

Studying the effects of Fibers and Mineral Admixtures on High Strength Concrete

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ABSTRACT -- This paper investigates on analyzing the effects of use of fibers and mineral admixtures in the mechanical properties of high strength concrete. This study involves the use of different mineral admixtures like fly ash, ground granulated blast furnace slag, silica fume along with steel fibers. It also includes determination of mix proportioning with different mineral admixtures and steel fibers, determination of water binder ratio, determination of basic properties of concrete such as tensile strength, compressive strength, flexural strength and water permeability. One of the main tasks of the construction industry is to increase the strength and reliability of structures while reducing construction costs. Effective use of fiber reinforced concrete is likely to lead to reduction in reinforcement. In the previous studies, very less research is carried out on use of fibers with a combination of two or more admixtures. Hence, it is felt that there is a need to explore the feasibility of arriving at an optimum mix using a combination of fibers with two or more mineral admixtures, so as to increase the properties at minimum cost.

Keywords— Fiber Reinforced Concrete, Fly ash, Steel Fiber Reinforced Concrete, Compressive strength, Tensile Strength.

I INTRODUCTION

Concrete is the most widely used man-made construction material in the world, and is second only to water as the most utilized substance on the planet. It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. Fresh concrete or plastic concrete when freshly mixed can mould into any shape and on harden state forms a rock like mass known as concrete. (Dr. M.C.Nataraja, 2003)

In the Present scenario, the use of high performance concrete has revolutionize the construction industries, however the use of steel fiber-reinforced concrete has significantly increased, because of its enhancement of material performance in toughness and crack control.

At present, the construction industry is turning towards pre-cast elements and requirement of post-tensioning has made the requirement of the high strength of concrete invariable. The construction today is to achieve savings in construction work. This can be achieved by using new and improved building materials, such as fiber-reinforced concrete. Compared to conventional concrete, fiber-reinforced concrete has higher static compressive, tensile, and shear strength, impact and fatigue strength, crack resistance and fracture toughness, heat resistance, and fire resistance.

II Review of Literature

Fiber reinforced concrete is cement- based composite material that has been developed in recent years. 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.

Fiber-reinforced concrete is becoming an increasingly popular construction material due to its improved mechanical properties over unreinforced concrete and its ability to enhance the mechanical performance of conventionally reinforced concrete. Fiber reinforcement is one of the most important modification methods to alter the brittle nature of plain concrete. Fibers are generally used as resistance of cracking and strengthening of concrete. (Rana, 2013)

A Use of fibers in concrete

Fibers are usually used in concrete for the following reasons:

- i. To control cracking due to both plastic shrinkage and drying shrinkage.
- ii. They also reduce the permeability of concrete and thus reduce bleeding of water.

B Steel Fiber Reinforced Concrete (SFRC)

Concrete is the most widely used structural material in the world with an annual production of over seven billion tons. For a variety of reasons, much of this concrete is cracked. The reason for concrete to suffer cracking may be attributed to structural, environmental or economic factors, but most of the cracks are formed due to the inherent weakness of the material to resist tensile forces. (Nguyen Van Chanh, 2007)

Advantages of steel fibers

- i. Steel fibers when added in concrete improve structural strength.
- ii. By adding steel fibers, steel reinforcement requirement reduces.
- iii. Addition of steel fibers improves the ductility of concrete.

III Materials and Properties

3.1 Ground granulated blast furnace slag

Ground Granulated Blast furnace slag (GGBS) is a by-product for manufacture of pig iron and obtained through rapid cooling by water or quenching molten slag. Here the molten slag is produced which is instantaneously tapped and quenched by water. This rapid quenching of molten slag facilitates formation of “Granulated slag”. Ground Granulated Blast furnace Slag (GGBS) is processed from Granulated slag. Though the use of GGBS in the form of Portland slag cement is not uncommon in India, experience of using GGBS as partial replacement of cement in concrete in India is scanty. (Karim et al., 2011)

3.2 Fly ash

Fly ash is the most widely used supplementary cementitious material in concrete. It is a byproduct of the combustion of pulverized coal in electric power generating plants. Upon ignition in the furnace, most of the volatile matter and carbon in the coal are burned off. During combustion, the coal’s mineral impurities (such as clay, feldspar, quartz, and shale) fuse in suspension and are carried away from the combustion chamber by the exhaust gases. In the process, the fused material cools and solidifies into spherical glassy particles called fly ash. The fly ash is then collected from the exhaust gases by electrostatic precipitators or bag filters. Fly ash is a finely divided powder resembling portland cement. (Vikrant S. Vairagade et. Al, 2012)

3.3 Silica fumes

Silica fume, also referred to as micro silica or condensed silica fume, is a byproduct material that is used as a pozzolanic. This byproduct is a result of the reduction of high-purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Silica fume rises as an oxidized vapor from the 2000°C furnaces. When it cools it condenses and is collected in huge cloth bags. The condensed silica fume is then processed to remove impurities and to control particle size. (S. Bhanja, 2004 et. al)

3.4 Superplasticiser

A substance which imparts very high workability with a large decrease in water content (at least 20%) for a given workability. A high range water reducing admixture (HRWRA) is also referred as Superplasticiser, which is capable of reducing water content by about 20 to 40 percent has been developed. The effect of Superplasticisers lasts only for 30 to 60 minutes, depending on composition and dosage and is followed by rapid loss in workability. High range superplasticiser was used in all the concrete mixes to achieve good workability. Superplasticisers are added to reduce the water requirement by 15 to 20%. (M.A.Rashida et. al, 2008)

3.5 Cement

Cement is a material that has cohesive and adhesive properties in the presence of water.

Such cements are called hydraulic cements. These consist primarily of silicates and aluminates of lime obtained from limestone and clay. There are different types of cement; out of that I have used two types i.e,

1. Ordinary Portland cement
2. Portland slag cement

3.6 Aggregate

Aggregate properties greatly influence the behaviour of concrete, since they occupy about 80% of the total volume of concrete. The aggregate are classified as

- (I) Fine aggregate
- (II) Coarse aggregate

Fine aggregate are material passing through an IS sieve that is less than 4.75mm gauge beyond which they are known as coarse aggregate. Coarse aggregate form the main matrix of the concrete, where as fine aggregate form the filler matrix between the coarse aggregate. The most important function of the fine aggregate is to provide workability and uniformity in the mixture.

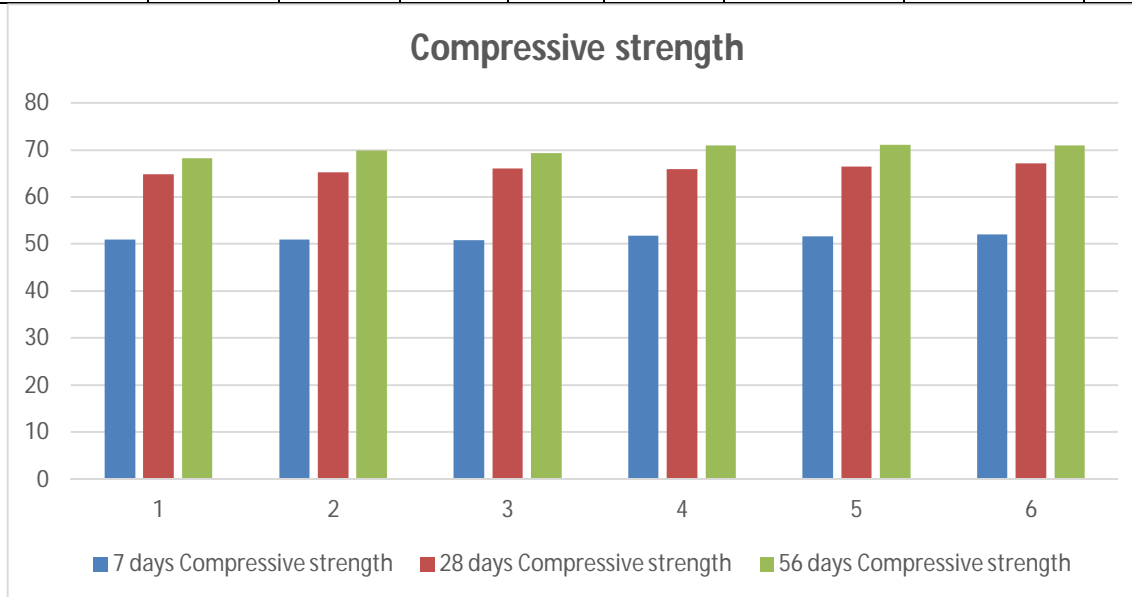
IV RESULTS

Compressive strength test results:

1. For different proportions of fiber

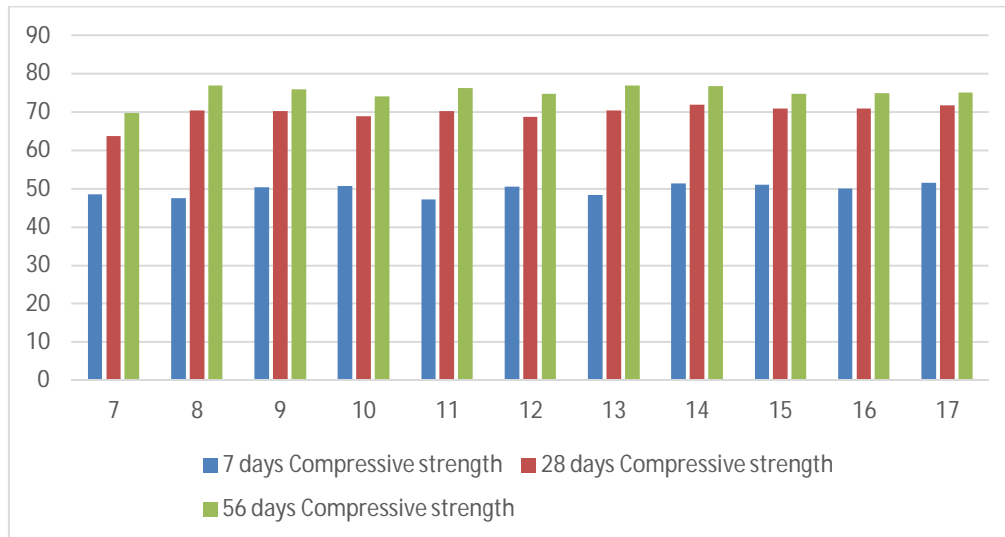
Mix Proportion No.	Cement	Fly ash	GGBS	Silica Fume	Fiber content %	7 days compressive strength in N/mm ²	28 days compressive strength in N/mm ²	56 days compressive strength in N/mm ²
1	50	20	30	0	0	50.9	64.8	68.2
2	50	20	30	0	0.5	50.9	65.2	69.9
3	50	20	30	0	1	50.8	66	69.3

4	50	20	30	0	1.5	51.8	65.9	71
5	50	20	30	0	2	51.6	66.4	71.1
6	50	20	30	0	2.5	52	67.2	71



Comparative results of compressive strengths
2. For different proportions of mineral admixtures

Mix Proportion No.	Cement	Fly ash	GGBS	Silica Fume	Fiber content %	7 days compressive strength in N/mm ²	28 days compressive strength in N/mm ²	56 days compressive strength in N/mm ²
1	100	0	0	0	1.5	48.5	63.7	69.7
2	80	15	0	5	1.5	47.6	70.4	77
3	80	0	15	5	1.5	50.3	70.2	75.9
4	75	20	5	0	1.5	50.7	68.9	74.1
5	75	20	0	5	1.5	47.2	70.2	76.3
6	70	20	10	0	1.5	50.6	68.8	74.7
7	70	20	0	10	1.5	48.3	70.5	77
8	70	15	15	0	1.5	51.3	72	76.8
9	65	20	15	0	1.5	51.1	70.9	74.8
10	65	20	0	15	1.5	50	70.9	75
11	60	25	15	0	1.5	51.6	71.7	75.1



Comparative results of compressive strengths

V CONCLUSION

The study on the introduction of effect of steel fibers can be still promising as steel fiber reinforced concrete is used for sustainable and long-lasting concrete structures. Steel fibers are widely used as a fiber reinforced concrete all over the world. Lot of research work had been done on steel fiber reinforced concrete and lot of researchers work prominently over it. The steel fibers are mostly used fiber for fiber reinforced concrete out of available fibers in market. According to many researchers, the addition of steel fiber into concrete creates low workable or inadequate workability to the concrete, therefore to solve this problem of superplasticiser without affecting other properties of concrete may introduce. The compressive strength test results indicate that the initial strength is high when GGBS is used. The optimum strength achieved is when we use fly ash and silica fume with sufficient reduction in cement content.

An effort was made to study the effect of use of fiber in high strength concrete and draw a conclusion with respect to an optimum mix with the balance between the cost and the advantage it offers with respect to the mechanical properties. The general perception of fiber hindering the flowability of concrete was discussed in detail with the industry experts and also observed during the conduct of field trails. It was inferred that the problem of hinderence in flowability can be neutralized through nominal enhanced dosage of superplasticizer without compromising on other properties. This will enable a flowable concrete with fiber thereby increasing the tensile of concrete. For an M-60 concrete, use of fiber enhances the 56 day compressive strength up to 77 MPa.

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