International Journal for Scientific Research
IJSR, London, UK
Vol. (3), No. (1)

IJSR
January 2024

المجلة الدولية للبحوث العلمية
E-ISSN 2755-3418
الإصدار (3)، العدد (1)

Effect of Aging Time on Split Strength of Silica Fume Reinforced High Strength Concrete Composite

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Abstract

The goal of this study is to gather a High Strength Concrete (HSC) composite reinforced with silica fume and superplasticizers. Specimens are Cured by water and tested after aging for 3, 7, and 28 days, which are basic components of the High Strength Concrete (HSC) composites. After designing mix proportions, according to design requirements, some adjustments were made. Both fresh and hardened properties of the specimens were tested under standard conditions (curing schemes, setting time, etc.). Split strength test results were gathered and compared with the requirements.

Keywords: Aging Time, Split Strength, Silica Fume, Concrete Composite.

1. Introduction

Concrete is a composite material composed of aggregate bonded together with a fluid cement that cures over time. Concrete has many properties especially High Strength Concrete (HSC) due to the combination of different materials (cement, aggregate, water etc.), in addition, this includes some admixtures depending on the required situation and concrete is the most important member of the construction.

Due to this design and production of HSC is not a simple process and there are no definite techniques to define the proportions of the materials used. In order to gather safe yield each member of the concrete should be tested. Depending on this situation, preparing mixture of the HSC carefully should be done. The cast specimens were 150x300 cylinder specimens used for tensile splitting strength test. For All specimens were cured in water tank until the specified test age.

2. Experimental Procedure

2.1 General

Cement, aggregate, and mixing tests and properties of the proposed HSC composite are performed according to specified standards.

2.2 Components of Reinforced High Strength Concrete Composite

2.2.1 Cement

Özgür Çimento PKC/B 52.5 cement was used.

2.2.2 Aggregates

Limestone crushed rock aggregate was used. 4 grading types of Aggregates, which are 1,2,3, and 4, having approximately max sizes 20, 14, 10, and 5 mm respectively. Only type 4 is taken as fine aggregate and the remaining are coarse aggregates.

The approximately percentages by weight of aggregates used in the mixture of concrete composite are given as follows from the finer aggregate to the coarser, type 4 was 47%, type 3 was 24%, type 2 was 18%, and type 1 was 11%.

2.2.3 Admixtures

2.2.3.1. Silica Fume

To increase the strength of the concrete composite, silica fume used as a reinforcement material; The high surface area of silica fume particles is an important factor affecting the reactivity of the particles and plays very important role in improving the physical and chemical properties of concrete. Silica fume addition benefits concrete in two ways, firstly, the minute particles physically decrease the void space in the cement matrix, and secondly, silica fume works as

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very effective pozzolan. Silica fume was used in the mixed design at 10 % addition by weight of the cement. Silica fume is used to increase strength and durability of concrete, but generally requires the use of superplasticizers for workability. The Chemical Composition of Silica Fume is announced in Table (1).

Table (1): Chemical Composition of Silica Fume

Ingredients	%
Insoluble SiO_2	50.66
Soluble SiO_2	25.90
Al_2O_3	0.70
Fe_2O_3	0.42
CaO	1.06
MgO	5.04
SO_3	1.18
Loss on Ignition	3.72

2.2.3.2. Superplasticizers

Superplasticizers, also known as high range water reducers. Plasticizers are chemical compounds enabling the production of concrete with approximately 15% less water content. Superplasticizers allow a reduction in water content by 30% or more. These additives are employed at the level of a few weight percent. Plasticizers and superplasticizers also retard the setting and hardening of concrete. and can be used to increase workability more than is practical with traditional plasticizers.

2.3 Mix Details

The water to cement ratio used was 0.375. Concrete samples were produced by using silica fume at percentages of 10% by weight of cement and superplasticizers at 7% by weight of water for mixes. Proportioning of each material was done by the balance which is the weight batching method and it is the best approximation for the determining quantity of each member of the mix. The superplasticizers

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were mixed with water then loaded into the mixer to get more efficient and uniform distribution.

2.4 Curing of Test Specimen

The specimens of concrete composite were cured by keeping it in the molds for 24 hours in the curing room and after 24 hours these test specimens were immersed into the water-curing tank, the duration of the specimens in this tank depending on the test ages (3, 7, 28 days).

2.5. Splitting Tensile Strength Test

Because of the difficulties in applying directly tension, test split-cylinder tensile test is widely used. The loading rate of this test was 0.04 Mpa/s. The tensile splitting strength f_{st} is then calculated from the equation as follows:

$$f_{st} = 2P/\pi LD$$

where:

f_{st}: is splitting tensile strength (MPa),

P: is the maximum applied load (Newton),

L: is the length of specimen (mm), and;

D: is the diameter of the specimen (mm).

The standard used for the tensile splitting strength test was ASTM C 496-90:1999.

3. Results and Discussions

3.1. Properties of Fresh Concrete

In the fresh state of concrete, tests of Slump, K-slump, and Ve-Be time (to measure workability) were conducted and explained in Table (2).

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Table (2): Fresh Properties of Trial Mix

MIX	W/C	SLUMP (mm)	Ve-Be (seconds)	K-SLUMP
	0.375	160	3	0.5

3.2 Splitting Tensile Strength Test

Table (3) shown below represents Tensile Splitting Strengths at target ages tested on 150x300 mm cylinder specimens. The tensile strength is gained rapidly at an early age as it is shown in Fig (1).

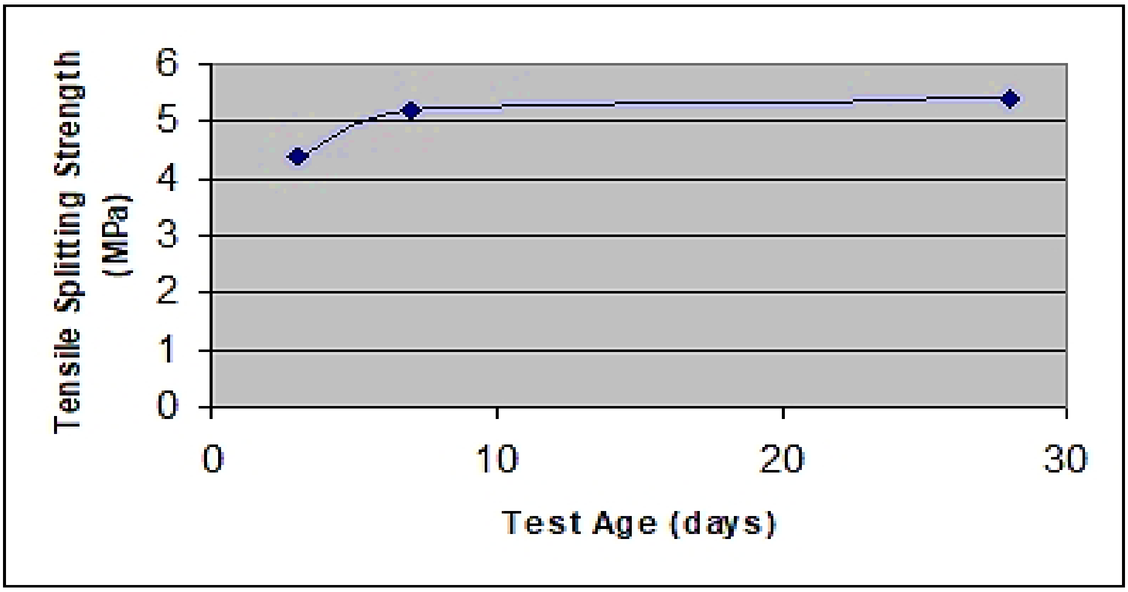

Fig (1): The Splitting Tensile Strength Gain with Age

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Table (3): Tensile Splitting Strength Results

Test age	Weight (kg)	Force (N)	Splitting Tens Strength (MPa)	Average
3	12.774 12.499 12.671	320 298.2 308	4.53 4.218 4.36	4.4
7	13.036 12.646 12.538	347 404 357	4.91 5.72 5.05	5.2
28	12.850 12.558 12.552	400 413 407	5.66 5.84 5.76	5.75

3.3 Water Permeability

Permeability is the ease with which liquid or gases can travel through concrete. Water to cement ratio influences concrete permeability to a great extent. The higher the w/c ratio the greater the concrete permeability. The water permeability reveals that there is about 87 percent reduction in the coefficient of permeability achieved by the inclusion of 10% Silica fume (SF) by weight of cement. The relation between 53.3 mm for the depth of penetration for normal strength which is prepared with the same aggregate and tested with the same equipment according to the same specification (DIN1048). When this result is compared with the obtained values from this study which was less than 10 mm, it is seen that high strength concrete has very low permeability than that of NSC. The use of admixtures such as silica fume, high-range water reducers allows the placement of highly impermeable concrete.

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4- Conclusion

High splitting tensile strength of silica fume reinforced high strength concrete composite was obtained at early ages. It gained 75% of its strength at 28 days after 3 days of curing time, and 90% of its strength at 28 days after 7 days of curing time. Then the splitting tensile strength increased slightly till 28 days.

It can be concluded that the use of silica fume and high-range water reducers leads to concrete with low water permeability compared with NSC.

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