

# Mechanical and Durability Properties of Hybrid Fiber Reinforced High Performance Concrete using Multiple Mineral Admixtures

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## ABSTRACT

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A study has been made for the high performance concrete of grade M70, where two mineral admixtures like GGBS and Metakaolin has been used with the two fibers, one B glass fibers and asbestos fibers. If two fibers are used in the concrete then we are call is having a fiber reinforced concrete the asbestos fibers percentage was kept constant of about 0.33% and glass fibers % have been changed from 0.25, 0.75 and 1.0%. The cubes are casted for different water cement ratios which is 0.25,0.30 and 0.35. there cubes are tested for the strength teste and durability zero.

**Keywords :** Hybrid Fiber, calcium oxide, Ultra-High-Performance Concrete

## I. INTRODUCTION

Concrete, in construction, structural material consisting of a hard, chemically inert particulate substance, known as aggregate (usually sand and gravel), that is bonded together by cement and water. Among the ancient Assyrians and Babylonians, the bonding substance most often used was clay. The Egyptians developed a substance more closely resembling modern concrete by using lime and gypsum as binders. Lime (calcium oxide), derived from limestone, chalk, or (where available) oyster shells, continued to be the primary pozzolanic, or cement forming, agent until the early 1800s. In 1824 an English inventor, Joseph Aspdin, burned and ground together a mixture of limestone and clay. This

mixture, called portland cement, has remained the dominant cementing agent used in concrete production.

### 1.1 Hybrid Reinforced Concrete

A hybrid fiber reinforced concrete is a composite of two or more fibers in concrete. The concept of using fibers as a reinforcement in the concrete mixture is not a new study. The use of fibers has been carried out from ancient times. There are different types of fiber reinforced concrete that are categorized based on the fiber that is employed. If steel fiber is used we get steel fiber reinforced concrete. Similarly, nylon reinforced concrete, glass fiber reinforced concrete, carbon fiber reinforced concrete etc. are some of the types. A

composite can be stated as a hybrid when two or more type of fibers is used in a combined matrix to produce a composite that will reflect the benefit of each of the individual fiber used. This will finally provide a synergetic response to the whole structure. Such a composite of concrete is termed as the Hybrid Fiber Reinforced Concrete (HFC).

### 1.2 Ultra-High-Performance Concrete

In the early 1970s, experts predicted that the practical limit of ready-mixed concrete would be unlikely to exceed a compressive strength greater than 11,000 pounds square inch (psi). Over the past two decades, the development of high-strength concrete has enabled builders to easily meet and surpass this estimate. Two buildings in Seattle, Washington, contain concrete with a compressive strength of 19,000 psi.

The primary difference between high-strength concrete and normal-strength concrete relates to the compressive strength that refers to the maximum resistance of a concrete sample to applied pressure. Although there is no precise point of separation between high-strength concrete and normal-strength concrete, the American Concrete Institute defines high-strength concrete as concrete with a compressive strength greater than 6,000 psi. Likewise, there is not a precise point of separation between high-strength concrete and ultra-high performance concrete, which has greater compressive strength than high-strength concrete and other superior properties.

Manufacture of high-strength concrete involves making optimal use of the basic ingredients that constitute normal-strength concrete. Producers of high-strength concrete know what factors affect compressive strength and know how to manipulate those factors to achieve the required strength. In addition to selecting a high-quality

portland cement, producers optimize aggregates, then optimize the combination of materials by varying the proportions of cement, water, aggregates, and admixtures.

When selecting aggregates for high-strength concrete, producers consider the strength of the aggregate, the optimum size of the aggregate, the bond between the cement paste and the aggregate, and the surface characteristics of the aggregate. Any of these properties could limit the ultimate strength of high-strength concrete.

### 1.3 Admixtures

Pozzolans, such as fly ash and silica fume, are the most commonly used mineral admixtures in high-strength concrete. These materials impart additional strength to the concrete by reacting with portland cement hydration products to create additional C-S-H gel, the part of the paste responsible for concrete strength.

It would be difficult to produce high-strength concrete mixtures without using chemical admixtures. A common practice is to use a superplasticizer in combination with a water-reducing retarder. The superplasticizer gives the concrete adequate workability at low water-cement ratios, leading to concrete with greater strength. The water-reducing retarder slows the hydration of the cement and allows workers more time to place the concrete.

High-strength concrete is specified where reduced weight is important or where architectural considerations call for small support elements. By carrying loads more efficiently than normal-strength concrete, high-strength concrete also reduces the total amount of material placed and lowers the overall cost of the structure.

The most common use of high-strength concrete is for construction of high-rise buildings. At 969 feet,

Chicago's 311 South Wacker Drive uses concrete with compressive strengths up to 12,000 psi and is one of the tallest concrete buildings in the United States.

#### 1.4 Objectives

1. By using the slump cone test, the workability characteristics of fresh concrete will be studied.
2. By using the industrial waste materials like GGBS and Metakaolin the cost-effective concrete is produced.
3. Partial replacement of cement and different percentage of water cement ratio is used for casting the cubes, cylinders, and prisms to obtain the strength characteristics of concrete.
4. The behaviour of strength characteristics of concrete will be studied when the glass fibers and the asbestos fibers are used.

## 2 REVIEW OF LITERATURE

### 2.1 Overviews

**H. Prashanth, M. Pavan Kumar** carried out work on "Assessment of Strength Properties for Hybrid Fiber Reinforced for Ultra High-Performance Concrete" in which he study has been made of mineral admixtures, such as ultra-fine Fly-ash and Metakaolin, and glass fibers and polypropylene fibers, to produce high performance Concrete. Glass fiber is maintained stable by volume by 0.25 percent by cement content in varying fractions (0.5 percent, 0.75 percent & 1.0 percent) and polypropylene fiber. SP 430 is applied to the concrete mix to ensure greater workability. The grade of concrete M70 is used. The cubes, cylinders and beams are casted for different water cement ratios of 0.275%, 0.30% and 1.00%. The strength tests are carried out for 14, 28 days and durability tests are carried for 56 days. The Behaviour of the HPC specimens in compressive strength, flexure and splitting tensile

strength were calculated. Due to the addition of mineral admixture & fiber volume into the mix, it gives very good performance & Suitable for construction.

The given conclusion is that Admixtures like mineral admixtures and compound admixtures will build the usefulness and strength of cement. Fibers increment the compressive strength of the solid and furthermore oppose abrupt breakdown in solidified state. Increasing the level of volume part of cross breed fiber diminishes the droop esteem, to keep up the steady droop we need to build the super plasticizers portion in concrete. As the water concrete proportion expands the compressive strength of the solid blocks additionally diminishes. Essentially for the split malleable and flexural strength. Be that as it may, there is expansion in their solidarity as the glass filaments expanded up to 1.00%. Durability of the concrete, In concentrated H<sub>2</sub>SO<sub>4</sub> and HCL the strength of solid declines as the water concretes proportion increments. In strength against sulphuric corrosive assault, most extreme rate decline is 9.78% and least rate decline is 5.50%. In strength against chloride corrosive assault, greatest rate decline is 9.39% and least rate decline is 5.4%.

## 3. METHODOLOGY

Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar, or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Here for the experimental work, the glass fibers and asbestos fibers are used. The asbestos fibers are kept constant of 0.33% and glass fibers variation has been done of 0.5%, 0.75% and 1.0%. The mineral admixtures are GGBS and Metakaolin is used at a percentage of 25% & 10% and also super plasticizer of 1.5% is added. The cubes, beams and cylinders are casted as per the IS standard dimensions for different

water cement ratios of 0.25, 0.30 and 0.35. The strength test is carried out on 14 days and 28 days and durability test is carried out on 56 days.

### 3.1 Cement

Cement is a finely milled mineral powder, usually grey in colour. The most important raw materials for the production of cement are limestone, clay, and marl. Mixed with water, cement serves as an adhesive to bind sand, gravel, and hard rock in concrete.

The Birla cement used in this experiment of Ordinary Portland Cement of 53 grade, conforming to IS 8112 -1989. The cement used has been tested for various properties as per IS 4031-1988.

**Table 3.1** Physical Properties of Cement

Physical Property	Results
Fineness	2945 cm <sup>2</sup> /g
Normal Consistency	30.9%
Initial Setting Time	54 Min
Final Setting Time	191 Min
Specific Gravity	3.14
Compressive Strength at 7 Days	24.32 N/mm <sup>2</sup>
Compressive Strength at 28 Days	41.68 N/mm <sup>2</sup>



**Fig 1** Slump Test



**Fig 3.1** OPC 53 Grade Cement thermal stresses that could result in cracking

### 3.2 Casting and Curing

Clean the standard cube moulds 6 No's thoroughly and tight all nuts-bolts properly. Apply oil to all contract surface of mould. Size of mould is normally from the mixing spot while concreting. Take the random sample from the mixing spot while concreting. Fill the concrete in cubes in 3 layers. Compact each layer with 35 No's of stroke by tamping rod. Finish the top surface by trowel after completion of last layer. Cover the mould hessian cloth immediately to prevent loss of water. Each specimen should be taken from 21 various locations of proposed concreting. After 24 hours remove specimen out of mould. While removing, take care to avoid breaking of edges. Put coding on cubes by paint or marker, coding should be self-explanatory showing site name, concrete location, building number and date of casting. Submerge the specimen in clean fresh water till the time of testing. Test 3 specimens for 7 days and 3 specimens for 28 days curing. Average strength of 3 cubes represents the strength of concrete of particular portion of the structure. The casted cubes were totally immersed inside water, throughout the curing period; the curing water was maintained at an average laboratory temperature of 28°C (82.4°F) to prevent by damp

## II. TESTS ON FRESH CONCRETE

### 4.1 Slump Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. The test is popular due to the simplicity of apparatus used and simple procedure. The slump test is used to ensure uniformity for different loads of concrete under field conditions.

**Table 1** Recommended Slump of Concrete

Concrete Mixes	Slump Range (mm)
Columns, Retaining Walls	75 – 150 mm
Beams and Slab	50 – 100 mm
CC Pavements	20 – 30 mm
Decks of Bridges	30 – 75 mm
Huge Mass Construction	25 – 50 mm

For the 0.25 water cement ratio, it is Zero slump (100mm)

For the 0.30 water cement ratio, it is True slump (80mm)

For the 0.35 water cement ratio, it is Shear slump (45mm)

### 4.2 Split Tensile Strength

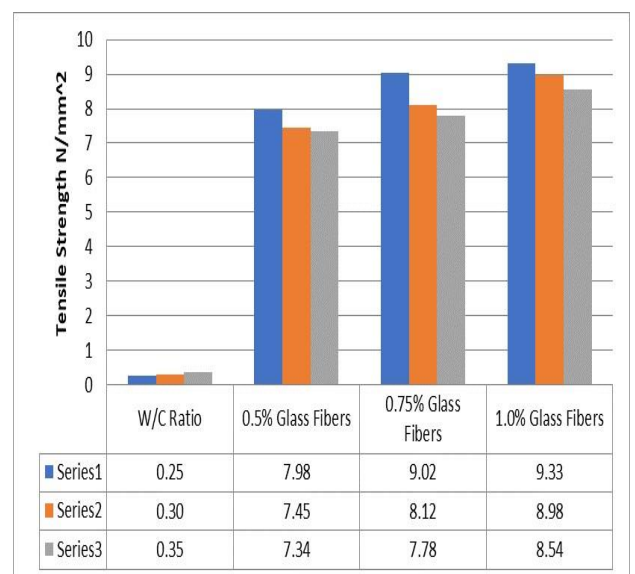
A method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. It is an indirect method of testing tensile strength of concrete.

**Table 2** Split Tensile Strength for 28 Days

W/C Ratio	Glass Fibers	Split Tensile Strength N/mm <sup>2</sup>
0.25	0.50 %	8.05
	0.75 %	8.54
	1.0 %	8.92
0.30	0.50 %	7.02
	0.75 %	7.89
	1.0 %	8.21
0.35	0.50 %	6.98
	0.75 %	7.05
	1.0 %	7.78



**Fig 2** Testing on Cylinders



### Fig 3 28 days Tensile Strength

As the water cement ratios increases the tensile strength decreases which is shown in the figure and also there is increase in the tensile strength when the glass fibers is increased up to the 1.0%.

### III. CONCLUSION

1. Increasing the percentage of volume fraction of hybrid fiber reduces the slump value, to maintain the constant slump we have to increase the super plasticizers dose in concrete.
2. As the water cement ratio increases the compressive strength of the concrete cubes also decreases. Similarly for the split tensile and flexural strength. But there is increase in their strength as the glass fibers increased up to 1.00%.
3. Durability of the concrete
  - In concentrated  $H_2SO_4$  and HCL the durability of concrete decreases as the water cements ratio increases.
  - In durability against sulphuric acid attack, maximum percentage decrease is 9.78% and minimum percentage decrease is 5.50%.

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