Task 6.4 - The Use of Coal Ash in Ceramics

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TASK 6.4 – THE USE OF COAL ASH IN CERAMICS

1.0 INTRODUCTION

Previous empirical tests at the Energy & Environmental Research Center (EERC) have indicated that coal combustion by-products are a viable starting material for the production of a variety of ceramic products, including brick, tile, and high-flexural-strength ceramics. The EERC has focused on high-temperature properties of coal ash and has provided valuable insight into ash transformation, fouling, and slagging for the utility industry. It is proposed to utilize the information generated in these past projects to develop material selection criteria and product manufacturing techniques based on scientific and engineering characteristics of the ash. Commercialization of the use of coal combustion by-products in ceramics is more likely to become viable if a quality-assured product can be made, and predictive materials selection is a key component of a quality-assured product.

2.0 OBJECTIVES

The objective of this task is to demonstrate the development and production of a ceramic material using coal ash as a key component. Chemical and high-temperature properties of ash will be carefully determined, with the objective of identifying criteria for materials selection and manufacturing options for ceramic production.

3.0 ACCOMPLISHMENTS

The emphasis of the literature search was on more recent work in the use of coal ash for ceramic production. Of particular interest was the chemistry of ashes used in ceramics and mineral wools.

Five fly ash samples were selected from the Coal Ash Properties Database (CAPD) on which to obtain ash fusion results. The samples were selected based on criteria for chemical analyses of fly ash used in the production of mineral wool and high-flexural-strength ceramics. Chemistry concentration limits for the major elements were used. Sodium was the primary element under consideration. The range reported for sodium oxide was 2.5%–10.1%. Table 1 shows the five fly ashes selected, with elemental analyses from the database. Trends in ash chemistry are noted in the table.

Ash fusion results (in an oxidizing atmosphere) are depicted in Table 2. The results were quite similar for the five samples, with initial to fluid temperatures ranging from 1164°–1398°C (2127°–2549°F). The greatest difference in temperature between samples for a given variable was 287° for hemispherical temperature. When the first two samples and the last three samples were reviewed as groupings, some trends in the data were evident.

Based on these results and the available budget, it was decided that five samples would be prepared for ceramic production. Calculation of mix designs was reviewed and updated for the fly ashes selected. Table 3 shows the mix design to be used.

4.0 FUTURE WORK

More work on sample description, identification, and coal types will be done from the database. K_2O content and total alkali will be added to the existing data. Correlations to ash fusion data will be pursued. Descriptions of the type of power plants used on the samples analyzed will also be done. Five samples will be made into ceramic cylinders for flexural strength testing if time permits.

TABLE 1

Fly Ash Chemistry

Sample No.	Plant Name	Na_2O	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	SO_3
93.0088	Hoot Lake – Minnesota	10.05	27.92	17.08	19.43	4.73	5.37	7.75
93.0051	Brett Admixtures	8.33	38.04	18.74	15.83	3.67	4.37	3.55
87.0144	Ontario Hydro – Ontario	6.10	47.90	21.90	13.30	2.90	4.90	1.10
84.0584	Battle River Power – Alberta	4.30	55.60	19.80	8.80	1.50	5.00	0.35
83.0046	Battle River Power – Alberta	2.53	58.20	19.60	9.30	1.60	5.60	0.22

Trends in ash chemistry were as follows:

- Na_2O , CaO , and SO_3 decreasing
- SiO_2 and Al_2O_3 increasing
- Fe_2O_3 constant at approximately 5%

TABLE 2

Coal Analysis Lab Ash Fusion Report

Sample No.	Plant Fly Ash	Oxidizing Atmosphere, °C/°F			
		Initial Temp.	Softening Temp.	Hemi. Temp.	Fluid Temp.
93.0088	Hoot Lake	1266/2311	1334/2433	1350/2461	1371/2500
93.0051	Brett Admixtures	1203/2197	1294/2361	1364/2487	1398/2549
87.0144	Ontario Hydro	1164/2127	1180/2156	1205/2200	1261/2301
84.0584	Battle River Power	1246/2274	1270/2318	1314/2397	1347/2456
83.0046	Battle River Power	1222/2231	1260/2300	1306/2382	1360/2480

TABLE 3

High-Flexural-Strength Ceramics Mix Design¹

Fly Ash, g	1540
Glass (-100 mesh), g	835
Clay (ball), g	125
Water, mL	300

¹ Proportions to be used for laboratory demonstration for optimum mix results.

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