Activity Summary of JSCE 262 Subcommittee - Guideline on Design, Manufacture and Construction Methods of Precast Concrete with Blast-furnace Slag Sand -

1. Introduction

Japanese cabinet office promotes cross-ministerial strategic innovation promotion program from 2014 to 2019. The program is abbreviated in SIP. The SIP is a national project that treats eleven important social issues in the term. One of the themes is "Infrastructure Maintenance, Renovation and Management". Around 60 detailed issues had been conducted in this theme. One of these issues was to develop and produce precast products made of ultra-high durable concrete.

The concrete committee of JSCE organized subcommittee 262 to establish guideline on design, manufacture and construction methods for the precast concrete products made of ultra-high durable concrete with granulated blast furnace slag sand. The members of subcommittee 262 are more than 50 researchers, working in five task groups to establish the guideline.

2. Effective use of blast-furnace slag and properties of the concrete

There is a long history of blast-furnace slag use as a cementitious material (GGBS) and a fine aggregate (BFS). Many data indicate the effectiveness of blast-furnace slag as the concrete making materials. Some recent researches give useful information on excellent durability to freezing and thawing action of the BFS and/or GGBS concretes even without the entraining of isolated air in the system. Especially, the BFS concrete exhibits no significant carbonation rate, lower drying shrinkage and creep strain, lower chloride ion diffusion and higher durability to erosion by sulfuric acid when BFS is used as all part of the fine aggregate. The use of precast concrete elements to make concrete structure also provides efficiency on construction using stable concrete. This is not only for new construction, it's also effective to update or renewal of existing structure.

3. Mechanism of ultra-high durability of BFS concrete

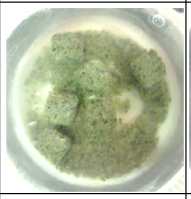
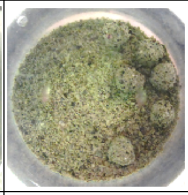
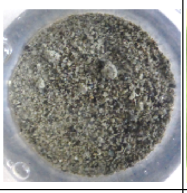
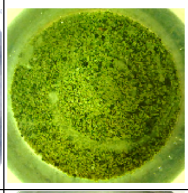
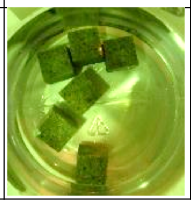
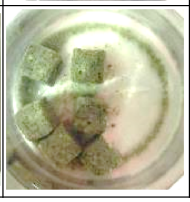
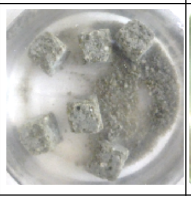
The excellent durability of BFS concrete is originated from chemical reaction of the BFS. The chemical reaction of BFS has two faces. One is the hydration of BFS. It gives dense transition zone around fine aggregate particles. The result of the reaction relates to excellent resistance to freezing and thawing action or chloride ion diffusion. The other is

the chemical reaction of BFS with sulfuric acids. It makes dense protective layer which consists of $CaSO_4 \cdot 2H_2O$ on the surface of concrete. It brings tremendous resistance to erosion by the sulfuric acids. Therefore, additional properties of the BFS on durability to freezing and thawing action or sulfuric acid attack should be quantified to achieve the high durability of the precast concrete products and the concrete structures.

4. New test methods for evaluating BFS

The committee has proposed the test methods to quantify the properties of BFS. One is the method to evaluate hydration of BFS by using severe freezing and thawing action. The result of the test tells the durability on the freezing and thawing action or chloride ion diffusion. The test method is specified in JSCE standards as "JSCE-C 507-2018, Evaluation test method of the quality of granulated blast furnace slag sand by freezing and thawing in salt water using small mortar pieces". In the method, mass loss ratio of specified mixture proportion mortar with freezing and thawing action. The higher mass holding shows the higher the durability of the mortar and effectiveness of the BFS hydration on it. Table.1 shows a comparison of the results.

Table 1. Comparison of the durability by used fine aggregate on freezing & thawing action

Fine Agg.	0-cycle	2-cycle	7-cycle	11-cycle	14-cycle
Crushed sand					
BFS					

The other is the durability on the erosion by sulfuric acids, also specified in JSCE standards as "JSCE-C 508-2018, Evaluation test method of the quality of granulated blast furnace slag sand by sulfuric acid immersion using mortar cylinder". In the method, the mortar made with BFS is immersed in dilute sulfuric acid with a given duration. After the immersion the diameter of keeping higher pH area is measured to calculate the erosion depth by the sulfuric acid. The lower eroded depth indicates the higher resistance of the

BFS to the sulfuric acid attack.

5. Outline of the guideline

The guideline consists of methods for performance verification, manufacturing, construction and quality control of precast concrete products made of BFS concrete and concrete structure constructed by using the precast elements. Also, it gives seven appendixes providing basic data of BFS concrete properties, related test methods, designing example and construction cases, helpful for understanding and using the description of the guideline.

The contents of the guideline are listed in Table 2.

Table.2 Contents of the Guideline

Chap.	Title		App.	Title
1	General		I	Standard Specification of BFS Concrete
2	Quality of BFS		II	Design Example of Precast PC Deck
3	Quality of BFS Concrete		III	Design Example of Precast RC Box Calvert
4	Design		IV	Simple Mobility Test Method by Tapping after Slump Test
5	Mix Proportion		V	Test Method for Scaling of Concrete (from JSCE-K 572)
6	Manufacturing		VI	Dependence of D_{ap} on Unsaturated Condition
7	Construction		VII	Construction case using Precast PC products
8	Quality Control		VIII	Construction case using Precast RC products
9	Inspection			

The guideline indicates methods to evaluate performance of BFS concrete, precast concrete elements and their joints. Also it shows the responsibility and co-operation system of manufacturer, contractor and owner of the concrete structure. The manufacturer should make stable managements for properties of concrete making materials especially for BFS, several equipments in the plant, mixture proportion, curing methods, transportation and storage the products to achieve stable production of high durability

BFS concrete precast products.

The guideline also proposes standard specification of BFS concrete in Appendix I. It shows standard specification of concrete making materials, factors for mixture proportioning and curing. The difference of performances of BFS concrete made of different BFS and curing conditions under standard testing conditions and actual plant manufacturing. The performances are elastic modulus, drying shrinkage, carbonation rate, chloride ion diffusivity, durability factor on freezing and thawing action and scaling weight. The standard prescribed mixture of BFS concrete and the standard manufacturing process proposed in this guideline can make the durability of precast concrete element enhanced considerably.