Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 7; April-June, 2015 pp. 626-629

http://www.krishisanskriti.org/jceet.html

Experimental Comparative Study on Basalt and Steel Reinforcement in RC Beam

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Abstract—*Basalt fiber reinforced polymer (BFRP) is a new material, which is used in construction and civil applications as an alternative material to steel rebar. This paper reviews the experimental investigation carried out to evaluate the performance characteristics between two materials steel rebar and basalt rebar in concrete beams. The tested beams were made of M20 Grade concrete and reinforced with basalt rebar and steel rebar. Totally ten beams were casted out of ten beams three beams were conventional beams (steel reinforcement) remaining seven beams basalt fiber reinforced polymer was provided as a reinforcement. Test were made to find the flexural and shear capacity of the beam. Results was compared between steel reinforced beams and basalt fiber reinforced polymer beams. From the test results showed that an improvement flexural strength and stress strain relationship and it confirms that the basalt fiber reinforced polymer is could be used as a good alternative material for reinforcement in beams.*

Keywords: *steel, basalt, reinforcement, corrosion, flexural, compression.*

1. INTRODUCTION

Basalt is a product from the source of volcanic rocks which is formed from molten lava from deep in earth's crust rises up and solidifies. They are environmentally safe and non-toxic. This rebar consists of 80% of fibers and has a tensile strength three times that of compared to steel rebar normally used in building construction. Concrete structures like bridges or underground tanks reinforced with traditional steel bar are subjected to corrosion attack due to environmental conditions. By the use of corrosion resistant non-metallic rebar may be fully reduce this problem. Basalt rebar is an excellent alternative material in those conditions and in marine environments and Chemical plants where corrosion is a continuous concern. Basalt is successfully used in fire protection. It has a good mechanical properties and thermal stability. The aim of this study was to clarify the effect of basalt bars in RC beams is supported by various tests such as workability, compressive strength, flexural strength and fracture energy. The improvement of mechanical characteristics of fiber reinforced polymer concrete beams. Rebar have been produced from steel, glass, and natural materials are used for commercial applications of fiber reinforced polymer bars have been great verity as per needs.

2. CURRENTLY USINGREBAR

2.1 Steel bars

Steel bars has an expansion coefficient nearly equal to that of modern concrete. If this were not so it would cause problems though additional longitudinal and perpendicular stress at temperatures. Although rebar has nibs that bind it mechanically to the concrete it can still be pulled out of the concrete under high stress. This approach increases the friction loading and high compressive strength of concrete.

2.2 Glass fiber reinforced polymer

Fiber reinforced polymer first developed in the mid 1930 it has become a staple in the building industry. Glass fiber reinforced polymer can be used for both interior and exterior fixtures in a verity of shapes, styles and textures, domes, fountains, molding etc. it is light weight when compared to steel. Resists salt water chemicals and remains safe.

2.3 Basalt fiber reinforced polymer

Basalt fiber reinforced polymer bars is a material made from fine basalt particles.it was manufactured by melting the basalt rock. These basalt fiber reinforced polymer do not contain any other additives BFRP have a better tensile strength compared to other fiber reinforced polymer bars.

2.3.1 Advantages of BFRP bars

1. High tensile strength than steel and glass FRP rebar of same diameter.
2. BFRP bars is 89% lighter in weight than other rebar.
3. BFRP bars in naturally resist to corrosion, alkali, rust, acids and it does not need epoxy coat.
4. It does not conduct electricity.
5. It can be cut easily length in the field by using normal cutting tools.

2.3.2 Drawbacks of BFRP bars

1. BFRP bars are designed to use in tension only, as their compressive strength and shear strengths are low.
2. Field bents are not allowed.
3. It is not wieldable.
4. Hence not suitable in earthquake prone areas.

3. MATERIALS PROPERTIES

The material used in this project are discussed below briefly on their characteristic of physical and chemical properties. For the beam specimens, the concrete attaining the design compressive strength of 20 N/mm2 was prepared using the locally available coarse aggregate of maximum size 20mm, having fineness modulus 6.15 and specific gravity 2.62, the fine aggregates passing through 4.75mm IS sieve conforming to zone II, having fineness modulus 2.72 and specific gravity 2.61, satisfying the IS specifications were used. Ordinary Portland cement conforming to IS specifications, having specific gravity of 3.01 was used. High yield strength deformed bars of Fe500 steel was used as the reinforcement in beams. Basalt fibre reinforced polymer properties are mentioned table 1.

Table 1: Properties of Basalt FRP rebar

Rebar diameter (mm)	10
Weight (g)	162
Nominal area (mm)	78.5
Tensile strength (Mpa)	1200
Ultimate force (kn)	94.20
Elastic modulus (Gpa)	52.00
Ultimate strain (%)	2.31

Fig. 1: Basalt FRP rebar

4. EXPERIMENTAL INVESTIGATION

4.1 Testing of basalt fibre reinforced polymer bar

The test was to determine the tensile strength, modulus of elasticity, strains at fracture limit, bond between reinforcing bars and concrete. By using 10mm diameter of BFRP bars these testes were carried out.

4.2 Bond test

This test is to determine the bond quality of reinforcing element. In this test, the concrete is subjected as compression and the reinforcing bar is subjected to tension and both the bar surrounding concrete issubjected to the same stress. The mechanism of these test is chemical adhesion friction and mechanical interlock between bar and concrete. The specimen was made by placing a concrete in cube and basalt rod is placed at the centre point of cube they were between 7 and 14 days old. The specimen was mounted in the testing machine so that the surface of the cube is gripped and reinforcement bar is also gripped in other end by the testing machine. The load was applied to the specimen the loadings and readings wererecorded at a sufficient number of intervals. Test results were given in table 2.

Table 2: Test results for bond test

Rebar	Rupture stress, Mpa	Rupture strain, %	Elastic modulus, Gpa
1	1200	2.31	52.00
2	1183.12	2.62	50.14
3	1183.09	2.58	49.95
4	1073.25	2.96	49.36
5	1053.09	2.84	48.32
6	1033.15	2.98	48.26
Average	1015.76	2.91	49.05

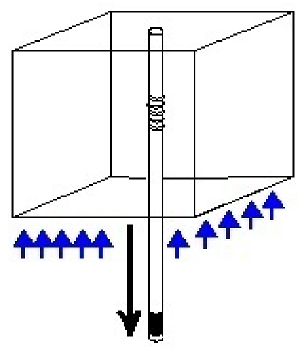
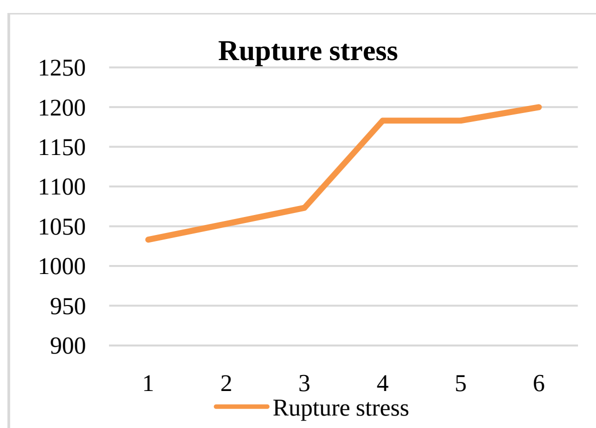
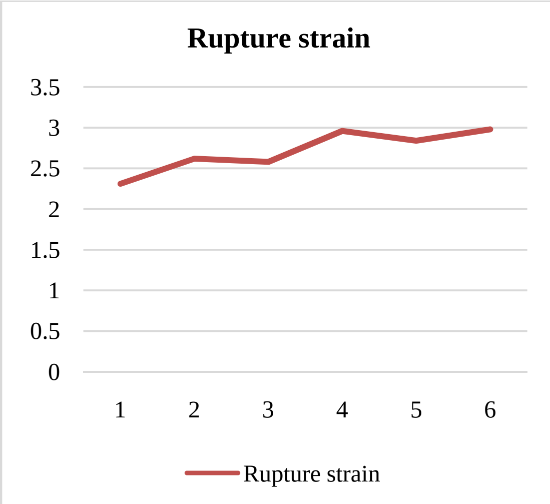


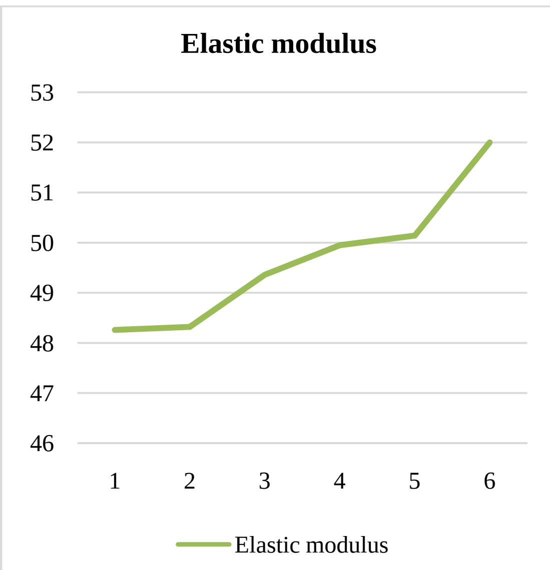
Fig. 2: bond test of specimen



Graph 1: Rupture stress curve



Graph 2: Rupture strain curve



Graph 3: Elastic modulus curve

4.3 Flexural test on beam specimens

Rectangular cross section reinforced concrete beams of eight numbers were casted at size of 100mm width, 150mm depth, 1000mm overall length. M20 grade concrete satisfies mix proportion of 0.5:1:1.57:2.92. 8mm diameter bar of 100 mm Centre to Centre are provided as stirrups for shear reinforcement based on design. Inner surface of steel mould were applied with machine oil. The measuredquantity of cement, fine aggregate and coarse aggregate were mixed thoroughly, the measured quantity of water was added to the dry mix and mixing was done properly. The steel reinforcement was placed inside the mould with proper cover. Concrete was poured layer by layer and compacted and finished well. The beam specimens were removed from the mould after 24 hours ofcasting and concrete beams were placed in curing tank for curing for 28 days. After 28 days age of curing specimens were ready for the test.

All tested beams have following dimensions: *b x h x l* = 100 x 150 x 1000 mm. during the test the beams were simply supported on two supports with span of 900mm. near the supports in all the beams steel stirrups for shear having a diameter of 8mm have been provided.

Fig. 3: Testing of beam specimen

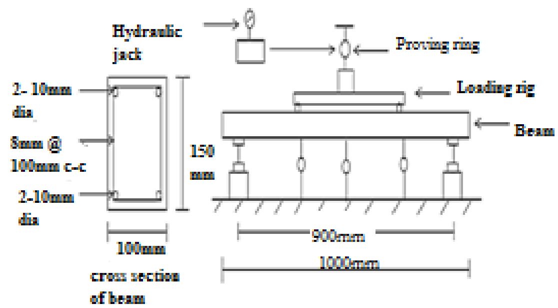


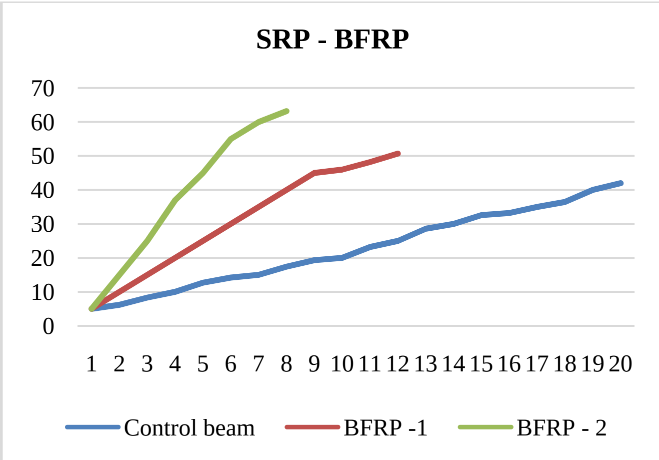
Fig. 4: Experimental set up

Table 3: Details of beams

Beam code	Size	Description of bars
Control beam	150x100x 1000mm	Two Nos of 8mm steel bars is placed in compression and 2 Nos of 10mm steel bars is placed in tension.
BFRP-1	150x100x 1000mm	Two nos of 8mm steel bars are placed in compression and 2 Nos of 10mm basaly bars placed in tension.
BFRP-2	150x100x 1000	Two Nos of 8mm steel bars placed in compression and 3 Nos of 10mm basalt bars placed in tension.

Table 4: Test result of beams

Beam code	Ultimate deflection mm	Ultimate load kN.m	First crack load kN.m
Control beam	20	42	12.5
BFRP-1	12.3	50.73	6
BFRP-2	8.7	63.25	4.3



Graph 4: Ultimate load of beams

5. RESULT AND DISCUSSION

The test results are given in table 2, table 4 and then graphically represented in graph 4. From then result it shows that beam having 3 nos of BFRP bars on tension side are less on deflection and increase in ultimate load and increase in stiffness than compared to control beams. Bond strength is also good. When comparing control beam and BFRP concrete beams BFRP shows 1.5 times increases in ultimate load and 0.35 times increase in first crack load. Almost three times three times of the mechanical readings of BFRP and SRC beams reinforcement indicates, beam load bearing capacity in same proportion. BFRP bars reduces tensile stress which is used to prevent sudden break with long term loaded bars. The over performance of the beam was good. The experimental relationship between the load level and concrete strains for the two SRC beam and BFRP beam shows the similar relationship between load and strains in the basalt reinforcement as well as strains in the steel reinforcement.

6. CONCLUSION

From the experimental study conducted on BFRP rebar provides better results.

1. When the beam is unloaded beam specimen is slightly return back to its original position.
2. Basalt fiber reinforced polymer bar provide good ultimate load and less in deflection i.e. stiffness is increased.
3. The comparison between experimental results and one of the other FRP similar products shoes that the BFRP rods could be a good alternative material to other FRP rods.
4. The bond between basalt rebar and concrete was good.
5. The tested rods with good tensile strength.
6. It can be used in some of civil applications like marine, underground water tank, bridges, and chemical factories. This product acts as a corrosion resistant in those environment.

7. ACKNOWLEDGEMENT

This research was carried out in the faculty of civil engineering at Dhirajlal Gandhi college of technology. The author would like to thank Mr S.C.Mehta project manager – composites distributer of Nickunj Eximp Enterprise P Ltd for supplying the basalt rebar.

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