

FINAL TECHNICAL REPORT
November 1, 1999, through January 31, 2001

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

ICCI Project Number: 99-1/2.1B-1

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ABSTRACT

The overall objective of the project is to utilize fly ash, produced by burning Illinois 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. Initially, a laboratory-scale investigation was conducted to validate the concept. The scale-up to a commercial tile manufacturing facility and addressing the manufacturing methods, processing parameters, and product qualities has been the focus of the subsequent programs. During this period, ceramic tiles containing more than 60% fly ash were successfully made. 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 order to achieve the objective of this project, a thorough investigation of the chemistry of the system was necessary. Through this thorough investigation, an effective processing method has been identified that does not complicate the manufacturing process. This approach downplays the compositional variability of fly ash, and thereby provides a general applicability of the method developed, provided fly ash characteristics do not vary significantly. This concept has been successfully extended to overcome the problems associated with the two processing methods being used. 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 in the fly ash-based system.

Pages 1-26 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 60 million tons of fly ash generated in the U.S. Approximately 20% of this fly ash 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 by the burning of Illinois coal 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 that are envisioned as a necessity to prove this concept and commercialize this technology are the following: 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 had been completed, and ceramic tile bodies with characteristics superior or similar to wall and floor tiles were produced in the laboratory. Steps II, III, and IV are interrelated and have been the focus of 1997-1999 and the present program. These steps are being carried out at a commercial tile manufacturing plant located in the State of Illinois, and fly ash-based tiles were manufactured with characteristics similar to those of commercial tiles. The parameters investigated in these programs 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 (TCA). 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 25%), and the resulting material has the consistency of putty. This procedure has the advantage of reasonably high production rates, and simple designs are adequately reproduced. In the slip casting method, a self-supporting shape, called a cast, is produced from a specially formulated slip. Any intricate designs can be adequately reproduced in this processing method. However, 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 properties to determine the quality and applications of ceramic tiles.

Several tiles were made in the previous programs with 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 parameters necessary for commercialization were also investigated by varying the amounts of fly ash and other additives. Upon extensive investigation of the chemistry of the system, an effective 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 present program was designed to refine this technology that has been proven to be achievable in a commercial tile manufacturing plant. Processing methods and parameters that are relevant to commercialization of this technology were emphasized in this present program, including presentation at technical meetings. Several processing methods are also being investigated in this program.

The results obtained in the present program demonstrate that high dosages of fly ash can be used in successful commercial manufacturing of ceramic tiles using wet pressing, slip casting, and dry pressing methods. The cause of a few problems relevant to processing and aesthetics have been identified and remedial measures developed. 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. Several fly ash tile bodies have also passed the standard specifications used in the tile industry, indicating potential for floor and outdoor applications. Also, the processing method developed has general applicability to other Class F fly ashes, although some specific processing steps may need adjustments due to significant shifts in the fly ash characteristics.

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