

FINAL TECHNICAL REPORT  
September 1, 2004, through December 31, 2005

Project Title: **COMMERCIAL PRODUCTION OF FIRED BRICKS WITH  
ILLINOIS COAL FLY ASH AND BOTTOM ASH**

ICCI Project Number: 04-1/4.1A-1  
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ABSTRACT

The goal of this project was to determine whether bottom ash could be used as an extended ash source, in addition to fly ash, for commercial production of fired bricks and to help further a developmental plan to build a new brick plant in Illinois to utilize Illinois coal ashes. Successful development and marketing of fly ash and bottom ash containing bricks would benefit Illinois coal companies, utility companies, and brick manufacturers by utilizing coal combustion waste products in a value added application and preserving shale and clay natural resources. Our previous studies have shown that commercially viable fired bricks can be economically produced with up to 40 wt% of fly ash, however industry partners have expressed concerns about whether their fly ash sources that are mixed with bottom ash will affect the brick making process. This project was conducted to provide answers to their questions and help further the plan of building a new brick plant to support using Illinois coal ashes.

The industry partners have provided ISGS with their existing shale and newly explored shale samples to blend with local ash samples for testing. More than 50 bench scale production test runs have produced commercial-size green bricks with various combinations of fly ash, bottom ash, and shale for firing evaluations. The chemical and physical properties of the raw materials, and the physical appearances and engineering properties of the final products were analyzed. In addition to the existing shale from the participating brick plant, the project also tested new shale samples from two potential locations for the anticipated new brick plant. The testing included determining the brick-making ability of various new shale samples collected from either outcrops or cores of future coal mines. The formulations that are best suited for commercial scale-up production tests have been developed. In addition, the economic, brick market, and environmental feasibility assessments have been updated. The project has proceeded to the stage that a commercial scale-up production evaluation is in order. This scale-up testing could be performed by the industry partners anytime before a new brick plant is built. By completing this project, brick industry partners have gained confidence in using Illinois coal fly ash and bottom ash in fired brick making. They are moving forward with their business plan to build a new brick plant in Illinois using the resources and expertise of the ISGS for their technical assistance, when necessary.

**Pages 1 to 20 contain proprietary information.**

## EXECUTIVE SUMMARY

The goal of this project was to determine whether bottom ash could be used as an extended ash source, in addition to fly ash, for commercial production of fired bricks and to help further a developmental plan to build a new brick plant in Illinois to utilize Illinois coal ashes. Successful development of such commercially viable brick products could provide an alternative use for the millions of tons of fly ash and bottom ash waste that is produced each year in Illinois.

Our previous studies have shown that commercial size bricks can be produced with up to 40 wt% of fly ash at several commercial facilities, and that these products either meet or exceed ASTM commercial specifications. However our industry partners have expressed concerns regarding their current fly ash sources that are mixed with bottom ash and how that will affect the brick making process. This project was carried out to provide answers to their questions and help further their plan to build a new brick plant to support using Illinois coal ashes.

The project objectives were:

- 1) To acquire samples of fly ash, bottom ash, and/or their mixed counterparts from sources associated with the anticipated new brick plant;
- 2) To acquire existing shale and clay samples and newly explored shale samples for lending with ash for fired brick testing;
- 3) To characterize raw materials (in single and/or mixed phases), intermediates, and final products;
- 4) To perform bench-scale production and possible commercial scale-up production evaluation of bricks made with fly ash and bottom ash;
- 5) To perform engineering properties tests of these bricks to evaluate the quality of the final products; and
- 6) To conduct a limited economic and environmental feasibility update.

Six tasks have been conducted to meet the project objectives.

Task 1: Acquire ash samples and determine logistics for collecting additional samples

Task 2: Acquire clay and shale samples

Task 3: Conduct chemical, physical, and engineering properties characterizations

Task 4: Conduct bench-scale and possible commercial-scale brick production tests

Task 5: Conduct environmental assessment, and economic and market updates

Task 6: Prepare technical and management reports

The fly ash and bottom ash samples collected from two power plants were blended with the existing shale of the participating brick plants for testing. The test bricks met the brick company's specifications for marketability and their compressive strength all exceeded the ASTM building brick specification for the severe weather grade. These results provided industry partners with the knowledge that brick production is possible with the inclusion of bottom ash samples and that future commercial scale-up tests are warranted.

Our previous economic studies show that profitable fly ash-brick production requires the availability of suitable raw materials (shale, clay, and fly ash) nearby. Building upon our

earlier findings, an industry team was formed for building a new brick plant near a specific Illinois power plant. The power plant would supply the new brick plant with ponded fly ash generated from burning Illinois coals. The transportation and brick market issues have been separately evaluated by the industry team. This project provided a limited update based upon the formulations developed, the current plant operation costs, and the current ash transportation cost estimates.

To help further the developmental plan of our industry partners, this project also conducted bench-scale production tests using ash of local sources blended with new shale samples collected from an outcrop in Illinois (Site-P) and various cores from drill sites at another location in Illinois (Site-B). The initial chemical and physical screening has helped to reduce the number of new shale samples to be tested for making fired bricks for engineering evaluation. However, most of the test bricks produced with the new shale samples from the Site-P area were bloated after firing and were not ready for the commercial market. Most of the test bricks produced with the new shale samples from the Site-B had a high quality color and physical appearance, but lime pops have surfaced from months of weathering. The formation of lime pops was most apparent in the bricks without ash addition. Thus, the new shale from Sites-P and B, which have thin deposits of brick-quality shale units and bands of limestone deposits were not acceptable for commercial application according to the brick company. Further efforts of the industry team are required to locate new local shale with thick and homogeneous deposits that are suitable for fired brick making.

The project provided critical information about the commercial viability of building a new brick plant for the manufacture of bricks with fly ash and bottom ash. When blending with the existing shale samples, the bricks produced with fly ash and bottom ash met the brick plant's own specification for marketability and their compressive strength all exceeded the ASTM building brick specification for the severe weather grade. The project was moved into the stage for a commercial scale-up production testing. Although the scale-up test could not be performed during this project period due to the unforeseen busy commercial schedule of the participating brick plant, a process of producing fired bricks that uses fly ash and bottom ash to replace part of traditional raw materials had been successfully developed. In addition, the economic and environmental feasibility assessments have been updated to include the use of bottom ash. By completing the bench-scale testing, the brick industry partners have gained confidence in the utilization of Illinois coal fly ash and bottom ash in fired brick making and are moving forward with their business plan to build a new brick plant in Illinois. The ISGS resources and expertise would be available to provide technical assistance when deemed necessary.

Successful commercial use of fly ash and bottom ash could provide an example for a growing and profitable market for Illinois coal ashes, encourage electric companies to continue to use Illinois coals, and develop new sources of raw materials for fired brick manufacturing. The amount of ash that can be consumed will depend on the brick plant's production rate and the amount of ash that can be successfully incorporated into the brick body. If bricks with 40 wt% of ash can be produced, and if a brick plant produces 50 million bricks per year, about 50,000 tons of ash could be consumed by the plant each year.