Pergamon

Cement and Concrete Research, Vol. 25, No. 6, pp. 1153-1158, 1995

0008-8846/95 $9.50+.00

0008-8846(95)00107-7

DURABILITY OF 'SELF-CURE' CONCRETE

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(Communicated by C.D. Pomeroy)
(Received June 1, 1995)

ABSTRACT

When cured in air, 'self-cure' concrete possesses improved properties in comparison to identically cured controls. This paper reports the results of several durability tests conducted on self-cure concrete specimens. It was found that initial surface absorption, chloride ingress, carbonation, corrosion potential and freeze / thaw resistance characteristics were all better in air cured self-cure concrete than in the air cured control. This improvement appears to be dependent on admixture dosage, and although the durability properties obtained in this study were not as good as the film cured concrete controls, it may be possible to achieve such properties with higher quantities of self-cure chemical.

Introduction

Concrete that is capable of retaining greater quantities of water than ordinary concrete when cured in air has been developed at these laboratories by means of an addition of a 'self-cure' chemical (SCC), which was a water-soluble polymeric glycol identified as chemical A1 in a previous publication (1). This water retention leads to a greater degree of cement hydration and hence improved properties in comparison to control specimens. One particular feature of self-cure concrete is its good durability properties. This paper reports the results of a series of durability tests conducted on self-cure concrete. The tests were the initial surface absorption test, the potential difference (PD) chloride diffusion test, depth of carbonation, half-cell corrosion potential and measurement of freeze / thaw resistance

EXPERIMENTAL DETAILS

Mixes

Three mixes were used throughout the programme: one containing only OPC as a binder, one containing a 40% GGBS cement replacement and one containing PFA as a 30% cement replacement. The mix proportions are given in Table 1.

TABLE 1.
Mix Proportions Used in Programme

Mix	Water	Binder			Aggregate			w/c Ratio
		OPC	GGBS	PFA	20mm	10mm	Sand	
1	185	300	-	-	773	379	761	0.62
2	175	180	120	-	773	379	761	0.58
3	170	210	-	90	773	379	761	0.57

SCC Dosage

The SCC dosages are expressed throughout this paper as the molar concentration of the chemical in the mix water. Two dosages were used: 0.005M and 0.100M.

Curing

Two sets of control specimens (i.e. specimens containing no self-cure chemical) were cast, kept under damp hessian and polythene for 24 hours and then stripped. One set was cured in air at 20°C / 60%RH for 28 days. The other set were kept for the same amount of time in the same conditions, but sealed in a water-resistant plastic film to ensure that no moisture was lost. The self-cure concrete specimens were also cured in air at 20°C / 60%RH.

Testing

The initial surface absorption test (2) was carried out on 150mm cubes. After the 28 day curing period these specimens were left in air at 20°C / 60%RH for 7 days before testing (the film sealed specimens were unwrapped for this period). The test was conducted on 3 faces of each cube.

25mm thick discs were cut from cylindrical concrete specimens of dimensions 300mm height and 100mm diameter. The diffusion of chloride ions through the discs was measured using the PD test (3). Chloride ion concentration measurements were made using an ion selective electrode in the case of the OPC and PFA specimens, and by X-ray fluorescence spectroscopy of the PD diffusion cell fluid in the case of the GGBS concrete.

Prisms of dimensions 100 X 100 X 500mm were used to perform carbonation depth measurements. These prisms were coated in wax with one rectangular face exposed and placed in a carbonation tank which provided an exposure atmosphere with a 4 % partial pressure of CO_2 and 50%RH. Determination of carbonation depth was performed by breaking off one end approximately 30mm thick from the prisms and spraying with phenolphthalein indicator (4). After testing the fractured end was resealed with wax.

To measure half-cell corrosion potential 100mm cubes were cast with two 12mm lengths of steel reinforcement embedded at a distance of 40 from each other. These rods had a diameter of 10mm and 60mm of their lengths exposed with 30mm at both ends coated in pitch epoxy resin. After curing, these cubes were coated with wax leaving the face next to one of the reinforcement rods exposed. They were then transferred to a chloride spray tank which was programmed to spray the specimens with chloride solution for a continuous period of 12 hours in every 24 hour period . Half-cell potential measurements (5) were made every 7 days using a silver chloride half-cell. The reinforcement rod closest to the exposed face was used as the reference electrode whilst the other rod was used as the secondary electrode (6)

Prisms of dimensions 75x75x300mm with reference studs embedded at each end were used to measure length change produced by cyclical freezing and thawing (7). The freezing and thawing periods lasted 4 hours each and their temperatures were -15 and 5°C respectively. Freeze / thaw testing was only conducted on OPC concrete specimens.

Results and Discussion

Initial Surface Absorption Test

Figure 1 shows the 10 minute ISAT values obtained from the concrete specimens. The surfaces of the air cured control specimens absorb water at the highest rate, whilst the least permeable surfaces are those of the film cured specimens. The higher dosage of self-cure chemical provides a greater improvement in surface characteristics, but at both concentrations the chemical decreases the rate of absorption at the surface.

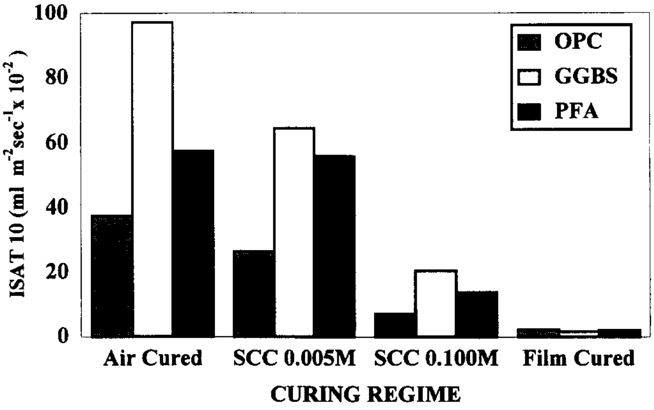

Figure 1. 10 Minute Initial Surface Absorption Test Results.

Chloride Ingress Measurement

The coefficient of diffusion (D) obtained using the PD test are shown in Figure 2. The same trends as the ISAT measurements are displayed by the D values for each individual binder type. However, when one compares concretes of different binder type, it can be seen that the GGBS and PFA concretes have considerably lower coefficients of diffusion than concrete containing only

OPC. This may be attributable to the greater chloride binding capacities of the two binder replacement materials (8). It should, however, be noted that this binding capacity is finite and since these are relatively early results the later chloride ingress behaviour will probably begin to become more dependent on the concrete's actual penetrability to chloride ions (and probably bear more resemblance to the ISAT results).

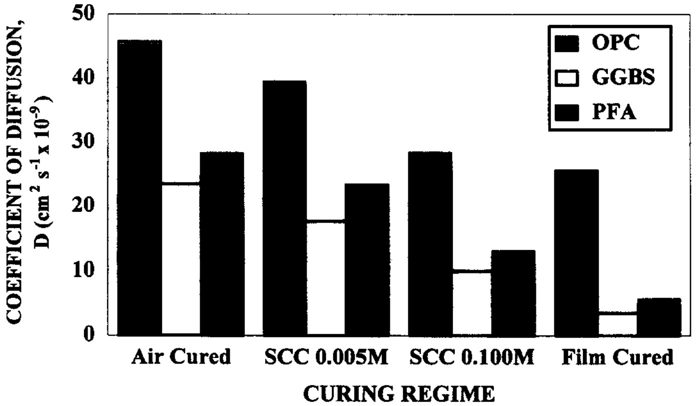

Figure 2. Coefficients of Chloride Ion Diffusion Measured Using the PD Test.

Depth of Carbonation

Figure 3 shows the depth of carbonation values obtained after 2 weeks exposure to a carbonating atmosphere. As expected, the specimens sealed in film during the curing period display the least amount of penetration by carbon dioxide, whilst the most carbonation has occurred in the air cured control specimens. The depth of carbonation measured in the self-cure specimens is reduced further as more of the chemical is added. It should be noted that at the highest SCC dosage the carbonation results are very close to those of the film cured concrete.

Corrosion Potential

The corrosion potentials obtained for the specimens after a period of 28 days of exposure in the chloride spray tank (Figure 4) show similar trends to the PD test results in that the PFA and GGBS

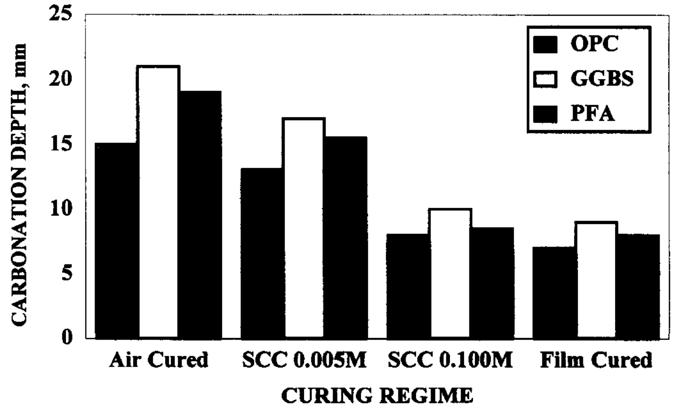

Figure 3. Depth of Carbonation After 14 Days Accelerated Exposure

specimens display a lesser potential to corrode than their OPC counterparts, presumably due to their enhanced chloride binding capacities.

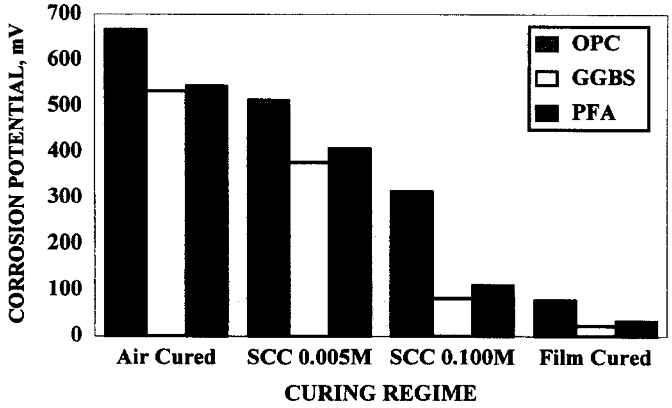

Figure 4. Half-Cell Corrosion Potential After 28 Days Chloride Spray Exposure

Freeze / Thaw Resistance

Figure 5. is a plot of length change of the OPC concrete prisms versus the number of freeze / thaw cycles experienced. There is a region of instability at the beginning of these measurements which is assumed to be due to the fact that the specimens were not soaked in water prior to testing. However, after a number of cycles the specimens begin to expand and it can be seen that the greatest amount of expansion is observed in the air cured control specimen, with the extent of expansion decreasing in the order 0.100M SCC, 0.005M SCC and finally the film cured specimen.

Figures 5(a), (b), (c), and (d) show the condition of the freeze / thaw specimens after 537 freeze thaw cycles. It can be seen that the air cured control specimen has lost a considerable quantity of its surface. However, the other specimens are still virtually intact. Both the self-cure concrete specimens appear to be in a similar condition to the film cured control.

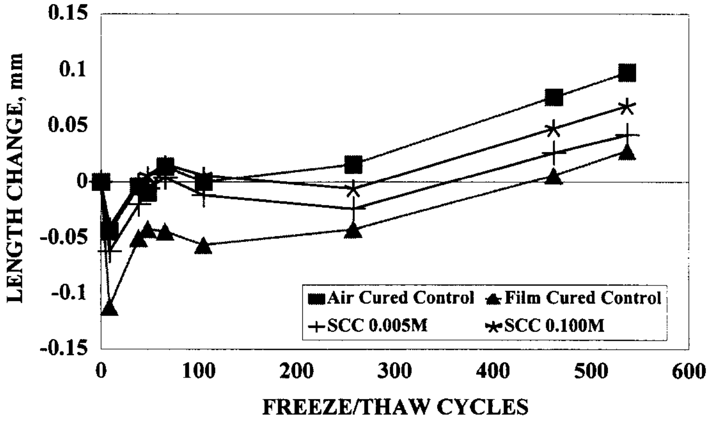

Figure 5. Length Change of Concrete Prisms Produced by Freeze / Thaw Regime

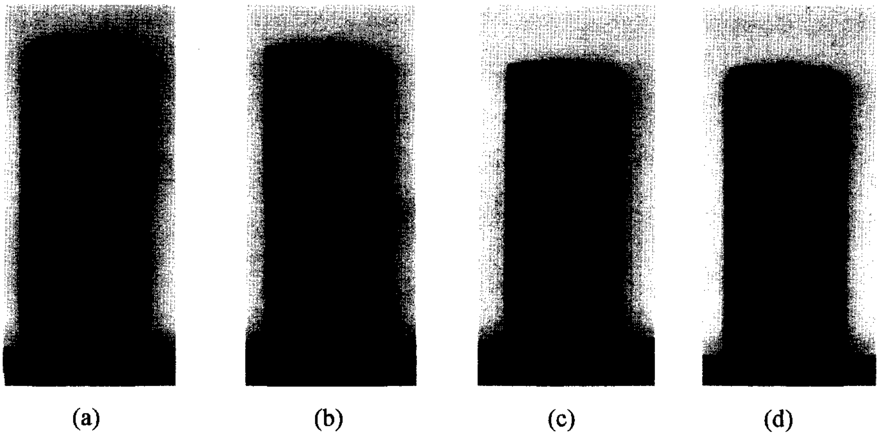

Figure 6. Freeze / Thaw Specimens at 537 Cycles (a) Air Cured Control, (b) 0.005M SCC, (c) 0.100M SCC, (d) Film Cured Control

Conclusions

1.With respect to surface quality, chloride diffusion, carbonation, corrosion potential and freeze / thaw resistance self-cure concrete provides improved performance when compared to air cured specimens.

2. The improvements in concrete durability properties are dependent on chemical dosage. At the highest dosage used in this study properties approaching, and in some cases as good as, those characteristic of the film cured control were achieved. It is conceivable that higher dosages could produce air cured concrete with properties rivalling those achieved in the film cured situation.

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