

Behaviour of Basalt Fiber Reinforced Polymer Structural Reinforced Concrete Beam Elements

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ABSTRACT: In recent times, more importance is given to the development of - infrastructures using concrete. The strengthening of structures is required for protection against degradation of structural materials due to some environmental effects. Nowadays, strengthening and rehabilitation of existing structures are - the most important challenges in Civil Engineering. Various rehabilitation technique have been developed to overcome the problems. In starting period, the external strengthening methods such as steel plates bonded to the tension side of the structure were used. But it has several problems including durability, manipulation, and heavy weight. Thus the need for alternative solutions, leads to the introduction of advanced composite materials, particularly fiber reinforced polymer (FRP), in structural engineering. It has - various benefits like good fatigue resistance corrosion free, excellent weight to strengthen the ratio and, flexibility to conform any - shape. Various FRP's are used such as Glass-FRP (GFRP), Carbon FRP (CFRP), and Slurry infiltrated fibrous concrete (SIFCON) laminates. Recently a new - composite material BFRP has been developed because of its superior properties like very high tensile strength, more modulus of elasticity and non-corrosiveness when compared to the previous FRPs.

In this paper, the individual properties of beam such as Flexural Strength were determined as per relevant Indian standards. The mix proportioning of M20 concrete is 1:1.5:3.15 with water cement is taken as 0.45. The flexural strength of concrete beam specimen is determined at 28 days.

KEYWORDS: Fine aggregate, Coarse aggregate, BFRP.

I. INTRODUCTION

Durability of building structures is one of the most important features of present design. Standard steel bars do not have corrosion resistance; hence traditional reinforced concrete (RC) structures are very sensitive to damage in aggressive environment. This problem does not affect fiber-reinforced polymer (FRP) bars, which exhibit such properties as corrosion resistance, electromagnetic neutrality and high durability. As a result it can have many applications – in structures used in marine environments, in chemical plants, when electromagnetic neutrality is needed, or in temporary structures. FRP bars (especially in the case of glass FRP) have low modulus of elasticity as well as high tensile and low shear strength. Moreover, they do not exhibit any yielding before failure and they behave almost linearly up to tensile rupture. Due to their mechanical properties, deflections and cracking in FRP RC beams are larger than these found in traditional RC members. Consequently, the design of FRP RC beams is often governed by the serviceability limit states. Basalt fiber-reinforced polymer (BFRP) bars are the newest type of FRP reinforcement used in civil engineering. The mechanical properties of basalt bars are similar to those of glass, so it can be supposed that BFRP and GFRP RC members can be designed according to the same design rules. Nevertheless, BFRP reinforcement is a relatively new material, so behavior of BFRP RC elements should still be thoroughly examined. 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.

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II. MATERIALS AND METHODS

Cement:

Cement is a binder that sets and hardens and can bind other materials together. Ordinary Portland Cement (OPC) 53 grade is used. All properties of cement were determined by referring IS 12269 - 1987. Standard consistency of cement was 30%.

Fine aggregate:

The specific gravity of fine aggregate was 2.64. The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water. In the present study the sand conforms to zone II as per the Indian standards.

Coarse aggregate:

Angular shape aggregate which passes through 20 mm sieve and retain on 10mm are used as coarse aggregate in this project work. The specific gravity of coarse aggregate was 2.77. Coarse aggregate is the most grounded and scarcest penetrable part of concrete. It is all around that pounded stone aggregate lead to higher qualities than adjusted ones. In the present examination, provincially accessible smashed rock of size 20 and 1.5mm in the degree of 67% and 33% exclusively by volume were used.

BASALT FIBER

Basalt rock is a volcanic rock and can be divided into small particles then formed into continues or chopped fibers. Basalt fiber has a higher working temperature and has a good resistance to chemical attack, impact load, and fire with less poisonous fumes. Some of the potential applications of these basalt composites are plastic polymer reinforcement, soil strengthening, bridges and highways, industrial floors, heat and sound insulation for residential and industrial buildings, bullet proof vests and retrofitting and rehabilitation of structures. Basalt is fine-grained, extrusive, igneous rock composed of plagioclase, feldspar, pyroxene and magnetite, with or without olivine and containing not more than 53 wt. % SiO₂ and less than 5 wt. % total alkalis. Many types of basalt contain phenocrysts of olivine, clinopyroxene (augite) and plagioclase feldspar. Basalt is divided into two main types, alkali basalt and tholeiites.

Mix Ratio For Epoxy And Hardener

Two part epoxy compounds are normally supplied in separate A - B designation; Part A is the epoxy resin and the Part B is the polyamine hardener, with some systems the Part B may be an anhydride. Epoxy resins are normally containers, either both full or in a pre-measured kit. Under the Resin lab clear to slightly amber, high viscosity liquids which may be filled with mineral fillers to improve performance and lower cost. These sometimes can settle to the bottom of the container and must be stirred to a homogeneous consistency before adding the hardener. Epoxy resins can cause mild skin irritation and a form of dermatitis upon repeated contact. It is important to limit skin contact with any epoxy resin or hardener. Therefore, we recommend that you wear rubber gloves when mixing and using the epoxy compounds.

Mix design:

The mix design of M20 grade concrete is calculated using IS 456-2000 and IS 10262-2009. The material required as per design are given in Table: 1

Materials	W/C ratio	Cement	Fine aggregate	Coarse aggregate
Ratio	0.5	1	1.51	3.17

TABLE: 1 Material required as per is method of design

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III. FLEXURAL STRENGTH FOR RCC BEAM

All beams (100mm x 150mm in cross section and 1600mm in length) were tested as simply supported beams under three point loading over an effective span of 1400mm. The load shall be applied at a rate of loading of 400kg/min for the 15 cm specimens and at a rate of 180kg/min for the 10cm specimens. The loads were applied at a distance of 533mm on either side of the mid span of the beams of 1600mm length. The loads were monitored through a high accuracy load cell with a load sensitive of 0.1 tonnes. For this case, mid span deflection was measured using dial gauges of least count 0.01mm. The parameters such as initial cracking load, ultimate load and the deflected shape of the specimens were noted.

Determine the modulus of rupture $(F_b) = 3Pl / 2bd^2$

Where

p = maximum load

L = length of the specimen in mm

b = breath of the specimen

d = depth of the specimen.

IV. EXPERIMENTAL RESULTS

FLEXURAL STRENGTH OF COMPOSITE BEAM:

The following table shows the details of the flexural strength of composite beams of different specimens of different thickness.

TABLE2: FLEXURAL STRENGTH OF BEAM

S.NO	SPECIMENS	LOAD (kN)	FLEXURAL STRENGTH(N/mm ²)
1	CONTROL BEAM	72	67.2
2	BFRP SINGLE LAYER BOTTOM WRAPPED BEAM- LONGITUDINAL DIRECTION	74	69.06
3	BFRP DOBLE LAYER BOTTOM WRAPPED BEAM- LONGITUDINAL DIRECTION	76	70.9
4	BFRP SINGLE LAYER U SHAPED WRAPPED BEAM- LONGITUDINAL DIRECTION	76	70.9
5	BFRP DOUBLE LAYER U SHAPED WRAPPED BEAM-	78	72.8

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	LONGITUDINAL DIRECTION		
6	BFRP SINGLE LAYER BOTTOM WRAPPED BEAM- TRANSVERSE DIRECTION	74	69.06
7	BFRP SINGLE LAYER BOTTOM WRAPPED BEAM- TRANSVERSE DIRECTION	78	72.8
8	BFRP SINGLE LAYER U SHAPED WRAPPED BEAM- TRANSVERSE DIRECTION	78	72.8
9	BFRP DOUBLE LAYER U SHAPED WRAPPED BEAM- TRANSVERSE DIRECTION	80	74.6

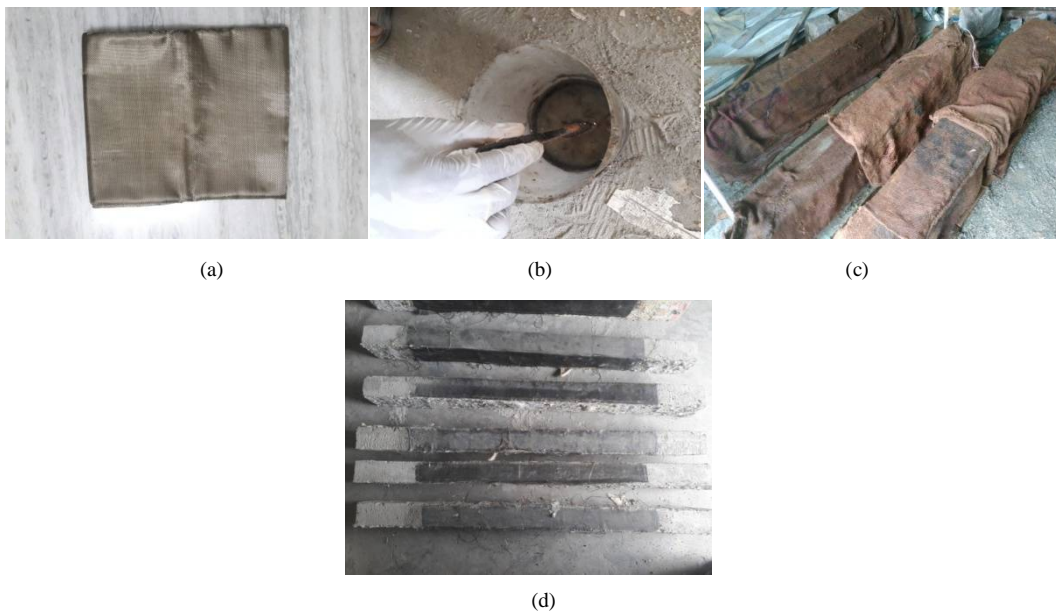


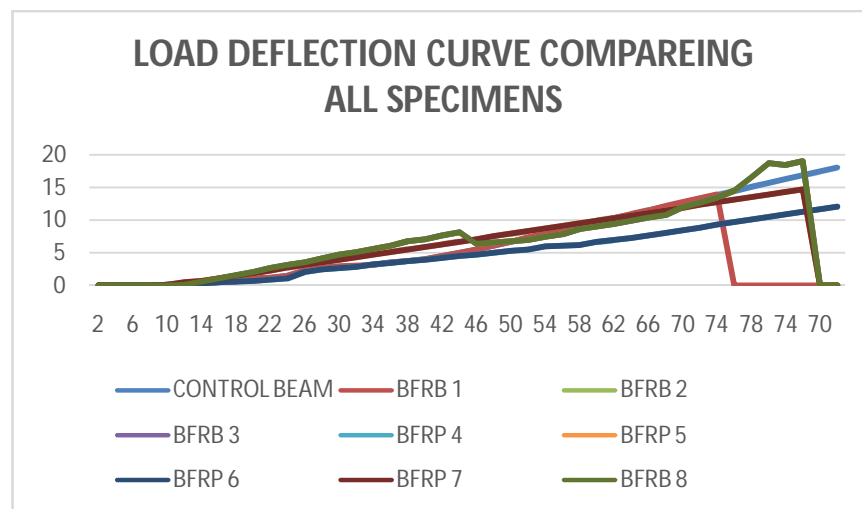
Fig. 2. Preparation of specimen (a) basalt fiber sheet (b) mixing of epoxy resin with hardener (c) curing of the beam (d) Casting specimen



(a)

(b)

(c)



(d)

Fig. 3 Testing of specimen (a)specimen ready for test(b) specimen ready for test (c)initial crack formation (d)load deflection curve comparing all specimens.

VI. CONCLUSION

- BFRP can be applied in strengthened RC beam, whose overall performance lies between those of control beam.
- Cracking of concrete can be effectively inhibited by external bonding of BFRP.
- The upgrading strength and ductility of strengthened beams with BFRP double layer u shaped wrapped beam-transverse direction are more remarkable. Whereas its flexural strength is 74.6 N/mm^2 .
- BFRP single layer bottom wrapped beam-transverse direction and longitudinal direction gives minimum flexural strength when compare with other specimens. Whereas its flexural strength is 69.06 N/mm^2 .
- Since the BFRP owns a higher ratio of performance to cost, eco-friendly quality and unique high temperature resistance, It can be a superior option as a strengthening material
- The graph load vs deflection(d) shows the major difference between all nine specimens.

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