Early Age Shrinkage by Self-Desiccation in Ultra-High-Strength Concrete

Yoo, Doo-Yeol* Min, Kyung-Hwan** Yang, Jun-Mo** Yoon, Young-Soo***

ABSTRACT

The high-strength concrete(HSC) compared to normal concrete represents higher autogenous shrinkage due to lower water-to-binder ratio(W/B) and supplementaries, fly ash(FA) and granulated blast-furnace slag(BFS), etc. The potential of early age cracking which reduces durability of concrete structures is normally influenced by autogenous shrinkage and degree of restraint. Therefore, this paper studies on the evaluation of the characteristics of autogenous shrinkage for HSC, ultra-high-strength concrete(UHSC) containing admixtures by experimental test and the test results are compared with existed prediction models.

1. Introduction

Autogenous shrinkage is mainly occurred by the tension force of meniscus, proportional to the capillary pressure(P_{vapor}-P_{water}) due to self-desiccation. In addition, chemical shrinkage, solid surface tension, and disjoining pressure influence the autogenous shrinkage of concrete.

2. Experimental programs

In this study, to evaluate the characteristics of early age autogenous shrinkage for HSC, various W/B (W/B of 30, 25, 20, 16, and 12%) is applied. Identical Type 1 Portland cement, aggregate and superplasticizer improving workability are used. Silica fume(SF) is added 8%(W/B 25%), 12%(W/B 20%-12%). Under W/B of 20%, FA and BFS are applied.

Autogenous shrinkage test is conducted as similar with the method proposed by JCI. The initial setting is estimated by KS F 2436 and teflon sheet is employed to control the restrained stress. After removal of the formwork, aluminum tape is applied to seal the specimens and shrinkage strain is measured at constant temperature, 20±1°C and humidity, 50±3%.

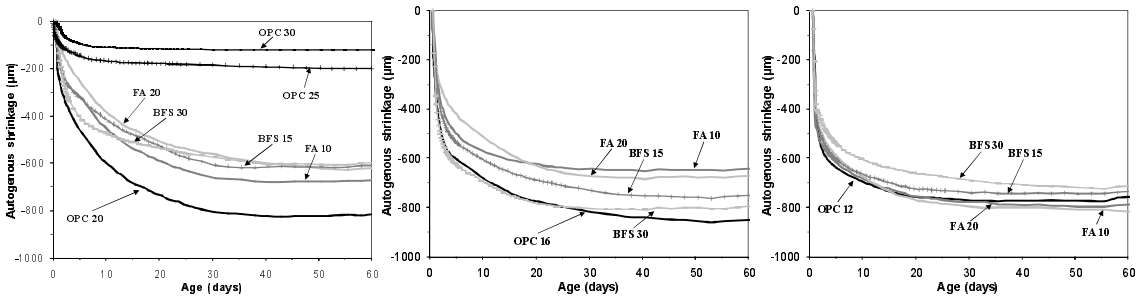
3. Results and Discussions

3.1 Effect of W/B and Admixtures for Autogenous Shrinkage

Fig. 1 represents the effect of W/B and admixtures for autogenous shrinkage. Autogenous shrinkage increases as W/B is reduced until 16% caused by increasing the suction pressure due to the reduced size of pores and the replacement ratio of SF. In the case of W/B of 12%, however, autogenous shrinkage decreases by insufficient hydration, whereas the early shrinkage strain increases as W/B is reduced.

Both FA and BFS reduce the autogenous shrinkage and the decrement of autogenous shrinkage become insufficient as W/B decreases. In the case of W/B of 20 and 16%, FA20 decreases autogenous shrinkage as 24.2%, and 21.3% respectively and the early shrinkage strain is reduced by adding FA, BFS.

* KCI Member, Graduate Student, School of Civil, Environmental and Architectural Engineering, Korea University
** KCI Member, Ph. D. Candidate, School of Civil, Environmental and Architectural Engineering, Korea University
*** KCI Member, Professor, School of Civil, Environmental and Architectural Engineering, Korea University



(a) W/B=30, 25, and 20% (b) W/B=16% (c) W/B=12%

Fig. 1 Autogenous Shrinkage with Different W/B and Admixtures

3.2 Comparison of prediction models and test results

The prediction models are compared with experimental results numerically using by the coefficient of error. The error coefficient M for shrinkage is defined as follows(Navile et al. 1983):

$$M = \frac{1}{S_{ave}(t,t_0)} \times \sqrt{\frac{\sum \left[S_0(t,t_0) - S_p(t,t_0) \right]^2}{n-1}} \quad (1)$$

where, $S_0(t,t_0)$ is the observed autogenous shrinkage, $S_p(t,t_0)$ is the predicted autogenous shrinkage, $S_{ave}(t,t_0)$ is the mean observed autogenous shrinkage for a number of observations n.

Table 1 represents the coefficient of error for prediction models with various W/B. The coefficient of error below 0.15 can be assumed to be acceptable(Mazloom 2007).

Therefore, the comparison results of experimental and predictive values indicate that most of the existed prediction models are inappropriate to HSC, UHSC under W/B of 0.3.

Table 1. The Coefficients of Error for AS with Various W/B

W/B (%)	The Coefficient of Error, M				
	JSCE	Eurocode 2	AFREM	Jonasson	Dilger
30	2.2787	0.5329	0.4670	0.3257	1.3944
25	2.1965	0.5040	0.3768	0.1363	1.4182
20	0.3891	0.9155	0.8455	0.7109	0.3551
16	-	0.9501	0.8528	0.7376	0.2907
12	-	0.9426	0.8097	0.7370	-
Average	1.6214	0.7690	0.6704	0.5295	0.8646

4. Conclusions

Autogenous shrinkage increases as W/B is reduced and FA is added until W/B of 16%. In the case of W/B of 12%, however, autogenous shrinkage decreases and the effect of FA is negligible. The BFS reduces autogenous shrinkage under W/B of 20% in contrast with the previous studies caused by the decrement of hydration products, $Ca(OH)_2$, and the growing of capillary tension effect. The most of existed prediction models are inappropriate to the HSC, UHSC under W/B of 30% and development of a proper prediction model is required.

Acknowledgements

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MEST) (No. 2007-0056796).

Reference

1. Mazloom, M. (2007). “Estimating long-term creep and shrinkage of high-strength concrete,” *Cement and Concrete Composite*, Vol. 30, No. 4, pp. 316-326.