PROJECT NO. RU-14

ANNUAL REPORT COMPREHENSIVE RESEARCH ON RICE
January 1, 2020 - December 31, 2021

PROJECT TITLE: Treatments to improve consistency in properties of rice ash for concrete

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OBJECTIVES AND EXPERIMENTS CONDUCTED, BY LOCATION, TO ACCOMPLISH OBJECTIVES:
This work focuses on improving the consistency and increasing the reactivity of rice hull ash (RHA) produced in conventional biomass energy-systems for potential use in cement-based materials. This work examines ashes captured from different locations in the energy systems, which have different combustion product compositions, from different years to identify

variability from effects of differences in rice hull characteristics or whether consistency can be achieved across these parameters. The objectives of this work are outlined below:

Objective 1: Assess the effects of grinding the ashes to increase reaction surface and assess the effects on variability between ash taken at different locations and using feedstock from different years.

Objective 2: Determine whether or not the beneficial impacts noted in portland-alkaline binders can be obtained with RHA by exposing ashes to cost-effective alkaline solutions prior to mixing with portland cement

Objective 3: Quantify the benefits gained from blending the ashes with other mineral admixtures used in concrete to gain a favorable oxide and phase composition of these cumulative additives.

The experiments and analysis to meet these objectives are outlined below:

(i) Analysis of isothermal calorimetry of RHA blended with conventional cement to assess heat of hydration, which informs our understanding of cement behavior during curing;

(ii) Measurement of oxide composition of RHAs to determine changes resulting from treatments;

(iii) Perform X-ray diffraction (XRD) imaging to assess phases of RHA, RHA blends, and cement;

(iv) Testing for compressive strength at 7 and 28 days to capture the effects of strength development;

(v) Conduct scanning electron microscopy (SEM) imaging to understand microstructures formed.

All experiments and/or analyses done to accomplish these objectives were performed on the University of California, Davis campus. To complete some of the proposed work, ash samples have been sent to an analytical facility off-campus to determine oxide composition and morphology in a timely manner.

SUMMARY OF 2020 RESEARCH (major accomplishments), BY OBJECTIVE:

Research is still underway (end date 12/31/2021), but to date, the following major accomplishments have been made:

Several types of rice-ash, namely, bottom ash from 2020, baghouse ash from 2020, baghouse ash from 2014, and fly ash from 2014 were obtained from EnPower's bioenergy facility in Williams, CA.

For Objective 1 - 3, each of these four ashes were considered with all three treatment types listed. For each objective, (1) grinding ashes, (2) leveraging portland-alkaline binders to improve reactivity; and (3) blending with ground granular blast furnace slag (a common mineral admixture in northern California) were performed. Isothermal calorimetry has been conducted on blends that reflect partial replacement of portland cement in concrete (results shown in Figure 1). Experimental XRD tests to quantify morphological characteristics and oxide composition analysis have begun, we anticipate results from these assessments within the next few months. Remaining experimental work will begin Winter quarter, with the goal of finishing experimental study by July 2021 and to begin compiling a write-up at that time.

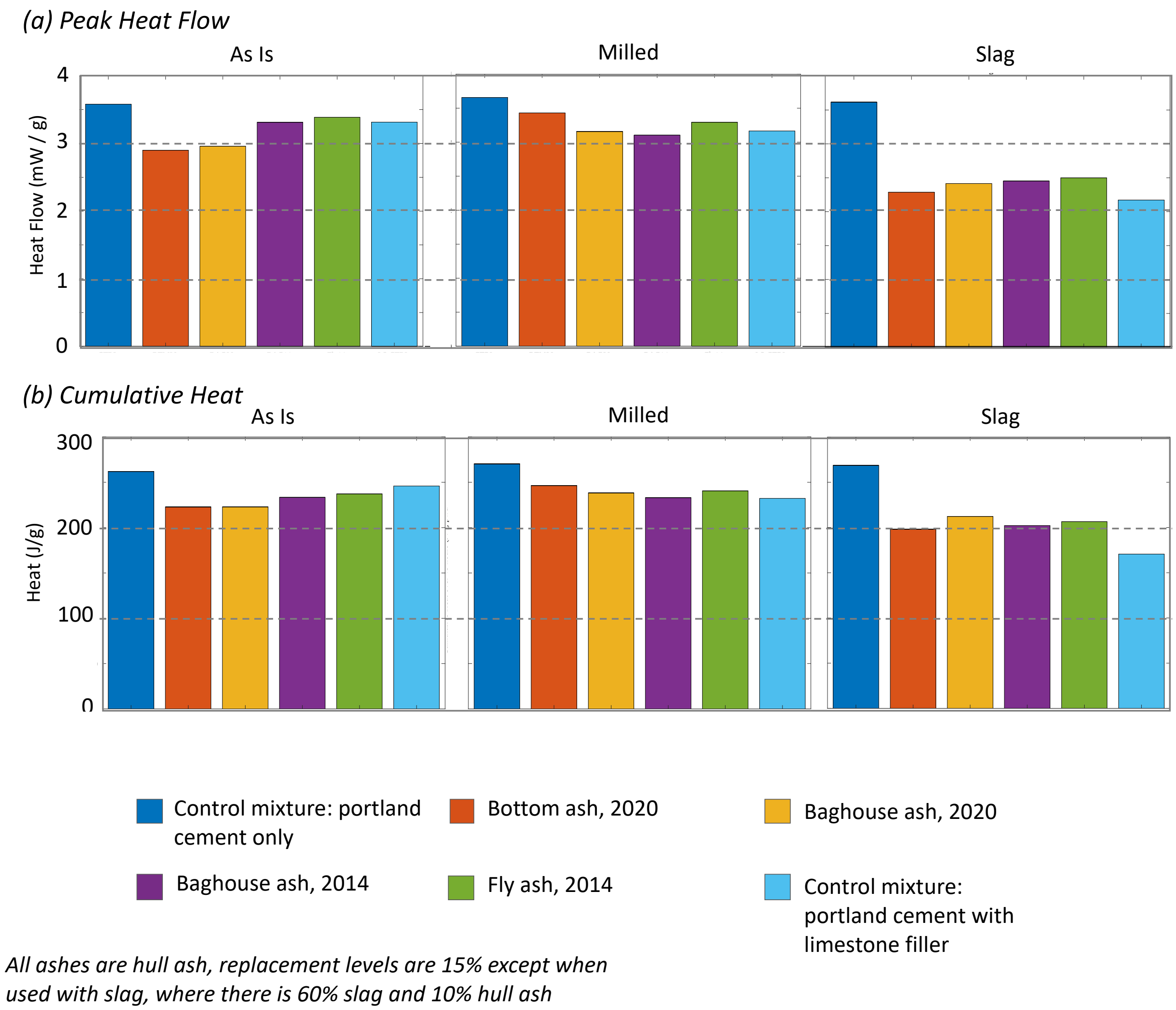

Figure 1. Initial testing results indicating hydration behavior of ashes as influenced by treatment method. Panel (a) shows the peak heat flow when each ash type and treatment method is examined. Panel (b) shows the cumulative heat of hydration for each ash type and treatment method.

PUBLICATIONS OR REPORTS:

A report will be compiled summarizing the work done and the findings from this research. It is also anticipated that at least one peer-reviewed publication will result from this research.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

Based on previous work, among the areas highlighted as critical for further study by the concrete industry was deriving means to obtain consistent properties in the ash in a way that resulted in their being a reactive material for cement composites. Ashes can contribute to desirable cement-based material performance through several mechanisms. Among the most desirable would be acting as a pozzolan to react during cement hydration; however, a secondary desirable use of these ashes could be through their contribution to improved packing in the concrete. Current results indicate that milling to increase reactive surface area could increase reactivity of the more recent ashes but may not be as effective at changing older ashes. This difference could be a function of factors such morphological or composition differences that could occur from differences between crops, which will be investigated further in the subsequent steps of this work. Further, blending ashes with slag shows higher levels of reactivity than were seen from the control mix that had inert filler (ground limestone) that improved packing. Further analysis, as proposed in the objectives, will be conducted to understand the influence of these treatment methods on morphology, composition, microstructure, and strength development. This work will support knowledge needed regarding treatment methods that could be implemented after conventional combustion methods to improve the consistency of ash.