

# **A Study of High Performance Fiber Reinforced Polymers (FRP)**

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**ABSTRACT:** This projects deals with experimental investigations of high performance property of the concrete and the strength of the concrete when the cement is partially replaced with fly ash and silica fume and also adding of fiber reinforced plastics.

Experimental investigation were carried out by preliminary test on all the ingredients of the concrete such as specific gravity test, fineness test & crushing strength etc., and where determined according to the IS codes.

Fly ash is a fine, glass powder recovered from the gases of burning coal during production of electricity. Concrete containing fly ash becomes stronger, more durable, and more resistant to chemical attack. Silica fume is a waste by-product of the production of silicon and silicon alloys. By the addition of silica fume in concrete, it is easier to make HPC for strengths between 63-98 N/mm<sup>2</sup>.

The mix was designed by Indian method, since this method gives approximates results. The mix design is done for M 20. Then the concrete cubes and cylinder are casted. The cubes and cylinder are subjected to compression test and the tension test as per codal provision.

Silica fume and fly ash was replaced by 15 % and 30% of weight of concrete while fibre reinforced plastics was used at 0.5%, 1.0% and 1.5% of weight of concrete.

## **I. INTRODUCTION**

The use of HPC is on increasing trend in the construction industry and is being seen as an optimized solution considering the economics, strength and durability required for special structures. The important governing factors for HPC's are strength, long term durability, serviceability as determined by crack and deflection control, as well as response to long term environmental effects. The ingredients of HPC's are almost same as those of conventional cement concrete (CCC). The high performance concrete usually contains both pozzalonic and chemical admixtures. Hence, the rate of hydration of cement and the rate of strength development in HPC is quiet different from that of conventional cement concrete. The scope of using HPC in our constructional activities lies large, viz., Precast prestressed Bridges, Multi-storied buildings, and structures on coastal areas.

Silica fume is a waste by-product of the production of silicon and silicon alloys. Silica fume is available in different forms, of which the most commonly used is in a densified form. By the addition of silica fume in concrete, it is easier to make HPC for strengths between 63-98 N/mm<sup>2</sup>.

Fly ash is a finely divided residue that results from the combustion of ground or powdered coal. Of the hundreds of millions of metric tons of fly ash which are produced annually on a worldwide basis, only a small portion i.e, 20% - 40% of the fly ash is reused for productive purpose, such as additive or stabilizer in cement. The remaining amounts of fly ash produced are disposed in controlled landfills.

Thus, silica fume and fly ash is used as an alternative binder material in the production of concrete which is seen as an optimized solution considering economics, strength and durability.

In this project the mix design is done for M20. Then the concrete cubes and cylinder are casted. The cubes and cylinder are subjected to compression test and the tensile test as per codal provision.

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## II. LITERATURE SURVEY

Research efforts in the last 30 years into understanding the mechanism of cement hydration and the benefits of using alternative materials to replace have been responsible for a great improvement in concrete strength and durability. These improvements are of significant importance to the corps of engineers because of the large volume of cement the corps uses every year, and because of the high demands we place on performance and durability of the structures we build. In the middle years of this past century, “high performance” of concrete was measured in terms of high strength, and high strength meant using high cement content mixtures with low water-cement ratios. Compressive strength of 45 to 50 N/mm<sup>2</sup> where considered high strength then, and durable concrete had approximately a 50 years life span. Today, with the many improvements that have been made, high performance can mean many things, and we are routinely capable of producing strength in the range of 100 N/mm<sup>2</sup> and often ask for design lives of 90 years or more.

In fact, today Portland cement based concretes incorporating Pozzolans such as silica fume and fly ash in combination with super plasticizers are known as High Performance Concretes (HPC). In High Performance Concretes, silica fume is used for its chemical and physical benefits. The chemical reaction known, as the “Pozzolanic” reaction, takes place when the Portland cement is hydrated (mixed with water), producing many compounds, including calcium silicate hydrate (CSH) and calcium hydroxide Ca(OH)<sub>2</sub>. The calcium silicate hydrate (CSH) sometimes called the gel is the source of strength in concrete. When silica fume is added to fresh concrete, it chemically reacts with the calcium hydroxide Ca(OH)<sub>2</sub> to produce additional calcium silicate hydrate (CSH). The benefits of this reaction can be seen in the crucial interfacial zone increasing the bond strength between concrete paste and aggregates, yielding greatly increased compressive strengths and a concrete that is more resistant to attack from aggressive chemicals than the weaker calcium hydroxide found in ordinary Portland cement concretes.

Long-term performance of structures has become vital to the economies of all nations. Concrete has been the major instrument for providing stable and reliable infrastructure since the days of the Greek and roman civilization. At the turn of the 20th century, concrete compressive strength was in the range of 13.8 N/mm<sup>2</sup>, by the 1960s it was in the range of 27.6 - 41.4 N/mm<sup>2</sup>.

As a result, new materials and composites have been developed and improved cements evolved. Today concrete structures with a compressive strength exceeding 138 N/mm<sup>2</sup> are being built world over. In research laboratories, concrete strengths of even as high as 800 N/mm<sup>2</sup> are being produced. One major remarkable quality in the making of High performance concrete (HPC) is the virtual elimination of voids in the concrete matrix, which are mainly the cause of most of the ills that generate deterioration.

ACI defines HPC as “Concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing and curing practices”. Such concretes can be either normal strength or high strength. Normal strength concrete by ACI definition is a concrete that has a cylinder compressive strengths not exceeding 42 N/mm<sup>2</sup>. All other concretes are considered High Strength Concretes (HSC). HPC’s with 140 N/mm<sup>2</sup> are currently being used in High rise structures in USA and Europe. Important governing factors for HPCs are strength, long term durability, serviceability as determined by crack and deflection control, as well as response to long term environmental effects.

High performance concretes (HPC) are concretes with properties or attributes which satisfy the performance criteria. Generally, concretes with higher strengths and attributes superior to Conventional concretes are desirable in the Construction Industry. HPC is defined in terms of Strength and Durability. Therefore HPC can be considered as a logical development of cement concretes in which the ingredients are proportioned and selected to contribute efficiently to the various properties of cement concrete in fresh as well as in hardened states.

## II. EXPERIMENTAL METHOD

The most commonly used supplementing cementitious materials/mineral admixtures for achieving HPC are:

### 1. Silica Fume

Silica fume is a waste by-product of the production of silicon and silicon alloys. Silica fume is available in different forms, of which the most commonly used now is in a densified form. In developed countries it is already available readily blended with cement. It is possible to make high strength concrete without silica fume, at compressive strength

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of upto 98 N/mm<sup>2</sup>. Beyond that strength level however, silica fume becomes essential. With silica fume it is easier to make HPC for strengths between 63-98 N/mm<sup>2</sup>.

Table 1: chemical properties of Silica Fume

ITEM	% BY MASS
SiO <sub>2</sub>	91.5
Al <sub>2</sub> O <sub>3</sub>	0.65
Fe <sub>2</sub> O <sub>3</sub>	0.3
CaO	0.9
Fineness as Surface Area (m <sup>2</sup> /kg)	16,000
Specific gravity	2.2

### 2. Fly Ash

Fly ash which is one of the residues generated in the combustion of coal is used as siliceous admixture to the lime mortar. The physical properties and the chemical composition of the fly ash used is given as follows.

Table 2: chemical properties of Fly Ash

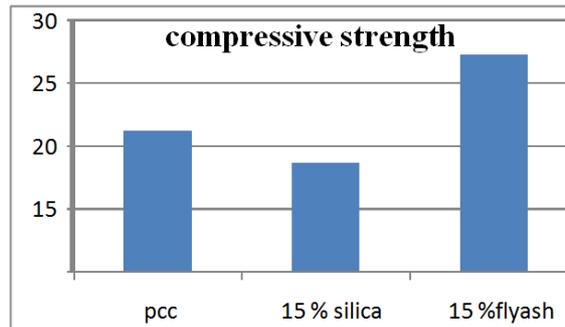
S.NO	CHARACTERISTICS	REQUIREMENT	AVAILABLE
1	SiO <sub>2</sub> +Al <sub>2</sub> O <sub>3</sub> +Fe <sub>2</sub> O <sub>3</sub> % by max, min	70.0	94.13
2	SiO <sub>2</sub> % by max, min	35.0	57.90
3	MgO % by max, min	5.0	0.49
4	So <sub>3</sub> % by max, min	2.75	0.13
5	Loss on ignition % by max, min	12	1.46
6	Cao % min	0.6	0.65
7	K <sub>2</sub> O % min	-	0.87

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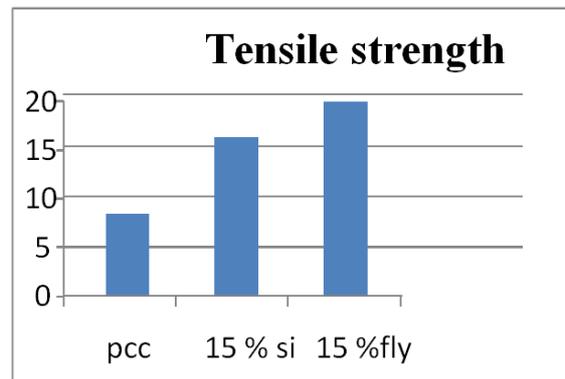
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## III. RESULTS



Graph 1: compressive strength with different % of admixtures



Graph 2 : Tensile strength with different % of admixtures

## IV. CONCLUSION

From the experimental investigation the following conclusions are drawn:

- 1) Concrete with 15% fly ash and 0.5% fibre reinforced plastics gives the ultimate compressive strength.
- 2) When concrete with 30% fly ash is added the compressive strength is less than the plain cement concrete.
- 3) Concrete with silica fume (15%, 30%) does not achieve the required strength.
- 4) Concrete with 15% fly ash and 1.5% fibre reinforced plastics gives the ultimate tensile strength.
- 5) Replacement of 15% fly ash with cement concrete gives more strength and lesser cost.

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