An Experimental Investigation on Internal Hydrophobation of Cement Based Materials

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Introduction

Internal hydrophobation is a method for reducing moisture problems in cement based materials. Hydrophobic agents can be added during the mixing process and make the paste internally hydrophobic when it is hardened. Since cement paste is the important part of cementitious materials concerning water sorption and compressive strength, studying the properties of the paste can help understanding the behavior of the composite material. Although there are some researches conducted in this area on concrete specimens [1], cement pastes have not been the focus of these investigations.
In this paper the effect of two types of internal hydrophobic agents on capillary suction and compressive strength of hardened cement pastes (hcps) is studied. Furthermore, since using silica fume (SF) in the cement mixture results in more C-S-H gels and finer pore structure and thus reduces permeability and increases compressive strength, silica fume is also considered as the other variable in this investigation.

Experimental

Materials
Alkyl alkoxysilane with small molecular size of 5-10 angstrom was used as the first hydrophobic agent in the cement paste. Since the cement paste consists of nano-gel-pores as well as small capillaries [2], using this silane product was of interest to see if it can affect these pores. Moreover, rapeseed oil which could probably be an environmental friendly substitute for existing chemical hydrophobic agents, was selected as the other hydrophobic material according to the previous studies [3, 4]. Both of the hydrophobic agents were used with dosage of 1% by mass of cement (m_c) and three water to cement ratios (w/c) of 0.36, 0.44 and 0.58 were investigated in this experiment. Furthermore, five paste mixtures with different w/c and SF dosage were considered for the experimental study. Table 1 shows the mix proportions of the cement pastes. Since SF reacts with cement hydration products and creates more C-S-H gel, it is normally considered as a part of binder in cementitious materials. Thus, the water to binder ratio (w/b) of the mixes containing SF is also given in the table. Different dosage of SF is considered in order to see the effect of this material working as pozzolana as well as filler. Furthermore, anti foaming admixture and plasticizer were used in all of the mixes in order to reduce undesirable macro air pores and provide a good consistency and dispersion of the binders during mixing.

Table 1 Mix proportions of the cement pastes.

Mix Type		*w/c*	*Admixture Dosage* [% m_c]
Reference		0.58	0
		0.44	0
		0.36	0
Silane		0.58	1
		0.44	1
		0.36	1
Oil		0.58	1
		0.44	1
		0.36	1
Silica Fume	w/b=0.48	0.58	20
	w/b=0.40	0.44	10
	w/b=0.37	0.44	20
	w/b=0.34	0.44	30
	w/b=0.30	0.36	20

Procedure
Cylinders with 25 mm height and diameter, were prepared and cured in water for 12 weeks [5]. The specimens were then dried for two weeks at 50°C in a ventilated oven in order to run the capillary suction test. The samples were then placed on the water surface for 4 days in order to measure the water sorption after this period. More detailed study on water sorption of tested materials in given in Ref. 5. The compressive strength samples were tested directly after water curing.

Results and Discussion

Figures 1 and 2 show the reduction in water suction for the tested materials compared to the reference materials with the same w/c. The results show that the Silane product is not effective in reducing water suction, while the oil has shown a significant reduction. Moreover, using 20% SF has also resulted in less water suction especially in lower w/c. The reduction in water suction due to finer and more segmented pore structure can be seen in Figure 2 by comparing the samples with different dosage of SF.

Although a high deviation was observed in the results of compressive strength of samples other than reference samples, there was an obvious reduction in compressive strength of the hydrophobed samples. On the other hand, SF samples showed higher compressive strength than the reference samples. Furthermore, the samples with 30% SF had relatively higher strength than the other specimens containing SF, This could probably be due to the filler effect of high SF dosage samples in addition to the pozzolanic effect of it.

Conclusions

Internal hydrophobation by simply adding the hydrophobic agent during mixing can be effective in reducing water suction but more research should be made to find the suitable material concerning hydrophobicity and compressive strength. This method may probably not be the best method for structural concrete due to reducing compressive strength, but it could be a suitable method for the non structural concrete in which the energy and durability aspects are more important than the compressive strength. Another alternative could be impregnation after the curing process which probably would not affect the compressive strength.

Adding SF and increasing its dosage, increases strength and reduces water suction of the material, however 1% of oil had a higher effect in reducing water suction than 30% SF.

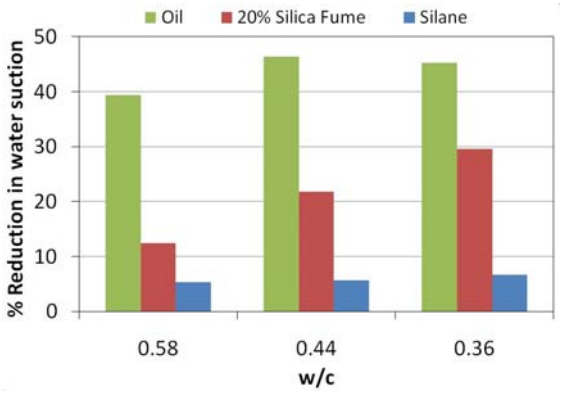

Fig. 1 % reduction in one sided water suction at 4 days compared to reference samples with the same w/c.

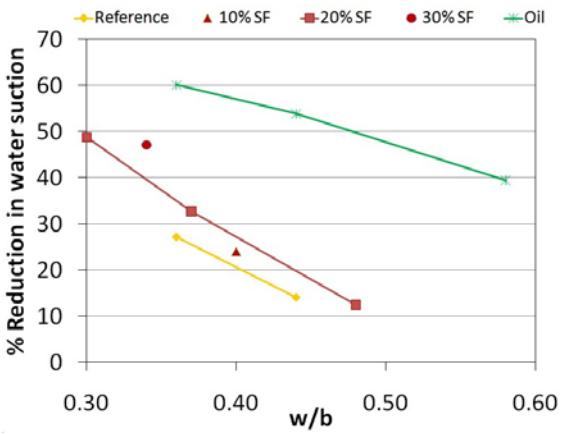

Fig. 2 % reduction in one sided water suction at 4 days compared to reference sample with w/c=0.58

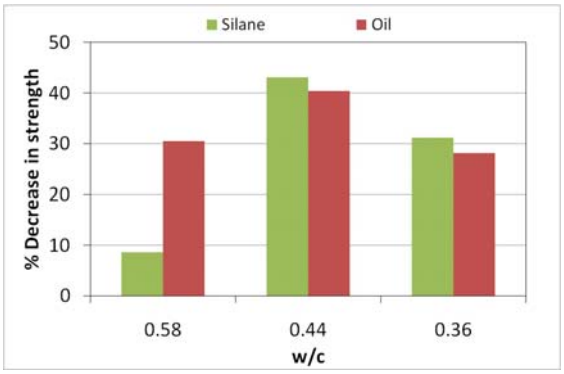

Fig. 3 % reduction in compressive strength compared to reference samples with the same w/c.

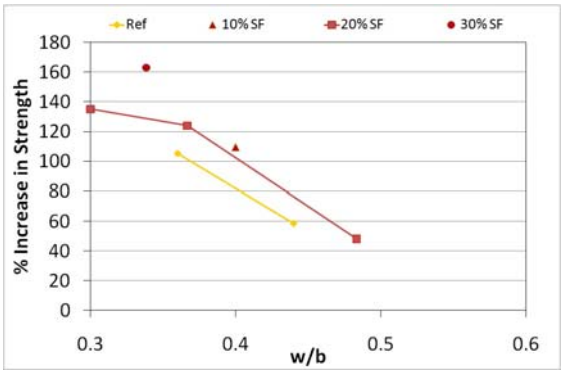

Fig. 4 % increase in compressive strength compared to reference sample with w/c=0.58

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