Study Of The Effect Of GGBS On The Self Healing Ability Of High Strength Concrete With Crystalline Admixture

C. Shaheena Begam#[1], Dr.T.Chandra Sekhara Reddy#[2].
#[1] M. Tech Student, Department of Civil Engineering, GPREC, Kurnool, AP, India.
#[2]Professor, Department of Civil Engineering, GPREC, Kurnool, AP, India.

Abstract: The aim of this study is analyzing the self healing capability of high strength concrete (M70) with GGBS and crystalline admixture in two types of environmental exposures i.e. water immersion, wet/dry cycles. The percentage replacement of cement with GGBS were 20%, 30%, 40% and with addition of 1.1% crystalline admixture. The specimens were pre-cracked at 28 days in the range of 0.10-0.40mm and the time set for healing was 42 days. The result shows that all the mixes have considerable amount of closing ability and strength regaining capability for all exposure conditions. The concrete with 30% Ground granulated blast furnace slag (GGBS) and 1.1% crystalline admixture (CA) has complete crack closing ability and 100% strength regain capability for WI and W/D conditions.

Keywords – Crystalline admixture, self healing, and High strength concrete GGBS.

1. INTRODUCTION

Cracks inevitably exist in concrete due to Chemical shrinkage, Dry shrinkage, Autogenous shrinkage, the relatively low tensile strength and so on. If micro cracks grow and reach the reinforcement, not only the concrete itself may be attacked, but also the reinforcing steel bars will be corroded. Therefore it is important to control the crack width and to heal the cracks as soon as possible. Self healing concrete also called as self-repairing concrete, is mostly defined as the ability of concrete to repair it cracks autogenously or autonomously. Self healing concrete can be categorized in two types: autogenous and autonomous self healing concrete. The autogenous self-healing mainly depends on further hydration of cement/ other binders and carbonation of Ca (OH) ϩ. However, the autonomous self-healing concrete depends on manual methods. Such as the use of super absorbent polymers (SAP's), bacterial concrete, microencapsulated healing agents, and the use of crystalline admixtures. Crystalline admixture is a waterproofing admixtures and it reduces the size of capillary pores, their numbers and continuity inside the concrete structure (10). They are many products in the market now a day which are available to protect the concrete structure from damage due to water penetration. For example, coatings, sealers, membranes etc. Are used to prevent water penetration.

Abram's (1) was among the first researchers who explained the autogenic self-healing in concrete. He suggested that the healed strength of concrete is caused by the retarded or the interrupted hydraulic of the cement. Edvardsen (2) conducted some experiments in order to verify the water flow in different crack width, under different pressure conditions. She found that, after 7 weeks exposure for lower pressure of the water, the cracks were closed completely whereas the same one for higher pressure had just 25% of closure. Sahraman et al (3) investigated the recovery of compressive strength after the induction of cracks marked by different cracking modes. Ferrara et al. (5) a methodology has been proposed and validated to assess and quantify the effects of self healing on the recovery of mechanical properties of normal strength concrete, with and without crystalline admixtures under different exposure conditions. M. Roig-Flores et al. (6) analyzing

the self-healing effect of a crystalline admixture in four types of environmental exposure comparing with a reference concrete. The studied crack openings were under 300µm and the time set for healing was 42 days. Specimens cast with concrete containing crystalline admixture and stored under water immersion achieved the highest self-healing rate. M. Roig-Flores et al (7) study on the self healing capacity of early- age fiber-reinforced concrete and the effectiveness of a crystalline admixture as self healing agent in different exposure conditions. The results show the best healing exposure condition among the once hear in investigated is water immersion at 30º c with the crystalline admixture.

The main objective of this project is to determine the self healing ability of high strength concrete (M70) with GGBS and crystalline admixture in different exposure conditions.

2. EXPERMENTAL PROGRAM AND METHODOLOGY

A. Materials and mix proportions

The materials used for this research were cement, coarse aggregate, fine aggregate, water, GGBS, Crystalline admixture, super plasticizer and steel fibers.

The type of cement was OPC 53 grade for normal concrete, concrete with GGBS, concrete with crystalline admixture and concrete with both GGBS and crystalline admixture. For better results, locally available portable water conforming to IS 456-2000 is used for making concrete. Aggregates of size (12-10mm) were selected as coarse aggregate, and river sand was used as fine aggregate. The quantity of steel fibers was fixes at 40 kg/m³ according to the criterion of making the crack opening easily controllable while avoiding excessive branching of cracks. A dosage of 1.1% of crystalline admixture was introduced in the concrete by partial replacement of cement. Two types of admixtures namely, GGBS as partial replacement of cement and super plasticizer, for increasing workability of the fresh concrete, were incorporated in the concrete mixture.

B. Experimental Methodology

The methodology used in this study to evaluate the effects of self healing consists of four stages;

1. Determination of mechanical properties of control concrete (CC), with GGBS, concrete with crystalline admixture (CCA), and combination of both crystalline admixture and GGBS at 28 days.

2. Creation of controlled damage in the specimens

3. Simulation of the conditions/ environmental exposures needed to achieve better healing results.

4. Evaluation of the regained mechanical properties and compare with results measured in stage

A total 5 group of specimens were cast, each group consists 3 cubes, were casted. Four groups are used for improvement of strength characteristics. They are; controlled concrete (CC), concrete with GGBS and crystalline admixture (GGBS+CA), concrete with crystalline admixture (CC+CA). 5 groups are used for structural cracks self-healing study under four exposure conditions respectively.

1) Determination of mechanical properties; mechanical properties studied in this study are 1. Compressive strength. Creation of damage (pre- cracking process) ; cube specimens (100X100X100mm) were pre- cracked at the age of 28 days for structural cracks, by means of a compression test, a controlled

damage; this was meant as the width of the crack, which was set to reach a target value, controlled by a loading.

2) Exposure simulation ; four environmental exposure conditions were considered in order to determine the influence of water availability and its temperature on the self healing capability of the tested specimens, comparing reference concrete with GGBS and crystalline admixture concrete. All specimens were left to heal for 42 days.

3) Evaluation of the regained mechanical properties; determine the regained mechanical properties after healing cracks in concrete specimens under four different environment exposure conditions.

3. RESULTS AND DISCUSSIONS

A. compressive strength

Compressive strength of M70 concrete with partial replacement of cement by GGBS is increases up to 30% replacement and with further increase in GGBS the compressive strength decreases. The maximum compressive strength of 89.83 N/mm² is achieved for the concrete mix with 30% replacement of cement by GGBS which is 7% more than that of reference mix (PC) for 28 days curing. At the age of 28 days, specimens were pre-cracked to introduce a structural crack width of 0.1-0.4mm. Thereafter, pre-cracked specimens are tested after self-healing of cracks, the regain mechanical properties after healing of structural cracks under water immersion. The regained compressive strength of concrete values are shown in FIG 1.

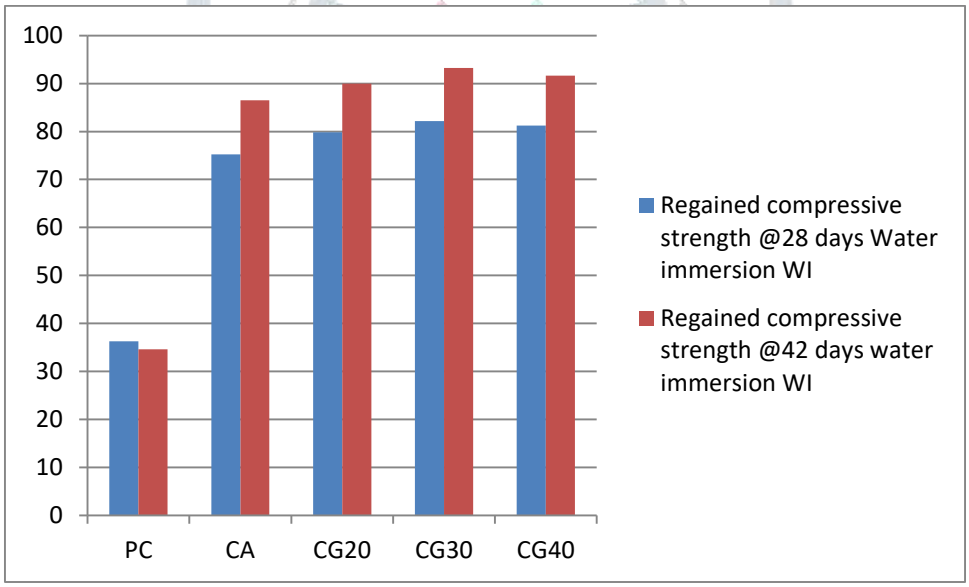

FIG 1. Variation of % of recovery of compressive strength under Water Immersion after 28 and 42 days curing.

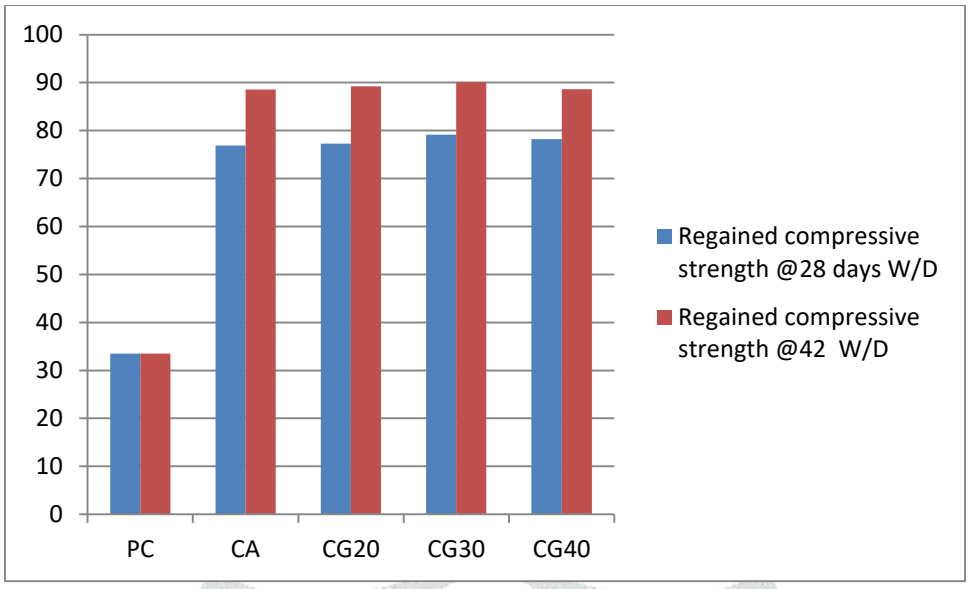

FIG.2. Variation of % of recovery of compressive strength under Wet/dry after 28 and 42 days curing.

CONCLUSIONS

This study investigates the Self-healing behavior of High strength concrete with GGBS and crystalline admixture. After 28 days of curing, the specimens were pre-cracked with subsequent healing in different exposure conditions. The recovery of mechanical properties was investigated.

1. Maximum compressive strength of 84.3 N/mm² is obtained for concrete mix with 1.1% of Crystalline admixture (CA) for 28 days curing.
2. The maximum compressive strength of 89.83 N/mm^2 is achieved for 30% replacement of Cement by GGBS (CG30) which is 7% more than that of reference mix (PC) for 28 days curing.
3. The best healing exposure condition is Water immersion with the 1.1% of crystalline admixture and GGBS 30%(CG30). The regained compressive strength is 93.25 N/mm² after 42 days curing.
4. The concrete specimens with 30% of GGBS and 1.1% of Crystalline admixture (CG30) has complete crack closing ability and strength regaining capacity.
5. Self-healing rate, calculated from the results of the regained mechanical properties of tested specimens are reliable compared to the control concrete specimens.

REFERENCES

1. Abrams A. Autogenous Healing of Concrete (J). Concrete, (1924)10-50.
2. Edvardsen, C. (1999). “Water Permeability and Autogenous Healing of Crack in Concrete”, ACI Mat. J., 96.

3. Şahmaran M., Keskin S. B., Ozerkan G., and Yaman I. O.,"Self-healing of mechanically-loaded self-consolidating concretes with high volumes of fly ash," Cem. Concr. Compos., vol. 30, no. 10, pp. 872–879, Nov. 2008.

4. K.Sisomphon, O.Copuroglu, E.A.B.Koenders , Effect of exposure conditions on self healing behaviour of strain hardening cementitious composites incorporating various cementitious materials, Constr. Build. Mater. 42 (2013) 217-224.

5. Liberato Ferrara, Visar Krelani , Carsana M. A ''fracture testing'' based approach to assess crack healing of concrete with and without crystalline admixtures. Construction and Building Materials 68 (2014) 535–551.

6. M. Roig-Flores, S. Moscato, P. Serna, L. Ferrara. Self-healing capability of concrete with crystalline admixtures in different environments. Construction and Building Materials 86 (2015) 1–11

7. M.Roig-Flores, F.Pirritano, P.Serna, L.Ferrara. Effect of Crystalline admixtures on the self-healing capability of early age concrete studied by means of permeability and crack closing tests. Construction and Building Materials 114 (2016) 447-457.

8. Guide for selecting proportions for High-Strength Concrete with Portland Cement and Fly Ash Reported by ACI 211.4R-93.

9. ACI Committee 212 (2010). Report ACI 212-3R-10, 2010. Report on Chemical Admixtures for Concrete.