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Retrofitting and Strengthening of Reinforced Concrete Beam with Polyester Bonded Basalt Fibre Fabric

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***Abstract*: Fibre reinforced polymer (FRP), as externally bonded reinforcement, is a very beneficial technique to repair and strengthen reinforced concrete (RC) members. This technique is used in a number of applications to increase the shear capacity of structural beams. The size of the beam is 1.4m length, 0.170m breadth, 0.250m depth. This feature is achieved by applying Basalt fibre reinforced polymer (BFRP) that is glued to the RC concrete member with an adhesive. The adhesive used for strengthening is polyester. The adhesive was used to strengthen concrete beams in flexure is Cement-based bonding material that would be beneficial to produce strengthening system that is fire resistant, also it significantly lower the cost of retrofitting on existing structures. An experimental investigation was conducted on shear behaviour of RC beams that are strengthened using BFRP external reinforcement with polyester resin as bonding agent. This experimental test program is set up to test the shear capacity of beam specimens. For the analytical verifications, ACI 440 guideline and TR55 guideline was used to verify the influence of externally bonded FRP reinforcement. The experimental investigation was conducted in two phases and consisted of 6 full-scale ordinary RC concrete beams. In phase 1 we had tested 3 sample conventional reinforced concrete beams and average results were taken. In phase 2 we are going to carry a flexural strength on reinforced concrete beams externally reinforced with Basalt fibre fabric.**

***Keywords*: retrofitting, reinforced concrete beam, basalt fibre fabric**

1. Introduction

Concrete as the most commonly used construction material is developing towards high performance, i.e., high strength, high toughness, high durability and good workability shrinkage and permeability resistance of concrete are two important properties relating to durability. An important measure of improving concrete impermeability is to improve the capability of resisting shrinkage and cracking. Concrete can be modified to perform in a more ductility form by the addition of randomly distributed discrete fibers in the concrete matrix.

The repairing, retrofitting and strengthening of reinforced concrete structures, damaged by earthquake, requires largest number of possible repairing techniques. Specialized technique of strengthening, stiffening and repair are needed to deal with damaged produced by unusual events such as fire, earthquake, foundation movement impact and overload.

In this research flexural strength test is carried on 3 sample reinforced concrete beams and average results were taken. Hereafter three reinforced concrete beams externally reinforced with Basalt fibre fabric is going to be examined.

2. Experimental setup

In this stage collection of materials required for the mix design are obtained by sieve analysis and specific gravity. Sieve analysis is carried out from

various fine aggregate(FA) and coarse aggregate(CA) samples and the samples which suits the requirement is selected. specific gravity tests are carried out for fine and coarse aggregate. The various materials use was tested as per Indian specification.

3. Materials and mix proportion

A. Materials

Raw materials required for the concreting operations of present work are cement, fine aggregate and coarse aggregate.

B. Cement

Cement is used as binding material in the concrete where the strength and durability resignificant important. The ordinary portland cement of 53 Grades conforming to IS 12269-1987 is used to manufacture the concrete. Also some test were content such as consistency test, setting time test and Specific Gravity test.

Table 1

S. No.	Properties	Observed Value
1	Standard Consistency Test	31%
2	Fineness Test	2%
3	Specific Gravity	2.92
4	Initial setting time	45 min
5	Final setting time	390 min
6	Compressive strength	54 N/mm^2

C. Fine Aggregate

The fine aggregate was used clean dry river sand conforming to IS 383:1970. The sand was sieved to remove pebbles. The total fines content of the mix is the function of both the binder (and filler) content and the fine aggregate content with the grading of fine aggregate being particularly important. The grading of fine aggregate in the mortar should be important such that both workability and stability are simultaneously maintained. Sand fineness modulus is between 2.4 to 2.6.

Table 2

S. No.	Test for Fine Aggregate	Observed Values
1	Fineness Modulus	2.46
2	Specific Gravity	2.29
3	Bulk Density (Kg/m^3)	1716.52
4	Sieve Analysis	Conforming to zone II

D. Coarse Aggregate

Hard granite broken stones of 20mm size were used as coarse aggregate conforming to IS: 383-1970. However, the influence of the grading of coarse aggregate has also to be considered if the spacing of the obstacles is very close to the maximum size of coarse aggregate. The specific gravity is found to be 2.7. The physical properties of coarse aggregate are shown in table

Table 3

S. No.	Test for Coarse Aggregate	Result
1	Water Absorption	2%
2	Specific Gravity	2.75
3	Fineness Modulus	2.39
4	Bulk density (Kg/m^3)	1659.53

E. Water

According to IS 3025, water to be used for mixing and curing should be free from injuries or deleterious materials; Portable water is generally considered satisfactory. In the present investigation available water within the campus is used for both mixing and curing purpose.

F. Super Plasticizer

Super Plasticizers also known as high range water reducers are chemicals used as admixtures where well dispersed particle suspension are required. Sulphonated Naphthalene is used in this study. Super Plasticizers are selected based in conforming to IS 9013. In general, efficient super plasticizer allow water reduction of at least 25% or more with new generation products, enhance slump retention and also reduce slump loss with time. Compatibility with the content is very necessary

G. Fibre Reinforced Polymer

Fibre reinforced polymer (FRP) is a composite material made of fibres that have high strength and adhesive that binds the fibres together to fabricate the structural material. Commonly used fibre types are aramid, carbon and glass, basalt fibres are relatively new in the civil engineering industry. The adhesive that is commonly used is epoxy. FRP was originally developed for aircraft, ships and high-speed trains, because of the beneficial advantages like low weight and resistance to environmental factors this was considered to be beneficial application for these producers.

1) In the 1980s, the use of FRP to strengthen civil engineering structures started.
2) Even though it has been used for a short time large number of projects have been carried out. It was discovered that the FRP strengthening technique is Suitable for structural repair and retrofitting of existing structures. Several Concrete structures are facing durability problems, such as environmental factors, increased load and corrosion.
3) Therefore, FRP system that is non-metallic material is considered to be a beneficial technique, due to e.g. FRP has more durability. The most practical solutions for repairing and retrofitting structures to resist higher design loads and other durability problems can be accomplished by using FRP. FRP composites is one of the latest development in the civil engineering industry, there are many others traditional techniques available like externally bonded steel plates, steel or concrete jackets and external post Tensioning.
4) Concrete beams are important elements in structural engineering. Like all other concrete elements they are vulnerable for situations where there is an increase in structural capacity. Generally reinforced concrete (RC) beams fail in two ways: flexural failure and diagonal tension (shear) failure. In nature the shear failure is more sudden and brittle.
5) It gives no warning prior to failure except for large cracks and it is more dangerous than flexural failure.

4. Types of fibers used for concrete reinforcement

A. Natural Fiber Reinforced Concrete (Nfrc)

Natural fiber consists of cellulose fibers that are processed from pine trees.this category is also producing good results. The recycled carpet waste has been successfully used for concrete reinforcement by using the waste carpet fibers.

B. Polypropylene Fiber Reinforced (Pfr) Concrete

Polypropylene is a cheap and abundant polymer widely used due to its resistance to forming chemical reactions.

Asbestos Fibers:

These fibers are cheap and provide the cement with mechanical, chemical and thermal resistance, although the asbestos fiber reinforced concrete appears to have low impact strength.

C. Carbon Fibers:

These fibers have been recently used due to their very high modulus of elasticity and flexural strength, characteristics such as strength and stiffness of elasticity and flexural strength, Characteristics such as strength and stiffness are better than those of steel fibers, although they are more susceptible to damage.

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D. Basalt Fibers

Basalt fiber is a material made from extremely fine fibers of basalt, which is composed of minerals plagioclase, pyroxene and olivine. It is similar to fiberglass, having better physico mechanism properties than fiberglass but being significantly cheaper than carbon fiber.

Basalt is a type of igneous rock formed by the rapid cooling of lava at the surface of a planet. It is the most common rock in the Earth's crust. Basalt rock characteristics vary from the source of lava, cooling rate, and historical exposure to the elements. High quality fibers are made from basalt deposits with uniform chemical makeup.

Basalt fiber is a high performance non-metallic fiber made from basalt rock melted at high temperature. Basalt rock can also make basalt rock, chopped basalt fiber, basalt fabrics and continuous filament wire.

Basalt fiber originates from volcanic magma and volcanoes, a very hot fluid or semi fluid material under the earth's crust, solidified in the open air. Basalt is a common term used for a variety of volcanic rock, which are gray dark in colour. The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber. The basalt fibers do not contain any other additives in a single producing process, which gives additional advantage in cost. Basalt rock fibers have no toxic reaction with air or water, are non-combustible and explosion proof. When in contact with other chemicals they produce no chemical reaction that may damage health or the environment.

Basalt fiber has good hardness and thermal properties. Basalt fibers have been successfully used for foundation such as slabs on ground concrete.

5. Why we choose basalt fiber?

A. Basalt Fiber Properties

Basalt fiber is a relative newcomer to fiber reinforced polymers(FRPS) and structural composites. It has a similar chemical composition as glass fiber but has better strength characteristics and unlike most glass fibers is highly resistant to alkaline, acidic and salt attack making it a good candidate for concrete, bridge and shoreline structures

B. Compared to carbon and aramid fiber

It has the features of wider application temperature range -452, Higher oxidation resistant, Higher radiation resistant, higher compression strength, and higher shear strength. o Producing fibers from basalt was researched during the cold war by the old soviet union and limited commercial research and production was done in the U.S. during the same period. The soviets researched basalt as a source of fiber for ballistic resistant textiles. o The price of fibers made from basalt is higher than those made of E-Glass, but less than Glass, aramid or carbon fiber production should reduce further.

C. Sources of Basalt Fiber

Basalt is a type of igneous rock formed by a rapid cooling of lava at the surface of planet. It is the most common rock in the earth's crust.

Basalt rock characteristics vary from the source of lava, cooling rate, and historical exposure to the elements. High quality fibers are made from basalt deposits with uniform chemical makeup.

Though the temperature required to produce fibers from basalt is higher than glass, it is reported by some researches that production of fibers made from basalt requires less energy by due to the uniformity of its heating. Though the temperature required to produce fibers from basalt is higher than glass, it is reported by some researchers that production of fibers made from basalt requires less energy by due to the uniformity of its heating.

Table 4
Mechanical properties

Fiber	Tensile strength (MPa)	Modulus of elasticity (GPa)	Ultimate tensile strain (%)	Unit weight (g/cm^3)
Basalt	2500	84	3.115	2.6

Basalt as a fiber used in FRPs and structural composites has high potential and is getting a lot of attention due to its high temperature and abrasion resistance. Compared to FRPs made from glass, aramid and carbon fiber, its use in the civil infrastructure market is very low.

The most widely used FRP strengthening technique is the manual application of wet layup. The main and the important feature of this technique is that the fibers of externally bonded FRP composites are in parallel as practicable with the direction of principal tensile stresses.

D. Specification of beam

- The size of the beam is 1.4m length, 0.170m breadth, 0.250m.
- The diameter of main rod in the reinforcement is 20mm and 16mm.
- The thickness of cover is 25mm.

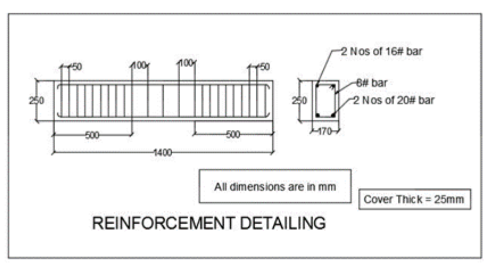

Fig. 1. Reinforcement detailing

E. Mix proportion

Mix design is a process of selecting suitable ingredients and determining their relative proportion with the objective of producing concrete of having certain minimum workability, strength durability as economically as possible. In this method water content and proportion of fine aggregate corresponding to the maximum size of aggregate are first determined from the reference values of workability, water-cement ratio, and the grading of fine aggregate is given in table 5.

Table 5

Mix	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Water (Lit)
M30	375	720	1250	158

6. Result

The flexural strength of sample conventional reinforced concrete beams after 28 days of curing is given below.

Table 6

Beam no.	Load (kN)	Bending Moment (kN-m)	Flexural strength (MPa)
1	2.19	2.15	3.83
2	2.28	2.17	3.79
3	2.25	2.14	3.89

7. Conclusion

- The flexural strength of reinforced concrete beams are carried and average results are taken.
- The reinforced concrete beams externally reinforced with basalt fibre fabric is to be examined in the upcoming days.

References

[1] Bhuvaneshwari “Strength and stiffness of damaged reinforced concrete beams,” 2015.
[2] Mohammed Mohammed Rasheed, “Retrofit of reinforced concrete deep beams with different shear by reinforcement by using CFRP,” 2016.
[3] R. Kotynia, “Debonding failures of RC beams strengthened with externally bonded strips,” 2005.
[4] Solrun Lovisa Sveinsdottir, “Experimental research on strengthening of concrete beams by the use of epoxy adhesive and cement based bonding material,” June 2012.