

THE CHANGE OF OSMOSIS PRESSURE BY CRACK SELF-HEALING OF CEMENTITIOUS MATERIALS

Myongshin Song¹, Sehun Jeon¹ and Youngjin Song¹

Kangwon National University, Research Institute of Chemical Engineering, Department of Chemical Engineering, 1 Choongang-ro, Samchuck-city, Kangwon-do, 245711 Rep. of Korea
Email: msong0422@kangwon.ac.kr

Keywords: Self-healing, Osmosis Pressure, Semi-permeability, Porosity, Water permeability,

ABSTRACT

Hardened cement is a porous material that has a wide range of micropores from the interlayer gaps inside the hydrate C-S-H of nanometer size to the entrapped air of a few millimeters. Water, gas and ions is permeated to pass through continuity of the gaps. Hardened cement have selective permeability depending on the types and properties of the permeating materials, the physical state of the hardened cement pores, and the correlation with the chemical properties of the pore surface. Because of the selective permeability, the hardened cement installed between the solutions of different concentrations allows water to permeate, but the solutes and ions can hardly permeate it in contrast to water. Due to the property, osmotic pressure is generated across the hardened cement.

On the other hand, the hardened cement with cracks can have more gaps or pathways through water, solutes, and ions can pass because of the physical cracks beside the basic gaps by the hydrate reaction, when compared with the hardened cement without cracks. In other words, there is a difference in the osmotic pressure between the hardened cement with cracks and the one without cracks because of the existence of cracks. Moreover, if the cracks are healed by the crack self-healing material, the osmotic pressure will be also different.

The pressure by the selective permeability of cement mortar depends on the mixing conditions of the cement mortar and is greatly affected by the W/C ratio and the fine aggregate quantity. From selective permeability, the overall osmotic pressure of hardened cement is assumed to be connected with the osmotic pressure generation by physical effects such as the size and number of pores, which play the role of a sieve to the moving ions or materials, and by the electrochemical effects of the pore surface of the hardened cement that is known to have positive charge by Ca²⁺ ions.

Of course, these do not have an independent effect but actually a complex effect. The inner permeation pressure of the hardened cement with cracks and without cracks will be definitely different with each other, and the osmotic pressure of the hardened cement of which cracks have been healed is also different from that of the hardened cement that still has cracks. Therefore, in this study, we interpreted the crack self-healing mechanism based on the osmotic pressure difference due to the different micropore structure in hardened cement, from the viewpoint of reviewing the crack self-healing mechanisms on the basis of the osmotic pressure difference.

A special instrument was produced to measure the osmotic pressure. The experimental mixing ratio was set to water/cement = 0.45 and sand/cement = 1.5 and 1.8. The test bodies were prepared as circular cement mortar molds with the height of 8 mm, and the diameter of 100 mm. The test bodies were polished and adjusted to 4 mm ± 0.2 mm, after the curing for two days at 20 ± 3 °C. Following the water curing for 28 days at 20 ± 3 °C, the osmotic pressure of the test body (P1, plain-1) was measured. Then, the osmotic pressure of the test body (P2) prepared by forcefully generating cracks in P1 was also measured. The test body to which the crack self-healing material was added (T1) was prepared with the same preparation method for P1 and P2. The osmotic pressure of the cracked T1 test body was measured after 60 days of water curing at 20 ± 3 °C.

Figures 1 and 2 show the measured osmotic pressure of P1, P2, and T1.

Figure 1 shows the osmotic pressure in the hardened cement mortar without cracks (P1) and the osmotic pressure of the same hardened cement mortar to which cracks were generated forcefully (P2). The osmotic pressure of P2 was lower than that of P1 because the pressure was lost through the cracks. Figure 2 shows the measure osmotic pressure in the hardened cement mortar of which cracks were healed by the mixed crack self-healing material after cracks were forcefully generated and then healed by the water curing for 60 days. The result showed that the osmotic pressure was increased as the cracks were healed when compared with that of P2. One important purpose of crack self-healing in hardened cement is to simply block water or ion permeation, but a more important issue in principle is how much the initial physical properties are restored by the healing of the cracks in the hardened cement. The result of this study showed that the crack self-healing material used in this study has a cracking healing effect in the hardened cement, and the increased osmotic pressure in comparison with that of the hardened cement with cracks indicated that the physical performance was restored. The restoration of the physical performance can be reconfirmed on the basis of the variation of the compressive strength and porosity of the crack self-healing hardened cement mortar.

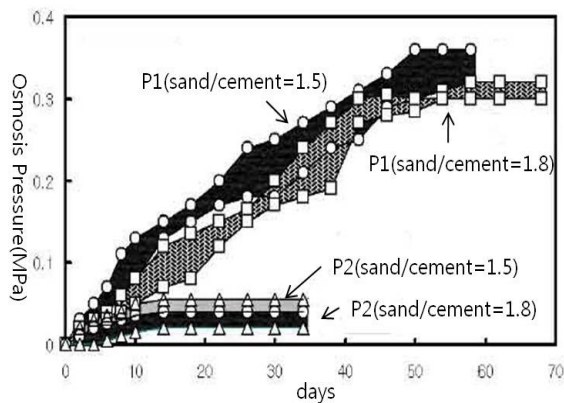


Figure 1: Osmotic pressure of cement mortar

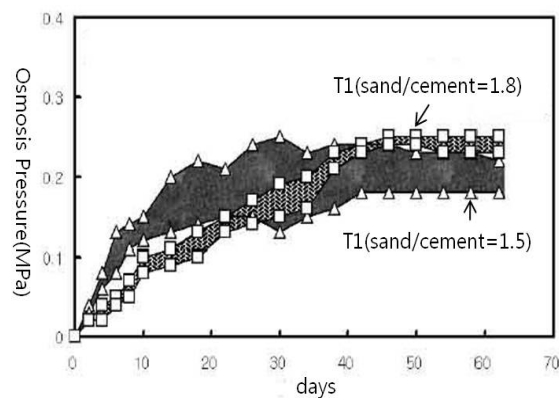


Figure 2 : Osmotic pressure of crack self-healing cement mortar

“This work was supported by the Korea Research Foundation Grant funded by Korea Government (MOEHRD), KRF-2007-359-D00007”

REFERENCES

- [1] K. Bae, A Study on Relationship Between Osmosis by Semi-permeability to NaCl solution and Pore Structure of Cement Mortar, *Journal of the Architectural Institute of Korea, Structure & Construction*, **22**, 2006, pp. 103-110.
- [2] Duncan McConnell, Richard C.Mielenz, William Y.Holland, Kenneth T.Greene, Cement-Aggregate Reaction in Concrete, *Journal of the American Concrete Institute*, **19**, 1947, pp. 93-128.
- [3] M. Günter, H.K Hilsdorf , Influence of physical and chemical interactions between a concrete substrate and organic surface coatings on bond strength, *Durability of non-metallic inorganic building materials*, 1988, pp.161-874