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(RESEARCH ARTICLE)

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Investigation on use of basalt fiber reinforced polymer for improvement in flexural strength of reinforcement concrete

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Abstract

Basalt fiber is a green, healthy and environmentally friendly high-tech fiber product without environmental pollution. It is widely used in military and civilian fields. It is not only of great theoretical significance but also of great strategic significance to strengthen the damage structures and members. The results show that, compared to glass fiber, carbon fiber and aramid fiber, basalt fiber, has good mechanical properties, acid-alkali resistance, excellent electrical properties, high wave permeability, non-conductive, and excellent sound insulation and insulation performance. This experimental study was conducted to determine the feasibility of using externally bonded BFRP fabrics to strengthen RC beams. Nine full-size specimens were tested. The following conclusions have been drawn from this research that of 4 types of different wrapping to the beam, beam with fully wrapped BFRP gained more flexural strength and load carrying capacity as compared to control beam.

Keywords: BFRP; Flexural strength; Wrapping techniques; RC member.

1. Introduction

A major problem that is currently facing the building and construction industry is the deterioration of concrete structures over time. To maintain efficient serviceability, older structures must be repaired or strengthened so that they meet the same requirements demanded of the structures being built today and in the future. The use of FRP for strengthening beams has attracted considerable attention worldwide due to the excellent durability and high strength-to-weight ratio of this material. Today a significant growth is observed in the manufacture of composite material. With this in mind energy conservation, corrosion risk, the sustainability and environment are important when a product is changed or new product is manufactures.

Basalt fibre is a high performance non-metallic fiber made from basalt rock melted at high temperature. Basalt fibre has good hardness and thermal properties. Basalt fibers have been successfully used for foundation. Ferro-cement possesses good toughness, ductility and durability. Furthermore, Ferro-cement can easily be cast into any shape to fit the contours of the elements to be repaired. Epoxy is used to ensure the full composite behaviour of RC beams and laminate under loading. The main aim of this study was to evaluate the failure mechanisms, deflections and ductility of simply supported BFRP RC beams depending on the reinforcement ratio. The results of experiments were compared with the results of the Finite Element Method analysis.

Concrete is a mixture of Portland cement, water, aggregates, and in some cases, admixtures. The cement and water form a paste that hardens and bonds the aggregates together. Concrete is often looked upon as “man-made rock”. Concrete is the most widely used construction material in the world. Performance of concrete is evaluated from mechanical

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properties which include shrinkage and creep, compressive strength, tensile strength, flexural strength, and modulus of elasticity. Workability of Concrete is a broad and subjective term describing how easily freshly mixed concrete can be mixed, placed, consolidated, and finished with minimal loss of homogeneity.

2. Literature Review

Fiber-reinforced polymer (FRP) composites are extensively used in advanced concrete technology given their superiority over traditional steel reinforcements. This review demonstrates that FRP composites can be used to recover the strength of damaged and corroded beams and exhibit good durability and insulation performance.(Ayesha siddika, md et.al, 2019). When the beam is retrofitted using wire mesh at the bottom the ultimate strength and flexural strength of the beam increased by 14.34 %. Hence it can be concluded that the beam strength can be improved by addition of fibers and for external strengthening wrapping completely with the wire mesh is more effective compared to other.(Poornima Pradeep, Biju Mathew 2019). To determine the feasibility of using externally bonded BFRP fabrics to strengthen RC beams It is greatly improved load carrying capacity at both yield and ultimate load points and found that when a beam is over reinforced with BFRP fabrics, the failure mode can change unexpectedly to brittle shear failure. (Sreekanta das et.al 2020).

According to Yajun Zhao 2019, the cracking, yielding and ultimate strengths of beam are improved by approximately 32%-86%,57%-71% and 49%-89% respectively. The reinforcement ratio has a significant effect on the flexural behavior of BFRP RC beams. An increase in the reinforcement ratio results in an increase in the ultimate loads and in the stiffness of the beams.(Dawid Pawlowski , Maciej Szumigała,2015). Due to the relatively lower elasticity modulus of basalt rods, compared to steel ones, both: the deflection and width of cracks can be a major factor in the designing the BFRP reinforced concrete beams.(Marek Urbanskia et.al 2013) Using BFRP sheets in confining RC short columns increases the load carrying capacity and ductility, particularly in case of lower aspect ratio (t/b =1.0). As the aspect ratio of the cross section increases, the strength gained of confined concrete columns decreases until it becomes insignificant at an aspect ratio of higher than 2.04.(Yehia A.Kotp,2018)

Due to the relatively lower elasticity modulus of basalt rods, compared to steel ones, both: the deflection and width of cracks can be a major factor in the designing the BFRP reinforced concrete beams.(Marek Urbanskia 2013). The inclusion of coir can slightly enhance the load carrying capacity and significantly increase the deformation capacity of the beams. (Xueqian Wu,Mengran Gao). BFRP bars achieved a compressive strength value which is half of its tensile strength value. The ultimate compressive strength of the BFRP bars varies a smaller amount with the increase of diameter. (P.Thiyagarajan et.al 2018). The permeability of the electromagnetic wave is excellent, if a basalt fiber cloth is added to the wall of the building.(Zongwen Li et.a;, 2018).

Basalt fabric was found effective in improving the flexural toughness of RC beams. The strengthened beams showed a remarkable increase in the flexural toughness. Retrofitting of control specimen using basalt textile mesh is effective as the flexural strength of the control specimen is increased.(Marek Aparna V. & Nitin Mohan,2019).

3. Methodology

Following Figure No. 1 shows the methodology adopted for the proposed work.

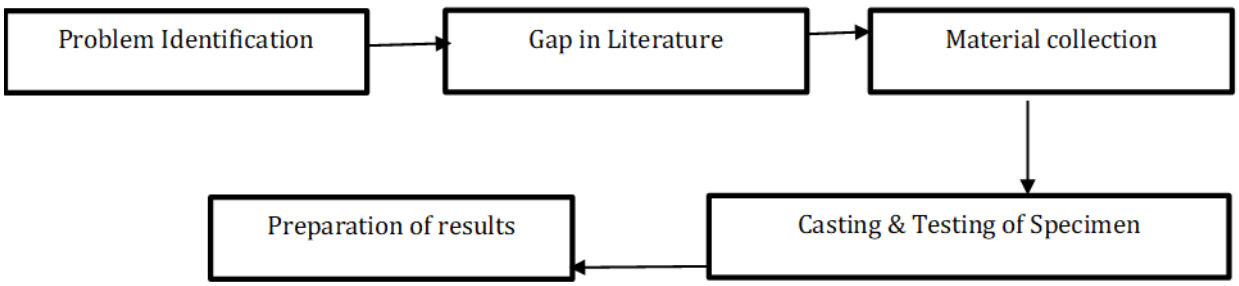

Figure 1 Methodology for the work

- Problem identification: Because repairing such damaged or structurally hazardous facilities would cost the public a lot of money and time, those structures must be strengthened.

- Literature review: Detailed literature review was carried out. Some of those are mentioned in this research paper.
- Material Collection: At post-Mumbai, we ordered basalt fibre, epoxy resin-520, and hardener-D
- Casting of Specimen: 09 concrete beam specimens are casted and wrapped them in various designs.
- Testing of Specimen: To determine flexural strength and load-carrying capacity, we tested a total of 9 beams on the UTM under centre point load.
- Comparing & Analysing Report: Flexural strength and load carrying capacity is compared to Control beam and other wrapping patterns.

3.1. Collection of Materials & Patterns of FRP Applications on Specimens

Following chemicals and M-25 Concrete was used for the proposed work.

Different materials used for wrapping BFRP are as bellow,

From the literature survey it was observed that researchers have adopted various wrapping patterns for their work. Pl refer Table No.1.

Table 1 Include details about the wrapping patterns adopted for the work

Specimen Wrapping Details			
Sample 1 (Control)	Sample 3 (FSW + BW)	Sample 5 (FSIW + BW)	Sample 7 (FSBW)
Sample 2 (FSW+ BW)	Sample 4 (FSIW + BW)	Sample 6 (FSBW)	Sample 8 (FW)

Figure No.2 includes graphical representation of various patterns adopted for wrapping of the specimen.

Figure 2 Shows wrapping patterns adopted for this work

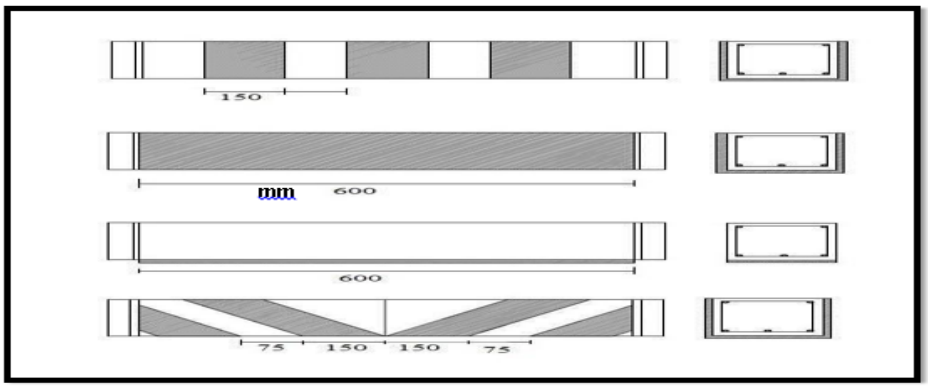

Figure 2 Different patterns adopted for the testing

4. Result and Discussion

Total 9 specimen were casted and then wrapped using the patterns. Those specimen were tested using Universal Testing Machine as shown in figure 3.

Figure 3 Images during Testing are summarized

This experimental study was conducted to determine the feasibility of using externally bonded BFRP fabrics to strengthen RC beams. Nine full-size specimens were tested. Figure 4 & 5 shows the variation in the results observed during the test programme.

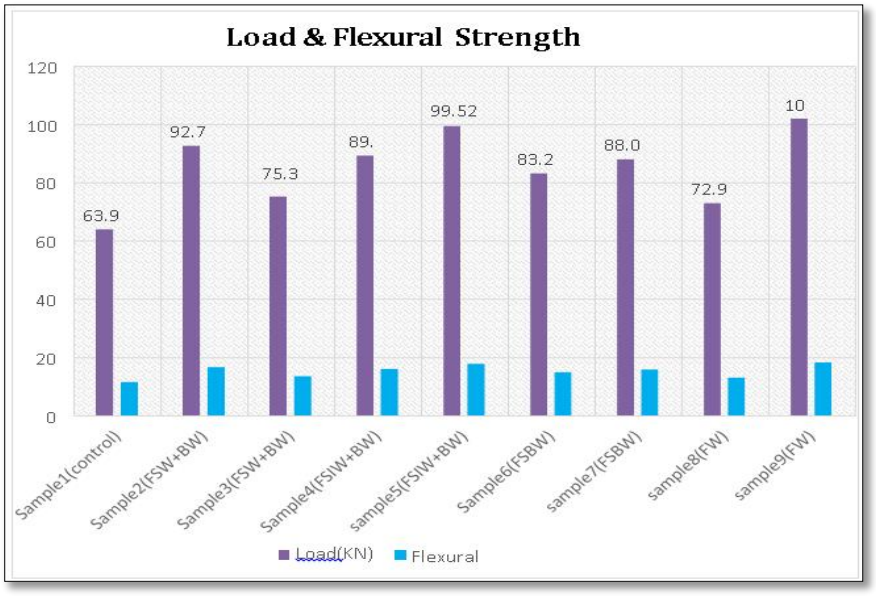

Figure 4 Results relation between load and Flexural Strength

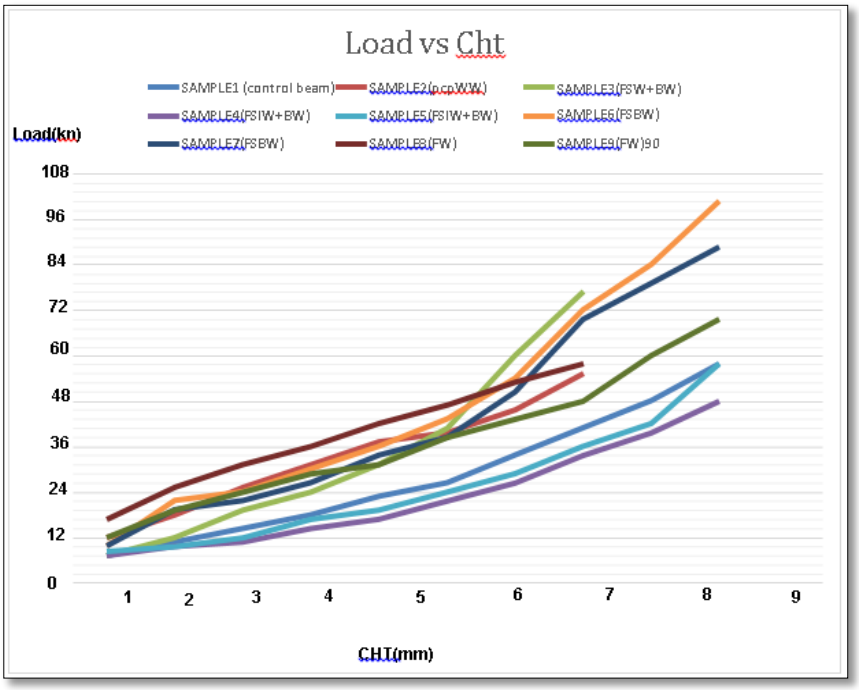

Figure 5 Relation in load & CHT

5. Conclusions

The following conclusions have been drawn from this research, and while the results are similar to previous studies, the conclusions may be limited to this study:

- Addition of basalt fibre into the beam increase the flexural strength from 14.17%to 59.5 % And load carrying capacity increase from 14.12% to 60%.

- When the beam is retrofitted with basalt FRP U- wrapped completely, the flexural strength was found to be more than other beam specimen and it is 59.5% more than control beam
- The beam retrofitted with basalt FRP U-wrapped completely has also higher load carrying capacity more than control beam i.e. 60%.
- The decreasing order of types of specimen U- shaped fully wrapped, inclined strip wrapped, vertical strip wrapped and bottom strip wrapped is :
- FW 90° > (FSIW 45° +BW 0°) > (FSW 90° +BW 0°) > FSBW 0°
- Hence it is concluded that the beam strength can be improved by applying external strengthen U- wrapped completely with basalt FRP is more effective compared to the other modes of wrapping.
- The results obtained for all samples are represented in the following Figure No.3 & 4.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The author has no conflicts of interest in connection with the research topic, results and research tools with other authors.

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