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A Study of Basalt Fiber Reinforced Polymer (BFRP) Rebar as a Replacement of Steel Rebar in Concrete

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Abstract. Today, the idea of externally strengthening reinforced concrete structural elements in order to restore their strength is widely accepted. Depending on the extent of the damage, the component is externally modified utilising techniques such casting, fiber-reinforced polymer (FRP) composites, external panel bonding, external prestressing, and cross-sectional enlargement. This article explains how he applies his FRP composites in the form of cloth or tape on structural members that have flaws like cracks by employing adhesive. This method can be used to strengthen or raise the load-bearing capacity of an element in addition to retrofitting without enlarging the section. For external reinforcement, fabrics consisting of carbon, glass, and basalt fibres are employed.

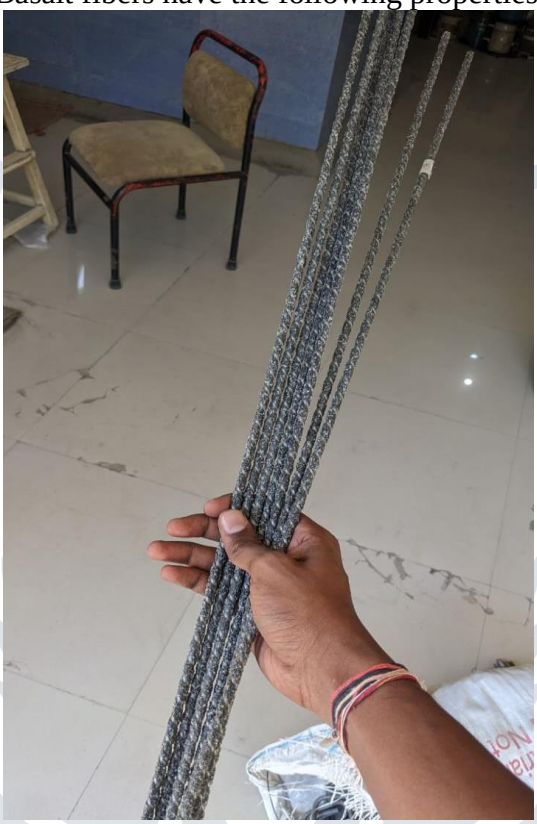
1.INTRODUCTION

Concrete structures in destiny will face structural deterioration. So the answer commonly furnished have been reconstruction or rehabilitation if feasible. Rehabilitation of strengthened concrete systems is often greater affordable and sustainable (much less cement intake, less CO2 production) than reconstruction. the use of composites for strengthening and repairing concrete structures has won full-size significance in civil engineering. textile reinforcement is a new generation of composite material that may even update reinforcement to some extent. The use of textile reinforcement is a commonplace method for retrofitting of concrete structures. The normally used FRP has a few drawbacks in strength concern. fabric strengthened Concrete (TRC) can triumph over these drawbacks. This textile reinforcement comprises Jute, Glass fibres, Basalt fibres, Nylons and so forth are the most typically used cloth meshes.

step by step, during the last 30 years, FRP materials are being utilized in building production. Composite materials primarily based on FRP significantly boom the monetary viability of construction of buildings and bridges . anyplace a decisive position within the production of civil engineering plays a energy, stiffness and resistance to environmental elements, composite materials based totally on FRP become top notch replacement for conventional metal reinforcement. Basalt bars of BFRP institution (basalt fiber reinforced polymer) have a number of blessings comparing to metal reinforcement and different FRP composites, inclusive of glass GFRP (glass fiber bolstered polymer) or carbon CFRP (carbon fiber reinforced polymer).The chemical composition of basalts, which can be

made BFRP basalt fiber is extremely different. similarly to the chemical composition, mechanical homes of basalt fibers originating from unique sources are numerous , probably because of the distinct chemical additives and processing situations along with the temperature of the fiber production. fiber tensile electricity has a tendency to growth from 1.5 to 2.nine GPa because the manufacturing temperature increases inside the range of 1200 ~ 1375°C. this is due to the boom in the proportion of crystal nuclei basalt at decrease temperatures. Basalt fiber younger's modulus ranging between 78 and ninety GPa , depending at the source, the very best M. Tech. (Structural Engineering), PIET, Parul University.

1.1 Basalt Rebar Basalt rebar is made from basalt fiber which is a high performance non-metallic fiber made from basalt rock melted at high temperature. The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber. Basalt fibers have the following properties.A.Properties of basalt



1) Thermal Resistance:-
Basalt fiber has excellent thermal properties of that of a glass fiber. It can easily withstand the temperature of 1200°C to 1300°C for hours continuously, without any physical change. Unstressed basalt fibers and fabrics can maintain their integrity even upto 1250°C, which makes them superior to glass and carbon fiber.

2) Mechanical strength:-
Basalt fiber has a tensile strength of 3000-4840 MPa. It has high stiffness and strength. Basalt fiber has slightly higher specific gravity, 2.6-2.8 g/cc, than other fibers.

3) Chemical Resistance:-
Basalt fibers have very good resistance against an alkaline environment, with the capability to withstand pH upto 13-14. It also has a good acid and salt resistance.

4) Corrosion and fungi Resistance:-
Basalt fiber has better corrosion resistance. It does not undergo any toxic reaction with water and air or gases also. Moisture regain and moisture content of basalt fibers exist in the range of less than 1%. Basalt materials have strong resistance against the action of fungi and microorganisms.

5) Abrasion Property:-

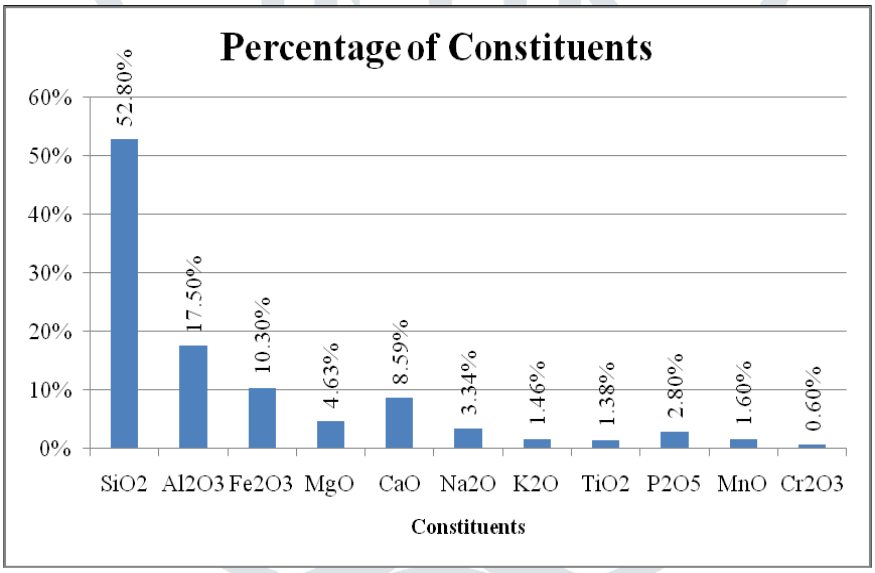
Basalt material is extremely hard and has hardness values between 5 to 9 on Mohr's scale, which results in better abrasion properties. Even continuous abrasion of basalt fiber-woven fabrics over the propeller type abraders does not result in the splitting of fiber by fracture and results only in breaking of individual fibers from woven structure which eliminates the possibility of causing hazards.

6) Ecological Friendliness :-

Basalt fibers have natural raw material, which is basalt rock; it does not cause any damage to health. Basalt fiber has no biological hazards and solves waste disposal problems. It does not clog the incinerator as glass. Hence, it is incinerator friendly.

1.2 Composition of Basalt

Being rich with oxides of Mg, Ca, Na, K, and Fe, Along with traces of alumina and earth crust consists of 33% of Basalt is a copious mineral. And Fig. 4 depicts chemical content of basalt which differs according to topographical distribution. Chemically, these fibres are composed of plagioclase, olivine, and pyroxene and clinopyroxene mineral .Based on the above chemistry; there are different types of basalt like Boninite (rich in magnesium), Alkali basalt (rich in sodium) and Tholeitc basalt.



1.3 Research on load capacity and deformability of basalt reinforcement beams

The research program contained a bending test of three model beams with bottom reinforcement made of BFRP bars (diameter of 6 mm) and, for comparison, a bending test of three simply supported reference beams with a traditional bottom reinforcement made of in the form of a traditional bottom three steel bars with a diameter of 6 mm. All the tested beams have the following dimensions: b x h x L = 700x150x150 mm. During the tests, the beams were simply supported on two supports with a span of 1000 mm. Near the supports in all the beams steel stirrups for shear having a diameter of 6 mm have been provided.

2. Aim & objective

2.1 Aim :-

• Basalt rebars can be good alternate for steel bars as it is better than them in case of sustaining chemical attack, impact loading, fire resistance and strengthening.

• Test in different forms (reinforcement, stirrups) in beams.

2.2 Objective :-

• The main objective of present study is to study the flexural behaviour of concrete beam with basalt rebar in comparison with steel reinforcement.

• To do experimental comparison between beams with different placing of reinforcement

3. LITERATURE REVIEW

Aparna V. and Nithin Mohan studied the experimental behavioural comparison between controlled RC beams and beams wrapped with Basalt fibre fabric. RC beam of dimension 150x200x3200 were casted using M25 grade of cement. Tests necessary (specific gravity, fineness modulus, water absorption, compressive strength etc) for knowing material properties of cement, coarse & fine aggregate and basalt fibres were conducted. For retrofitted beam two wrapping profiles (U shaped and Bottom layer) were considered. Two point loading system was used for testing flexural strength of the beams. Also crack patterns were studied along with maximum load comparison among the controlled, U shaped wrapped and Bottom layer. Finally, the moment deflection curves were plotted for all three type of specimens. Control beam showed 19.8knm ultimate moment. Retrofitted beams were partially loaded with 0.8 times of ultimate moment and result showed ultimate moment to be 27.2knm and 23.1knm for U shaped and Bottom layer wrapping respectively.

Jongsung Sim tested carbon, glass and basalt fibres for their durability, mechanical characteristics and strengthening effects. Basalt fibre used here had density of 2.593 g/cm^3 and a diameter of 10.6μm measured by SEM and after conducting test for tensile properties it was found that basalt fibre had 30 to 60% of the strength of the carbon and S- glass fibre respectively. For durability comparison of all 3 fibres, tests conducted were Alkali-resistance, weathering resistance, autoclave stability and thermal stability. Tensile strength test was conducted after each test as comparison criteria. In alkali resistance test, all 3 fibres were immersed in 1M NaOH solution for 7, 14, 21&28 days. Later volume reduction was determined using SEM images and tensile strength of each was tested. Both basalt and glass fibre showed significant amount of volume and strength reduction compared to carbon but glass fibre showed the most reduction in least time. Fibres were not much affected by weathering test and fibres differed by 1-2 % in test for M. Tech. (Structural Engineering), PIET, Parul University

autoclave stability. Fibres were heated for 2 hours at 100, 200, 400, 600 and 1200 c and later checked for tensile strength under thermal stability test.

Dr.KL.Muthuramu conducted flexure test on RCC beam of M20 grade. Initially all the needed tests were conducted to know the properties of material's used. In all one controlled beam and two retrofitted beam with basalt fibre wrapping were casted and tested for flexural strength. Definitely, in result beam wrapped with basalt fibre showed 42.9% more ultimate strength than of controlled beam. Lastly, they got load deflection curves for the beams showing non-linear behaviour.

5.Results

5.1 Mechanical properties of Basalt rebar compared to steel rebar.

In this project we have casted concrete beams of 150x150x700 mm with steel reinforcement & basalt rebars of 6 mm. As basalt rebar is new material we need to find the mechanical properties of basalt rebar. As after knowing the mechanical properties of basalt we can know more about basalt. So in the below table the the report on mechanical properties of basalt is presented,

Sr No.	Types of steel	Size	Weight	Yield Strength (N/mm2)	Tensile Strength (N/mm2)	Elongation %
1	Basalt	6 mm	0.067 kg/m	541	657	13.93
2.	Mild Steel	6mm	0.226 kg/m	263.4	455	26.8

6.CONCLUSION

The flexural behavior of concrete beams reinforced with Steel rebar and basalt rebar was compared, and several significant findings were identified. Basalt rebar has lower modulus of elasticity than steel rebar, which resulted in increased deflection compared to steel rebar-reinforced concrete beams. However, basalt rebar exhibited a higher ultimate strength, increased ductility, and produced a fragmented failure pattern, compared to the brittle failure pattern observed in steel rebar reinforced concrete beams.

• It has been stated in this study that basalt reinforcement has a linear dependence until the entire the beam section load capacity has been exhausted.

• It was noted that critical load for tested beams reinforced with BFRP bars was much greater than the carrying capacity of beams with conventional steel reinforcement, which arose from the different degrees of mechanical reinforcement in both types of beams.

• The failure of beams with BFRP reinforcement did not occur suddenly and this effect was a result of transformation of the beam into a tie system because of flexural basalt reinforcement remained unbroken.

• Deflections of beams with BFRP reinforcement were significantly higher than the reference beam deflection, due to the much lower modulus of BFRP bars compared to steel bars.

• Deformation of the reinforcement of concrete beams with basalt reinforcement were considerably higher than the beams with steel reinforcement.

• However, in the final phase of the loading the difference decreased to 40% due to the phenomenon of plasticity in the beams of conventional RC beams.

• Average width of cracks on the section constant cross-section in beams with basalt reinforcement was 4 times higher than in the reference beams.

• Since the width of the cracks is primarily a function of the deformation of the reinforcement and the concrete between adjacent cracks, due to the much greater deformations in the reinforcement and the surrounding concrete with reinforcement for basalt beams, relatively to reference beams, the above phenomenon is as expected.

• 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.

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