EVALUATION ON SHRINKAGE CHARACTERISTICS OF HIGH PERFORMANCE CONCRETE BY MOCK-UP TEST

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1. Introduction

Recently, researches related to high performance concrete presenting high strength and high fluidity are actively under way, and applications on field on real structures are progressively increasing. In order for such concrete to satisfy the required performances, high performance concrete has low water-binder ratio and uses large quantities of unit binders. This leads concrete to display high level of autogenous shrinkage which, in some cases, degrades the durability of concrete by inducing the development of cracks. The research team involved in this study already performed a series of studies to derive the optimum mix proportion using admixtures, expansive additives and shrinkage reducing additives that reduces shrinkage in high performance concrete.

This study investigates the shrinkage characteristics exhibited by 800×800×800mm specimens manufactured according to the optimum mix proportion suggested in our previous research results.

2. Experimental program

2.1 Materials and mix proportion

The materials used to manufacture the specimens are cement(OPC, density 3.14g/cm^3), fly ash(fineness 3,850cm^2/g, density 2.22g/cm^3), silica fume(fineness 240,000cm^2/g, density 2.10g/cm^3), fine aggregate(river sand, density 2.67g/cm^3), coarse aggregate(crushed aggregate, density 2.63g/cm^3), expansive additive(CSA type, density 2.93g/cm^3) and shrinkage reducing agent(glycol type, density 3.16g/cm^3).

Table 1 summarizes the mix proportions of concrete used in this study. The mix proportions are plain concrete with W/B ratio of 30% mixed with 20% of fly ash and 10% of silica fume, and for the optimum mix proportion, plain concrete supplemented with 5% of expansive additive and 1% of shrinkage reducing agent.

In order for the concrete to satisfy a slump flow of 60±5cm and air content of 4.5±1.0%, the proportion of superplasticizer and AE agent has been adjusted.

Table 1 Mix proportions of concrete

Type	W/B (%)	s/a (%)	Unit content (kg/m^3)						SP (%)	AE (%)
			W	B	S	G	EA	SR		
Plain	30	45	175	525	686	839	0	0	1.75	0.03
LSC			175	525	681	832	29	6	2.20	0.02

2.2 Test method

The specimens assumed as columns have been manufactured for drying shrinkage and autogenous shrinkage purposes with dimensions of 800×800×800mm.

Measurement in the drying shrinkage test was performed using surface contact gauges disposed on the specimen after its removal from the mold at 7 days. To prevent evaporation and absorption of moisture in the autogenous shrinkage test, the whole surface of the specimen has been wrapped with a polyester film and the strain has been measured by means of embedded gauges.

3. Results and discussions

3.1 Material properties of concrete

Table 2 lists the material properties of concrete. It appears that the required fluidity and air content were satisfied regardless of the type of concrete. But, concrete with the optimum mix proportion presenting lower fluidity than plain concrete, the proportion of SP agent has been increased and the quantity of AE agent has been reduced to decrease the subsequent increase of air content. In addition, the use of CSA-type expansion agent was seen to accelerate the setting of the optimally mixed concrete by about 6 hours compared to the plain concrete.

Table 2 Properties of concrete

Type	Slump Flow (cm)	Air content (%)	Setting times (hrs)		Compressive strength (MPa)		
			Initial	Final	7D	28D	91D
Plain	64.3	5.6	24.2	26.7	47.3	66.2	70.9
LSC	62.8	4.6	15.5	18.0	49.7	68.9	72.7

Keyword : High Performance Concrete, Shrinkage, Expansive additive, Shrinkage Reducing Agent
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The strength increased with time to exhibit high strength beyond 70MPa at 91 days. Moreover, relatively larger compressive strength was observed for the concrete with optimum mix proportion than plain concrete. This can be explained by the enhanced compaction of the structure produced by the hydration process of the expansive agent.

3.2 Temperature history of concrete

Fig. 1 plots the temperature histories by type of specimen. The temperature of the specimens increased suddenly at first regardless of the type of specimen to reach a maximum at about 1.5 days and then reduced slowly. The maximum temperatures ran around 65℃, 64℃ and 58℃ at the center, middle and surface, respectively. The temperatures observed at the center and middle were quasi-identical.

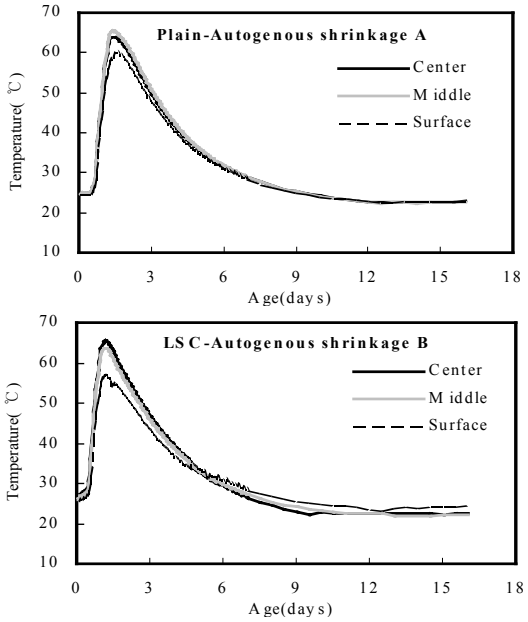

Fig. 1 Temperature history of concrete

3.3 Shrinkage characteristics

The shrinkage characteristics by type of specimen are illustrated in Fig. 2. In the autogenous shrinkage test, the strain at 1 day including thermal effect of the plain concrete specimen A reached about 150×10^{-6}, and the autogenous shrinkage strain removed from thermal effect was -340×10^{-6} at 49 days. For specimen B corresponding to concrete with optimally mix of proportions, the strain at 1 day including thermal effect reached about 200×10^{-6}, and the autogenous shrinkage strain attained -175×10^{-6}, which represents a reduction of shrinkage by 50% compared to specimen A. Considering the drying shrinkage, the strain at 49 days measured at the center of specimen C standing for the optimally mixed concrete reached about -150×10^{-6}, which is nearly similar to the autogenous shrinkage strain exhibited by specimen B. This can be explained by the quasi non-evaporation of moisture inside concrete in the drying shrinkage specimens.

On the other hand, the mock-up specimen shrank suddenly at first compared to the 100×100×400mm specimen. This phenomenon probably occurred due to the active hydration induced by the high heat of hydration. The drying shrinkage strain at the surface measured by the contact gauges after removal from the mold was seen to be relatively larger than the autogenous shrinkage.

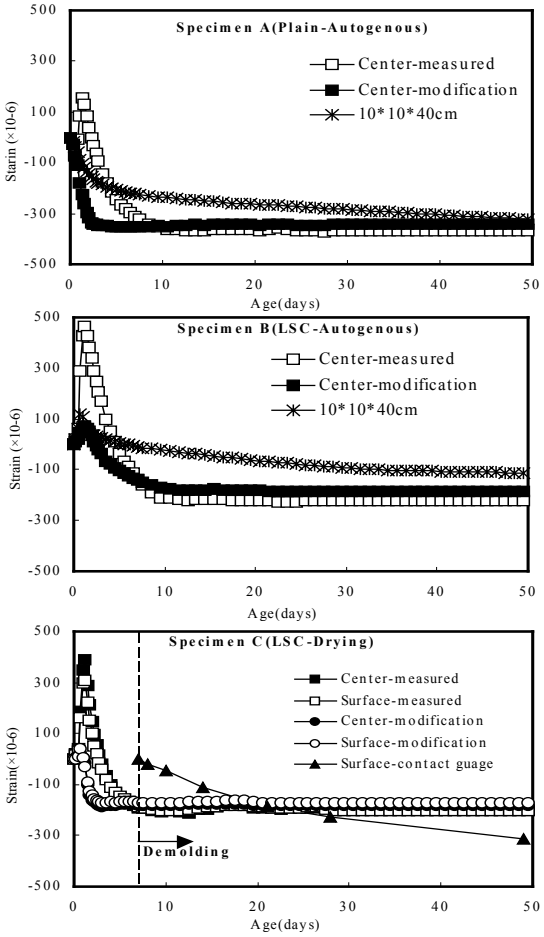

Fig. 2 Results of concrete shrinkage

4. Conclusion

The shrinkage characteristics of high performance concrete using a combination of expansive additive and shrinkage reducing agent have been experimentally examined through 800×800×800mm specimens. Test results revealed that autogenous shrinkage reduced by about 50% compared to plain concrete.

References

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