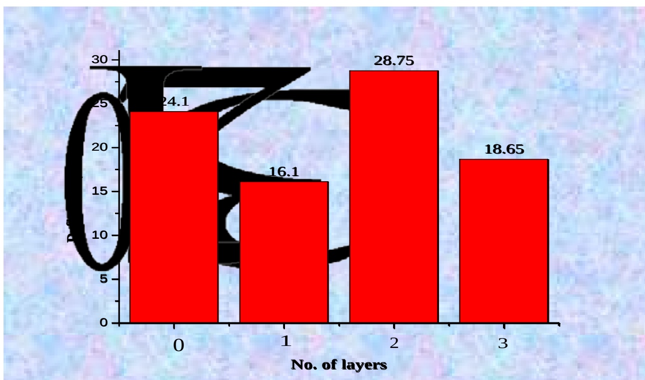


Fig.7 Testing of beam with III-layer of BFRP cloth –A3



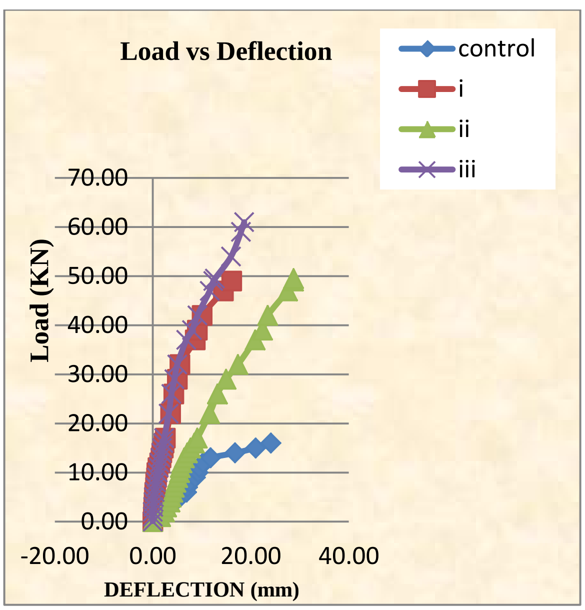
Graph.5 Ultimate load-Number of layers



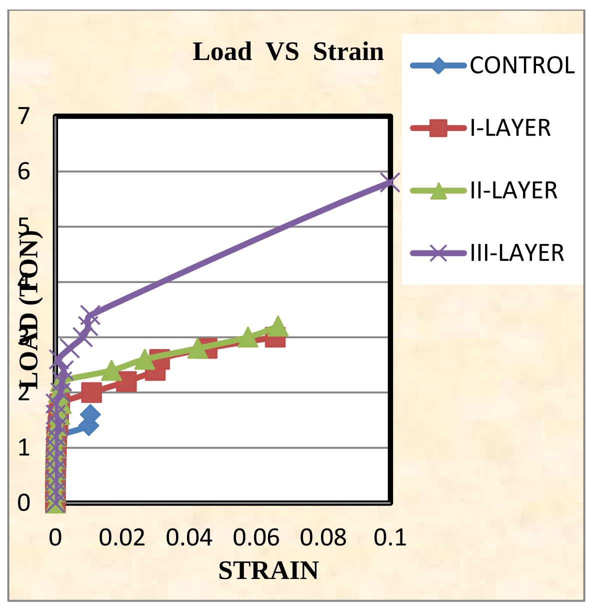
Graph.6 Deflection-Number of layers

TABLE-2
BEAM RESULTS

ANALYSIS			
S.No.	Nos. of layer	Ultimate load(Ton)	Deflection (mm)
1	Controlled bear	1.6	24.1
2	I-Layer	4.9	16.1
3	II-Layer	4.95	28.75
4	III-Layer	6.1	18.65



Graph.7 Load-Deflection



Graph.8 Load -Strain

IV. CONCLUSIONS

-Wrapping the concrete cube and cylinder specimen to 25%increase the strength compared to controlled specimens.

-For cube, cylinder &prism of the mould compared to the controlled RC elements to increase the first and second layer then increase the compression, tension and flexural strength. But in case third layer donot increase the strength after one more layer presented decreased the strength.

-BFRP inducing a less brittle failure mode than that achieved in the controlled RC elements.

-The flexural strength of the element of the strengthened RC beams increases significantly after strengthening with BFRP cloth.

- Increasing the number of BFRP cloth.ie, more than two cloth is found to brittle failure.

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