

FINAL TECHNICAL REPORT
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Project Title: **COMMERCIALIZATION OF FIRED BRICK WITH FLY ASH
FROM ILLINOIS COALS**

ICCI Project Number: 01-1/3.1B-3
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ABSTRACT

The overall goal of this project for making fired bricks from fly ash is to develop commercially viable products that could provide an alternative use for millions of tons of Illinois coal fly ash currently being ponded or landfilled. Phases I & II (1999-2001) focused on assessing the technical feasibility of the process by maximizing the amount of fly ash substituted for other raw materials for fired-brick production and conducting a preliminary economic evaluation. More than 700 bar-size test bricks, containing various amounts of dry fly ashes from two Illinois power plants balanced with mined clay and shale, raw materials of an Illinois brick company, were produced for evaluation. Phase II was concluded with a successful pilot plant test run. Phase III (2001-2002), covered by this report, focused on commercial-scale production demonstration, economic evaluation, and commercialization.

Since not many Illinois power plants installed dry fly ash collection systems, the commercial-scale test runs in Phase III included ponded fly ash. During Phase III, five commercial-scale production runs were conducted at a second brick plant, and more than 15,000 full-size face bricks with 20 to 40% fly ash substituted for standard raw materials were produced. In addition, a run was conducted to produce 2,000 face bricks containing no fly ash for comparison. The characteristics of the bricks produced in the commercial-scale tests were, in general, consistent with these of the small-scale bar-size test bricks. The bricks produced with and without fly ash met or exceeded minimum specifications for commercial face bricks. The bricks made with 20 to 40 % fly ash substitution had greater fired compressive strength and lower thermal conductivity than bricks made without fly ash. Overall, the fired bricks made with fly ash showed greater resistance to damage and according to ASTM specifications, belong to Grade SW, suitable for use under severe weathering conditions. The proximity of clay and shale resources to power plants producing fly ash from Illinois coal has an important impact on the economics of fly ash use for brick-making. Shipping costs and production cost-saving incentives were analyzed for three brick plants. The full-size brick samples with up to 40 % fly ash addition were distributed to power plants and brick companies located in-state or out-of-state. Many power plants and brick companies showed interest in adopting the technology. Continued ISGS/UIUC work will focus on helping those who showed interest in adopting the technology for commercial production.

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EXECUTIVE SUMMARY

Fly ash generated from burning Illinois bituminous coals is generally classified as ASTM class F, while fly ash from lignite and subbituminous coals of other states is generally class C. Since class F ash has lower lime content (lower cementing value) and higher unburned carbon content, class F fly ash is unsuited to making cement-base products compared to class C fly ash. However, the lower lime content of class F fly-ash is an advantage for producing fired bricks, and the unburned carbon is not a technical concern for the same purpose. Therefore, the 3,000,000 tons of fly ash produced each year from burning Illinois coals, most of which is currently ponded or disposed of in landfills, is readily available and well-suited for making fired bricks.

The overall goal of this project is to develop a technology and to help establish industrial commitments for manufacturing commercial fired brick with class F fly ash produced from burning Illinois coal. This is a joint effort among the Illinois State Geological Survey (ISGS)/ University of Illinois (UIUC), Global Clay Marseilles (GCM), Colonial Brick Company (CBC), Richards Brick Co. (RBC), Ameren Central Illinois Public Services (CIPS), Central Illinois Light Company at Edwards Power Plant (CILCO), and J.C. Steel & Son (JCSS). Phase I (year 1; 1999-2000) and Phase II (year 2; 2000-2001) have been completed. Phase I focused on technical feasibility assessment of producing fly ash containing bricks with clay-rich formulation, and Phase II focused on pilot plant production demonstration and extended small-scale testing to evaluate fly ash containing bricks with shale-rich formulations. The objective of Phase III (year 3; 2001-2002), covered by this report, focused on commercial-scale production demonstration, economic evaluation, and commercialization of the technology.

In Phase I, more than 380 bar-size test bricks were produced. 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 clay-rich formulations was maximized and additives to improve the appearance and strength of the bricks were investigated. The results obtained were very promising. Test bricks produced with clay-rich formulations with amounts of fly-ash ranging from 20 to 70 wt %, met commercial specifications and had greater fired compressive strength and greater heat insulation capability than a conventional brick made without ash. In addition, according to GCM, the test bricks made with Illinois fly ash were better in color and physical consistency than the high-quality, medium-tan conventional clay bricks they produced.

GCM indicated its interest in balancing its clay and shale resources by developing an additional fly ash brick product with a shale-rich (more shale than clay) formulation. Because the shale material has less plasticity than the clay material, the technology developed for the medium-tan, clay-rich products needs modification before application to the red, shale-rich products. Thus, in addition to a pilot plant production demonstration, Phase II also involved making small batches of red, fly-ash bricks using a shale-rich (more shale than clay) formulation. The tests were also expanded to include not only dry ash samples obtained from an electrostatic precipitator, but also wet samples collected from impoundment ponds. This was done because few utilities are planning to install a dry ash-collection system in the near future. If ponded fly ash works as well as dry fly ash, this

will greatly increase the economic incentive and enhance the commercial potential of using fly ash for brick making. During Phase II, about 600 full-size test bricks with 50 wt% of fly ash were produced from two pilot plant tests and more than 340 bar-size test bricks were produced for evaluation. The small test bricks produced using a mix of 92% shale/8% clay as the balance and with fly ash contents ranging from 20 to 50% by weight, showed good commercialization potential. However, the results of the pilot plant tests showed several correctable surprises, and corrective measures were then executed with a successful pilot plant run at the conclusion of Phase II.

During Phase III, this report, more than two hundred full-size green bricks were made at the ISGS laboratory. These green bricks, produced with several combinations of clay/shale and fly ash mixes, were used for preliminary in-plant firing tests at various brick production facilities. The preliminary firing results obtained were used to guide the commercial-scale tests. In addition to a commercial-scale run with standard raw material, five commercial-scale production tests with amounts of fly ash substitution ranging from 20 to 40 v% (by volume) (about 38 wt%) were conducted. More than 15,000 full-size face bricks with 20 to 40 v% fly ash substituted into the raw materials of a second brick company were produced for evaluation.

The characteristics of the bricks produced in the commercial-scale tests were consistent with those of the laboratory test bricks. The bricks produced with and without fly ash met or exceeded minimum specifications for commercial face bricks. The bricks made with 20 to 40v% fly ash substitution had greater fired compressive strengths and lower thermal conductivity than bricks made without fly ash. Overall, the fired bricks made with fly ash showed greater resistance to damage and, according to ASTM specifications, belong to Grade SW, suitable for use under severe weathering conditions. The bricks produced with various fly ash additions were distributed to power plants and brick companies to promote interest in commercialization discussion. Many power plants and brick companies showed interest in adopting the technology.

Production cost and raw material cost (mainly shipping cost) are the two most important factors in economic assessments for making fly ash containing fired bricks. Since these factors are case sensitive, evaluation was conducted on a plant-by-plant basis. The potential production cost incentives for producing fly ash bricks at three brick plants were estimated. The results were optimistic. As part of this estimation, additional shale and clay resources in Illinois were included, especially for those resources within a reasonable shipping distance of existing plants producing fly ash from Illinois coals. In general, a trucking distance of less than one hundred miles would be economically favorable.

Instead of building a public structure for a long-term weathering effect evaluation, a freezing and thawing test was completed in Phase III at the ISGS under conditions more extreme than a real life situation. These accelerated weathering tests were conducted on full-size bricks made with 40 wt% fly ash and a conventional brick made without fly ash by a brick company. All these bricks tested have passed the fifty cycles of freezing and thawing as specified by ASTM standard method C67, and can be used for severe weather conditions.

The up to date results show that the extrusion parameters to produce good and consistent green bricks established in the pilot plant production at 300 bricks per batch have been standardized in commercial-scale production of 2,000 and 5,000 bricks per batch at a commercial facility. Specific in-plant firing parameters for a tunnel kiln running at 10 cars/day at one commercial facility have successfully produced 300 commercially acceptable face bricks. Commercial-scale production runs of 5000 bricks and 2000 bricks in a beehive kiln at another commercial facility also produced face bricks that met commercial specification. However, for faster firing in a tunnel kiln, for example running as fast as 20 cars/day, and for consistent firing in a beehive kiln and for maximizing fly ash substitutions (greater than 40 wt%), continued commercial-scale testing to optimize in-plant firing parameters will be necessary.

The full-size bricks containing up to 40 wt % fly ash were distributed to power plants and brick companies located in-state or out-of-state. Many power plants and brick companies showed interest in adopting the technology. Continued work by the ISGS/UIUC for the next year, funded by the DCCA/ICCI, will focus on helping those who showed interest in adopting the technology.

PAGES 1 TO 18 CONTAIN PROPRIETARY INFORMATION.