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A Parametric Study on Fibre Reinforced Concrete

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Abstract: The investigation is focused to study the effect of various types of fibres on compressive strength, split tensile strength and flexural strength of High strength concrete. The water to cementitious material ratio considered for the study of High strength concrete was 0.25. The content of silica fume and fly ash in every mix was 5% and 10% by the weight of cementitious material. Two types of fibres considered for the study include, Polypropylene Fibres (PF) and Flat Steel Fibres (FSF). Dosage of fibre was varied from 0.5% to 4% at an interval of 0.5% by weight of cementitious material. Type of cement, fine aggregate, coarse aggregate, type of Superplasticizer and its dosage are kept constant in every mix. The use of High Strength Concrete (HSC) is increased now a days. It is observed that HSC relatively brittle material. Fibres are added to improve its ductility. Experimental study is carried out to assess mechanical properties of high strength concrete (HSC) of grade M70.
Keyword: fibres; high strength concrete; ductility; cementitious material; fly ash; superplasticizer.

I. INTRODUCTION

The theoretical basis for producing high-strength concrete (HSC) was originally developed in the field of ceramic materials in the late 1950s and early 1960s. Based on single-phase polycrystalline ceramic materials, it was shown that reduced particle dimension increased the strength. The dependence of the particle size on the strength was explained on the basis of Griffith's theory for the rupture of brittle materials with internal cracks. In accordance with this theory the strength of the material should increase with decreasing pore and particle size by a square root law. Later on, it was shown that there was a similar relationship between microstructure and strength for cement pastes with densely packed cement particles at a very low water/ cement ratio. However, it was not until the early 1970s that new and very effective agents for dispersing the fine cement particles in water became available, and then, a tremendous advance in the production of high-quality concrete was achieved. At the same time, large quantities of ultrafine condensed silica fume particles also became available. Therefore, a commercial basis for production of concrete with very high density and strength was established, and a rapid development of HSC took place. Since a low porosity concrete with high density will also enhance the overall performance of the material, the term "high-performance concrete" (HPC) was also soon introduced, which is inclusive of the term "HSC." More and more, however, the term "HPC" was mostly used and specified for concrete durability rather than for concrete strength. In the literature, there are a number of definitions of both "HSC" and "HPC," but as properly discussed by Aitcin in his book on HPC (Aitcin, 1998), there is no clear consensus about the meaning of either of these terms. In the literature, some people try to define HSC as different from "normal strength concrete," "ordinary concrete," or "usual concrete," but what is "normal," "ordinary," or "usual" is rapidly changing. Also, some definitions are based on a maximum water/cement ratio, but nor is the term "water/cement ratio" easy to define any longer. For many years, when concrete was mostly based on pure Portland cement and simple procedures for concrete production, the concept of water/cement ratio was the fundamental basis for characterizing concrete quality.

II. MATERIALS

A. *Cement*

Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent of the total volume of concrete mix, " is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Any variation in its quality affects the compressive strength of the concrete mix. Ordinary Portland cement is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 grade, 43 grade, 53 grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipment's, maintaining better particle size distribution, finer grinding and better packing.

Generally use of high grade cement offers many advantage for making stronger concrete Ordinary Portland cement (OPC) of 53 Grade (Ambuja cement) was used throughout the course of the investigation. It was fresh and without any lumps. OPC 53 Grade cement is required to conform to BIS specification IS:12269-1987 with a designed strength for 28 days being a minimum of 53 MPa or 530 kg/sqcm.. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture. The various tests conducted on cementare initial and final setting time, specific gravity, fineness and compressive strength.

Fig 1. Cement

B. Fine Aggregate

The aggregate most of which pass through 4.75mm IS are termed as fine aggregates. Generally, there are no specific properties performance requirements for aggregates exposed to marine environments. aggregates should be well-graded, have suitable physical properties, be frost-resistant (if exposed to freeze- thaw in service), and meet the normal requirements for aggregates for concrete construction given in standard specifications. If the aggregates are alkali-silica reactive, then appropriate measures should be taken minimize the risk of deleterious reaction. The exception to the aforementioned in areas of structures that are exposed to severe abrasion, such as ice abrasion. In these cases the aggregate should be selected to produce a high degree of abrasion resistance, gene any, Siliceous aggregates are more resistant than carbonate aggregates. In general, it is preferable to maximize the aggregate content in theconcrete mix to enhance durability, subject to other concrete requirements such as adequate workability, cohesiveness and so on. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories--fine and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter.

Fig 2. Sand

C. Coarse Aggregate

The aggregates which is retained over IS sieve á 4.75mm is termed as coarse aggregate. The coarse aggregates may be of following types: Crushed graves or stone obtained by crushing of gravel or hard stone.

Uncrushed gravel or stone resulting from the natural disintegration of rocks. Partially crushed gravel obtained as product of blending of above two types. The normal maximum size is gradually 10-20 mm; however the particle sizes up to 40mm or more have been used in self compacting concrete. Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of interlocking of angular particles, while rounded aggregates improved the flow because

Fig 3. Coarse aggregate

D. Water

Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually issuitable. Water from such sources should be avoided since the quality on the water could change due to low water or by intermittent tab water is used for casting. The portable water is generally considered satisfactory for mixing and curing of concrete in material testing laboratory. This was free from any detrimental contamination and was good potable quality.

E. Steel Fibres

Steel fibre is a metal reinforcement. Steel fibre for reinforcing concrete is defined as short, discrete lengths of steel fibres with an aspect ratio (ratio of length to diameter) from about 20 to 100, with different cross-sections, and that are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the usual mixing procedures. A certain amount of steel fibre in concrete can cause qualitative changes in concrete's physical property, greatly increasing resistance to cracking, impact, fatigue, and bending, tenacity, durability, and other properties. Basically, steel fibre can be categorized into five groups, depending on the manufacturing process and its shape and/or section: cold-drawn wire, cut sheet, melt- extracted, mill cut, and modified cold-drawn wire. In 2003, Wen and Chung first fabricated cement paste with self-sensing properties using steel fibres with a length of6 mm and diameter of 8 µm. Hong employed steel fibres with a length of 32 mm and diameter of 0.64 mm to develop self-sensing concrete. Hou and Lynch also developed an engineered cementations composite with sensing properties by incorporating steel fibres. Teomete and Kocyigit used steel fibre with a length of 6 mm to fabricate self- sensing concrete with tensile strain-sensing properties.

Fig 4. Steel fibre

F. Fly Ash

Fly ash is a fine gray powder consisting mostly of spherical, glassy particles that are produced as a byproduct in coal-fired power stations. Fly ash has pozzolanic properties, meaning that it reacts with lime to form cementations compounds. It is commonly known as a supplementary cementation material. Fly ash is a residue generated in combustion and comprises the fine particles that rise with the flue gases. Ash that does not rise is called bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is aheterogeneous material. The main chemical components present in fly ash are:

1) Silicon dioxide
2) Aluminum oxide
3) Ferric oxide
4) Calcium oxide (occasionally)

Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify rapidly while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm.

Fly ash significantly improves concrete performance and also provides many benefits in cement and non-cement applications. Also, when treated with sodium hydroxide, fly ash appears to function well as a catalyst for converting polyethylene into a substance similar to crude oil in a high temperature process called pyrolysis.

Fig 5. Fly ash

Silica fume (SF) is a by-product of the smelting process (reduction of high-purity quartz with coal in electric furnaces) in the production of silicon and ferrosilicon alloys. It is also collected as a by-product in the production of other silicon alloys such as ferromanganese, ferromagnesium, ferrochromium, and calcium silicon (ACI 226-3R-87). It contains extremely fine amorphous particles of silicon dioxide (SiO_2) which usually make up more than 90% of SF constituents. SF is also known as microsilica, volatized silica, and condensed SF or silica dust. SF, because of its extreme fineness and high silica content, has been recognized as a pozzolanic material conforming to specifications of ASTM C1240 for use as supplementary cementitious material in cement mortar and concrete to enhance mechanical and durability properties. According to the Florida Department of Transportation, the quantity of SF should be between 7% and 9% by mass of cement replacement for mortar and concrete production. Silica fume particles are spherically shaped and very fine, having a mean size of 0.1–0.3 µm. In some cases, individual particles can fuse together to form small agglomerates that may range from 1 to 100 µm in size. The specific gravity of silica fume is 2.20–2.30. The surface area of silica fume particles can range between 13,000 and 30,000 m^2/kg, measured by nitrogen absorption equipment. The bulk density of the as-produced silica fume ranges from 130 to 430 kg/m^3. Compacted or densified silica fume and slurried silica fume have a bulk density that can range from 200 to 600 and 1300 to 1400 kg/m^3, respectively. Silica fume can also be pelletized, whereby the silica fume is mixed with water and some cement. The silica fume pellets can be ground with Portland cement clinker to form a blended cement. Irrespective of the delivery form of silica fume (i.e., as-produced, compacted, slurried, or pelletized), similar concrete properties and performance can be achieved. silica fume has a high content of silicon dioxide, and the X-ray diffraction analysis of silica fume shows a broad hump locatedat the peak of. The silicon dioxide content of silica fume varies with the type of alloy that is being produced. For example, silicon metal (98%) produces silica fume with 87%–98% silicon dioxide content, whereas the alloy, 50% ferrosilicon, produces silica fume with 74%–84% silicon dioxide content. Many international standards require silica fume to have a minimum silicon dioxide content of 85%. However, in Canada, two grades are defined, namely, Type SF and Type SFI, which have a minimum silicon dioxide content of 85% and 75%, respectively. The use of SF is well established in concrete industries throughout the world and, perhaps, represents the most deeply entrenched and accepted use of industrial by-products in the construction industry.

Fig.6 Sillica fume

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III. MIX PROPORTION

Mix design carried out for two type of concrete such as concrete with steel fibres and concrete without steel fibres. After calculation the mix proportion are tabulated below.

Table1. Mix design of M70 grade concrete

	CEMENT	
Type of Cement		OPC (53 Grade)
Specific Gravity of Cement		3.15
Maximum Cement Content		IS456:2000 Cl.8.2.4.2
	SITE CONDITIONS	
Exposure		Severe
Workability		120mm
Method of Placing		Pumping
Degree of Supervision		Good
	ADMIXTURE	
Mineral Admixture		Fly Ash (15%)
Specific Gravity of Mineral AdmixtureChemical Admixture (HRWRA) Specific Gravity of Chemical AdmixturePozzolana Material Specific Gravity of Pozzolana		2.2 Super plasticizer (0.5%) [Poly Carboxylate Ether] 1.08 Silica Fume (5%) 2.2

Table 2. Materials for M70 concrete with fibre reinforced concrete.

PROPER		**Fine Aggregate (Zone-2)**
Specific Gravity at SSD	2.74	
Water Absorption	0.	2.65
Moisture Content	5%	1%
Type of Aggregate	Crushed Angular Aggregates	
Maximum Normal Size	20 mm	

Table 3. Details of reinforcement

STEEL	Length = 8mm Diameter = 0.2mm

Table 4. MATERIALS REQUIREMENT for fibre reinforced concrete

Water	153 kg/m^3
Water-Cementitious Ratio	0.2636
Cement	428 kg/m^3
Fly Ash	80 kg/m^3
Silica Fume	27 kg/m^3
Admixture (Super Plasticizer)	2.675 kg/m^3
Steel Fibers	40 kg/m^3
Fine Aggregate (SSD)	631 kg/m^3
Coarse Aggregate (SSD)	1135 kg/m^3

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Table 5. mix proportion of concrete without fibre

Cement	428 kg/cum.
Fly ash	80.25 kg
Silica fume	26.75 kg/cum.
Water	141 kg/cum.
Fine aggregate	589 kg/cum.
Coarse aggregate	1219 kg/cum.
Chemical admixture	2.67 kg/cum.
Water-Cement ratio	0.264

IV. RESULT AND DISCUSSION

Considering the real situation where the selected parameters vary within a certain range, a study of the fibre reinforce concrete is carried out in order to gain further insight into the functional performance of the high strength concrete.

1) *Effect on Compressive Strength:* The compressive strength is a important parameter in concrete design. The concrete should have adequate strength to resist compressive load. Compressive strength of concrete is increased as increased in no. of days as shown in fig no. 8 However compressive strength is slightly increased in high strength concrete with steel fibre as compared to concrete without steel fibres. The target strength of concrete is 70 Mpa. It has seen that the concrete has achieved more than target strength in both fibre reinforced concrete and concrete without fibre.

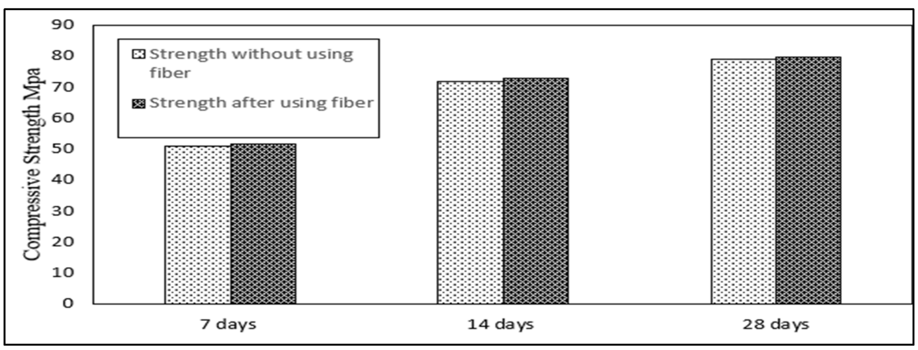

Fig 7. Effect on compressive strength

2) *Effect on Workability:* In many researches it has been seen that if we add steel fibers in concrete its workability is affected than that of concrete without steel fibers. After mixing of steel fibers in concrete the mobility of ingredients gets decreased, so we need more energy to obtain optimum compaction as a result the workability will be decreased, therefore we have to add super plasticizer to get workability. In this paper it has been seen that slump value of concrete is decreased by 3% in steel fibre concrete as shown in fig 8.

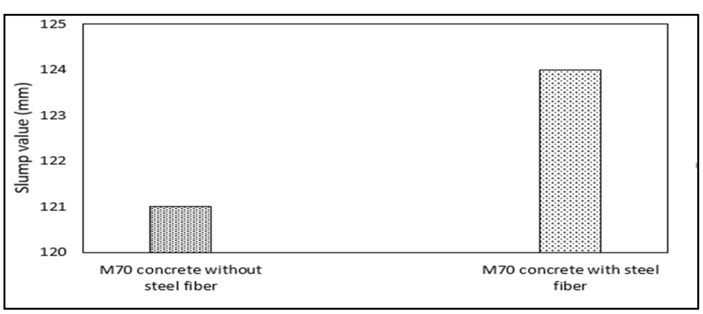

Fig 8. Effect on workibility

V. CONCLUSION

A parametric study is carried out for two different types of concrete to determine the effect of strength and workability of concrete. The concrete is designed and casted in laboratory and strength, workability is measured. Based on results, the following conclusions can be drawn.

1) In this study it is aimed that to prepare a Comparative analysis of high strength concrete's(M70) properties with and without using steel fibre like compressive strength and workability.
2) While testing we observe that due to the mixing of steel fibre the work ability of concrete gates decreased as compared to without steel fibre mix.
3) But the comprehensive strength which we have gotten the compressive strength of M70 (with steel fibre) is snidely more than that of m70 concrete without steel fibre.

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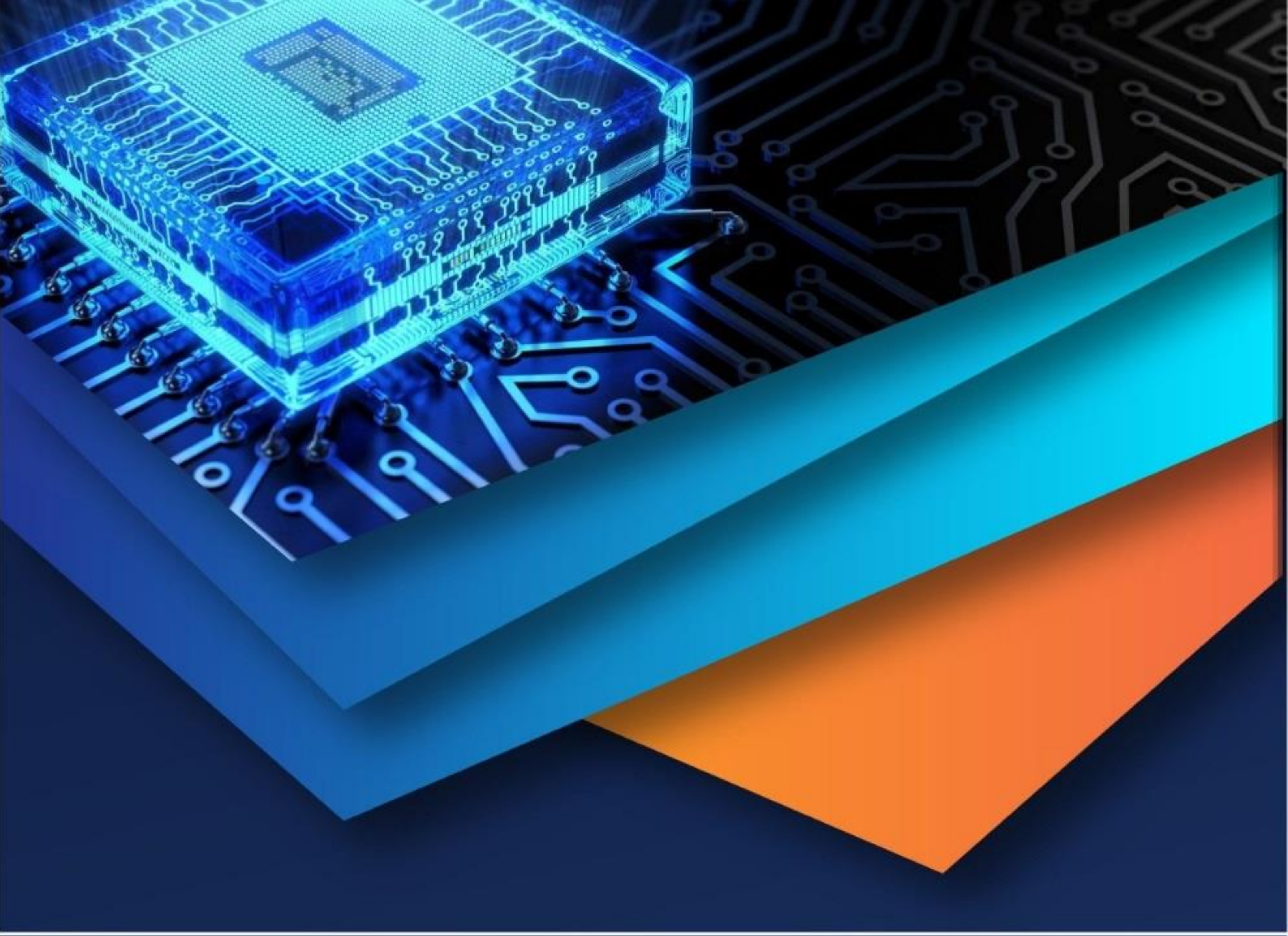

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