Center for
By-Products
Utilization

Development of Manufacturing Technology for
Low-Cost, High-Performance, Blended Cements
in Wisconsin

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CBU Report No. 272
September 1995

Department of Civil Engineering and Mechanics
College of Engineering and Applied Science
THE UNIVERSITY OF WISCONSIN - MILWAUKEE
DEVELOPMENT OF MANUFACTURING TECHNOLOGY
FOR LOW-COST, HIGH-PERFORMANCE,
BLENDED CEMENTS IN WISCONSIN

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ACKNOWLEDGEMENTS

The authors express their deep sense of gratitude to the University of Wisconsin System for providing partial financial support for this project through its Applied Research Grant Programs. The authors would also like to thank the College of Engineering and Applied Science of the University of Wisconsin-Milwaukee for providing facilities for conducting this research work.

The primary sponsors of the Center for By-Products Utilization are: Dairyland Power Cooperative, LaCrosse, Wisconsin; Madison Gas and Electric Company, Madison, Wisconsin; Manitowoc Public Utilities, Manitowoc, WI; National Minerals Corporation, St. Paul, Minnesota; Northern States Power Company, Eau Claire, Wisconsin; Wisconsin Electric Power Company, Milwaukee, Wisconsin; Wisconsin Power and Light Company, Madison, Wisconsin; and Wisconsin Public Service Corporation, Green Bay, Wisconsin. Their continuing help and interest in the activities of CBU are gratefully acknowledged.
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(a) A Statement of Project Objectives

Although it is well-known among cement chemists that use of blended cement provides economical, technical, ecological, and environmental benefits, its production and use in the USA are quite low. This is probably the result of insufficiently developed technology for manufacture of blended cements incorporating various types of low-cost/no-cost industrial by-products. Therefore, this research was primarily directed toward developing technology for manufacture of low-cost, high-performance, blended cements incorporating industrial by-products generated in Wisconsin.

(b) A Statement of Progress Toward Objective(s) and/or Setbacks Encountered

This research project was divided into three major tasks (Task I, Task II and Task III). Task I was associated with accumulating information pertaining to blended cement production technology using national and international literature sources. Task II consisted of material characterization of selected industrial by-product materials. The results obtained in Task II were used to select materials for Task III. Task III consisted of mixture proportioning, manufacturing, testing, and evaluations of various types of blended cements developed in this project.

The information accumulated under Task I was compiled into a state of the art report. The state of the art report contains valuable information about blended cements investigated as well as manufactured throughout the world. This information will be of special interest to potential manufacturers of blended cements in Wisconsin and elsewhere. Tasks II and III were primarily directed toward optimizing mixture proportions and production technology for blended cements. To accomplish this, an extensive experimental investigation was designed and conducted. This involved proportioning, manufacturing, testing, and evaluations of over 150 blended cement mixtures under laboratory conditions. These mixtures were composed of various combinations of portland cement, six different industrial by-product materials, and chemical additives. Each mixture was tested and evaluated for strength characteristics as a function of age. An economic analysis was carried out to determine economic viability of all blended cements tested in this work.
The test data showed that it is possible to produce low-cost, high-performance blended cements with large amounts of industrial by-products. Up to 80% cement can be replaced with low-cost/no-cost by-product materials. The results substantiated that industrial by-products can be used to produce blended cements which provide superior strength gain and low-cost compared to ASTM Type I portland cement. Blended cements were found to provide material cost savings of over 30 percent compared to portland cement for a given strength requirement. Blended cements exhibiting equivalent early-age strength and higher later-age strengths were produced with significant materials cost savings. The results further showed that it is possible to produce blended cements with low early-age strength but equivalent later-age strength in order to reduce cost of materials by over 40%. Blended cements providing increased early-age strength were also manufactured. Use of these blended cements can result in material cost savings of about 20 percent. Based on strength and economic data, optimum mixtures were selected and recommended for commercial production of blended cements with large amounts of industrial by-products currently being generated in Wisconsin.

(c) Qualitative and Quantitative Measures of Success of Project

The major objective of the project was to establish blended cement production technology using various industrial by-products generated in Wisconsin. This objective was fulfilled through innovative research completed in this project. The technology developed is simple and can be easily adopted by potential manufacturers of blended cements. Thus, the blended cement technology developed in this project will help start a new manufacturing facility for a product that Wisconsin needs for its own use and export purposes for economic gains.

(d) Economic Impacts in Wisconsin

Wisconsin currently imports about 2 million tons of cement, at a retail cost of about 150 million dollars, from outside Wisconsin. Based on data obtained in this project, a new industrial production facility in Wisconsin can be started for producing low-cost, high performance, blended cements. Such cements will assure supply of cement to Wisconsin, reduce construction costs, improve productivity, and enhance competitiveness of the Wisconsin concrete industry. Additionally, starting a new blended cement manufacturing facility will create jobs in Wisconsin. Currently, all of the cement used in Wisconsin is produced outside Wisconsin. Cement market price on the spot market has jumped to over $90.00 per ton due to shortages in the USA due to worldwide increasing demands. This does not include energy conservation, environmental and technical benefits, non-polluting manufacturing, and recycling of industrial by-products which are currently landfilled in Wisconsin. Use of industrial by-products will result in large savings on disposal costs to the producers, currently averaging about $20/ton and rising by about 10% per year. The use of blended cements by concrete producers will lead to lower cost
concrete. It will also help achieve better performing and durable concrete materials.