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EXTENDED ABSTRACT

Autogenous Self- Healing of High Strength Concretes

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1. Introduction

Concrete elements can be easily cracked due to several reasons, such as tensile stresses. When these cracks are connected to each other, permeability will increase and bearing capacity will decrease. Therefore, cracks may decrease the durability of concrete structures. Repair of cracked concrete structures is often expensive and sometimes impossible. Therefore, researchers by inspiration from autogenous recovery of small scratches in the body of live creatures, have presented self-healing concrete based on concrete characteristics. Utilization of such concretes may increase the durability of concrete structures and minimize repair and rehabilitation costs. Self-healing phenomenon is not new; Academy of science in France has observed the healing of micro cracks in 1836 (Hearn, N, Morley, 1997). The self-healing refers to the reduction of crack width itself. Systematic investigation of self-healing was started by Glanville in 1926. Autogenous self-healing is a case of healing that happens without using external agents (Glanville, 1931). Cementitious materials have such ability, because rehydration of cement particles may be continued and reaction products such as C-S-H and Portlandite will fill the cracks. Of course, when the unhydrated cement particles and water are available in the cement paste, this type of self-healing will occur. Parameters such as crack width, pH of curing water, temperature, the chemical composition of cement and etc. may influence on the self-healing process. The mechanism of autogenous self-healing is described as follows:

1- Rehydration of unhydrated cement particles.
2- precipitation of $CaCO_3$
3- Filling of cracks by microscopic particles available in the water or separated from the paste owing to cracks formation.

Coarse cement particles with diameters larger than 75 microns often are available in the cement particles because of their unsuitable grinding. These particles are not completely hydrated during the initial curing time and could be effective in the self-healing process. In the present study, cracks of concrete samples were healed by substitution of cement particles by coarse cement particles as a self-healing agent. In addition, the effect of two different water-cement ratios on the self-healing process of high strength concretes was investigated. The low specific surface of coarse cement particles and low water-cement ratios lead to a decrease in hydration degree of cement paste which consequently results in incomplete hydration of the cement particles, which leads to suitable healing performance. Therefore, the inner part of cement particles will be unhydrated until the cracks are happened and moisture is reached to the cement particles. In this case, unhydrated parts of cement particles will react with water and hydration products will fill the cracks and consequently healing process will be occurred.

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2. Methodology

In the present study, first, High Strength Concretes (HSCs) were made by using an ideal grading curve of aggregates and superplasticizer, where coarse cement content was considered 0, 75, 150, and 225 kg/m^3 and the water-cement ratio was considered 0.28 and 0.33. Next, a longitudinal crack in the moist cured cylindrical specimens was developed by using the splitting test method. Then, the specimens were tightly fastened to keep the crack width constant and equal to 200 micron. After all, the specimens were re-cured in water and then the mechanical properties and water passing content through the cracked concretes were measured as self-healing criteria. A schematic illustration of water passing through the cracked specimen is shown in Fig. 1. (Rahmani and Bazrgar, 2015). Also, self-healing material was separately investigated by SEM.

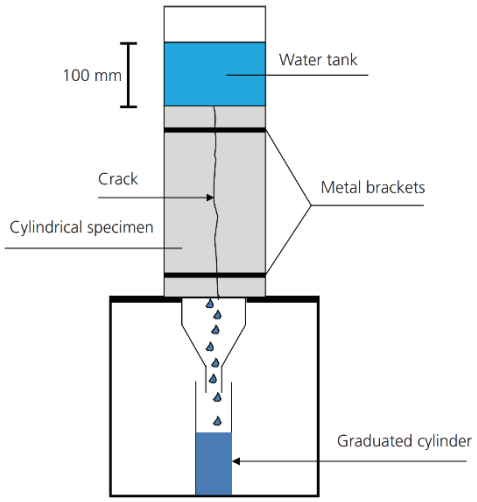

Fig. 1. Test setup for determination of water passing through the cracked concrete (Rahmani and Bazrgar, 2015)

3. Results and discussion

Results showed that the self-healing capacity is available for all considered mixtures and the effect of coarse cement particles on the self-healing process is greater than that of the water-cement ratio has. In addition, 12-29 percent healing in the mechanical properties and 41-100 percent healing in the water passing through the cracked concrete were seen. Also, coarse cement replacement up to 225 kg/m^3 decreased compressive and tensile strength up to 29 and 37 percent, respectively.

4. Conclusions

In the present study, an experimental program was conducted to investigate the self-healing of high-strength concretes. The mechanical healing of cracks was evaluated by the tensile strength recovery and the permeability healing was investigated by water passing content through the cracks. Coarse cement contents and water-cement ratio were considered as variables. The results of the conducted experiments are explained in the following:

Compressive and tensile strength of high strength concretes were reduced by increasing coarse cement particles and water-cement ratio, where the decrease in tensile strength was more obvious, while self-healing capacity was increased with increasing coarse cement particles and decreasing water-cement ratio, where increasing self-healing ability is more dependent to coarse cement particles rather than a water-cement ratio. Also, self-healing progress was certainly governed by the re-curing time where the permeability healing is considerably more than mechanical healing.

5. References

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