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Research Paper

Study on Behaviour of Self-Healing Concrete Using Silica gel

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Abstract

The procedures to enhance the strength and reliability of materials depend on the worldview of damage prevention, i.e. the materials are composed and arranged so that the development and expansion of damage is postponed however much as could reasonably be expected. The reinforced concrete structures are subjected to various loads such as heavy vehicles movement, earthquakes, and strong winds etc. which inevitably develop micro cracks. When micro cracks originates, a sequence of events begin within structures. These cracks affect the performance and strength of the structure, in addition withdurability of the structure.

To overcome the above problems, it is required to consider the use the Self-Healing Concrete (SHC). In this work the attempt is made to study the use of silica gel as self-healing agent in M60 grade of concrete. The healing agent is mixed in varying proportions are 0.1%, 0.2%, 0.3% and 0.4% respectively by weight of cement inblended concrete mix grade of M60. The performance of silica gel as a self-healing agent was analyzed at different curing periods of 7, 14 and 28days. The concrete specimens were prepared to study the mechanical strength properties lie compressive strength, split tensile strength and flexural strength of blended concrete with and with addition of silica gel.The compressive strength of the blended cement concrete with addition of 0.3 % of silica gel gives 6.54% more strength compare to the control specimens at the age of 28 days testing. The performance of the 0.3% of Silica gel replacement in mechanical strength properties gives considerable effective enhancer compare to the control specimens. Based on the results it can be concluded that the optimum replacement is 0.3% silica gel. Silica gel can be used as one of the healing material in the construction of tunnel, underwater structures etc..

Keywords: *Self-Healing Concrete, Silica gel, Mechanical Strength properties, Compressive strength*

1. Introduction

Concrete is one of the extensively used civil engineering materials in the construction industry due to its strength characteristics, moderately minimal cost, etc.One hostile property of this is its affectability to formation of crackdue to low tensile strength. The crack occurring will affect the long term property of concrete structures as forceful fluids and gasses may enter into the matrix along these cracks and cause damage [1,2]. Subsequently, cracks may become more extensive and the support might be presented to the earth. Once the reinforcement begins to erode, total failure of the structure may happen. Repairing of cracks will be troublesome when cracks are undetectable or out of reach. The above said issue can be salved by applying the principles of self healing concrete.

To get healing it is essential that particles or atoms spill out of their underlying position in the region of the damage site to the actual crack and once arrived there, the physical contact between both crack sides are regained. In time, the material recently saved in the crack will construct substantial load carrying capacity. Current material outline in designing takes after the idea of damage counteractive action and design option outline rule is that of self-healing materials, as per the idea of damage administration as presented by previous researchers. Crack formation does not really bring about issues, in the event that it is consequently healed. Self healing materials need to serve a few parts and meet a few properties [3,4].

In the event of concrete long term property is predominantly considered for harm to be healed, with a specific end goal to reduce expenses of repair and maintenance. Focus for self healing concrete is to reduce lattice permeability via fixing or blocking cracks. healing agent is fused in the concrete matrix and acts without human intercession. Inclination lies in operators acting as an catalyst, empowering numerous healing events. To make the material in technically and financially focused, healing agent should be cheap in connection to the low cost of concrete, remain conceivably dynamic for long periods time. Self healing is essential to watertight structures and to increases the service life of infrastructures. Self-healing can be characterized as capacity of material to heal damages consequently [5,6].

The self healing has two sorts are autogenous (necessities human intervention) or outer triggering autonomic (with no intercession). The capacity of natural self healing of concrete is named as Autogenous healing. The principle procedure of autogenous healing are swelling and hydration of cement paste, precipitation of calcium carbonate precious stones and blockage of stream ways because of deposition of water impurities that different during the cracking procedure.

In the present work, an attempt was made to investigate the effect of self healing agent silica gel on mechanical strength properties like compressive strength, Split tensile strength and flexural strength of the M60 grade concrete by adding varying quantity of silica gel 0.1%, 0.2%, 0.3% and 0.4% t various curing periods 7,14 and 28days were studied.

2. Experimental Programmed

2.1. Materials Used

In this investigation were used Ordinary Portland cement 53 grade conforming to Indian Standard IS: 12269-2013[6], which is having the specific gravity of 3.14 and fineness modulus was 3. The smooth textured fine aggregate is used, conforming to Indian Standard IS: 383-1970 [7]having the specific gravity and fineness modulus of 2.6 and 2.76 respectively.The coarse aggregate used in the experiment were about 20 mm and tested as per IS: 2386-1963 (III) [8] specifications, having specific gravity of 2.5 and fineness modulus of 5.195.Silica Fume (SF)and Fly Ash (FA)sample with proper spherical morphology can increase the workability and decreasing the water-to-cement ratio to 0.3 in favourable cases. The specific gravity of Silica fume and Fly ash are 2.22 and 2.10 respectively. The role of Super plasticizer can rise the workability of concrete mix and shrink the amount of water demand, thus produce HPC. The super plasticizer used for this project is SP CONPLAST 430 having specific gravity of 1.20. Silica gel which used in the form of hard capsules. It possesses specific gravity of 2.10.

2.2 Mix Design for M60 Grade of Concrete

The mix design was carried out for 5 mix proportions with Silica fume and Fly ash along with Silica Gelas per AITCIN-1998, IS10262, 1984 [9]. The Mix design was arrived by calculations based on the material properties and tested values of the ingredients. Silica Gel was used in the four mixes with Silica fume and Fly ash. The quantities of materials for M60 grade of concrete using silica gel are Cement is 422 Kg/m3, Coarse Aggregates is 1075 Kg/m3, Fine aggregates is 647 Kg/m3, Silica fume is 23.45 Kg/m3, Fly ash 23.45Kg/m3, Water 146.4 Kg/m3, Super Plasticizer is 4.9Kg/m3 and the silica gel is 0.1, 0.2, 0.3, 0.4% of replacement are 0.43, 0.85, 1.27, 1.69 Kg/m3 respectively.Trail mixtures were prepared to obtain the required strength. The mixes were designed with around 20% replacement Silica fume, Fly ash in OPC, which is taken as control mix. In addition to that, 0.1%, 0.2%, 0.3% and 0.4% of Silica Gel has been added by the weight of cement. Various specimens were casted to check different strength at 7, 14 and 28 days ages of concrete according to the IS 516:1959 [10].

2.3. Specimen Preparation and Testing

To determine strength properties, specimen wascasted and tested at various curing period. The specimens were casted as per the test requirement in the code references. For compressive strength test 150×150×150 mm cubes were casted. For testing flexural strength 100×100×500 mm beams were castedaccording to IS 516:1959. For split tensile strength cylindrical specimen of 150 mm diameter and 300 mm length were castedaccording to IS 5816:1999 [11]. The specimens were demoulded after 24 hours of casting and were cured in water until the testing age.

3. 3 Results and Discussion

3.1 Basic properties of Blended materials

The basic properties of materials were studied such as specific gravity, fineness, consistency, setting time, fineness modulus. The consistency of cement is 34% and the initial setting time is 35 minutes. The fineness modulus of coarse aggregates and fine aggregate is 5.2 and 2.76 according to the IS 383.1960.

3.2 Compressive Strength Test of Self-Healing Concrete

The compression strength test was carried out on cubes casted for the control concrete and silica gel addition of 0.1%, 0.2%, 0.3%, and 0.4% concrete mixes were studied at the age of 7, 14, 28 days results shown in Fid.1 and 2.Initially the specimens are loaded to induce the initial minor crack, after that these specimens have been cured and retested to determine the strength regained after the periods specified [12]. From the results, the compressive strength is increased up to 62.38% with the addition of 0.3 % of silica gel when compared to control specimens at age of 28 days. The results are clearly shows that the compressive strength is less before healing of concrete at all the ages compare to the control specimens. The compressive strength was increased 6% more compare to the control specimens at the 0.3% replacement of silica gel after healing. In general, compare to the before healing concrete with after healing concrete, the after healing concrete shows higher compressive strength at the all ages.

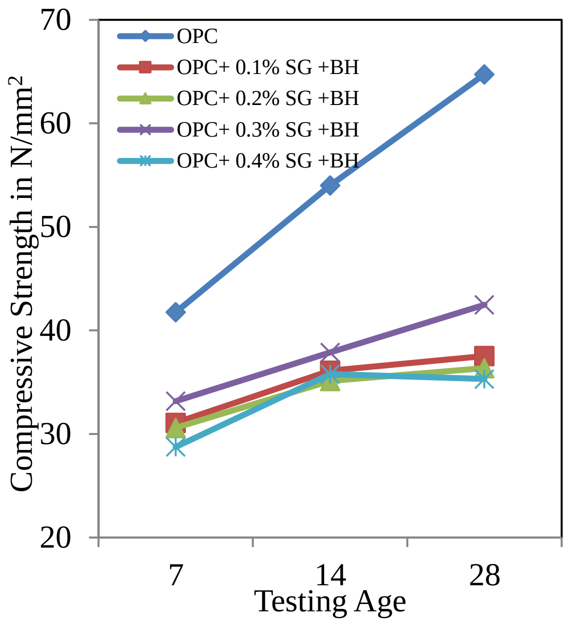

Fig.1 Compressive strength of Concrete before healing with different % of SG

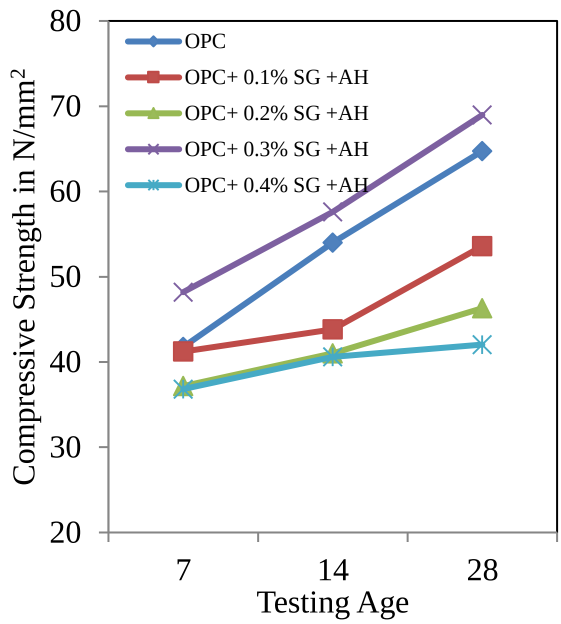

Fig.2 Compressive strength of Concrete After healing with different % of SG

3.3 Split Tensile Strength Test of Self-Healing Concrete

The Split Tensile strength test were studied by casting the cylinder specimens containing silica gel as healing agent with the dosage of 0.1%, 0.2%, 0.3%, and 0.4% added by the weight of cement at the age of 7, 14, 28 days results were shown in Fig.3 and 4. The cylindrical specimen was put with its axis between horizontal platens on the testing machine and the load was gradually increased until failure by part in the plane containing the vertical diameter of the specimen. The specimens have been subjected to applied load to actuate initial crack [13,14]. From the results, the split tensile strength is increased up to 59.50% with the addition of 0.3 % of silica gel when compared to control specimen at age of 28 days. In general the split tensile strength was improved for after healing compare to the before healing of the concrete specimens at all the ages of testing.

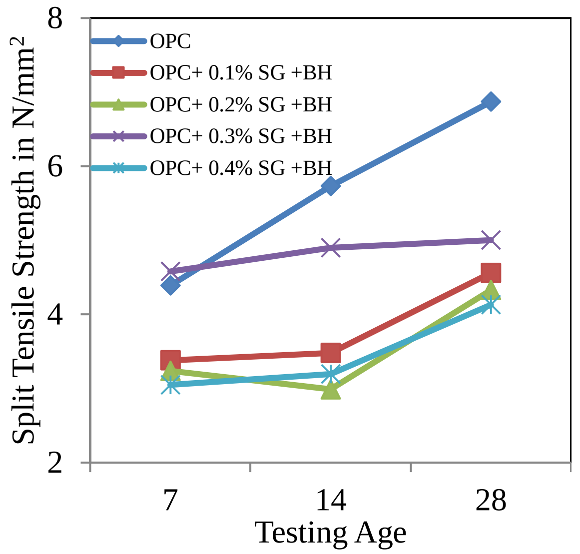

Fig.3Split Tensile strength of Concrete before healing with different % of SG

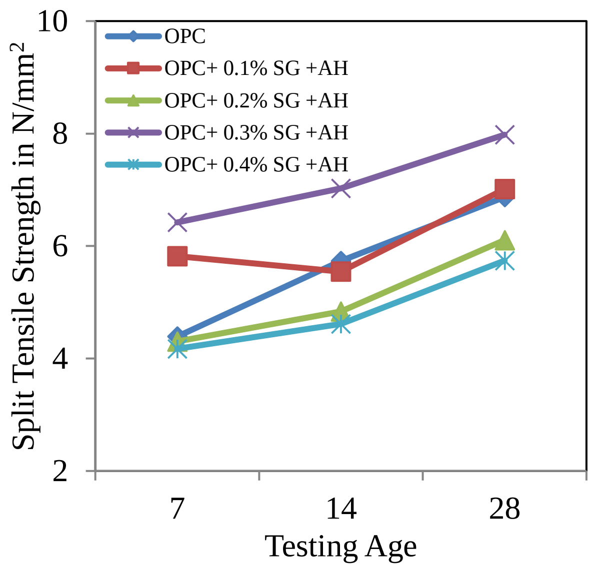

Fig.4Split Tensile strength of Concrete After healing with different % of SG

3.4 Flexural Strength Testof Self Healing Concrete

To study flexural behavior of concrete, the beam was casted for the control mix as well as silica gel replacement with differentproportions mix and test at specified ages results were shown in Fig.5 and 6. The beams were casted in supported on a steel roller bearing near each end is loaded through similar steel bearings placed at the third points on the top surface (2-point loading) according the IS 516:1959. For two-point loading a steady bending moment is delivered in the zone between the upper roller bearings. This initiates a symmetrical triangular stress dispersion along vertical sections (accepting elasticity), from compression over the neutral axis at mid height to strain beneath the neutral axis [15-17]. The specimens have been subjected to a connected load to prompt initial crack. The crack is minor and interior as it were. Form the test results, it is observed the flexural strength is increased up to 47.04% with the addition of 0.3 % of silica gel when compared to control specimens at the age of 28 days. In general, the addition of silica gel with different proportions after healing concrete gives higher strength compare to the before healing concrete specimens.

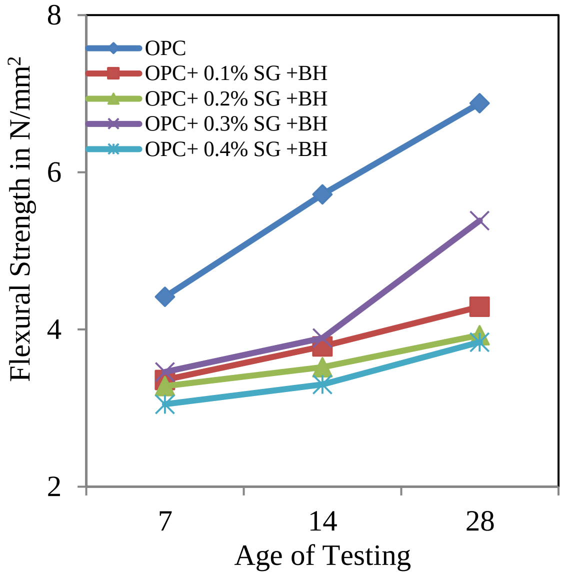

Fig.5 Flexural strength of Concrete before healing with different % of SG

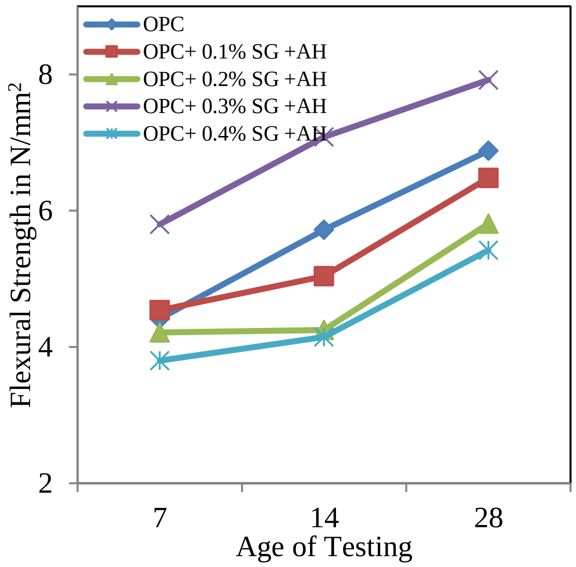

Fig.6 Flexural strength of Concrete After healing with different % of SG

4. Conclusion

Based on the experiments conducted in this study, the following conclusions were drawn.

- The compressive strength arrived at 28 days are 68.98 N/mm2 for Silica Gel. It indicates that, the usage of silica gel is increasing the compressive strength by 6.54% than control concrete. Similar results were observed in flexural and split tensile strength and concrete with control concrete was 15.11% and 16.15% more than concrete with silica gel respectively.

- 0.3% of Silica gel are the optimum dosage for increasing the compressive strength, split tensile strength test and flexural strength.This type of self healing concrete can be used for water retaining structures and tunnel structures. It reduces the direct cost for maintenance and repair.

- The self healing agents like silica gel, polyurethane have an influence on compressive strength, split tensile strength and flexural strength on concrete in a larger scale. Further this investigation may be extended to compare the various agents.

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