EFFECT OF CURING TEMPERATURE AND HUMIDITY ON HYDRATION OF BLAST FURNACE SLAG POWDER IN SLAG CEMENT

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ABSTRACT: It is believed that using the concrete mixed with Blast furnace slag cement is one of the effective measures to overcome Global warming problems, and the demand for using slag cement is increasing in recent years to reduce carbon dioxide emissions.
But there are also many reports pointing out the problems caused by the use of blended cement. Most of them have focused on the importance of curing. Curing period of blended cement is specified longer than that of ordinary Portland cement by ambient temperature. However humidity of curing is not clear in Standard specification of concrete structure by JSCE and JASS5.
This research investigated the effect of Humidity of curing on cement hydration under various temperature and humidity conditions by comparing ordinary Portland cement with Blast furnace slag cement by experiment.

1. INTRODUCTION

In recent years, using slag cement for concrete structures increases for the purpose of reducing carbon dioxide emissions and improving the durability. But the mechanism of hydration on slag cement is not clear. The curing is very important for the adequately hydration of binder. And it is necessary to consider how high is the temperature and humidity of hydration.
So this research investigated the effect of humidity of curing on cement hydration under various temperature and humidity conditions by comparing ordinary portland cement with Blast furnace slag cement. When the minimum humidity that hydration proceeded is investigated, essential humidity of curing is understood for concrete structures.

2. EXPERIMENTS

The materials used in this study were ordinary Portland cement (OPC) and blast furnace slag powder (BFS) with 4000 cm^2/g of Blaine specific surface area. The mix proportions of the cement in this study are shown in Table 1. 2 kinds of blend were examined, OPC and OPC replaced by 40 mass% BFS. Cement paste was a water-to-cement ratio of 0.5. The specimens are shown in Figure1. The specimen size was 20×30×10mm in order to maintain uniform humidity in each specimen. Specimens were prepared in the laboratory set 20℃, and demolded after 24 hours, exposed to various curing conditions. But specimens were dried in the atmosphere for 2 or 3 hours before exposing several curing condition in order to avoid changing the setting humidity by water evaporation of specimens. The setting curing conditions were the temperature and the humidity. It is shown in figure 2.The temperature was set 7.5℃,20℃,40℃, and the humidity was set RH 40%,RH60%,RH80% and sealed. And the humidity was controlled by a sodium hydroxide in order to preventing from changing the cement construction for carbonation. The humidity control error was ±3%. The reaction of Specimens was measured by ignition loss and selective dissolution method by Acetone, methanol and salicylate. When the ignition loss was measured, N and BB was heated at 700℃ because of preventing ignition loss of BB from increasing for oxidation of the slag power in BB. The examination was conducted on Immediately after demolding, age of 3,7,28 days.

Table 1 Mix proportion of cement

Sample Name	Mixing Ratio(mass%)	
	OPC	BFS
N	100	-
BB	60	40

Figure 1 Specimen form

Temperature(℃)
7.5
20
40

×

Humidity
RH40%
RH60%
RH80%
Sealed

Figure 2 The temperature and the humidity of curing conditions

3. MESUREMENT AND CONSIDERATION

3.1 The results of hydration by Ignition loss

The results of ignition loss is shown in figure 3,4,5,6. The cement hydration in the sealed condition progressed each kind of cement and temperature. The lower is the curing humidity, the lower is the initial ignition loss. And the cement hydration stopped due to lack of hydration water in dry conditions. Because hydration ratio of cement of RH40% and RH60% was similarly low. On the other hand, the hydration of RH80% was lower than the hydration of sealed, and the hydration proceeded over the age. So the minimum humidity that hydration proceeded was between RH60% and RH80%. About effect of temperature, hydration delayed in low temperature. On the other hand, early hydration proceeded afterwards stopped in high temperature.

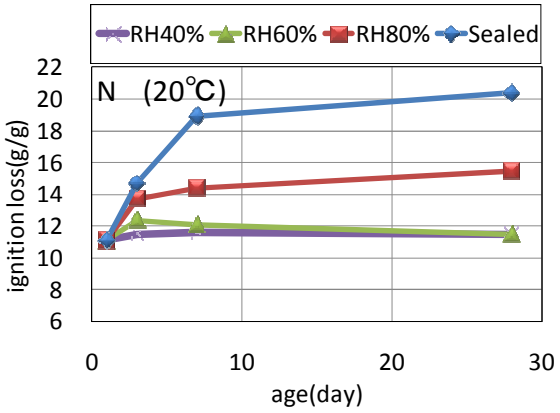

Figure 3 Progress of hydration of N(differences in humidity)

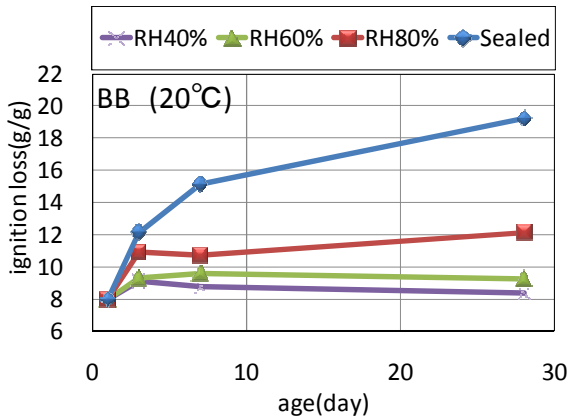

Figure 4 Progress of hydration on BB(differences in humidity)

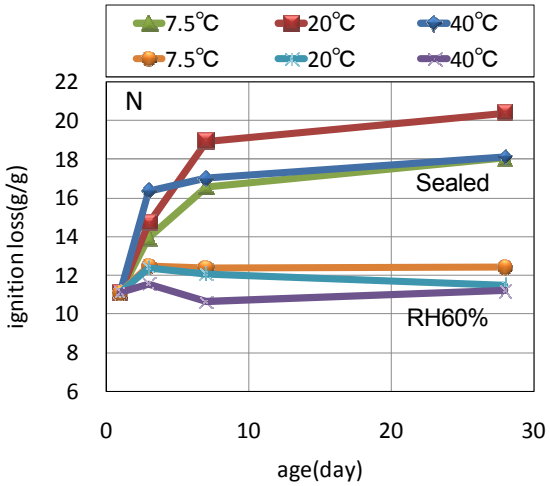

Figure 5 Progress of hydration on N(differences in temperature)

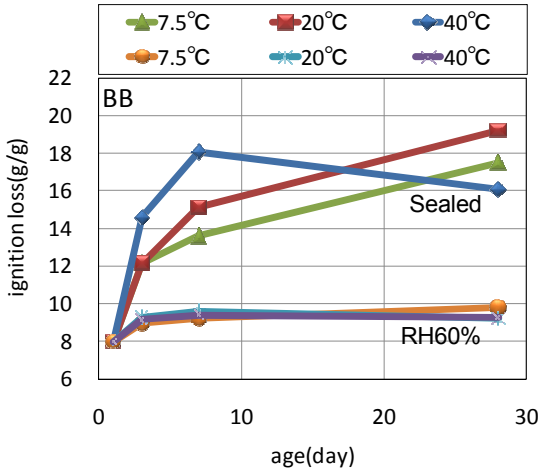

Figure 6 Progress of hydration on BB(differences in temperature)

3.2 The results of hydration by selective dissolution method

The results of reaction of blast furnace slag powder by selective dissolution method is shown in figure 5,6. As well as ignition loss, reaction proceeded in high humidity. But the reaction stopped in dry conditions (RH40% and RH60%).About effect of temperature, the reaction delayed in low temperature. And the reaction of RH80% stopped as RH60% in low temperature. But in high temperature, the results of RH80% approximated the results of sealed.

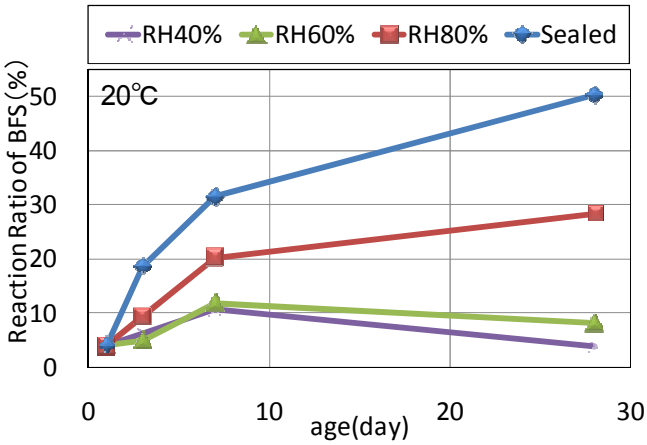

Figure 7 Reaction ratio on BFS(differences in humidity)

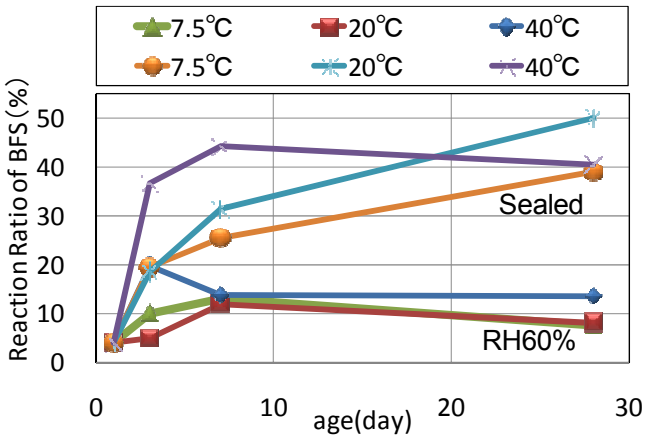

Figure 8 Reaction ratio on BFS(differences in temperature)

3. SUMMARY

(1) It is able to quantify the difference of hydration of binder in each temperature and humidity of curing.
(2) Regardless of the temperature, the hydration of binder stopped in RH60%. On the other hand, it proceeded in RH80%. So the minimum humidity that hydration proceeded was between RH60% and RH80%.
(3) In case of using slag cement, it is very important to keep the temperature and the humidity of curing in order to proceed hydration