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# Strength and Analysis of Basalt Fibre in Concrete

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**Abstract :** This experiment study aimed to investigate the compressive, flexural, and split tensile strength of basalt fibre reinforced concrete. Concrete had a good future and is unlikely to get replaced by any other material on account of its ease to produce, infinite variability , uniformity ,durability and economy with using of basalt fiber in high strength of concrete. Basalt fiber offers more characteristics such as light weight, good fire resistance and strength. The main aim of this investigation is to study the effect of different proportion of basalt fiber in the mix. In this study trial test for concrete with basalt fiber and without basalt fiber are conducted to show the difference in compressive strength and flexural strength by using cubes, cylinders and concrete beams of grade M25.This paper provides data of fiber reinforced concrete containing fibers of 12mm length of various percentage by weight of cement.
**Keywords :** Basalt fiber, compressive strength, Flexural strength, Split tensile strength, Fiber reinforced concrete

## 1.1 Introduction

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement that hardens over time. Most concretes used are lime -based concretes such as Portland cement concrete or concretes made with other hydraulic cement. However, asphalt concrete, which is frequently used for road surface, is also a type of concrete, where the cement material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer.

Concrete is a compound material made from sand, gravel and cement. The cement is a mixture of various minerals which when mixed with water, hydrate and rapidly become hard binding the sand and gravel into a solid mass. The oldest known surviving concrete is to be found in the former Yugoslavia and was thought to have been laid in 5,600 BC using red lime as the cement.

The first major concrete users were the Egyptians in around 2,500 BC and the Romans from 300 BC The Romans found that by mixing a sand-like material which they obtained from Pozzuoli with their normal lime-based concretes they obtained a far stronger material. The sand turned out to be fine volcanic ash and they had inadvertently produced the first 'pozzolanic' cement. Pozzolana is any siliceous and aluminous material which possesses little or no cementitious value in itself but will, if finely divided and mixed with water, chemically react with calcium hydroxide to form compounds with cementitious properties.

The Romans made many developments in concrete technology including the use of lightweight aggregates as in the roof of the Pantheon, and embedded reinforcement in the form of bronze bars, although the difference in thermal expansion between the two materials produced problems of spalling. It is from the Roman words 'caementum' meaning a rough stone or chipping and 'concretus' meaning grown together or compounded, that we have obtained the names for these two now common materials. However, Romans are known to have made wide usage of concrete for building roads. It is interesting to learn that they built some 5,300 miles of roads using concrete. Concrete is a very strong building material. Historical evidence also points that Romans used Pozzalana, animal fat, milk and blood as admixtures for building concrete.

The first recorded fact points to the year 1756 when John Smeaton, an engineer made the present day concrete by mixing coarse aggregate (pebbles) and powered brick and mixed it with cement. In 1793, he built the Eddystone Lighthouse in Cornwall, England with the use of hydraulic cement. Another major development took place in the year 1824. An English inventor Joseph Aspdin invented Portland cement. He made concrete by burning grounded chalk and finely crushed clay in a limekiln till the carbon dioxide evaporated, resulting in strong cement.

It was in Germany that the first systematic testing of concrete took place in 1836. The test measured the tensile and compressive strength of concrete. Another main ingredient of concrete is aggregate and includes sand, crushed stone, clay, gravel, slag and shale. Concrete that uses imbedded metal is called reinforced concrete or Ferro concrete. It was Joseph Monier who first invented reinforced concrete in 1849. He was a Gardner who made flowerpots and tubs of reinforced concrete with the use of iron mesh. The reinforced concrete thus combined the tensile power of metal and the compression strength of concrete for tolerating heavy loads. He received a patent for this invention in the year 1867.

In 1886, the first rotary kiln was introduced in England that made constant production of cement. In 1891, George Bartholomew made the first concrete street in Ohio, USA. By 1920s, concrete found major usage in construction of roads and buildings[3,4]. It was in 1936 that the first concrete dams Hoover and Grand Cooley were built.

There has been no looking back for concrete since its modern development. Known as the strongest building material, concrete has found major uses in dams, highways, buildings and many different kinds of building and construction.

**1.2 Fiber Concrete**

Fibers have been used for concrete reinforcement since prehistoric times though technology has improved significantly, as is applicable for other fields. In the early age, straw and mortar were used for producing mud bricks, and horsehair was used for their reinforcement[5,6]. As the fiber technology developed, cement was reinforced by asbestos fibers in the early twentieth century.

During the middle of the twentieth century, extensive research was in progress for the use of fiber materials in concrete. Later, the use of asbestos concrete was discouraged due to the detection of health risks. New materials like steel, glass, and synthetic fibers replaced asbestos in concrete. Active research is still in progress on this important technology.

Fiber concrete is considered to be one of the greatest advancements in the construction engineering during the twentieth century. A fiber concrete has been developed recently that is called Engineered Cementitious Composite (ECC). It is claimed that this concrete is

40 % lighter than normal concrete, resistance to cracking exceeds 500 times, and strain hardening exceeds several percent strain. Thus, the ductility is significantly greater than normal concrete. It is also known as bendable concrete. Itcan self-repair minor cracks by the reaction with carbon dioxide and rainwater.

**1.3 Types Of Fibers**

In modern days wide range of fibers are used in concrete.The following are the few types of fibers

1. Basalt fiber
2. Steel fiber
3. Asbestos fiber
4. Carbon fiber

5. Synthetic fiber
6. Glass fiber
7. Polypropylene fiber
8. Nylon fiber
9. Acrylic fiber
10. Polyster fiber
11. Polethylene fiber

**1.4 Basalt Fibers**

A hard,dense volcanic rock that can be found in most countries across the globe,basalt is an igneous rock,which means it began in a molten state.For many years,basalt has been used in casting processes to make tiles and slabs for architectural applications. Additionally,cast basalt liners for steel tubing exhibit very high abrasion resistance in industrial applications. In crushed form,basalt also finds use as aggregate in concrete.

More recently, continuous fibers extruded from naturally fire resistant basalt have been investigated as a replacement for asbestos fibers, in almost all of its applications.In the last decade, basalt has emerged as a contender in the fiber reinforcement of composites. Basalt fiber is a unique product derived from basalt rock, a natural material that is found in volcanic rocks originated from frozen lava. The rock itself is extremely hard and it has been used as crushed rock in construction since ancient times. This rock has excellent strength, durability and thermal properties.

The fibers are created by melting the basalt rock between1500 and 1700 °C and forcing it through in platinum/rhodium crucible bushings. These fibers are manufactured as chopped fibers and continuous fibers. They are very similar to glass fibers, but better in terms of thermal stability, heat and sound insulation properties, vibration resistance, as well as durability (more stable in strong alkalis than glasses). Basalt fibers also have good resistance to chemical attack and in seawater environment. For these reasons they are a good alternative to glass fibers as reinforcing material and combined with the lower cost of basalt, this fiber type could potentially replace glass fibers in various fields; aerospace, automotive, transportation and shipbuilding for instance . They can be used from very low temperatures (about -200 °C) up to high temperatures in the range of 700-800 °C, which makes them an excellent economic alternative to other high-temperature-resistant fibers[7]. They are typically applied in heat shields, composite reinforcement, and thermal and acoustic barriers. In the mechanical properties of basalt fibers are compared with Kevlar, high-strength carbon and glass.

**1.5 Properties**

The various properties of basalt fiber are shown in the table below

**Table: 1 Properties of Basalt Fiber**

| Properties | Values |
|---|---|
| Tensile strength | 4.85 Gpa |
| Elastic modulus | 89 Gpa |
| Elongation at break | 3.15% |
| Density | 2.7 g/cm$^3$ |

## 1.6 Methodology

This chapter deals with the strength characteristics and properties offiber reinforced concrete. In this case while comparing other type of concrete, a fiber-reinforced concrete the mix proportions is mainly depends upon the requirements for a project, in terms of workability, strength, durability and so on.The main aim of this experimental investigations is to examine the compressive strength,split tensile and flexural strength of a mixtures for a concrete of 25 MPa.The mix design used for fiber reinforced concrete is same as that of conventional concrete for relatively small fiber volume of less than 0.5%. However, for larger fiber volumes, the mix design procedures should be based on workability considerations.Workability and maximum fiber volume are governed by parameters such as

- Maximum aggregate size

- The type and content of the fibers used
- The matrix in which the fibers are embedded
- The properties of the constituents of the matrix on their own
- Fiber addition and mixing process

As mentioned above, it is essential to base the mix design procedures of FRC on workability considerations. Therefore in this chapter, the optimization of material composition of fiberreinforced concrete based upon the desired workability, flowability and stability characteristics will be described.

The project is divided into following sections

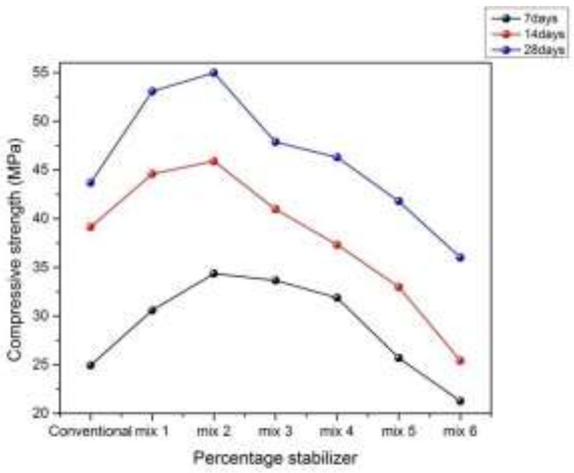
1. Material selection
2. Mix design
3. Testing of fresh concrete
4. Testing of samples

**1.7 Result and Discussion:**

**1.7.1 Compressive Strength Test**

Compressive Strength tests were carried out on cubes of 100 mm size using a compression testing machine of 2000 KN capacity as per IS516:1959`[1,2]. The test was conducted every 7 days and the temperature of water must be at 27±2ºC. Remove the specimen from water after specified curing time and wipe out excess water from the surface. Take the dimension of the specimen to the 54 nearest 0.2m. Align the specimen centrally on the base plate of the machine. Rotate the movable portion gently by hand so that it touches the top surface of the specimen. Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails. Record the maximum load and note any unusual features in the type of failure. Minimum three specimens should be tested at each selected age. If Strength of any specimen varies by more than 15 per cent of average Strength, results of such specimen should be rejected.

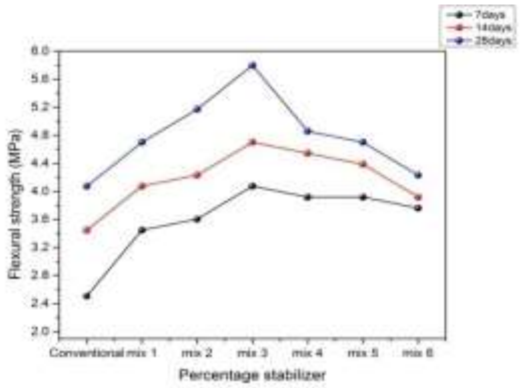
The compressive strength is gradually increased and decreased with the addition of basalt fiber with varying percentage. Basalt fiber is added by the weight of cement. The addition of 0.5 % of fiber results in increased strength of 5.64 Mpa when compared to the conventional specimen. The further addition of fiberof 1% shows increased strength of 9.41 Mpa but 1.5% fibers reduced the strength of 8.71.The compressive strength of addition of 2,2.5 and 3% shows tremendous decreases of strength in the $7^{th}$ day test of specimens. In the $14^{th}$ day test the strength is increased for 0.5 and 1% as 5.45 and 6.75 Mpa but the further addition of fibers shows the decrease in strength. As well as the $28^{th}$ day test is also exhibits the same result of increment of strength for 0.5 and 1% as 9.38 and 11.27 Mpa compared to conventional specimen.



### 1.7.2 Flexural Strength Test

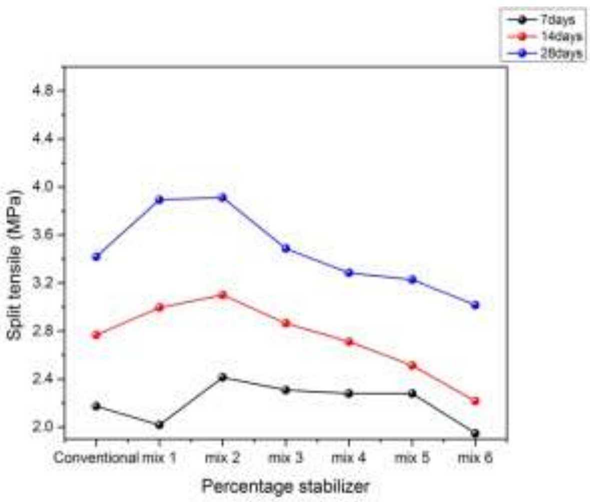
Flexural Strength tests were carried out on prisms of size 100×100×250 mm on flexure testing machine of capacity 100 KN as per IS 516:1959.

The flexural strength of conventional concrete shows the results of 2.51 Mpa and the addition of basalt fibers of various percentage of 0.5, 1, 1.5, 2, 2.5, 3% exhibits the results of 3.45, 3.60, 4.07, 3.92, 3.92, 3.76 Mpa. The flexural strength of fiber reinforced concrete increased as well as decreased. The 14$^{th}$ and 28$^{th}$ day test evaluates the same result for first two percentages and decreased gradually for the further percentages




### 1.7.3 Split Tensile Strength Test

Split tensile Strength tests were carried out on cylinders of 100 mm diameter and 200 mm height using a compression testing machine of 2000 KN capacity as per IS 516:1959.Split tensile test is one of the most commonly used test. The split tensile strength of basalt fiber concrete increased and decreased in a zigzag manner for first 7$^{th}$ day test. The split tensile strength of first 7$^{th}$ day varies as 2.02, 2.41, 2.31, 2.28, 2.28, 1.95 Mpa.In 14$^{th}$ day test the strength increased for first two percentage and varies in a decreasing manner,as well as for 28$^{th}$ day teat the strength increased for 0.5 and 1% as 3.42 Mpa and 3.89 Mpa and gradually decreased for the further percentages as 3.49, 3.28, 3.23, 3.01 Mpa.

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