Abstract

[Research Title]

Demonstration Development of Recycling Technology for Woody Biomass Combustion Ash for Geopolymer Concrete

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[Abstract]

In this research, we classified the types of wood biomass fly ash (WBFA) and selected WBFA suitable for this program. A continuous modification device to remove unburned carbon and heavy metals from WBFA was developed. We then verified the feasibility of the proposed method by developing a pilot plant with a production capacity ten times that of existing lab-scale equipment, thus achieving resource recycling of WBFA. We aimed to significantly reduce CO2 emissions in the construction sector by developing geopolymers concrete utilizing modified combustion ash slurry (MCAS).

A questionnaire survey of woody biomass power generations in Japan estimated that 820,000 t-wet/year of combustion ash would be generated in 2026. Hierarchical cluster analysis, principal component analysis and decision tree analysis were performed on the collected woody biomass combustion ashes (fly ash, bottom ash) from each power plant to classify the ash types. Decision tree analysis estimated the resource quantities for various beneficial utilization purposes of combustion ash emitted from 220 facilities. The results showed an estimated 700,000 tons wet weight per year for fertilizer use, 320,000 tons wet weight per year for cement use and 170,000 tons wet weight per year for use in geopolymer after modification treatment.

A continuous flotation process was developed and a pilot plant for a continuous WBFA modification system was constructed in Kitakyushu Eco-town. It was confirmed that the processing capacity exceeded the initial target by 20%, reaching 360 tons per year. The processing cost of the pilot plant reached the initial goal with a 2% reduction, amounting to 7,858 yen per ton. The WBFA verified in the experiment met the discharge standards for heavy metals, leading to the discovery that recycling treated water is the most cost-effective and straightforward method. Detailed challenges were extracted from these experimental data and a preliminary design proposal for a full-scale plant consisting of three lines with a capacity of 3,000 tons per year each, totaling 9,000 tons per year, was developed.

The mix proportion of steam-cured geopolymer concrete with MCAS are determined and a three-year exposure test was conducted in Okinawa, Kitakyushu and Kushiro. The results confirmed that, except for a

slight tendency towards inferior corrosion resistance of steel reinforcement, geopolymer concrete with MCAS exhibits performance equal to or better than cement concrete. By optimizing the mix proportion of geopolymer concrete with MACS, a workable time of 60 minutes and a CO2 emission reduction rate of 62.5% were achieved.

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