

A Survey on Strength Aspects of Basalt Fiber Reinforced Concrete

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ABSTRACT: As we know that from the past few decades, the concrete construction field has seen a growing interest in the advantages by using fiber reinforced concrete structures. Between the different types of fibers available, basalt fiber is considered a promising new material to use. It has extremely good strength characteristics and thermal resistance, high resistance to an alkaline environment, and is cheap product, making it an excellent material to reinforce concrete. In view of the significance of basalt fibers for concrete, and because different lengths and proportions of basalt fibers have an effect on the mechanical properties of concrete, it is proposed to review the effect of using different hybrid fibers with basalt fibers lengths and content on the mechanical properties of concrete. Basalt is well known as rock found in virtually every country around the world. Its main use is as a rock used in construction of industrial, highway engineering and infrastructural engineering projects. However it is not commonly known that basalt can be used in manufacturing and made into fine, superfine and ultra-fine fibers. Comprised of single-ingredient raw material melt, basalt fibers are superior to other fibers in terms of thermal stability, heat and sound insulation properties, vibration resistance.

KEYWORDS: Basalt fiber, Compressive strength, Flexural strength, Split tensile strength, Fiber reinforced concrete

I. INTRODUCTION

In this modern age, civil engineering constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. It has been found that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. It is now established that one of the important properties of Fiber Reinforced Concrete (FRC) is its superior resistance to cracking and crack propagation. Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, basalt fiber, synthetic fibers and natural fibers – each of which lends varying properties to the concrete. In addition, the character of fiber reinforced concrete changes with mixing fiber materials, geometries, distribution, orientation, and densities.

The weak matrix in concrete, when reinforced with fibers, uniformly distributed across its entire mass, gets strengthened enormously, thereby rendering the matrix to behave as a composite material with properties significantly different from conventional concrete. Because of the vast improvements achieved by the addition of fibers to concrete, there are several applications where fibers Reinforced Concrete (FRC) can be intelligently and beneficially used. These fibers have already been used in many large projects involving the construction of industrial floors, pavements, highway overlays, etc. in India. These fibers are also used in the production of continuous fibers and are used as a replacement to reinforcing steel. High percentages of steel fibers are used extensively in pavements and in tunneling. Use of basalt fibers are picking up in western countries.

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Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion, and shatter-resistance in concrete.

II. EXISTING METHODOLOGIES

2.1 Steel Fibers

The majority of the applications with steel fibers in the United States, has been with mixes using normal weight concrete. For safelight steel fibers, the primary factors that controlled the properties of the composite were fiber volume fraction and aspect ratio of the fibers. The amount of fiber used ranging from 89 to 119 kg/m³ of concrete. The major problems encountered in the early stages were difficulty in mixing and workability. At higher volume fractions, fibers were found to ball up during the mixing process. This process called balling was found to occur frequently for longer fibers. The size of the coarse aggregate was normally restricted to facilitate the use of short fibers and to avoid balling. Additionally, the mortar fraction of concrete was increased to combat the balling problem. There was always a reduction in workability with the addition of fibers. This tends to affect the quality of concrete in place, especially for higher fiber volume fractions [8] [9].

2.2 Carbon Fibers

From mid-1980's the high cost of carbon fibers limited their use in Portland cement composites. More recently, low cost carbon fibers have been manufactured with petroleum and coal pitch. Carbon fibers are very light with a specific gravity of about 1.9 and inert to most of the chemicals. Even though their cost is higher than polymeric fibers, carbon fibers have potential for special applications that require high tensile and flexural strength. Carbon fibers are available in stands (tows) that can contain up to 12,000 individual filaments and have elastic modulus as high as steel and are two to three times stronger than steel [2].

2.3 Glass Fibers

Experiments using glass fibers have been conducted in the United States since the early 1950's as well as in the United Kingdom and in Russia [7]. Applications of fiber reinforced concrete investigated since the mid 1960's have included road and floor slabs, topping layers, refractory materials, and some precast concrete products. Glass fibers are primarily used for glass fiber reinforced cement (GFRC) sheets [11].

2.4 Synthetic Fibers

Synthetic fibers are most commonly added to concrete for slab-on-grade construction to reduce early plastic shrinkage cracking and increase impact and abrasion resistance and toughness. The fibers also can be added to precast concrete to improve resistance to handling stresses, to pumped concrete to improve cohesiveness, and to concrete, to reduce rebound and material waste. Synthetic fibers are mainly polypropylene fibers and their use started since the early 1960's. The common forms of these fibers are smooth mono-filament, twisted, fibrillated and tri-dimensional mat. Polypropylene fibers are hydrophobic, so they don't absorb water and have no effect on the mixing water requirements. It has a low density and is also chemically inert. The major shortcomings of polymeric fibers are low modulus of elasticity, poor bond with cement matrix, combustibility, and low melting point. Their bond to cement matrix is improved by twisting several fibers together or by treating the fiber surface. The latest development in the field of synthetic fibers is polyolefin fibers, with low aspect ratio similar to steel fibers for use in concrete. These fibers are available in various lengths and diameters and their addition will improve the structural properties of concrete like the steel fibers. They can be mixed with concrete in large quantities, as much as 20 % by volume without causing any balling, segregation or increase in entrainment in concrete. It is possible to produce high volume fiber reinforced concrete using the regular concrete mixture proportions including coarse aggregates whereas high volume fiber concrete using steel fibers are produced using cement slurry instead of regular concrete. There are a number of advantages for polyolefin fibers, such as no corrosion potential, chemical interbreeds, and no hazardous or nuisance conditions when fibers become loose or protrude from the concrete surface. Unlike steel fibers, these fibers are non-magnetic and non-corrosive.

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2.5 Basalt Fibers

Basalt fibers are manufactured in a single-stage process by melting pure raw material. They are environmentally safe and non-toxic, possess high heat stability and insulating characteristics and have an elastic structure. When used for composite materials, they provide unique mechanical properties. They can be easily processed into fabric with high reliability. The tensile strength of continuous basalt fibers is about twice that of E-glass fibers and the modulus of elasticity is about 15-30% higher. Basalt fibers in an amorphous state exhibit higher chemical stability than glass fibers. When exposed to water at 70° C (1580 F), basalt fibers maintain their strength for 1200 hours, whereas the glass fibers do so only for 200 hours.

According to Kabayet. Al.[1], the effect of basalt fiber (BF) on physical and mechanical properties of concretes is reported. High strength and normal strength concretes were cast by adjusting W/C ratios as 0.45 and 0.60 and a total of ten mixtures were prepared by incorporating different amounts and sizes of BF into those concretes. Test results showed that an improved flexural strength, fracture energy and abrasion resistance can be obtained by using BF even at low contents. However inclusion of BF in concrete resulted in a decrease in the compressive strength. A quite strong relationship was established between abrasive wear and void content and flexural strength of concretes. Therefore this should be considered and precautions should be taken in order to compensate this possible decrease when compressive strength is of importance. The effect of BF on durability of concrete was out of scope of this study; therefore further studies should be performed to determine its effect on this aspect.

Existing studies of hybrid fibers with basalt fiber used in concrete with different parameters like addition of 0, 1, 2, 3, 4 kg/m³ of basalt fibers also replacing steel with BFRP using different water cement ratios in concrete resulted in positive as well as negative improvements in some mechanical properties of concrete. The various tests on FRC like flexural strength, tensile strength, compressive strength, modulus of elasticity, toughness, bond strength, impact strength, fracture energy, environmental assessment, temperature and weathering effect on concrete was conducted by researchers.

From above review papers, it is observed that there is a need to improve the properties of concrete by using BF and basalt rebar's as a structural point of view. We are using chopped basalt fibers in concrete to calculate optimum % of basalt fiber mixed in concrete and by using same dosage with basalt rebar's in BFRC to study performance of concrete. Most of the researchers could not exhibit the improvement in properties like durability and no significant improvements in compressive strength, workability results, early age cracking etcetera. Even though these properties are plays an important role in desired quality concrete for building structures.

1. Objective of Survey

1. To find optimum dosage of BF in concrete to improve compressive strength.
2. To observe the workability by using BF in concrete.
3. To obtain improvement in flexural strength of BF mixed concrete.
4. To obtain improvement in split tensile strength.

2. Parameters

1. Use of BF in concrete by 0, 0.5, 1, 1.5, 2 and 2.5% for improvements in mechanical properties for M30 grade.
2. To conduct flexural strength on specimens by using basalt rebar's.
3. Use of BF in concrete with different W/C ratios 0.45 and 0.55
4. To compare the results of fiber mixed concrete with Normal concrete.

5. Scope of work:

The scope of this research includes the following.

1. Undertaking detailed literature review.
2. Mix design for the plain concrete.
3. Mix design for the BF concrete specimens.
4. Preparation of specimens for testing.

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5. Curing of test specimens for seven days and twenty eight days.
6. Testing the specimens with required instrumentation and data acquisition (manually) system in AISSMS'sCOE Pune Laboratory.
7. Analyzing the test results.
8. Comparing the results with normal concrete.
9. Writing thesis.

6. Proposed Work: Dosages of basalt fiber addition in the specimens.

The dosage of basalt fiber to be added while preparing the specimens in % by volume will be prepared in each casting i.e. for 0.122 m³. The starting % of basalt fiber to be mix will be 0% then 0.5, 1, 1.5, 2 and 2.5% by volume. We scheduled to carry casting of specimens in addition of dosage of basalt fiber and basalt rebar's specified in following tables.

Table 1: Dosage of Basalt Fiber for Each Casting

Casting no.	% of Basalt Fiber to be added
1	0.0
2	0.5
3	1
4	1.5
5	2
6	2.5

Table 2 : Details of concrete cube specimens:

Specimens details (150 mm ³)	7th Day	28th Day	Total
Normal Concrete(NC)	3	3	6
C.C+ 0.5% basalt Fiber	3	3	6
C.C+ 1% basalt Fiber	3	3	6
C.C+ 1.5% basalt Fiber	3	3	6
C.C+ 2% basalt Fiber	3	3	6
C.C+ 2.5% basalt Fiber	3	3	6
Total	18	18	36

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Vol. 6, Issue 8, August 2017

Table 3 : Details of split tensile strengthspecimens

Specimens details (300*150 mm i. e. HxD)	7th Day	28th Day	Total
Normal Concrete(NC)	3	3	6
Optimum % basalt fiber + W/C ratio .45	3	3	6
Optimum % basalt fiber + W/C ratio .55	3	3	6
Total	9	9	18

Table 4 : Details of flexural strength of basalt rebar’s specimens

Specimens details (700*150*150 mm ³)	7th Day	28th Day	Total
Normal Concrete (RCC)	3	3	6
Optimum % basalt fiber + basalt rebar’s W/C ratio .45	3	3	6
Optimum % basalt fiber + basalt rebar’s W/C ratio .55	3	3	6
Total	9	9	18

III. CONCLUSIONS

Satisfactory workability can be expected, with the addition of basalt fibers, up to (0 - 2.5%) by volume, different quantities of fibers compared to existing fibers. Different W/C ratios can be added without causing any segregation. The performance of basalt fiber reinforced concrete is superior that different fiber reinforced concrete currently being used in the market. The results shall be compared with the control specimens; there will be considerable increase in the mechanical properties and performance of concrete is expected. The most important contribution due to the addition of basalt fibers is the change of mode of failure from a brittle to ductile, when subjected to compression, bending, tension and impact with improvements in properties of concrete specified in the catalog provided by the supplier.

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