A STUDY ON BEHAVIOR OF ULTRA HIGH STRENGTH CONCRETE AT ELEVATED TEMPERATURES

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ABSTRACT

Concrete is a composite material composed of cement, coarse aggregate, fine aggregate and water in pre-dominant proportions. These days concrete is being used for wide varieties of purposes to make it suitable in different conditions. In these conditions ordinary concrete may fail to exhibit the require quality performance or durability. In recent years, the terminology "Ultra High Strength Concrete" has been introduced into the construction industry. Most high strength concrete produced today contains materials in addition to ordinary Portland cement to help achieve the compressive strength or durability performance. These materials include fly ash, silica fume and ground-granulated blast furnace slag used separately or in combination. At the same time, chemical admixtures such as high-range water-reducers are needed to ensure that the concrete is easy to transport, place and finish. For high-strength concretes, a combination of mineral and chemical admixtures is nearly always essential to ensure achievement of the required strength. In our present work, we have used Silica Fume as the air entraining admixture and Ceraplast 300 as the water reducing admixture for obtaining the required strength.The Mix Proportion for M100 grade concrete has derived as by using ACI Method. The present study deals UHSC and its thermal behavior. The first part deals by changing the various percentages of silica fume and ceraplast 300 and the strength is attained at desired percentage. The second part deals with the effect of elevated temperature ranging from 500C to 2500C for different duration of hours i.e. (1, 2, 3 hours) at each temperature.

***KEY WORDS**: Ultra High Strength Concrete (UHSC), silica fume, ceraplast300, compressive strength, spilt tensile strength.*

I. INTRODUCTION

1.1. Ultra High Strength Concrete

Long-term performance of structures has become vital to the economies of all the nations. Concrete has been the major instrument for providing stable and reliable infrastructure. Detoriation, long term poor performance, and inadequate resistance to environmental affects led's to the accelerated research into the microstructure of cements and concretes and more number of codes and standards. As a result, new materials and composites have been developed and improved cements evolved. One major remarkable quality in the making of Ultra High Strength Concrete (UHSC) is the virtual elimination of voids in the concrete. UHSC is defined in terms of Strength and Durability. Therefore UHSC 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.

1.2. Thermal behavior of UHSC

Concrete properties are changed by fire exposure, as fire is one of the most severe conditions when the structures are exposed for it. Mechanical properties such as compressive strength and modulus of elasticity are considered. When the concrete is subjected to elevated temperature, the incompatibility of thermal deformations within the constituents of concrete initiates cracking. Internal stress is also caused by microstructure change due to dehydration and steam pressure build up in the pores. Exposure to elevated temperatures causes physical changes in Ultra strength concrete including large volume changes due to thermal shrinkage and creep related to water loss. The changes in volume will result in large internal stresses thus leading to micro cracking. Elevated temperature also generates some chemical and micro structural changes such as migration of moisture and thermal incompatibility of interface between cement paste and aggregate. All these changes will have a bearing on the strength and stiffness of concrete. Based on the limited amount of experimental data available to date, it has been found that the effects of elevated temperatures on the mechanical properties of Ultra strength concrete vary with a number of factors including the test methods, permeability of concrete, the types of aggregate used and moisture content.

1.3. Objective

The objective of the present paper is to produce UHSC and to study the behavior of M100 concrete when exposed to elevated temperatures for different duration of hours.

II. MATERIALS

The materials used in this study are ordinary Portland cement of 53 grade of concrete with a specific gravity of 3.12, locally available sand with a specific gravity of 2.58, coarse aggregate conforming to IS: 383 -1970 of 20mm and 12 mm with a specific gravity of 2.74 is used.

2.1. Silica fume

It is a by-product of producing silicon metal. One of the most beneficial uses for silica fume is in concrete. Because of the chemical and physical properties and it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silicon metal and alloys are produced in electric furnaces. Raw materials are quartz, coal, and woodchips. Smoke that results from furnace operation is collected and sold as silica fume, rather than being land filled. Perhaps the most important use of this material is as a mineral admixture in ultra strength concrete.

2.2. Ceraplast300

It is a high-grade super plasticizer based on Naphthalene, highly recommended for increased workability and high early and ultimate strengths of concrete.

III. METHODOLOGY

According to ACI 211.1, the mix proportion for M100 grade of concrete has been derived, maintaining a W/C ratio of 0.25. For the derived mix proportion, compressive strength & split-tensile strength are determined. In the above derived mix proportion by changing the various percentages of silica fume (2%,4%,6%,8%,10%,12%,14%) & Ceraplast300 (0%,0.5%,1%,1.5%,2%) the test are performed in order obtain the optimum percentage of silica fume.

Based on the optimum percentage of silica fume, cubes are casted & an oven with a maximum temperature of 300^0C was used for exposing the specimens to different elevated temperatures. The specimens were kept in the oven for a specified duration after the temperature in the oven reached the defined temperature. The specimens were heated to different temperatures of 50, 100, 150, 200 and 250^0C for different durations of 1, 2 and 3hours at each temperature, the thermal behavior of concrete is analyzed.

3.1. Test Procedure

The concrete cubes of size 150 mm and cylinders of size 300 mm height and 150 mm diameter are casted and used as test specimens to obtain the compressive strength and split tensile strength. Tests are conducted at the end of 28 days from the date of casting in order to attain the optimum percentage of silica fume.

3.2. Casting and curing specimens

The test specimens were demoulded after a lapse of 24 hours from the commencement of casting and submerged in water until the time of testing.

IV. Experimental Test Results

Table 1. Determination of Compressive Strength, Split tensile strength & Flexural strength

PERCENTAGE OF SILICA FUME	PERCENTAGE OF CERAPLAST 300	Compressive Strength (N/mm^2)	Split tensile Strength (N/mm^2)
2	0	48.61	4.25
4	0.5	66.23	5.41
6	1.0	77.76	5.78
8	1.5	98.29	5.91
10	2.0	110.40	5.93
12	2.0	87.77	5.4
14	2.0	65.90	4.96

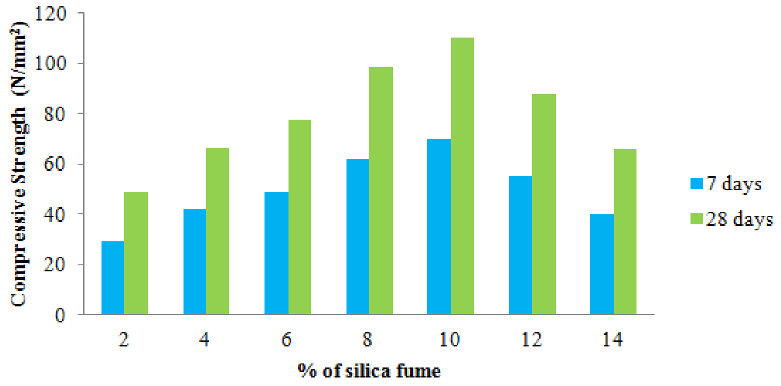

Figure 1. Variation of % of silica fume with compressive strength

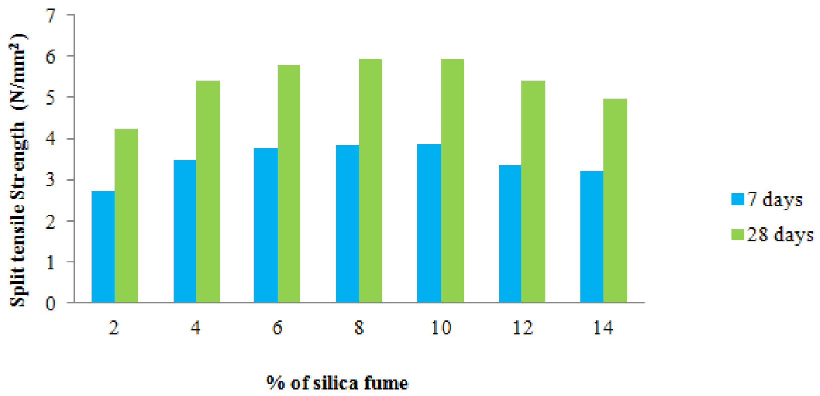

Figure 2. Variation of % of silica fume with split tensile strength

4.1. Exposing the specimen to elevated temperatures

An oven with a maximum temperature of 300^0C was used for exposing the specimens to different elevated temperatures. It was provided with a thermostat to maintain constant temperature at different ranges. The specimens were kept in the oven as shown in fig. for a specified duration after the temperature in the oven reached the defined temperature. The specimens were heated to different temperatures of 50, 100, 150, 200 and 250^{0}C for different durations of 1, 2, 3 hours at each temperature. The specimens were tested for their strengths with minimum delay after removing from the oven in a hot state under unstressed condition.

Figure 3. Cube in oven while heating

Figure 4. Testing of concrete cube

Table 2. Compressive strengths at 7days of cubes after exposing to elevated temperature

Temperature (^{0}C)	Compressive Strength (N/mm^2)		
	1 hour duration	2 hours duration	3 hours duration
27	69.54	69.54	69.54
50	72.13	70.49	69.86
100	74.22	72.14	71.64
150	77.76	72.82	74.84
200	62.66	62.48	56.82
250	54.75	52.71	45.46

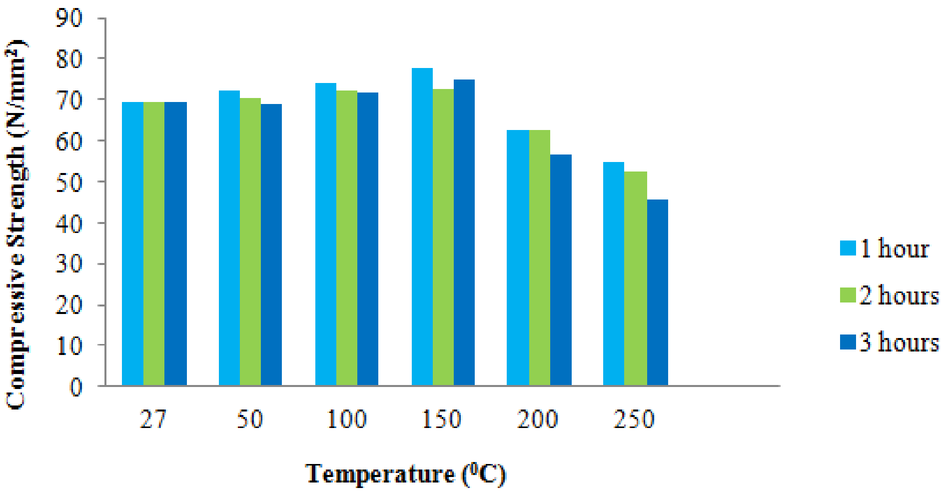

Figure 5. Variation of % compressive strength with temperature

V. CONCLUSIONS

On the basis of the experimental work the following conclusions are drawn.

1. By maintaining the w/c ratio as 0.25, the 28-day strength of the concrete is achieved as 110.40 N/mm^2 at 10% of silica fume and 2% of Ceraplast300.
2. It was also observed that for 10% of silica fume and 2% of Ceraplast300 the split tensile strength is achieved 5.93 N/mm^2 .
3. The strength of the concrete may be still increased by reducing the w/c ratio & increasing the percentage of silica fume.
4. The compressive strength of M100 concrete are increased initially up to a temperature of 50 - 150^0C and beyond that they got reduced rapidly with increasing the temperature.
5. The compressive strength is lost very much when they are heated at 250^0C.

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