STUDY OF THE INFLUENCE OF CARBONATION ON PERMEABILITY OF SALT WATER IN MORTAR USING BLAST FURNACE SLAG CEMENT

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ABSTRACT

Blast furnace slag cement has high resistance of chloride ion penetration. On the other hand, carbonation resistance is low. It is also reported that the pore of blast furnace slag cement become bigger after carbonation. If the pore became bigger, salt water easy to permeate and resistance of chloride ion penetration decrease. In this study, it was investigated the resistance of chloride ion penetration carbonated mortar using blast furnace cement. As a result, carbonated mortar using blast furnace slag cement became easier to penetrate salt water.

Keywords: *Ground granulated blast furnace slag, Carbonation, Permeability*

1. INTRODUCTION

In recent years, global warming has become a world problem. So reduction of carbon dioxide emissions is required in all industries to prevent global warming. Focusing on the construction industry, Ordinary Portland cement (OPC), which is the most widely used construction material, emits a large amount of carbon dioxide during the manufacturing process. Therefore, the use of mixed cements, that replace part of Ordinary Portland cement with other cementitious materials such as ground granulated blast furnace slag (GGBFS) and fly ash, are receiving a lot of attention. Blast furnace slag cement has high salt resistance, on the other hand, its carbonation resistance is low. Previous studies have reported that when submitted to carbonation process, the pores of samples made with blast furnace slag cement become bigger. Then, it is easier for chloride ion to penetrate in carbonated samples made with blast furnace cement. In this study, it was examined the salt penetration resistance of carbonated samples of mortar using blast furnace as a cement partial replacement.

Table 1. The mix proportion of mortar

Symbol	W/B	S/C	Binder ratio(%)	
			OPC	GGBFS
OPC	50	3	100	0
B50			50	50
B70			30	70

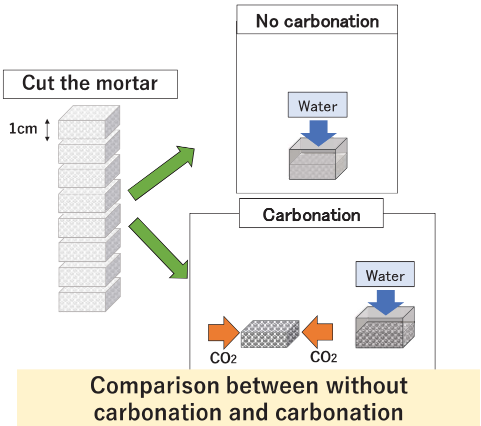

Fig.1 Water permeability testing method

2. EXPERIMENTS

2.1 Water permeability test

If water permeability is high, salt water will also permeate. Therefore, a water permeability test was carried out using mortar. The mix proportions of mortar are shown in **Table 1**. The test procedures are shown in **Fig.1**.

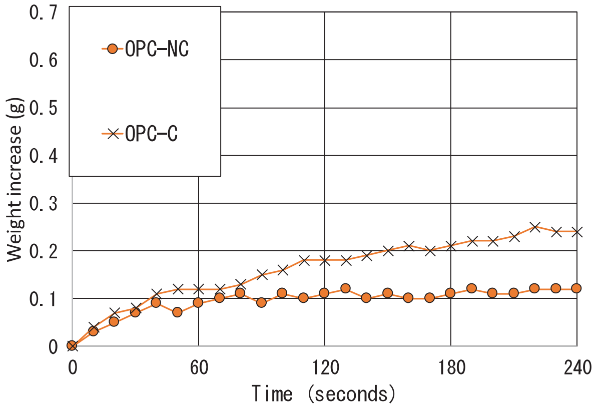

Fig.2 Water permeability (OPC)

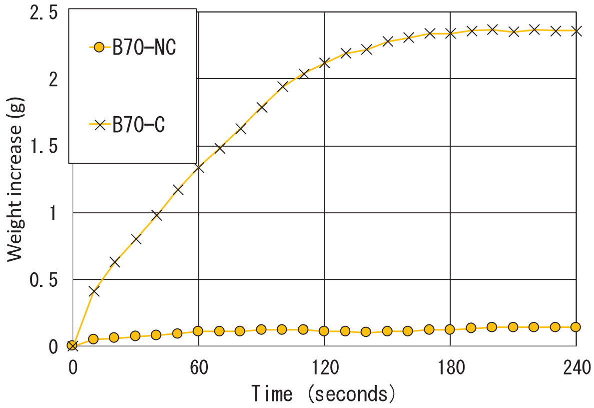

Fig.4 Water permeability (B70)

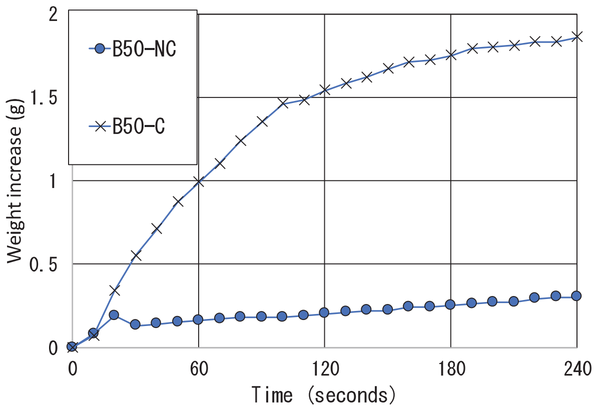

Fig.3 Water permeability (B50)

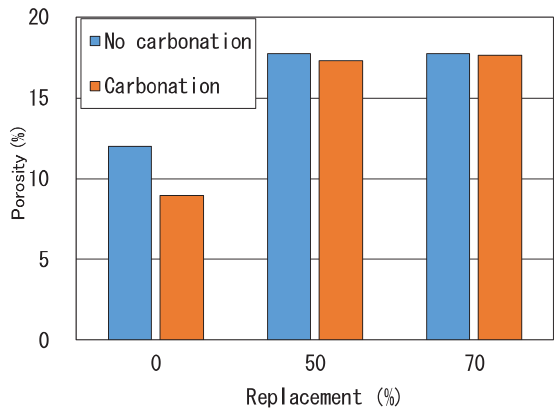

Fig.5 Weight increase rate

The mortar samples were casted with dimensions of 40 mm × 40 mm × 160 mm. It was demolded in the next day. Then it was cut to 1 cm in order to accelerate the carbonation. The results of water permeability test are shown in **Fig.2** to **Fig.4**. As a result of OPC, the permeability slightly increased by carbonation. The results of B50 and B70 show that the water permeability increases when the samples are carbonated. The results of the increase in mass rate are shown in **Fig.5**. In the case without carbonation, the weight increase rate is similar. However, the carbonated samples with blast furnace slag cement have higher mass increase rate. In other words, the carbonated samples with blast furnace slag cement may have bigger pores.

2.2 Chloride penetration test

The test procedures are shown in **Fig.6**. The resistance to chloride penetration after carbonation was tested. To check which layer the salt water reached. 8 mortar pieces used in the water permeability test were stacked to prepare a test specimen. After 50 hours, the rate of weight and salt concentration of each piece was

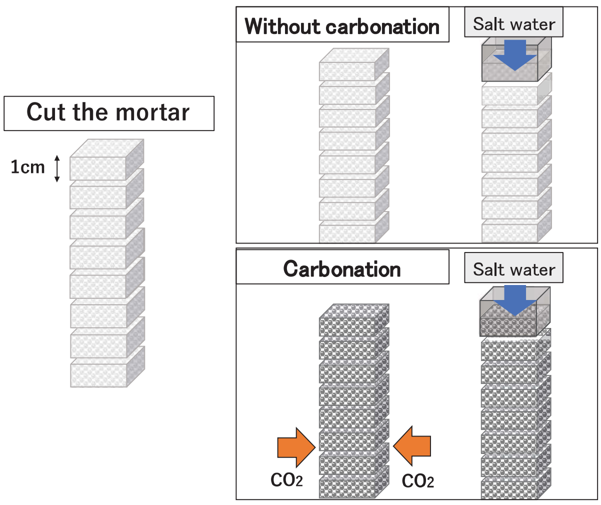

Fig.6 Water permeability testing method

measured. without carbonation, the weight rate did not change even when GGBFS is used as a cement partial replacement, as can be observed in **Fig.7**. However, as shown in **Fig.8**, when the samples with GGBFS are

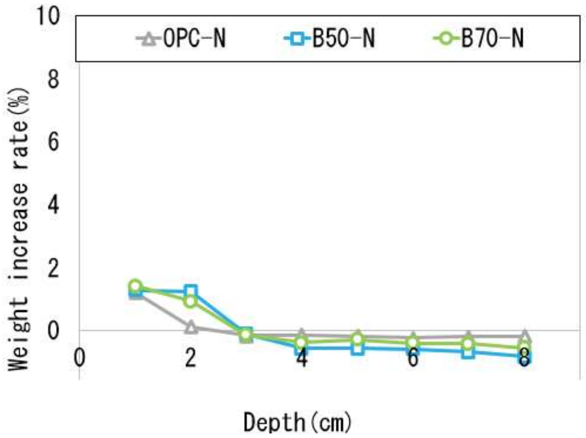

Fig.7 Salt penetration test (Non-carbonated)

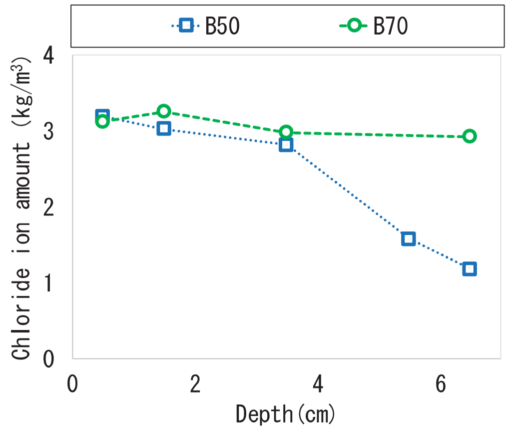

Fig.9 Chloride ion amount of each layer

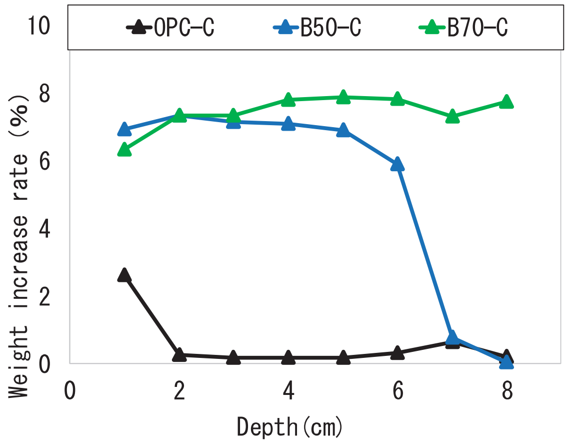

Fig.8 Salt penetration test (Carbonated)

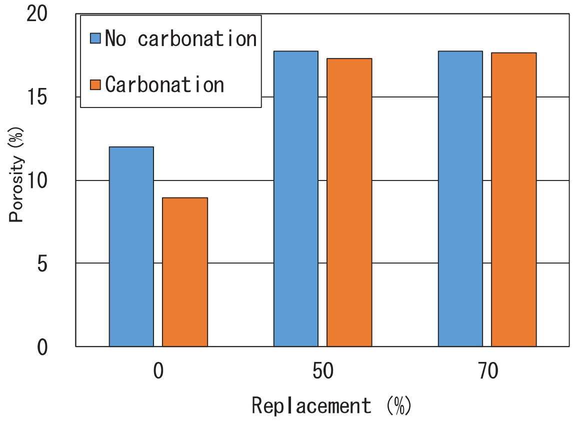

Fig.10 Results of Archimedes

carbonated, the weight rate increased. The amount of chloride ion was measured in each layer of the carbonated samples containing blast-furnace slag cement. The results of the chloride ion amount of each layer are shown in **Fig.9**. The carbonated B70 C had chloride ions penetrated into all layers.

2.3 Archimedes test

In order to confirm the change in the pore structure due to carbonation, the porosity was calculated. Using one of the cut specimens, the porosity was calculated from the absolute dry mass, saturated water mass, and underwater mass.

$$P_0 = (W_s - W_d)/(W_s - W_u) \quad (1)$$

P_0 : Porosity(%)
W_s : Saturated water mass(g)
W_d : Absolute dry mass(g)
W_u : Underwater mass(g)

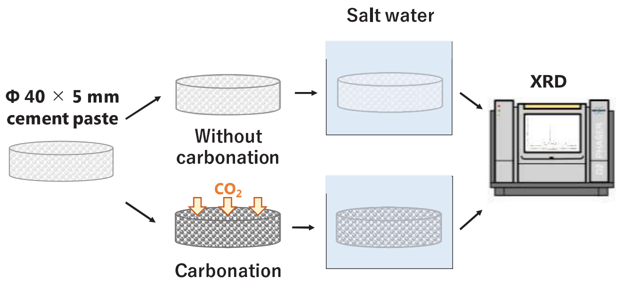

Fig.11 XRD testing method

The porosity results are shown in **Fig.10**. Carbonated OPC has the lowest porosity when compared with the other results. Carbonated B50 and B70 have similar porosity. Therefore, it is conceivable that the pore structure becomes bigger. In the future, the pore structure will be measure with a mercury intrusion porosimeter.

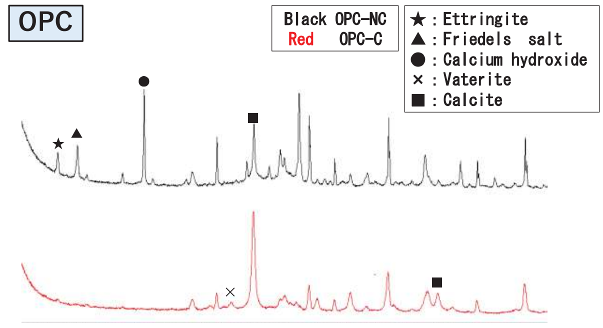

Fig.12 XRD results (OPC)

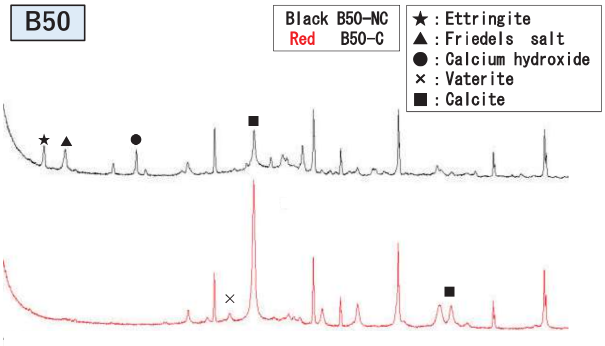

Fig.13 XRD results (B50)

2.4 Effect of carbonation on product after salt water immersion

It became easier to water permeate when carbonated. Then, the influence of carbonation on the product after salt water immersed was examined. The test procedures are shown in **Fig.11**. The samples were casted using water cement ratio of 50% and GGBFS with replacement rate set as 0%, 50% and 70%. After immersed in salt water, the products of hydration could be identified using cement paste. The results of XRD are shown in **Fig.12**. to **Fig.14**. The results were named according to the test procedure, being "NC" immersed in salt water without carbonation, and "C" carbonated and then immersed in salt water. As a result of OPC, Friedel's salt is produced when not carbonating. However, when carbonated, it is produced. Also, carbonated OPC samples do not produce monosulfate and ettringite. Friedel's salt can also not be detected in B50 C carbonated OPC samples do not produce monosulfate and ettringite. Friedel's salt can also not be detected in B50 C and B70 C. In other words, the carbonated cement specimens cannot immobilize chloride ions.

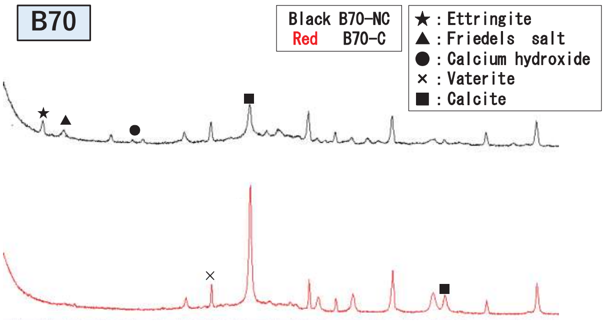

Fig.14 XRD results (B70)

3. CONCLUSIONS

(1) When mortar using blast furnace cement is carbonated, it becomes easy to permeate

(2) Carbonated blast furnace cement mortar becomes easy to permeate but porosity is similar.

(3) The carbonated samples did not produce Friedel's salt.

In this experiment curing was not a parameter. In the future we will conduct experiments considering curing conditions.

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PHOTOS AND INFORMATION

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