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Quality Evaluation of Granulated Blast Furnace Slag Sand Via Acid Immersion and Freeze-Thaw Tests

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1 Introduction

Granulated blast furnace slag (GBFS) is produced by injecting pressurized water to rapidly cool the molten slag produced in the blast furnace. This product is popular in Japan and other countries for use as raw material for cement. In recent years, the use of GBFS sand as fine aggregate in concrete has been increasingly discussed from the viewpoint of environmental impact reduction and effective utilization of by-products in Japan. The various physical properties of concrete with GBFS sand were evaluated, such as the compressive strength, drying shrinkage, and carbonation. Consequently, it was shown that GBFS sand can modify the interface between hardened cement paste and itself owing due to the reaction of amorphous phase in GBFS sand. This study will focus on freeze-thaw (F-T) and sulfuric acid resistance to investigate the performance of GBFS sand. In addition, we examined various test conditions to establish a simple quality evaluation method for GBFS sand.

2 Outline of Experiment

2.1 F-T Test

The test evaluated the GBFS performance by F-T with 1 cm cubic specimens in salt-water. We examined the effects of the curing period and test period on the F-T evaluation method in salt-water. Furthermore, to investigate leaching during the test, it was compared with a test system using a saturated aqueous solution of calcium hydroxide as the solvent.

2.2 Acid Immersion Test

In the test, the erosion depth was measured after the cylindrical specimen was immersed in acid for eight weeks. In the acid immersion evaluation method, we compared the specimen to sulfuric acid and nitric acid. In addition, we investigated the possibility of reducing acid waste and the number of test processes by comparing the “with” and “without” test solution exchanges.

3 Result

3.1 F-T Test Result

GBFS mortar showed higher F-T resistance than crushed sand mortar. Moreover, the

difference was notable when the curing period was longer. Leaching was found to occur during the test. However, F-T destruction due to leaching did not significantly affect the test results.

3.2 Acid Immersion Test Result

With either acid, GBFS was more resistant than crushed sand. In particular, the reaction with sulfuric acid prevented further deterioration by the produced dihydrate gypsum. However, in the reaction with nitric acid, calcium nitrate was not produced and erosion progressed. The liquid exchange prevented the product from precipitating and hindering the reaction. Therefore, there was a difference in the erosion depth for conditions considering "with" and "without" solution exchanges.

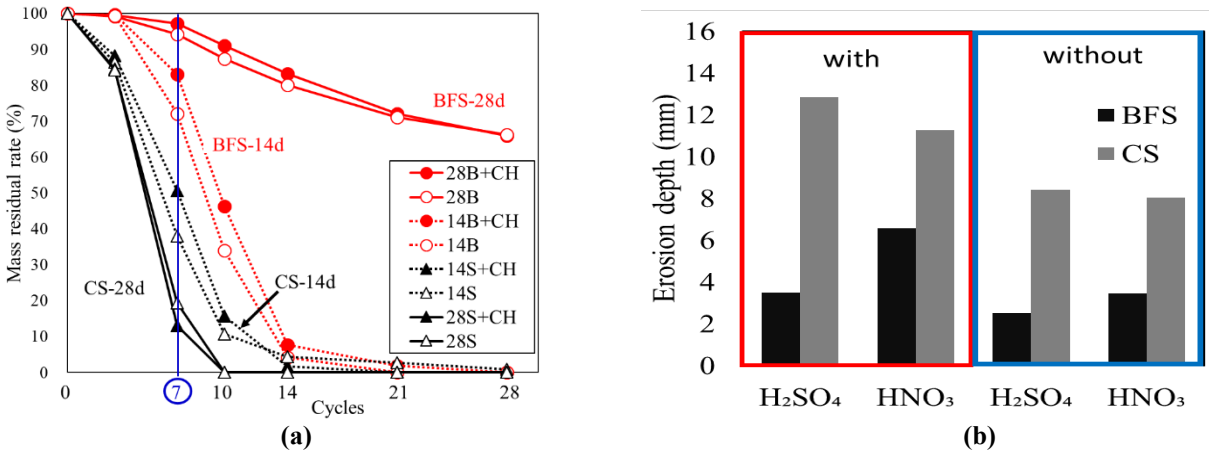

Figure 1. Test results. (a) Results of F-T test. (b) Results of the acid immersion test.

4 Conclusions

The quality of GBFS fine aggregate was evaluated via immersion tests in sulfuric acid and F-T in salt-water. Especially, GBFS sand mortar showed a significantly higher resistance to sulfuric acid than crushed sand mortar. In the reaction with nitric acid, although GBFS sand mortar showed higher resistance than crushed sand mortar, it did not show special resistance like sulfuric acid. The F-T resistance of GBFS sand mortar was higher than that of crushed sand mortar. Although leaching occurred during the test, it was found that destruction by F-T was superior. Or, even if leaching occurred, its effect was small when the liquid to solid ratio was 10. Long-cured GBFS mortar demonstrated a significantly improved resistance to F-T.

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