

FINAL TECHNICAL REPORT
November 1, 1998, through October 31, 1999

Project Title: **UTILIZATION OF ILLINOIS FLY ASH IN MANUFACTURING
OF CERAMIC TILES**

ICCI Project Number: 98-1/3.1C-3

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ABSTRACT

The overall objective of the project is to utilize fly ash, produced by burning Illinois basin coal which is currently being landfilled (due to lack of resource utilization), as a major raw ingredient to manufacture value-added ceramic tiles and to commercialize the technology.

Several steps are necessary to achieve this objective. Laboratory-scale investigation to validate the concept and scale-up in a commercial tile manufacturing facility was addressed in the 1996-1998 project periods. Ceramic tiles containing more than 70% fly ash were successfully made in that investigation. These fly ash tiles exhibited lower firing shrinkage and water absorption than those of the standard clay and talc-based tiles manufactured by a commercial tile manufacturer in Illinois collaborating in this project.

In the present phase, various parameters relevant to commercial production of these tiles, development of data necessary for commercialization of this technology, and some ongoing developmental work were addressed. In order to achieve this objective several mixes with various amounts of fly ash were made to manufacture fly ash tiles using the two different processing methods. In order to facilitate the manufacturing process, a thorough investigation of the chemistry of the system was necessary. In this thorough investigation, a cost effective and simple processing method has been identified. This approach also downplays the compositional variability of fly ash. The results obtained clearly indicate that fly ash can be utilized as the major raw ingredient in successful manufacturing of ceramic tiles. The results also indicate that the requirements for floor and outdoor applications are also achievable, but more work is necessary to consistently produce products satisfying the required properties.

Pages 1-19 contain proprietary information.

EXECUTIVE SUMMARY

The fine particulate material that is electrostatically precipitated or mechanically collected from the stack gases of power plants burning pulverized coal is called fly ash. Annually, the state of Illinois produces over 5% of the 59 million tons of fly ash generated in the U.S. Approximately 20% of this is utilized by the cement and concrete industry and the majority of the rest is landfilled. Any non-concrete utilization of the fly ash currently being disposed will not only be environmentally sound and cost effective, but also will create a stable year-round demand.

The overall objective of this project is to utilize fly ash generated in Illinois as the major raw ingredient for manufacturing value-added ceramic tiles for wall, floor, and outdoor applications. Considering the size of the tile industry, a considerable fraction of the fly ash produced in Illinois can be utilized to prepare ceramic tiles. As raw materials contribute to the major cost in running a tile plant, replacement of costly raw materials by fly ash is attractive to tile manufacturers. Such utilization is environmentally attractive, and the state economy will benefit from such an undertaking.

The four steps envisioned as necessary to prove this concept and commercialize this technology are: Step I - laboratory-scale investigation to validate the concept; Step II - scale-up investigation in a commercial tile manufacturing facility; Step III - address the parameters and develop data necessary for commercialization of this technology; and Step IV - implementation of this technology to manufacture commercial tiles.

Step I and part of Step II were completed during the 1996-1997 and 1997-1998 project periods, and ceramic tiles with characteristics superior or similar to wall and floor tiles were produced in the laboratory and in a commercial tile manufacturing plant.

The objective of the present phase was to address Steps II and III. The present work was carried out at a tile manufacturing plant located in the State of Illinois. The parameters investigated in the current program were selected based upon what is necessary for commercial manufacturing of fly ash-based tiles. Development of such information is essential for commercialization of this technology.

The properties of commercial tiles are specified in the American National Standard Specifications for Ceramic Tiles (ANSI A137.1), published by the Tile Council of America.

According to ANSI A137.1, tiles can be glazed or unglazed, and the performance requirements vary depending upon the application. Commercially, green tile bodies are manufactured using three processing methods, dry pressing, wet pressing, and slip casting.

In dry pressing, approximately 5% water is added based upon the weight of solid. The floor, wall, and outdoor tiles produced in this method mostly have a flat surface, and the production rate for this method is very high. In wet pressing, the amount of water used is relatively higher (approximately 22 to 25%) and the resulting material has the consistency of putty. This procedure has the advantage of reasonably high production rates while the intricate designs are adequately reproduced. In slip casting method, a self-supporting shape, called cast, is produced from a specially formulated slip. A number of parameters play an important role in successful slip casting, which is even more complex in the presence of the multimineralic nature of fly ash.

Upon sintering of the green tile body, which forms solid bonds between particles, the tile

body is glazed at a relatively lower temperature. Glazing improves the surface durability and adds different aesthetic values to tiles. A glaze is a glassy material designed to melt on the surface of a ceramic body and to stay adhered upon cooling. In order to achieve a defect-free surface, it is important that the thermal expansion of the glaze must be equal or slightly more than that of the ceramic body. Among other properties, breaking strength and water absorption are the most important ones to determine the quality and applications of ceramic tiles.

Several tiles were made last year using the wet pressing method and glazed with sixteen different colors and textures. The firing shrinkage of the fly ash tiles was less than that of the clay and talc-based tiles, indicating superior dimensional stability. The water absorption of wet pressed tiles was also significantly lower than that of clay and talc-based tiles prepared under similar conditions and used for wall applications. The lower water absorption of fly ash-based tiles is a positive feature as this brings the promise of making tiles for floor and outdoor applications.

The present program was designed to refine this technology that has been proven to be achievable in a commercial tile manufacturing plant. Processing parameters and tile characteristics that are relevant to commercialization of this technology were emphasized in this present program.

In order to investigate these parameters, several mixes with various amounts of fly ash were made to manufacture fly ash tiles. Upon extensive investigation of the chemistry of the system, a cost effective and simple processing method has been identified that can be used for plants with medium production capacity. In addition, this approach also minimizes the influence of compositional variability of fly ash in day-to-day tile production and quality control. The results obtained in the present program demonstrate that high dosages of fly ash can be used in successful commercial manufacturing of ceramic tiles. A preliminary investigation of a faster processing method has shown even more promise with respect to final product characteristics.

The test results indicate that characteristics of fly ash-based tiles are far superior to those required for wall tile applications, and comparable to those required for floor and outdoor applications.

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