EVOLUTION OF MICROSTRUCTURE IN MORTARS CONTAINING SUPERABSORBENT POLYMERS DURING THE PERIOD OF INITIAL EXPANSION

Kanazawa University Student Member ○Hu Qiaoying
Kanazawa University Member Shin-ichi Igarashi

1. INTRODUCTION

Superabsorbent polymers (SAP) have been used as an internal curing material for concrete with low water-to-cement ratios. When SAP is used, large expansion is often observed in concrete. The expansion is usually explained by the reabsorption of bleed water at early ages. Thus the internal water retained by SAP may increase the bleeding. However, the mechanism for internal bleeding due to SAP is not fully understood.

The objective of this study is to investigate the evolution of microstructure in mortars with SAP during the early setting and subsequent hardening process. The evolution is discussed in relation to expansion at early ages.

2. EXPERIMENTAL

2.1. Materials and mixture proportion

Ordinary Portland cement was used. A commercial product of silica fume was used. The fine aggregate was siliceous sand. A polycarboxylic acid type superplasticizer was used. Two types of SAP (A and B) were used. SAP-A is produced by aqueous polymerization while SAP-B is obtained by inverse suspension polymerization. Their absorption capacities in cement pastes are 10.0g/g and 13.3g/g of dry mass, respectively. The SAP was sieved to obtain two particle size distributions, large (300~600μm; SAP-AL, SAP-BL) and small (150~300μm; SAP-AS, SAP-BS). Mixture proportion of mortars is given in Table 1.

2.2. Experimental procedures

(1) Length change test

Length change of mortars was measured by the corrugated tube method in accordance with ASTMC1698-09. Mortar specimens using corrugated plastic molds were placed in a room at 20℃. Length changes of the specimens were measured by the dilatometer (Fig. 1).

Table 1 Mixture proportion of mortars (mass fraction)

Mixes	W/B	C	SF	S	SP	SAP
Control	0.28	1	0.094	1.89	0.017	-
SAP	0.28	1	0.094	1.89	0.017	0.003

(2) Electrical resistivity test

The electrical resistivity of fresh mortars was measured by the four electrodes method in accordance with JSCE-K 562-2008. Mortars were directly placed into a cylindrical mold shown in Fig.2.

(3) Rheology test

Plastic viscosity of mortars was measured with a commercial rheometer. Measurement was made at prescribed time intervals up to a few hours after the addition of water.

(4) Degree of hydration

The degree of hydration (α) was determined from non-evapolable water. The non-evapolable water content was determined by the loss on ignition in accordance with JIS R 5202.

(5) Absorption capacity test of SAP

Absorption capacity of SAP was evaluated by the tea-bag method in accordance with JIS K 7223. Saturated solution of calcium hydroxide was used instead of deionized water.

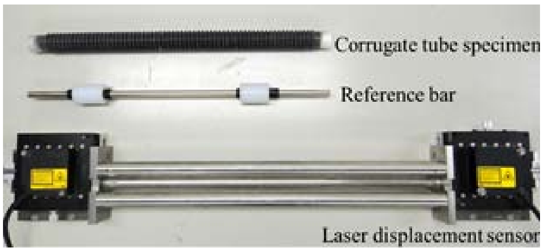

Fig. 1 Measuring instruments for length change test

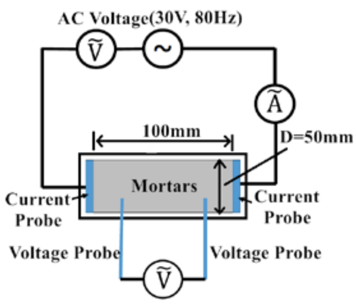

Fig. 2 Schematic diagram of electrical resistivity test

Keywords: superabsorbent polymer, expansion, electrical resistivity, plastic viscosity, degree of hydration
Contact address: Kakumamachi, Kanazawa, Ishikawa, 920-1192, Japan, Tel:+81- 76-264-6373

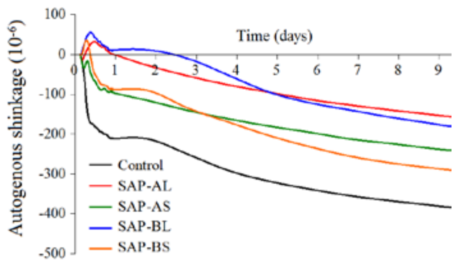

Fig.3 Autogenous deformation of mortars

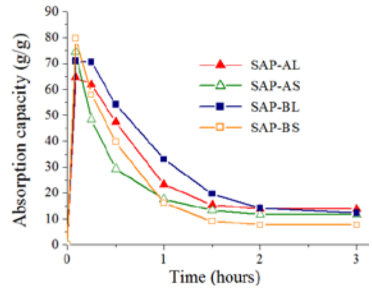

Fig.4 Change in absorption capacity with time

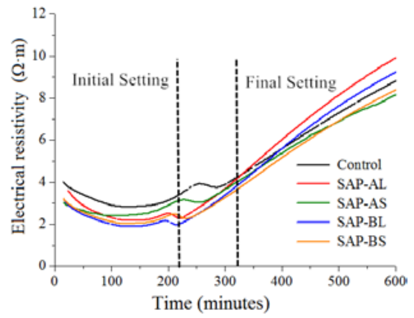

Fig.5 Change of electrical resistivity in mortars wih SAPs

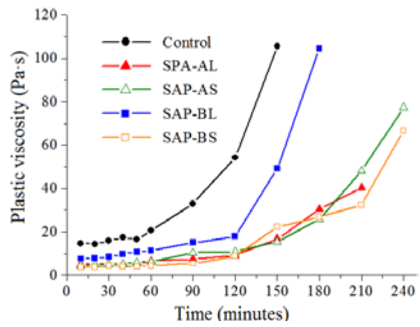

Fig.6 Development of plastic viscosity at early age

3. RESULTS AND DISCUSSION

Autogenous deformation behavior of mortars using each SAP is shown in Fig.3. The SAP mixtures exhibited pronounced expansion after the initial setting, while the control mortar showed autogenous shrinkage. The large particles of SAP resulted in greater initial expansion and longer periods of the expansion than those with the small particles.

Changes in absorption capacity of SAPs are shown in Fig.4. All the SAPs exhibited their maximum absorption capacity at ten minutes after soaking, and then decreased quickly. Therefore, the SAPs in actual mortars are likely to release the internal curing water at very early age.

The electrical resistivities and the initial setting time are shown in Fig.5. A similar tendency over time was observed for all of the mixtures. Table 2 shows the degree of hydration. In spite of the early increase in resistivity for the SAP mortars, differences in the degree of hydration between the mixtures are relatively small. Therefore, the water released from SAP does not greatly accelerate the hydration of cement at early ages. Nevertheless, different dilation behaviors due to the absorption of bleed water are observed, as shown in Fig.3.

Table 2 Changes in degree of hydration of cement

α (%)	Control	SAP-AL	SAP-AS	SAP-BL	SAP-BS
6h	23.92	22.49	23.18	26.49	28.21
12h	39.99	35.89	37.03	40.89	41.05
24h	49.92	50.01	49.74	55.97	55.71

Fig.6 shows changes in plastic viscosity. At first they kept a stable value, then started increasing rapidly. The control mortars exhibited a little higher plastic viscosity. When SAP was used, a remarkable increase was observed for the mortars with SAP-B, while other SAP mortars showed gradual increase. Furthermore, the plastic viscosity in the SAP-B mortars depends on its particle size. It should be noted that all the changes in the plastic viscosity were recorded before the initial setting time when the internal water of SAP was released. Plastic viscosity reflects the internal friction of a material. Thus, even if it is in the dormant period, there must be some differences in the evolution of microstructure between the mixtures with different SAPs. The internal friction in mortars with SAP is influenced by a liquid phase. Therefore, differences in spatial distribution of SAP particles resulted in different moisture distribution in the mortars at early ages. It may affect the expansive behaviors of mortars with SAPs.

4. CONCLUSION

Early age expansion of the mortars with SAP is contributed from the internal water released from the SAP. Difference in expansive behaviors of mortars with SAPs may be related to the initial moisture distribution.

ACKNOWLEDGMENTS

The support of JSPS KAKENHI (Project No. 24560564) is gratefully acknowledged.