論文の内容の要旨

論文題目「Fundamental Study on Improvement of Salt Damage Resistance of Mortar with Various Blast Furnace Slag based on Chloride Ion Immobilization Capacity」

（各種高炉スラグ微粉末配合モルタルの塩化物イオン固定化性能に基づく耐塩害性向上に関する基礎的研究）

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キーワード：Effective diffusion coefficient; Blast furnace slag; Chloride ion penetration; Friedel's salt; Immobilization performance

In this study, steam-cured products' durability by replacing blast furnace slag and various materials and replacing conditions (blast furnace) that affect mechanical properties and durability against salt damage (suppression of chloride ion penetration and immobilization performance). Focusing on the effects of slag powderiness, basicity, substitution rate, etc.) and manufacturing conditions (preparation time, presence/absence of steam, secondary curing, etc.), the purpose is to acquire and organize technical information that contributes to the manufacture of high-quality precast products was decided.

Chapter 1 summarizes the current state of deterioration of concrete structures, which is the background of the research. The deterioration mechanism has repair and reinforcement and the current state of various material utilization techniques for improving durability.

Chapter 2 summarizes examples of deterioration and repair of marine structures, which is also a problem in the author's home country of Thailand.

Chapter 3 summarizes a literature survey on blast furnace slag-blended concrete, which is being actively utilized to reduce environmental effect. In the previous

studies, the main positive effects are the crack suppression effect by reducing the heat of hydration and improving salt damage resistance, while the negative effects are the decrease in initial strength and the risk of cracks due to self-shrinkage increases have been reported. Increases have been reported. Most of these studies are for concrete in which blast furnace slag 4000 Blaine is replaced with cement by 45 to 50%. There are some cases where the substitution rate is as low as 30%, and the substitution rate is as high as 70%, but the findings are insufficient. On the other hand, considering the application of the results of this study to the manufacture of precast products, it is not realistic to use a large amount of substitution compounding exceeding 50%. Therefore, the replacement rate in this study was set to 45% and half the value (22.5%).

Chapter 4 summarizes the experimental methods in this study. The effective diffusion coefficient evaluated the effect of suppressing the permeation of chloride ions by the electrophoresis method (Rapid Chloride ion Penetration Test; JSCE-G571-2003). There is not established method for "quantification of chloride ion immobilization amount," which is the main theme of this paper. Therefore, it devised an originally devised quantification method. After the cement paste was hardened and crushed, the sample size was adjusted to eliminate the influence of the difference in the amount of physical adsorption. The prepared material was soaked in 5 wt% sodium chloride solution, which is 10 times its mass, for 28 days, then washed and dried. Immediately, it was confirmed that the quantification of Friedel's salt could be performed accurately by XRD analysis by the corundum internal standard method.

Chapter 5 summarizes the findings on improving the salt damage resistance of mortar obtained in this study. The higher the powderiness of the blast furnace slag fine powder used, the better the salt damage resistance, the minimum substitution factor exists for performance improvement, and the performance deterioration when steam curing is 1 compared to normal curing. In addition, it was found that the preface time was about a percentage, and the effective diffusion coefficient was not affected, but the immobilization performance increased as the preface was longer. The findings regarding salt damage resistance are as follows.

<Durability 1: Effective diffusion coefficient of chloride ion>

- The higher the Blaine value, the smaller the effective diffusion coefficient. It was confirmed that the 6000 Blaine 45% replacement product was halved compared to the non-replacement product.

- The above effect is in the case of 45% replacement, but it is confirmed that the difference from the non-replacement product is slight at half the replacement rate, and it is necessary to set a replacement rate of more than 22.5% in order to improve durability.
- There was almost no significant difference between 0.5h and 3.0h in terms of the effect of the pre-preparation time of steam curing.
- It was confirmed that steam curing increased the effective diffusion coefficient by about 9.4% compared to the standard curing product, which hindered the improvement of salt damage resistance.
- It was confirmed that the service period of the structure can be extended by about 30% by replacing the blast furnace slag 6000 Blaine product by 45%.

<Durability 2: Chloride ion immobilization performance>

- It was found that the greater the degree of Blaine and the replacement rate, the increased the immobilization performance. It was confirmed that 6000 Blaine 45% replacement increased by about 65.4% in comparing with the non-replacement product.
- Although the effect of slag basicity on durability has not been seen so far, in this study, it was found that the immobilization ability was increased by 1.5 times by slightly increasing the basicity (1.8 → 2.0).
- Regarding the effect of the pre-preparation time of steam curing, the amount of immobilization increases for 3.0h compared to 0.5h, unlike the result of the effective diffusion coefficient. Furthermore, it was found that the effect became more pronounced as the Blaine value increased.
- In addition to the effect of reducing the effective diffusion coefficient, further extension of the life of the structure is expected, given the immobilization capacity.

Chapter 6 is a summary of this research. Considering the existing data on the utilization of blast furnace slag for precast concrete products, we contributed to the reduction of environmental load by incorporating the knowledge on the influence of various manufacturing parameters on the improvement of salt damage resistance obtained in this study into the product manufacturing plan. At the same time, technological development for the production of high-quality precast products can be expected. In addition, the Japan Society of Civil Engineers has proposed an estimation formula for the chloride ion concentration that contributes to the estimation of the remaining service life,

but the effect of immobilization performance is not considered or reflected. In the future, based on this knowledge, it will be possible to improve the accuracy of the prediction formula.