

FINAL TECHNICAL REPORT  
November 1, 2000, through October 31, 2001

Project Title: **MANUFACTURING COMMERCIAL BRICK WITH FLY ASH FROM ILLINOIS COALS**

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ABSTRACT

The overall goal of this three-phase (three-year) program of making bricks from fly ash is to develop commercially viable products to provide an alternative use for millions of tons of Illinois coal fly ash currently being ponded or landfilled. This is a joint effort of the Illinois State Geological Survey, University of Illinois at Urbana-Champaign, Global Clay Marseilles, Richards Brick Co., Ameren Central Illinois Public Service, Central Illinois Light Company's Edwards Power Plant, and Power Plant Services. Phases I and II were completed. Phase III has just begun.

Phase I (year 1) focused on small-scale tests to make fly ash-containing bricks in a clay-rich formulation, with dry fly ash samples collected from two power plants' electrostatic precipitators. Phase II (year 2), covered in this report, on the one hand focused on a pilot plant medium-scale demonstration of the production of bricks with fly ash and on the other hand focused on small-scale tests to make fly ash-containing bricks with a shale-rich formulation. Both dry and ponded fly ash samples were tested. In addition, the market survey and the economic analysis were updated

In Phase II, a total of more than 340 small-size test bricks were produced for evaluation. The test bricks produced with amounts of fly-ash, ranging from 20 to 50%, in shale-rich formulations, met ASTM building brick specifications and showed high possibilities for successful commercialization. Also, three medium-scale (300 full-size bricks per batch) pilot plant production demonstrations were conducted, which produced a total of more than 950 full-size bricks for evaluation. All the concerns encountered during the first set of two pilot plant tests were successfully resolved during the third test and a batch of about 300 good full-size bricks were produced. Transfer of the developed technology to the commercial sector was also initiated. Phase III (year 3) will focus on both commercialization and refining of pilot plant performance to increase the variety of fired brick products and improve their quality.

"Pages 1 to 20 contain proprietary information."

## EXECUTIVE SUMMARY

About 82.5 million tons (Stewart, 1999) of fly ash, bottom ash, and boiler slag were produced during 1999 in the U.S. from coal burning power plants. The fly ash generated annually from the combustion of Illinois coal is about 3 million tons, most of which is typically disposed of in ponds or landfills. The ASTM C-618 standard classifies coal fly-ash into class F and class C. In general, coal ashes generated from combustion of bituminous coals such as those in Illinois are ASTM class F, whereas those generated from combustion of lignite and sub-bituminous coals are ASTM class C.

ASTM class C fly-ash has long been recognized and commercially demonstrated as a construction material used mostly in cement, concrete products, structural fills, embankments, road bases and sub-bases. Although some research has been conducted on the utilization of class F fly-ash in concrete and concrete products, its utilization rate in cement-based products is much less than ASTM class C fly-ash. Class F ash has lower cementing values due to its lower lime content. It also contains a greater amount of unburned carbon, measured by its loss on ignition (LOI) value. Although, the lower lime content of class F fly-ash compared to class C fly-ash is an advantage for producing fired-bricks instead of cement-based products, there is a lack of commercial products containing high volumes of class F fly-ash compared to class C fly-ash. The class F fly-ash from Illinois coals represents a continuing disposal problem and discourages increased consumption of Illinois coals. From an economic and landfill disposal point of view, there is a need to develop a technology that uses the large volumes of class F fly-ash produced by burning Illinois coals.

The purpose of this investigation is to develop a technology that utilizes the large volumes of class F fly-ash, produced from burning Illinois coal, in making marketable fired-bricks for construction. According to a report on Clay Construction Products prepared by the U.S. Department of Commerce, U.S. Census Bureau, the number of bricks produced in the U.S. as standard brick equivalents (SBE) has increased each year from 7.8 billion SBE in 1997, to 8.1 billion SBE in 1998, to 8.6 billion SBE in 1999, and to 9 billion SBE in 2000. The 9 billion SBE production (about 5 lb per SBE) translates into at least 22 million tons of brick production in 2000. If a large quantity of fly-ash can be used in the manufacture of fired-bricks and other related products, the disposal problem will be decreased and a value-added construction product will be created. Successful results of this research will not only directly benefit the coal industry in Illinois and utilities using Illinois coals, but will also benefit the brick manufacturers. The potential benefits of the technology for brick manufacturers include, but are not limited to, the saving of energy and the reduction of raw material consumption.

The mineral matter in coals is fired during combustion of the coal so much of the energy that would be consumed in firing them during brick manufacture is not needed. The fly ash can also function like quartz to speed the firing of clay components in the bricks. Manufacturers of fired-clay products will also be able to reduce clay and shale consumption and may reduce raw material costs in direct proportion to the amount of fly-ash substituted in their products.

The overall goal of this three-phase (three-year) program of making brick from fly ash is to develop commercially viable products to provide an alternative use for the millions of tons of Illinois coal fly ash currently being ponded or landfilled. This team effort includes the Illinois State Geological

Survey, University of Illinois at Urbana-Champaign, Global Clay Marseilles, Richards Brick Co., Ameren Central Illinois Public Services, Central Illinois Light Company's Edwards Power Plant, and Power Plant Service. Phases I and II have been completed, and Phase III has just begun.

Phase I (completed 1999-2000) focused on producing medium-tan, clay-rich, fly ash containing bricks. The test bricks were made on a small scale (30 bricks per batch), on site at Global Clay Marseilles in Marseilles, Illinois. The amount of fly-ash in the clay-rich formulations was maximized and additives to improve appearance and strength of the brick were investigated. The results obtained were very promising. Test bricks produced with the clay-rich formulations and amounts of fly-ash ranging from 20 to 70 wt % met commercial specifications. Some properties, such as fired compressive strength and the heat insulation capability were better than those of standard test bricks made without ash.

Phase II (completed 2000-2001), on the one hand focused on a pilot plant medium-scale demonstration of brick production with the fly ash and on the other hand focused on small-scale tests to make fly ash-containing bricks with a shale-rich formulation. Both dry and ponded fly ash samples were tested. In Phase II, we produced more than 340 small test bricks and about 950 commercial-size bricks for evaluation. The results of Phase II are summarized in this report. Bricks with 40 wt% fly-ash substitution were successfully produced with pilot plant equipment. The fired bricks showed a fired compressive strength of 11,500 psi which greatly exceeds the ASTM C 62 specification of 3,000 psi for the Grade of SW (severe weather). The shrinkage rate, ignition loss, and water absorption values of the test bricks were typical for fired brick, and met ASTM specifications. The mixed starting material was easily extruded, and the green bricks produced were strong enough for direct setting. The fired bricks showed no scum, no black cores, and no bridge cracks. The acceptable extrusion data suggest that the amount of fly ash in the bricks can be increased to more than 40 wt%. Transfer of the developed technology to the commercial sector has been initiated. The information and the validated technology results have been presented to the commercial sector whenever possible.

Phase III (2001-2002) will focus on commercialization as well as refining of pilot plant parameters to increase the variety of products and improve product quality. Up to five commercial-scale production runs (300 to 5,000 bricks per batch) will be conducted. Ponded fly ash will be tested because it can be provided at no cost to the nearby brick producers. Also, the balanced shale/clay materials of the individual brick producers or other available sources will be tested.

**The remainder of this report contains proprietary information and is not available for distribution except to the sponsor(s) of this project.**