# Experimental Study on Hybrid Fiber Concrete (Polypropylene Fiber with Basalt Fiber)

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## Abstract

***Improving the characteristics of concrete have been focus on study by many researchers over past few decades. Combination of two or more types of fibers for getting high quality hybrid fiber concrete (HFC) is a topic of interest amongst researchers. Use of small, discrete, randomly oriented basalt fibers improves the strength and resistance against deformation characteristics of concrete members. Aloe vera fibers improve shear strength, tensile strength, crack resistance, and energy absorption of concrete. The combination of these two fibers in predefined proportions in the concrete and its effect on strength characteristics of HFC beams. Conventional concrete is weak in tension which results in low tensile strength and brittle failure of concrete elements. In order to overcome this weakness of concrete, we use of combination of different types of suitable fibers is practiced in these days. Experimental test results of $M_{30}$ Grade concrete mix by inclusion of basalt fiber and aloe vera fibers.***

**Keywords**: Fibers, $M_{30}$grade, Concrete and Basalt.

## 1. INTRODUCTION

Fibre reinforced cement and concrete materials (FRC) have been developed progressively since 1960s. By the 1990s, a wide range of fibre composites and FRC products were commercially available and novel manufacturing techniques were developed for use with high fibre content. In parallel with the commercial development of FRC materials and products, an extensive research programme was undertaken to quantify the enhanced properties of FRC materials and more specifically to allow comparisons to be made between various types of fibres. Fibre reinforced concrete (FRC) is a composite material consisting of cement, sand, coarse aggregate, water and fibres. In this composite material, short discrete fibres are randomly distributed throughout the concrete mass. The behavioural efficiency of this composite material is far superior to that of plain concrete and many other construction materials of equal cost. Due to this benefit, the use of FRC has steadily increased during the last two decades and its current field of application includes: airport and highway pavements, earthquake-resistant and explosive-resistant structures, mine and tunnel linings, bridge deck overlays, hydraulic structures, rock-slope stabilization, etc. Fibre reinforced cement and concrete materials (FRC) have been developed progressively since 1960s. By the 1990s, a wide range of fibre composites and FRC products were commercially available and novel manufacturing techniques were developed for use with high fibre content. In parallel with the commercial development of FRC materials and products, an extensive research programme was undertaken to quantify the enhanced properties of FRC materials and more specifically to allow comparisons to be made between various types of fibres. Fibre reinforced concrete (FRC) is a composite material consisting of cement, sand, coarse aggregate, water and fibres. In this composite material, short discrete fibres are randomly distributed throughout the concrete mass. The behavioural efficiency of this composite material is far superior to that of plain concrete and many other construction materials of equal cost. Due to this benefit, the use of FRC has steadily increased during the last two decades and its current field of application includes: airport and highway pavements, earthquake-resistant and explosive-resistant structures, mine and tunnel linings, bridge deck overlays, hydraulic structures, rock-slope stabilization, etc.

## 2. METHODOLOGY

Figure 1 shows the Methodology of the study.

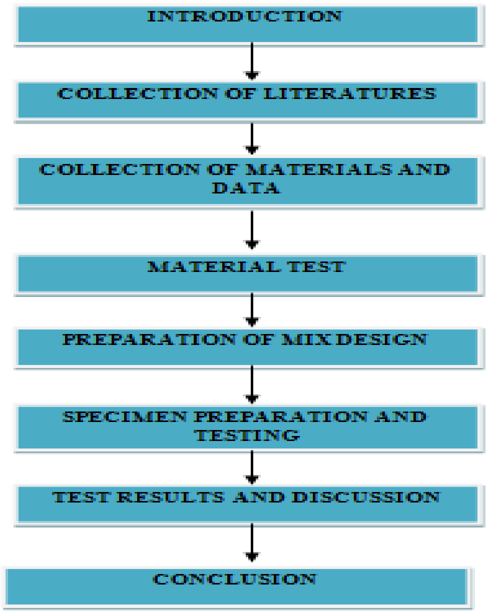


**Figure 1** Methodology

## 3. MATERIAL COLLECTION

*3.1 Cement*

The cement used was ordinary Portland cement 53 (OPC 53).All properties of cement were determined by referring IS 12269 - 1987. The specific gravity of cement is 3.15. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 30%. Cement is one of the binding materials in this project. Cement is the important building material in today's construction world. 53 grade Ordinary Portland Cement (OPC) conforming to IS: 8112-1989. Table 1 gives the properties of cement used. Table 1 shows the properties of cement.

**Table 1:** Properties of cement

| **Description of test** | **Test results obtained** | **Requirements of IS: 8112 1989** |
|---|---|---|
| Initial setting time | 65 minutes | Min. 30minutes |
| Final setting time | 270 minutes | Max. 600minutes |
| Fineness (specific surface by Blaine's air permeability test) | 412.92 $m^2$/kg | Min. 225 $m^2$/kg |

*3.2 Course Aggregate*

20mm size aggregates-The coarse aggregates with size of 20mm were tested and the specific gravity value of 2.78 and fineness modulus of 7 was found out. Aggregates were available from local sources. Locally available crushed blue granite stones conforming to graded aggregate of nominal size 20 mm as per IS: 383 – 1970.Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

Table 2 shows the property of coarse aggregate.

**Table 2:** Property of coarse aggregate.

| S.no. | Description of materials | Properties |
|---|---|---|
| 1 | Specific gravity | 2.69 |
| 2 | Fineness modulus | 7.950 |
| 3 | Loose bulk density kg/m³ | 1290 |
| 4 | Compacted bulk density kg/m³ | 1584 |
| 5 | Water absorption % | 1.343 |

*3.3 Fine Aggregate*

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60. Locally available river sand conforming to Grading zone I of IS: 383 –1970.Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.

Fine aggregate is defined as material that will pass a No. 4 sieve and will, for the most part, be retained on a No. 200 sieve. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

Table 3 shows the properties of fine aggregate.

**Table 3:** Properties of Fine aggregate

| **S.No.** | **Description of materials** | **Properties** |
|---|---|---|
| 1 | Specific gravity | 2.8 |
| 2 | Fineness modulus | 4.44 |
| 3 | Loose bulk density kg/m³ | 2500 |
| 4 | Compacted bulk density kg/m³ | 2890 |
| 5 | Water absorption % | 0.46 |

*3.4 Water*

The water used for experiments was potable water. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. It should be free from organic matter and the pH value should be between 6 to 7

*3.5 Basalt Fiber*

Basalt fiber (solidified volcanic lava) is known for its resistance to high temperature .strength& durability. Basalt fiber is extruded from molten basalt rock at diameter generally in between 13-20 μm BFRP fibers products are available in various forms such as bars, mesh, cages, spirals ,fabric& chopped fibers, it used as reinforcement in concrete structures.

Basalt fiber properties: basalt fibers reinforced concrete has good characteristics such as, volume stability, good workability, good stability ,excellent thermal resistance ,anti -seepage, crack resistance & impact resistance. Figure 2 shows the basalt fiber.

**Figure 2** Basalt Fiber

Table 4 shows the properties of basalt fiber.

**Table 4:** Properties of Basalt fiber

| | |
|---|---|
| Density gr. m-3 | **2.6-2.8** |
| Failure stress, Gpa | **1.9-2.6** |
| Extension at failure, % | **3.5-4.5** |
| Elasticity modulus Gpa | **70-90** |
| Tensilestrength（MPa） | **3000-3500** |

## 4. MIX DESIGN

*4.1 Mix Proportion*

Table 5 shows the Mix proportion.

**Table 5:** Mix Proportion

| **Cement (kg)/m$^3$** | **FA (kg)/m$^3$** | **CA (kg)/m$^3$** | **Water (liter)/m$^3$** |
|---|---|---|---|
| 531.43 | 639.048 | 1068.09 | 186 |

## 5. TEST PROCEDURE

*5.1 Sorptivity Test*

The sorptivity can be determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used of the test fluid. The cylinders after casting were immersed in water for 90 days curing. The specimen size 100mm dia x 50 mm height after drying in oven at temperature of 100 + 10°C were drowned as with water level not more than 5 mm above the base of specimen and the flow from the peripheral surface is prevented by sealing it properly with non absorbent coating. The quantity of water absorbed in time period of 30 minutes was measured by weighting the specimen on a top pan balance weighting up to 0.1 mg. surface water on the specimen was wiped off with a dampened tissue and each weighting operation was completed within 30 seconds.

*5.2 Split Tensile Test*

Tensile strength is the capacity of a material or structure to withstand tension. It is measured on concrete cylinders of standard dimensions using a Universal Testing machine. Both conventional and fiber reinforced specimens were tested at varying percentages of fiber and the average value was obtained .Split tensile test 7, at 14 and 28days of curing, the split tensile strength of concrete mixture increases by HFRC respectively

## 6. TEST RESULT

*6.1 Compressive Strength Of Cube*

Table 6 shows the compressive strength test results.

**Table 6:** Compressive strength test results

| MIX DESIGN | **% OF REPLACEMENT** | **COMPRESSIVE STRENGTH(N/mm$^2$)** | | |
|---|---|---|---|---|
| | | 7DAYS | 14 DAYS | 28DAYS |

| | | | | |
|---|---|---|---|---|
| $M_{30}$ | 0 | 26.77 | 31.01 | 37.96 |
| | (0.5 +0.5 ) | 28 | 38.6 | 43.16 |

Figure 3 shows the compression test graph result.

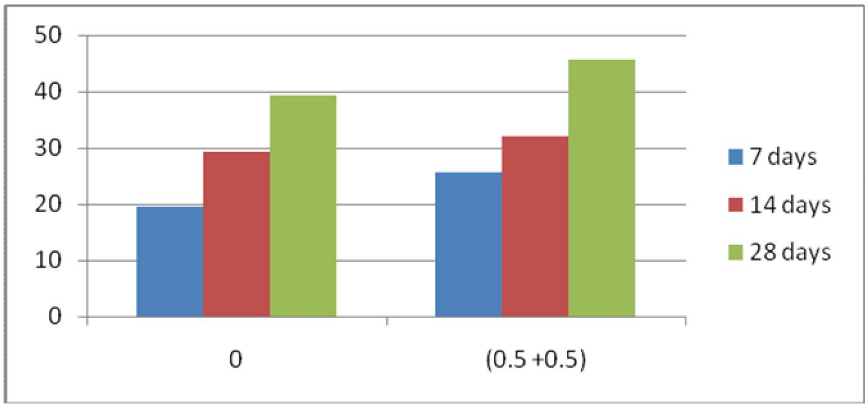


**Figure 3** Compression Test Graph Result

*6.2 Split Tensile Test for Cylinder*

Table 7 shows the split tensile test for cylinder.

**Table 7:** Split tensile test for cylinder

| MIX DESIGN | % OF REPLACEMENT | SPLIT TENSILE TEST (N/mm$^2$) | | |
|---|---|---|---|---|
| | | 7 DAYS | 14 DAYS | 28 DAYS |
| $M_{30}$ | 0 | 1.78 | 2.91 | 3.75 |
| | (0.5 +0.5 ) | 3.1 | 3.9 | 4.3 |

Figure 4 shows the split tensile graph result.

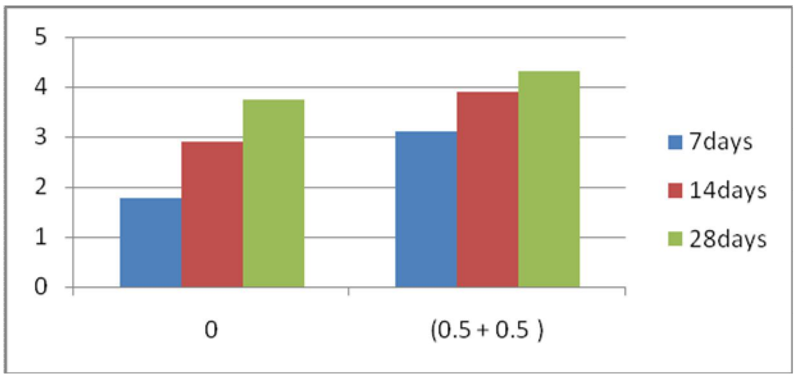


**Figure 4** Split Tensile Graph Result

*6.3 Flexural Strength Test*

Table 8 shows the flexural strength test results.

Table 8: Flexural strength test results

| MIX DESIGN | **% OF REPLACEMENT** | **FLEXURAL STRENGTH TEST ($N/mm^2$)** | | |
|---|---|---|---|---|
| | | 7 DAYS | 14 DAYS | 28 DAYS |
| $M_{30}$ | 0 | 3.1 | 4.8 | 5.39 |
| | (0.5 +0.5 ) | 3.7 | 5.2 | 6.8 |

Figure 5 shows the flexural strength graph results.

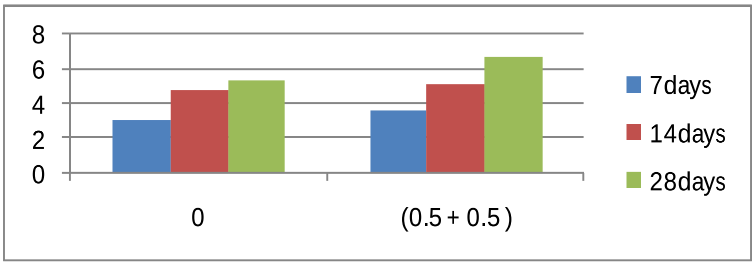


**Figure 5** Flexural Strength Graph Result

*6.4 Sorptivity Test*

*Table 9 shows the sorptivity test.*

**Table 9:** Sorptivity test

| **GRADE OF CONCRETE** | **SAMPLES** | **Dry Wt In Grams** | **Wet Wt In Grams** | **Sorptivity Value in $10^{-5}$ $mm/min^{0.5}$** |
|---|---|---|---|---|
| M30 | M0% | 1108 | 1108.7 | 1.15 |
| | (0.5 +0.5 ) | 1022 | 1022.9 | 1.47 |

Figure 6 shows the graph of sorptivity test.

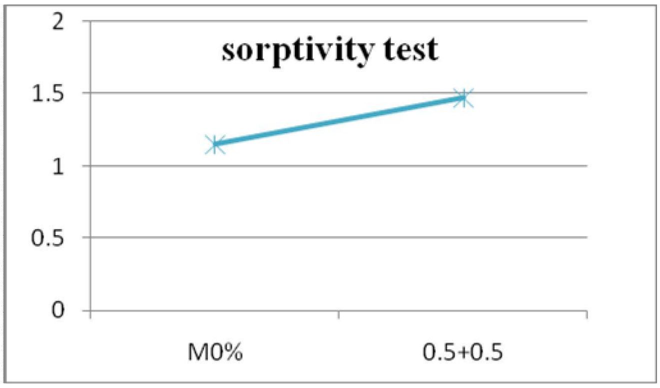


**Figure 6** Sorptivity test

## 7. CONCLUSION

- The addition of fibers increased compressive strength with 0.5% fiber-cement ratio and little increase for 1% of fiber-cement ratio compared to plain concrete. The addition of Basalt & Aloevera fibre with 0.5% in concrete will increases the compressive strength of concrete.
- The maximum compressive strength of specimen after 28 days is 43.16N/mm² with 1% of hybrid fibers (Basalt fibre and aloevera) comparisons of normal concrete and other mix. It is 10% increase overcome with normal concrete.
- The improvement in flexural strength reveals that the toughness would be much more than that of non-fibrous concrete which improves ductility and durability of concrete.
- Increase in fiber-cement ratio is tending to voids in concrete though thoroughly compacted because of improper bonding of materials in concrete with increase in fibers.
- The maximum flexural strength of M30 mix after 28 days is 6.8N/mm² with 1% of hybrid fibers (Basalt fibre and aloevera) comparisons of normal concrete value 5.39 N/mm² at 28 days.

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