IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 1, January 2018, ||V-3|| PP 01-05

Flexural Study on Basalt Rebar Reinforced Concrete Beams

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ABSTRACT: *Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. 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. They are made from basalt rock, are very light and have tensile strength, over twice as high as steel. BFRP Repair systems provide an economically viable alternative to traditional repair systems and materials. BFRP bars have high tensile strength and low elastic modulus compared with steel bars. The bond strength between BFRP bars and concrete is similar to the bond strength of steel bars and concrete and shows good bond performance. The superior properties of polymer composite materials like high corrosion resistance, high strength, high stiffness, excellent fatigue performance and good resistance to chemical attack etc., has motivated the researchers and practicing engineers to use the polymer composites in the field of rehabilitation of structures. FRP materials possess great promise for the future construction. An experimental investigation is carried out on a concrete beam for M-30 grade concrete. Material was produced, tested and compared with conventional concrete in terms of workability and strength.*

KEYWORDS: *BFRP, Tensile Strength, Bond Strength, Compressive strength.*

I. INTRODUCTION

Concrete is the world's most used man-made construction material today. It is relatively cheap and easy to form when cast in India. The most common reinforcing material for Reinforced Concrete (RC) used until now and is still used today is steel. Using steel as reinforcement has numerous advantages; it is strong in tension and has a high modulus of elasticity. The thermal expansion is similar to concrete and it works well with concrete under The production process for steel is very stable and thus the material properties are also very stable, then steel is easy to form and work with. But using steel as reinforcement has also some disadvantages; it can corrode with time and has low fire resistance. The price of steel has also been rising over the last few years.

The main challenge for civil & structural engineers is to provide sustainable, environmental friendly and financially feasible structures to the society. Finding new materials that can fulfill these requirements is a must. FRP's have become increasingly more studied and utilized in the reinforcement and prestressing of structural members. However, most of the FRP materials to date have at least some type of major drawback which prevents them from becoming more widely utilized for structural applications.

Basalt fiber has the advantage of high temperature resistance, chemical stability, corrosion resistance, thermal conductivity, and insulation. Continuous basalt fiber has wide application. It not only used to produce reinforced plastics for making fiber reinforced cement and fiber reinforced plastic but also used to resolve many other problems because of its acid resistance, alkali resistance, high strength, high temperature resistance, low temperature resistance, smoothness, softness, scratch-resistance, and insulation. Continuous ballast fiber can be used to prevent the corruption of steel bars and mitigate the health hazards caused by asbestos. In some cases, basalt fiber can take the place of carbon fiber for making reinforced composite material for its good compatibility with metal, plastic, and inorganic non-metallic materials.

The use of fiber reinforced polymer tendons (FRP bars) as a substitute for steel bars in concrete structures is an effective method. This method can be used to resolve the problem of concrete durability caused by the corruption of steel bars and meet the requirement of special structures which need protection from electromagnetic interference. Currently, the performance of FRP bars and concrete Structures reinforced with FRP bars is an important area of research in civil engineering and this new structure is widely being used in coastal engineering and subway engineering. But FRP bars have characteristics of high tensile strength, low elastic modulus, and linear deformation.
This study will therefore focus on flexural behavior on basalt rebar reinforced concrete beams.

1.1 Availability of BFRP Rebar's

Basalt/epoxy rebar is currently being pultruded in the Ukraine, and is in the process of being certified for U.S. construction. A few manufacturers have already started manufacturing Basalt rebars in USA. One of the products, with the name Rock Rebar TM is marketed by Southwestern Composite Structures Inc. Another company, Sudaglass Fiber Technology (Houston, Texas), a basalt fiber producer with facilities in Russia and the Ukraine, has broken ground on a U.S. production facility in northern Texas.

1.2 Basalt Rebar – the alternative to steel and fiberglass

Made from volcanic rock basalt rebar is tough, stronger than steel and has a higher tensile strength. Much lighter than steel, 89% percent in fact. One man can easily lift a 500 foot coil of 10 mm basalt rebar. Basalt rebar is naturally resistant to alkali, rust and acids. Moisture penetration from concrete does not spall. Needs no special coating like fiberglass rods. Basalt rebar has the same thermal coefficient expansion as concrete. Allowing thinner, lighter panels and decks, basalt rebar reduces the thickness and spacing between the rods and the concrete and surface. Much more flexible design! Smaller rods allow for more critical spacing and designs. Basalt rebar is easily cut to length with regular tools. Basalt rebar does not conduct electricity. Basalt rebar is perfect for Marine environments and Chemical plants where corrosion is a continuous concern. Basalt Rebar is available in the following diameters: 4mm. 6mm. 8mm. 10mm. 12mm. and 25mm.

1.3 Advantages of BFRP

- Much higher tensile strength than steel or fiberglass rebar of the same diameter: BFRP is well over twice as strong in tension to prevent concrete cracking.
- BFRP does not rust or absorb water hence the thickness of concrete cover can be reduced. This allows for thinner concrete sections, resulting in savings of materials and cost.
- BFRP is an ideal choice for applications such as marine structures, off-shore structures, parking structures, bridge decks, highway under extreme environments, and structures highly susceptible to corrosion (paper and chemical industries) and for pervious concrete pavements, which are used to reduce water retention or run off.
- BFRP is 89% lighter in weight than steel rebar. Thus, we may not require hoists to handle BFRP supplies in many projects. Moreover, this results in much less fatigue for installation workers (compared to steel), and a reduction in injuries and medical expenses. Yet BFRP is at least 2.2 times stronger than steel in tension.
- BFRP's light weight allows for much faster fabrication, installation, handling, and a better overall job.
- BFRP is naturally resistant to corrosion, rust, alkali, and acids. Basalt Rebar is inert to a pH of 13. Since BFRP cannot rust, spalling of concrete from moisture penetration is totally eliminated.
- Unlike FRP bars, BFRP does not need a special coating to resist the high pH from exposure to concrete.
- Very high strength allows for smaller diameter reinforcement rods. In many cases, the diameter of the rebar may be reduced when using BFRP. Smaller diameter rods allow more rods to be installed in critical structural designs.
- BFRP does not conduct electricity. This prevents electrolysis in marine applications.
- BFRP is non-magnetic and does not induce magnetic fields when exposed to electromagnetic or radiofrequency (RF) energy. Hence, it can be used in applications like magnetic resonance imaging (MRI) rooms and around Radio Frequency Identification (RFID) readers.
- Use of BFRPs, increases the life of reinforced concrete structures, resulting in sustainable structures. With these bars as reinforcements, we can now design RCC for a life span of 100 years or more.

1.4 Scope of Study

- The solution of concrete construction in areas of Poor load bearing soil condition, Remote geographic location, sensitive environment areas can achieved by usage of lightweight reinforcement (BFRP).
- These rebars are highly corrosive resistance and thus the cover thickness can be minimized through which the self weight of structural components can be reduced.
- The basalt bars are of great interest for the building industry and can be used for example in bridge decks and offshore Structure.

II. METHODOLOGY

In order to cast a set of conventional concrete, initially the mix design M30 grade of concrete has to be done. Tests on fresh concrete were carried out. OPC grade 53 cement was used in casting. Workability was checked by carrying out slump test. BFRP bars are high tensile that cannot bar bent up manually, so the four bars are cut into required length and tied up as like conventional stirrups in order to increase the shear capacity of concrete beam. The basic preliminary tests are carried out in order to calculate mix design as per IS 10262:2009. Preliminary tests are carried out for concrete materials such cement, fine aggregate and coarse aggregate. Then the cubes and cylinder are casted. These specimens are tested to determine compressive and split tensile strength of concrete after 28 days of curing.

For the same mix design prismatic beams are casted using conventional steel and BFRP (basalt fibre reinforced polymer) bars. The beams are tested for flexural strength and deflection curve under loading condition. Thus the results are compared with the calculated theoretical values as per Indian Standards.

III. BASALT REBAR

Basalt Rebars are manufactured from continuous Basalt filaments, epoxy and polyester resins using a pultrusion process. It is 80% basalt rock fiber by weight, and balance is epoxy. It is used as a fireproof textile in The aerospace and automotive industries and can also be used as a composite to produce products such as camera tripods.

Basalt is one of the most common rock types in the world. Basalt is a dark-colored (green or black), fine grained, igneous rock composed mainly of plagioclase, pyroxene and olivine minerals and often has a glassy appearance. The name "basalt" is usually given to a wide variety of dark-brown to black volcanic rocks, which form when molten lava from deep in the earth's crust rises up and solidifies. Basalt differs from granite in being a finegrained extrusive rock and having a higher content of Iron and Magnesium

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.

Fig. 1 Basalt Rebar

3.1 PROPERTIES OF BASALT REBAR

Table. 1 Properties of Basalt Rebar

PROPERTY	VALUE
Tensile Strength	6.25 Gpa
Elastic Modulus	110 Gpa
Elongation at Break	4.15%
Density	2.65 g/cm^3
Specific Strength	1.57 – 1.81
Specific Modulus	37.7 – 41.5

3.2 TENSILE PROPERTIES

Table. 2 Tensile properties for BFRP and steel bar

TYPE	DIAMETER OF BAR	TENSILE STRENGTH (N/mm^2)	PEAK LOAD (KN)
BFRP	10mm	625	41.5
STEEL	10mm	515	32.8

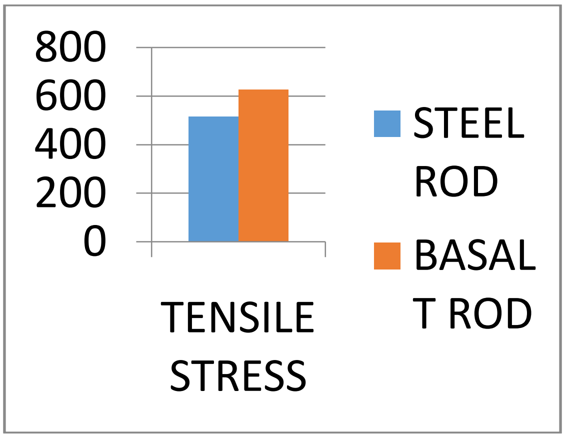

Fig. 2 Steel Rod

Fig. 3 Basalt Rod

IV. CONCLUSION:

In this project we have done the compressive and the split tensile stress in the conventional cubes and the cylinders. The tensile strength for the basalt rebar is 25% more than the steel rod. Further an experimental investigation is carried out on a concrete beam of standard size 1000 ×200 ×250mm for M-30 grade concrete. Material was produced, tested and compared with conventional concrete in terms of workability and strength. These tests were carried out on standard beam for 28 days to determine the flexural strength of the concrete.

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