THE BEHAVIOUR OF SUBERABSORBING POLYMERS AS A SEALING AGENT IN CONCRETE: ABSORPTION KINETICS, DEGRADATION AND WATER PERMEABILITY

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ABSTRACT

Concrete has a low tensile strength. This makes it prone to cracking due to direct loads, temperature gradients, plastic shrinkage, internal expansive phenomena (e.g. rebar corrosion), ... Without a proper treatment, maintenance costs will rise during its lifetime. Cracking exposes the concrete to the harsh environment and endangers the durability by forming a pathway for harmful particles dissolved in fluids and gasses. Superabsorbent polymers (SAP) in concrete have proven their use in decreasing the autogenous shrinkage. This diminishes internal stresses and protects concrete from shrinkage cracking at young age. The current research in self-sealing concrete focuses on the swelling behaviour of the polymers in cracked concrete. When cracking occurs, the SAP is exposed to the humid environment and swells. This swelling seals the crack from intruding potentially harmful substances (figure 1).

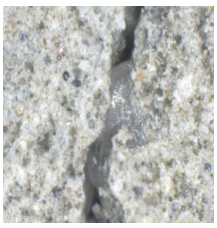

Figure 1: Swollen SAP that bridges the crack.

Based on our preliminary results, we believe SAP have a future importance in self-sealing and self-healing concrete. Careful modification of polymers can raise their performance as a crack sealing agent and allow concrete to regain its water tightness even better. This research compares three types of polymers. Two commercially available SAP's are produced by BASF©, one based on sodium acrylate (A, fine graded)) and one based on polyacrylate and potassium salt (B, coarser particle size than A). The third polymer was synthesised at the PBM Research Group (P, even coarser). In order to create a crosslinked polymer network, a synthetic polymer was modified with cross-linkable vinyl groups under 2h of UV radiation.

To assess the sealing capacity of the polymers, the swelling capacity of a polymer is calculated from the volume increase between the vacuum dried and the saturated material. This is done in de-ionised water as well as in a filtered cement slurry (20 g CEM I in 200 g of water, pH 12.8). This value is compared to water absorption in 100% relative humidity environment, during dynamic vapour sorption (DVS) measurements (table 1). The values for SAP A and B are in accordance to the values found in literature for acrylic SAP's. The absorption capacity of the newly developed hydrogel P is lower, but quasi-stable in a high-pH environment.
Table 1: Absorption of SAP [g water/g SAP] (average of three repetitions)

Method	*New formulation*	*SAP A*	*SAP B*
DV de-ionised water	29.4	140	140
DV slurry	26.0	60	60
DVS	0.77	1.26	1.11

Next to free swelling of the SAP, the sealing capacity is measured through a decrease in water permeability of HPFRCC cylinders. The mixture is composed of 571 kg OPC/m³, 685 kg flyash/m³, 456 kg silicasand 0/2/m³, 332 kg water/m³ and 1 V% of Redco PVA fibres. Loading is done as described in [1] and the crack width varies between 50 and 280 µm. A complete description of the test procedure, based on the method provided by Aldea et al. [2] is given in Van Tittelboom et al. [1]. The measurement of the water permeability coefficient k after 30 days, shown in figure 2, indicates how different SAP perform. The reliability of the results is expressed with the standard error.

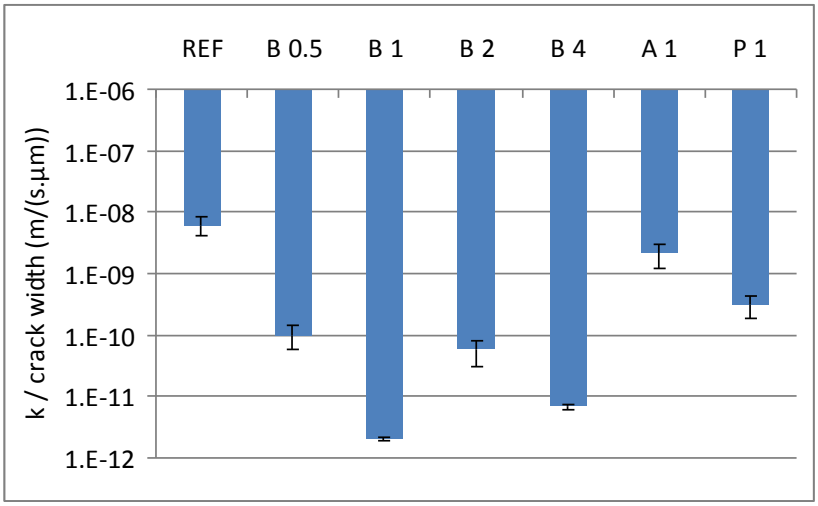

Figure 2: Water permeability k (per µm crack width) for HPFRCC cylinders with different types and concentrations of SAP; REF = reference; B0.5, B1, B2, B4 = SAP B at 0.5, 1, 2 or 4 m% of cement weight, A1 = SAP A - 1 m% of cement weight, P1 = new polymer - 1 m% of cement weight.

From the graph, it is clearly visible that all SAP types induce crack sealing properties in HPFRCC, with SAP B showing the best performance. This could be due to a more suitable particle size of SAP B compared to SAP A (crack width too large for the fine graded SAP) and the new formulation P (less SAP bridging the crack due to coarser grading). Future research will focus on fine-tuning the chemical composition of the newly developed formulation to increase the swelling behaviour.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Van Tittelboom, K., N. De Belie, et al. "Self-healing efficiency of cementitious materials containing tubular capsules filled with healing agent." Cement and Concrete Composites, in Press.

[2] Aldea, C. M., W. J. Song, et al. (2000). "Extent of healing of cracked normal strength concrete." Journal of Materials in Civil Engineering 12(1): 92-96.