DETERMINATION OF MECHANICAL PROPERTIES OF STEEL FIBER REINFORCED CONCRETE WITH MINERAL ADMIXTURES

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ABSTRACT

This paper investigation on M-30 grade of concrete with water cement ratio 0.45 to study the compressive strength, and tensile strength of steel fibers reinforced concrete (SFRC) containing fibers of an interval of 0.5%,1%,1.5% volume fraction of hook end steel fibers of aspect ratio 60 were used. The different percentage of one or more mineral admixtures with combination of steel fibers is used in this study. After curing this specimen were tested as per relevant codes of practice Bureau of Indian standard. A result data obtained has been analyzed as compared with a control specimen. A relationship between compressive strength VS. days and flexural strength VS days respected graphically. Result data clearly shows percentage increase in 7, 28 & 54 days compressive strength for M-30 grade of concrete.

1. INTRODUCTION

1.1 GENERAL

Fiber reinforced concrete (FRC) is Portland cement concrete reinforced with more or less randomly distributed fibers. In FRC, thousands of little fibers are dispersed and distributed at random in the concrete during mixing, and thus get better concrete properties in all directions.

FRC is cement- based compound material that has been developed in recent years. It has been effectively used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is a successful way to raise toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. Fiber is a small part of reinforcing material possessing certain characteristics properties. They can be rounding, triangular or flat in cross-section. The fire is often described by a convenient parameter called ―aspect ratio. The characteristic ratio of the fiber is the ratio of its span to its diameter. The principle reason for incorporating fibers into a cement matrix is to raise the toughness and tensile strength and improve the cracking deformation characteristics of the resultant compound. For FRC to be a viable construction material, it must be able to complete cheaply with existing reinforced system.

Plain concrete possesses a very low tensile strength limited ductility and little resistance to cracking internal micro cracks are naturally present in the concrete and its poor tensile strength is due to the propagation of such micro cracks eventually leading to brittle fracture of concrete.

In the past, attempts have been made to impart development in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining techniques. Although both these methods provide tensile strength of concrete members, they however, do not raise the inherent tensile strength of concrete itself.

In plain concrete and similar brittle materials, structural cracks (micro cracks) develop even before loading, mainly due to drying shrinkage or other causes of volume change. The breadth of these original cracks rarely exceeds little microns, but their other two sizes may be of superior magnitude.

1.2. FIBER REINFORCED CONCRETE

1.2.1. Introduction

Fibers are generally used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also decrease the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce better impact abrasion, and shatter resistance in concrete. Normally fibers do not amplify the flexural strength of concrete, and so cannot substitute moment resisting or structural steel reinforcement. Indeed, some fibers

The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed "volume fraction" (V_f). V_f typically ranges from 0.1 to 3%. The aspect ratio (l/d) is designed by separating fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an corresponding diameter for the calculation of aspect ratio. If the fiber's modulus of elasticity is higher than the matrix (concrete or mortar binder), they help to carry the load by rising the tensile strength of the material. rising the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. However, fibers that are too long tend to "ball" in the mix and make workability problems.

Some recent investigate indicate that using fibers in concrete has limited effect on the impact resistance of the materials. This finding is very important since conventionally, people think that ductility raise when concrete is reinforced with fibers. The results also indicate that the use of micro fibers offers better impact resistance to that of longer fibers.

2. LITERATURE REVIEW

2.1. GENERAL

Some of the early research works had done using different pozzolanic materials with the substitutement of cement using super plasticizer for the development high performance concrete. Also the development in the field of fiber reinforced concrete along with mineral admixtures. So beneath an over view of different studies has been represented.

Aitkin [1] (1995) cited on development in the application of high performance concrete. Over the last few years, the compressive strength of some of concrete used has raised dramatically. In 1998, a 120 Mpa concrete was delivered on site, while, until relatively recently, 40 Mpa was considered indicative of high strength. The spectacular raise in compressive strength is directly related to a number of recent technical developments, in particular the discovery of the extra normal dispersing action of super plasticizers with which flowing concretes can be made with about the same mixing water that is actually required to hydrate all the cement particle or even less. The reduction in water/cement ratio results in the hydrated cement paste with a micro structure so dense and strong that coarse aggregate can become the concrete’s weakest constituent. Silica fume, a highly reactive pozzolana, considerably enhances the paste/aggregate interface and minimizes deboning. Finally, the use of supplementary cementitious materials, such as fly ash and specially slag, helps resolve slump loss problems which become dangerous at low w/c ratios.

Ajdukiewicz and radomski [2] (2002) delve into trends in the polish research on high performance concrete. They analyzed the main trends in the research on high performance concrete (HPC) in Poland. There they sighted on some example of the relevant investigations. e fundamental engineering and economical problems concerning the structural applications if HPC in Poland are presented as well as the needs justifying the raised use of the this material are briefly described.

Aitkin[2](2003) studied on the durability characteristics of high performance concrete. He examined durability problems of normal concrete can be associated with the severity of the environment and the use of in appropriate high water/binder ratios. High performance concrete that have a water/binder ratio between 0.30 and 0.40 are regularly more durable than regular concrete not only since they are less porous, but also since their capillary and pore networks are somewhat detached due to the maturity of self-desiccation. In high-performance concrete (HPC), the infiltration of aggressive agents is quite hard and only superficial. However, self-desiccation can be very injurious if it is not prohibited through the early phase of the development of hydration reaction, therefore, HPC must be cured fairly another way from normal concrete. Field knowledge in the North Sea and in Canada has shown that HPCs, when they are correctly designed and cured, execute adequately in very harsh environments. However, the fire resistance of HPC is not as good as that of normal concrete but not as bad as is occasionally written in a few negative reports. Concrete, whatever its type remains a safe material, from a fire resistance point of view, compared to other building materials

AI-khalaf and A. yousif (4) (1984) examined on use of RHA in concrete. They studied the actual range of temperature require to burn rice husk in order to get the desired pozzolanic product, use of rice husk as partial substitutement of cement on compressive strength and volume changes of different mixes. And showed that up to 40% substitutement can be complete with no significant modify in compressive strength compared with the organize mix. He tested on mortar cube, by testing on50mm cubes. In his investigation also he deduced that the most convenient and economical burning conditions required converting rice husk into a homogenous and well burnt ash is at 500^0c for 2 hours. Also for a given grinding time, there is a considerable reduction in the specific surface area of RHA content, the water requirement decreases as the fineness of the ash raises. The minimum pozzolanic activity can be obtained, when the ash has a specific surface of about 11,500 cm^2/gm. The strength of cement RHA mortar approaches the strength of the corresponding plain mortar when the specific surface of RHA about $17000cm^2$/gm.

3. MATERIALS AND METHODS

3.1. MATERIALS

The materials used in this present investigation are Normal Portland cement (53 grade), water, coarse aggregates, fine aggregates (sand, sag).In recent years, improvements in concrete properties have been achieved by blending cements with cementitious admixtures such as fly ash (FA),granulated blast furnace slag (GBFS). Incorporation of these materials in concrete mixes improves the durability concrete. The movement of aggressive substances such as chloride ions and carbon dioxide into concrete which are the main causes of deterioration of concrete structures that affect their integrity and long term serviceability life, is thus very much reduced. The deterioration of concrete is not a result of only aggressive agents, but the overall quality of concrete and also plays a major role. In view of this problem, a growing number of concrete structures are constructed or under construction with the use of cement substitutement materials. Therefore any attempt to alleviate the deterioration-risk implies producing good performance concrete capable of withstanding the harsh environmental conditions.

In this chapter, the materials and methods described together with their properties. In this the tests carried out on different concrete mixes, curative regimes, mix proportions and casting of specimens is discussed.

3.1.1 Fly ash (FA)

Fly ash is a by-product of the combustion of pulverized coal in power stations. It is a solid material extracted by electrostatic and mechanical means from the flue gases of furnaces fired with pulverized bituminous coal. During production of FA, the coal passes through the high temperature zone in the furnace and the carbon and volatile matter are burned off, whereas most of the mineral impurities, such as clays, quartz, and feldspar melt at high temperature. The fused matter is quickly transported to low-temperature zones, where it solidifies as spherical particles of glass. Some of the mineral substance agglomerates forming bottom ash, but most of it flies out with the flue gas stream and is called "fly ash". This ash is subsequently removed from the gas by mechanical separator, electrostatic precipitators. Its main constituents are SiO_2, AL_2O_3 and Fe_2O_3 with smaller quantities of other metal oxides, the chemical composition of fly ash.

Due to its unique mineralogical and granulometric characteristics, fly ash generally does not need any processing before use as a mineral admixture. Bottom ash is much coarser, less reactive and therefore requires fine grinding to develop a pozzolanic property. Average worldwide utilization of fly ash is about 15%, whereas in India, its utilization is form 2 to 5% only. In the present study Fly ash is collected from RTPP. It is conformed to grade1 of IS: 3812-1981.

The physical properties of fly ash are shown in the following table 3.1

Table: 3.1 Physical properties of fly ash

S.NO	DESCRIPTION	
1	Specific Gravity	2.5
2	Physical Form	Powder
3	Colour	Dark grey

3.1.2Silica fume

Silica fume is a by-product of silicon or Ferro-Silica industry and is 100 times finer than cement. A silica fume is also referred to as micro silica or strong silica fumes. It consists of amorphous silica and has high reactivity towards lime. The substitute level of silica fume is generally low at about 10%. When SF is used in concrete mix, its beginning affects the physical understanding of the system, particularly near the aggregate surface where porosity exists. Silica fume starts reacting at the early stage of hydration procedure. The pozzolanic action of silica fume reduces considerably the quantity and size of “CH” crystals in hydrated cement paste. This phenomenon along with low W/C ratio reduces the thickness of conversion zones and thus the preferential orientation of CH crystals is significantly reduced. All these result in more uniform, stronger conversion zone potential of micro cracking.

Silica fume, also known by other names, such as condensed silica fume, volatilized silica, or simply as micro silica, is a by-product of the induction arc furnaces in the silicon metal and ferrosilicon alloy industries. Reduction of quartz to silicon at temperatures of up to 2000°C

Produces Compared to normal Portland cement and typical fly ashes, condensed silica fume samples show particle size distributions that are two orders of magnitude finer. This is why on the one hand the material is highly pozzolanic, but on the other it creates problems of handling and increases the water requirement in concrete appreciably unless water reducing admixtures are used. The by-product from the production of ferrosilicon alloy with 50 percent silicon contains much lower silica content and is less pozzolanic.

The silica fume used in all concrete mixes was obtained from Elkem Materials Limited. The chemical composition information is given in Table 3.2. It can be seen that the silica fume contains 85% silicon dioxide. The physical properties of Silica fume are shown in the following table 3.2

Table: 3.2 Physical properties of Silica fume

S.NO ·	DESCRIPTION	
1	Specific Gravity	2.2
2	Physical Form	Powder
3	Colour	Grey

4. RESULTS OF INITIAL AND FINAL SETTING TIME

4.1 Initial and final Setting time of cement with replacement of fly ash

The variations in the initial and final setting times of cement with addition of fly ash. From table 4.1 it is observed that both the initial and final setting times got retarded and accelerated by replacement of fly ash in the ordinary Portland cement.

Table 4.1: Initial and Final setting time values cement with replacement of fly ash

S.NO	Details of Material	Initial Setting Time (minutes)	Final Setting Time (minutes)
1	100% cement + 0% FA	45	300
2	95% cement +5% FA	50	300
3	90% cement +10% FA	60	290
4	85% cement +15% FA	70	280
5	80% cement +20% FA	70	260

5.3.2 Initial and final Setting time of cement with replacement of silica fume

The variations in the initial and final setting times of cement with addition of silica fume. From table 5.4 it is observed that both the initial and final setting times got retarded and accelerated by replacement of silica fume in the ordinary Portland cement.

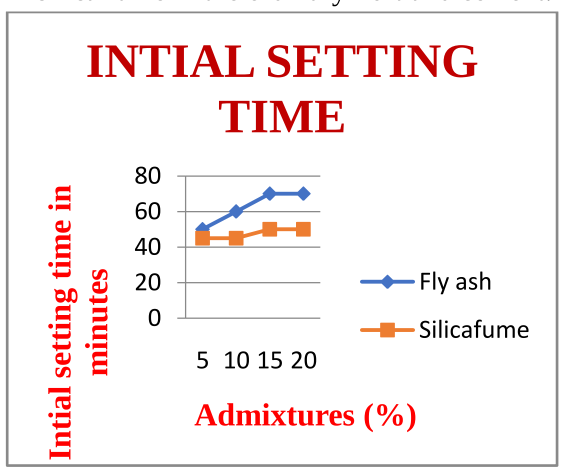

Figure 4.1: Effect on initial setting time for replacement of cement with different Admixtures

From above results it can be known that the initial setting time of normal cement paste is 45 minutes. From figure 4.1 the initial setting time was found to increase as the replacement percentage increases after the replacement of 5%. As per the Indian standards, the initial setting time should not be less than 30 minutes. Here all the replacement percentages satisfy this requirement.

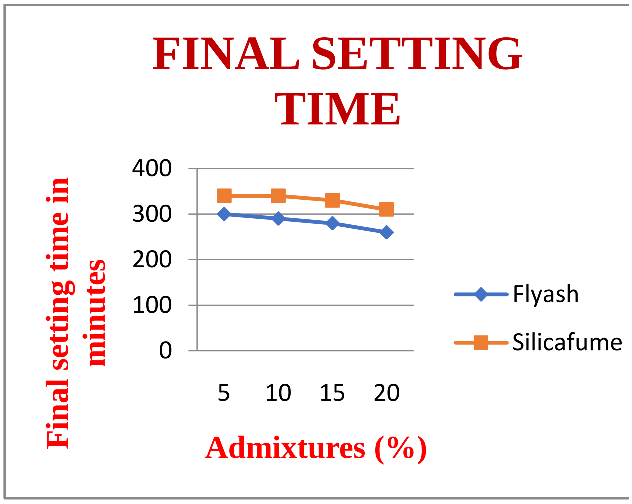

Figure 4.2: Effect on final setting time for replacement of cement with different admixtures

From above results it can be known that the final setting time of normal cement paste is 300 minutes. From figure 4.2 the final setting time was found to decrease as the replacement percentage increases after the replacement of 5%, as per the Indian standards, the final setting time should not be more than 600 minutes. Here all the replacement percentages satisfy this requirement.

CONCLUSIONS

The study on the effect of steel fibers with Fly Ash and silica fume can still be a promising work as there is always a need to overcome the problem of weakness of concrete. The following conclusions could be drawn from the present research.

1. Marginal raise is observed in the workability as percentage of Fly Ash and silica fume rises.
2. Density of concrete is more as the proportion of steel Fiber raises.
3. Compaction factor is raises as the Steel Fiber proportion decreases.
4. Higher percentage of Steel Fibers slump was down.
5. Water falling agent is required for workable mix as percentage of Steel Fiber raises.
6. Stiffness of specimens is raised because of Steel Fibers, Fly Ash and silica fume.
7. The strength of specimen is about 82% at 28th day and 95 to 100% at 45 days, because of steel fibers, Fly Ash and silica fume.

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