

Fundamental Properties of Infilled Concrete for Hollow PC

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Abstract—The purpose of this study is to find the basic characteristics of HPC consolidating concrete. The results are presented as follows: In terms of compression strength, the strength of BS mixed with Alkaline Activator (AA) was stronger than that of general BS. It is judged that Shrinkage Reducing Agent (SRA) considerably less influences compression strength. In terms of length change, the length of BS mixed with the AA changed smallest. It was found that the length change reduced further with the use of SRA.

Keywords—hollow PC; length change; shrinkage reducing agent; alkaline activator

I. INTRODUCTION

The current construction market features high-rise buildings, large buildings, and complex buildings. As a result, there are more demands of the buildings with a large span and story height. As reinforced concrete construction technique is applied to the buildings, there are more temporary works like formwork which cause a limit to a shortened construction period. PC method for supplementation has low economy because of increased joint portions and need to secure structural performance of joints. In addition, compared to Reinforced Concrete method, the PC method one has weak connection and some problems like insufficient concrete filling. To overcome the problems, Hollow PC (HPC) that improves construction performance of connections, secures integrity and has a hollow generated by centrifugal force making are combined with and cast-in-place concrete. Therefore, a combined HPC column is developed and is studied for commercialization. In the mean

time, general concrete is cast in HPC, and after integration a column section is generated. However, drying shrinkage occurs in the cast concrete of HPC, it is possible to make integration of a column section. It can be one of causes that deteriorates the mechanical characteristics of HPC.

Therefore, this study tries to review the shrinkage properties and improvement direction of the concrete filled in HPC and thereby to provide a reference material for improving the mechanical characteristics of HPC.(Reference to Figure 1, 2)



Figure 1. Production process of HPC specimen

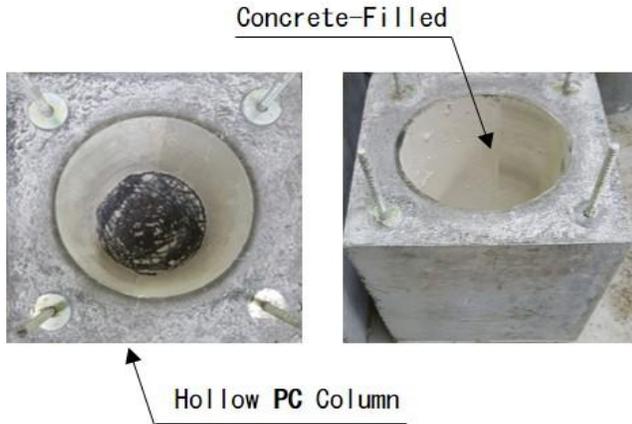


Figure 2. Centrifugal molding HPC

II. EXPERIMENTAL OUTLINE

A. Experimental Plans

The experimental design of this study is presented in Table 1. A target strength was 27 MPa types of powder were OPC, 60% substituted Blast furnace Slag at mass ratio, BS (AA) mixed with alkaline activator, and each BS case mixed with SRA. At this time, in terms of mass, powder typed alkaline activator had 1.5% of Blast furnace Slag and 1% of SRA powder (Binder) mixed. During testing, compression strength and length change were measured, and SEM photographing was performed.

TABLE I. EXPERIMENTAL PLANS

Experimental factors	Test level	
Target strength (MPa)	1	27
Powder type	6	OPC, BS, BS(AA) OPC-SR, BS-SR, BS(AA)-SR
BS Replacement ratio (%)	1	60
AA Replacement ratio (%)	1	1.5
SRA Replacement ratio (%)	1	1.0
Experimental details	3	Compressive Strength, Length change, SEM
BS:blast furnace slag, AA:alkaline activator, SRA:shrinkage reducing admixtures		

B. Materials

The basic properties of the powder (Binder) and alkaline activator used in this study are presented in Tables 2~4. Ordinary Portland Cement (OPC) of Korean S and Blast furnace Slag of H were used. As an alkaline activator, Modified Alkali Sulfate of was used.

TABLE II. PHYSICAL AND CHEMICAL PROPERTIES OF BINDER

	Density (g/cm ³)	Fineness (cm ³ /g)	Chemical Composition (%)		
			MgO	SO ³	Ignition Loss
OPC	3.14	3,390	3.46	2.62	1.87
BS	2.91	4,370	5.80	2.36	0.37
BS(AA)	3.03	4,060	3.12	2.52	2.62

TABLE III. PHYSICAL PROPERTIES OF ALKALINE ACTIVATOR

Type	Image	Density (g/cm ³)
Modified Alkali Sulfate	Light gray inorganic Powder	2.75

TABLE IV. PHYSICAL PROPERTIES OF SRA

Image	Density (g/cm ³)	pH
Light gray inorganic Powder	2.75	-
Liquid Type	0.950	6.0

C. Experiment Methods

Testing compression strength and length change was carried out in accordance with Korean Industrial Standards. To measure a change in length, a buried-typed gauge was applied. For SEM photographing, OOO equipment of OOO company was used to observe the microstructure of sample surface. Photo specimens produced for the length change measure is as figure 3.



Figure 3. Production process of HPC specimen

III. RESULT & ANALYSIS

A. Compressive Strength & SEM Analysis

Fig.4 shows different compression strength depending on whether SRA is used. Generally, there was almost no difference in compression strength depending on whether SRA is used. However, regarding types of powder, the specimens with OPC and BS (AA) powder had relatively strong compression strength, whereas the specimen with BS powder had weak compression strength. In particular, in the case of 3-day age, the Blast furnace Slag specimen (BS (AA)) mixed with alkaline activator (AA) had a strength value similar to that of OPC. As shown in Fig.5, it is judged that the addition of alkaline activator in BS powder leads to activating the generation of Ettringite. Also when associate compressive strength results and the SEM photo (1-day age), generation of C_3H_7 has been created BS (AA) more than BS a lot, so Early-Age strength analyzed highly determined. Seeing the value of Ettringite when inserted SRA, compared to BS, generation of hydrates is faster than OPC, BS (AA), so it determined that effect of Early-Age strength increase.

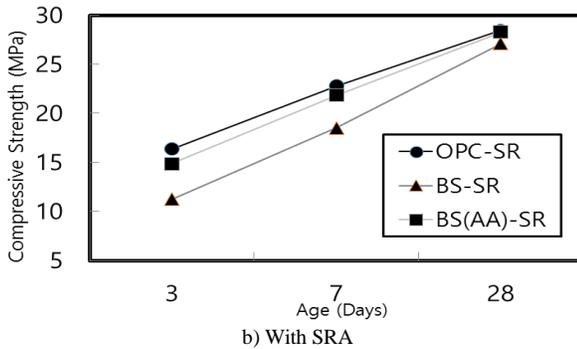
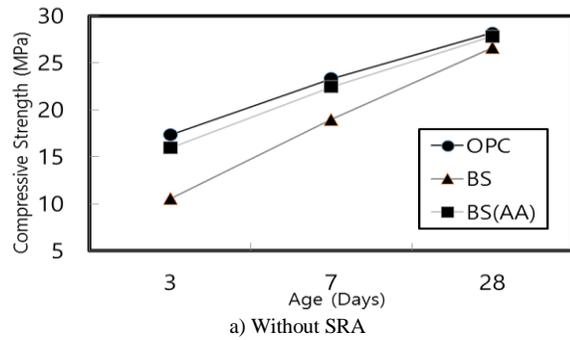


Figure 4. Compressive Strength Properties

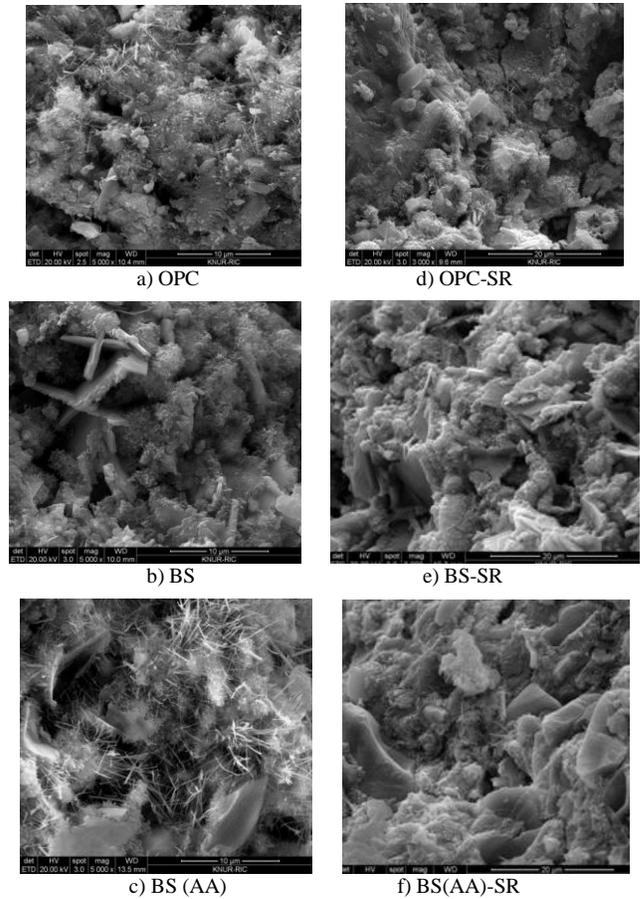


Figure 5. SEM photo

B. Length Change Properties

Fig.6 illustrates a change in length depending on whether SRA is mixed. Generally, with a rise in age, the length change rate increased. The case without SRA (a) had the range of $530\sim480 \times 10^{-6}$ on the basis of 28-day age. BS (AA) had the lowest, and BS had the highest.

The case with SRA had the range of $490\sim325 \times 10^{-6}$ on the basis of 28-day age. In particular, the cases of BS (AA) and BS had a smaller reduction in length change as SRA was used. In general, SRA inserted to control capillary tension, in case of changing pore structure so it is hard to compared as hydrates. With the SEM pictures, it is judged to be hard to analyze the cause. Instead, it is considered to analyze micro pores.

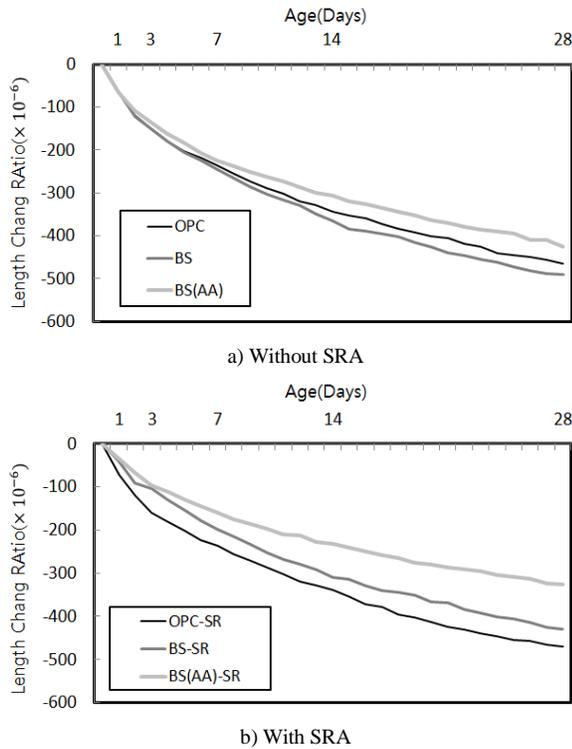


Figure 6. Length change properties

IV. CONCLUSION

This study reviewed the shrinkage characteristics of the concrete filled in HPC, and the results are presented as follows.

A. Compressive Strength & SEM Analysis

There was no big difference in compression strength depending on whether SRA was mixed. However, when Blast furnace Slag was applied, the initial strength reduced remarkably. Mixing with alkaline activator was found to improve the initial strength noticeably. Seeing the value of Ettringite when inserted SRA, compared to BS, generation of hydrates is faster than OPC, BS(AA), so it determined that effect of Early-Age strength increase.

B. Length Change Properties

When SRA was not mixed, the specimen using Blast furnace Slag (BS) had the largest length change. However, the cases of BS (AA) and BS mixed with SRA had a considerably more reduction in length change than the cases without SRA.

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