Priority Subjects — **Further Improvement of Facility Operations and Maintenance Technologies**

Development of Technologies for Increasing Use of Coal Ash

Background and Objective

Since the Great East Japan Earthquake, coal-fired power plants have remained in full operation as base-power generation plants and the annual generation of coal ash is approaching nine million tons. Approximately 65% of the coal ash is recycled by cement companies and used as raw material for cement; however, the demand for coal ash as a cement material is now almost saturated. Thus, other uses of coal ash are being sought. In addition, there are power plants that do not have landfill disposal sites and those with a remaining useful life of only a few years. Therefore, the expansion of coal ash applications is urgently required.

The objective of this research is to promote the use of coal ash as a concrete admixture and in materials used in civil engineering (e.g., artificial ground materials and secondary concrete products). With this objective, quality standards for the above products have been prepared, as the lack of standards will impede the promotion of their use. In addition, technology for stably ensuring the quality and volume of these products has been proposed and developed.

Main results

1 Development of a rapid quantification method for SiO_2 content and its incorporation in JIS

For the quality control of fly ash used for concrete admixture to ensure its stable strength, a SiO_2 analysis method that complies with JIS A6201 is required as the majority of SiO_2 in fly ash reacts with the calcium hydroxide in cement. The conventional analytical method has drawbacks such as a long measurement time of three days and the generation of toxic gas during the test. The research team developed new procedures, in which fly ash is pulverized depending on its properties (Fig. 1), pressed, and subjected to X-ray fluorescent spectrometry to determine the SiO_2 content (N14021). With this method, the results can be obtained within half a day and no toxic gas is generated, contributing to efficient and stable quality control. The achievements of this study were reflected in the revision of JIS A6201 in March 2015.

2 Development of cement-free concrete —Development of fly ash concrete—

A technique for manufacturing concrete without using cement is desirable as the environmental impact of the CO_2 emitted during cement manufacturing is high. The research team has been developing fly ash concrete by steam curing using fly ash and an alkaline aqueous solution. The application of the fly ash concrete to Hume pipes* was examined to utilize its high resistance to sulfuric acid. Regarding the compressive strength ($\geq 50\ N/mm^2$ required for actual application), which has been an issue to be resolved, it was found that a compressive strength of $\geq 60\ N/mm^2$ was obtained by adding a small amount as a powder material and incorporating an improved mixing method, indicating the practical applicability of the fly ash concrete to these pipes (Fig. 2).

3 Development of a rapid method of measuring boron content and amount of eluted fluorine

The consideration of environmental safety is essential for the use of coal ash, for which measurement of the contents and amounts of eluted trace substances will be of fundamental importance. Thus far, the research team has developed a simple and rapid measurement method for chromium, selenium, and arsenic among the trace substances requiring special consideration from the viewpoint of environmental safety (V13023). A rapid measurement method is also required for boron and fluorine, which are similarly considered to be important elements. Thus, the research team has developed a neutron boron gauge that can rapidly determine the content of boron in coal ash in approximately 5 minutes (one-twentieth of the time of conventional methods) using the property of boron that captures thermal neutrons (V14003). In addition, a new test method was developed involving the use of a wet ball mill that can reduce the time required for the elution of fluorine from a sample to one-twelfth of the conventional method (V14004). By combining these techniques, environmentally-safe coal ash can be screened in a short time and the quality of the material for artificial ground containing coal ash as a major ingredient can be effectively controlled during manufacturing (Fig. 3).

* Reinforced-concrete aqueduct used for irrigation water and sewage requiring high strength and acid resistance.

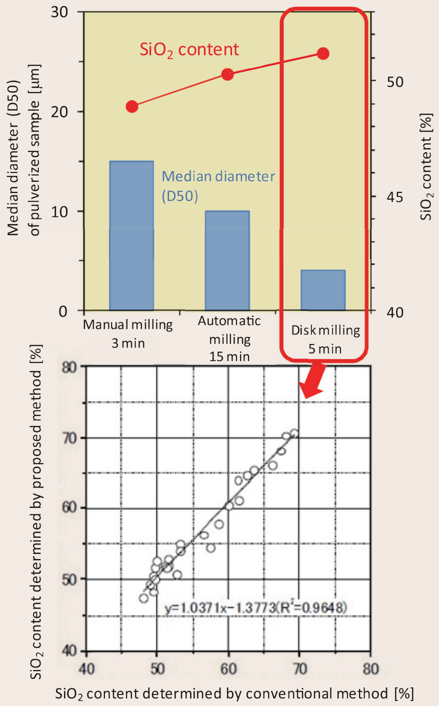

Fig. 2: Effect of pulverization method on analyzed SiO_2 content (upper) and correlation between the SiO_2 contents determined by proposed and conventional methods (lower)

Complete pulverization of a sample in a disk mill followed by pressure forming is effective for precisely measuring the content of SiO_2 in fly ash by X-ray fluorescent spectrometry.

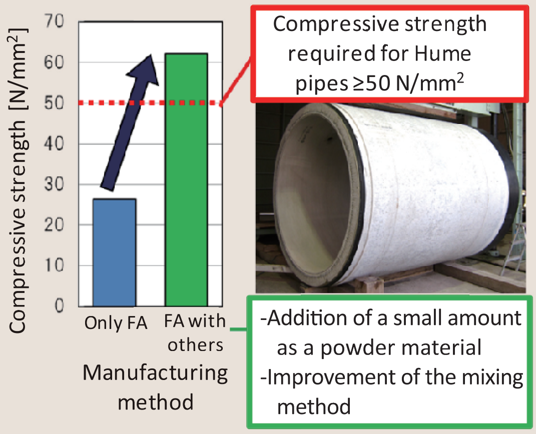

Fig. 2: Improvement of fly ash concrete strength

The maximum compressive strength of the fly ash concrete, manufactured by the method used until last fiscal year, was approximately 27 N/mm² (left bar in the figure). By adding a small amount as a powder material, incorporating an improved mixing method, and reducing the water-powder ratio, * the research team demonstrated the possibility of manufacturing fly ash concrete with a compressive strength of ≥60 N/mm² and a flexural strength of ≥7 N/mm².

* Water-powder ratio: (mass of water)/(mass of powder materials) × 100 (%)

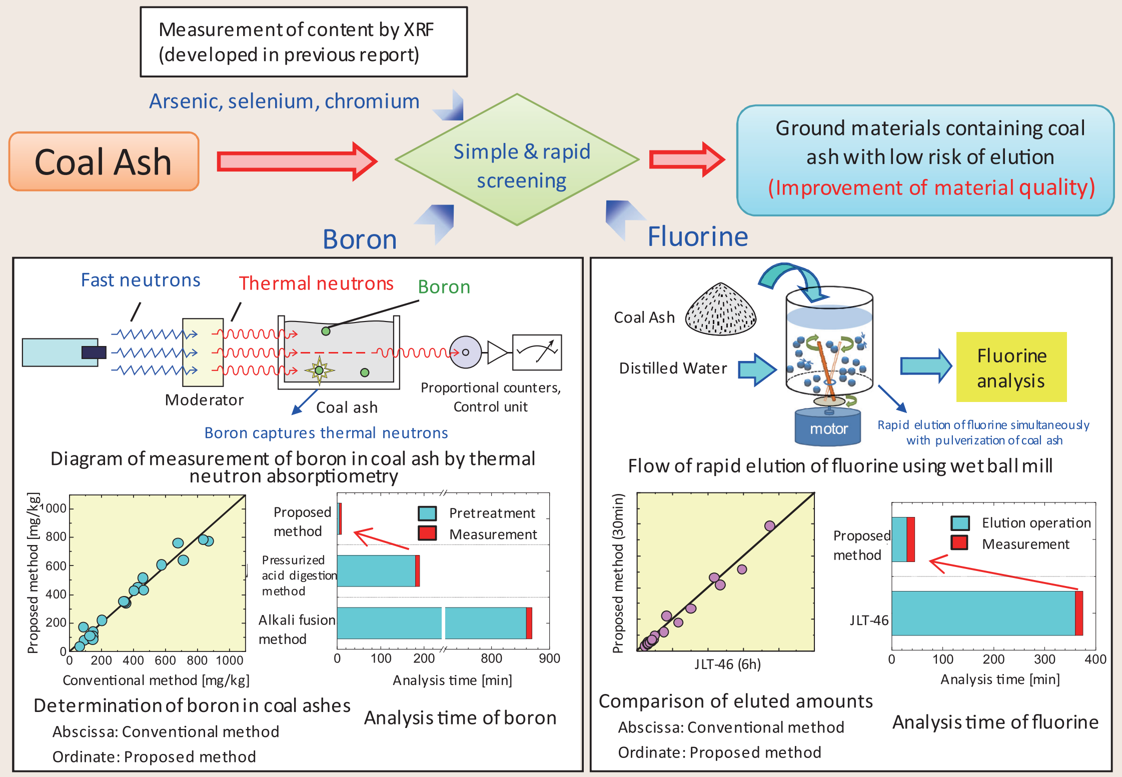

Fig. 3: Simple and rapid measurement method for content of boron in coal ash by thermal neutron absorptiometry and amount of eluted fluorine using wet ball mill

Using thermal neutrons and a wet ball mill, the boron content and the amount of eluted fluorine can be determined in a shorter time with a precision comparable to that of the conventional method.