

INTERIM FINAL TECHNICAL REPORT  
September 1, 2003, through August 31, 2004

Project Title: **FIELD DEMONSTRATION OF ROAD BARRIERS MADE WITH  
ILLINOIS COAL COMBUSTION PRODUCTS**

ICCI Project Number: 03-1/6.1B-2  
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ABSTRACT

Temporary road barriers are used to channel traffic during construction and maintenance of highway structures. Several hundred thousand of these barriers are currently in use in Illinois. The Illinois Department of Transportation (IDOT) has recently adopted a new design of the road barriers and effective July 01, 2008 the existing road barriers will no longer be used and will be replaced by the new barriers. This means that in the next 5 to 10 years, several hundred thousand of new barriers will be constructed. Use of coal combustion products (CCPs) in construction of temporary road barriers has not been reported so far. This is primarily due to the lack of available data demonstrating the effective use of Illinois CCPs in construction of temporary road barriers. This project was geared towards developing viable composites utilizing Illinois bottom ash, and demonstrating their suitability for construction of temporary road barriers. SIUC teamed up with City Water Light and Power Company, Springfield, Illinois (CWLPC), Illinois Department of Transportation (IDOT), American Engineering Testing, Inc., and the largest manufacturer of precast concrete products in Midwest, Egyptian Concrete Co., Salem, Illinois (ECC) to achieve the objectives of this study.

The goals of the study have been accomplished by conducting a series of laboratory tests and monitoring the performance of full-size barriers made with Illinois bottom ash under actual field conditions. Based on a detailed laboratory study, two concrete composites prepared by replacing 100 percent of natural sand with Illinois PCC bottom ash and by replacing 50 percent of natural sand with Illinois PCC dry bottom ash were identified. Full-size road barriers were constructed using these concrete composites and an equivalent conventional concrete. The results obtained so far show that the performance of concrete composites is similar to that of an equivalent conventional concrete. Some durability laboratory tests and evaluation of field performance of the barriers are in progress. Final results of the study will be available in March 2005.

## EXECUTIVE SUMMARY

The main objectives of the project were to develop scientific data to demonstrate the effective use of Illinois PCC fly ash and bottom ash in construction of temporary road barriers and to develop suitable composites containing Illinois PCC fly ash and bottom ash that could be used to construct the barriers. It is important to note that IDOT has recently changed the design of road barriers and any new barriers are required to meet the new IDOT specifications. The old barriers will phase out of use by July 01, 2008, which means several hundred thousand feet of new barriers will be constructed in the next 5 to 10 years.

To achieve the intended objectives, laboratory tests were performed on samples of concrete composites and an equivalent conventional concrete mixture, and full-size barriers were constructed using the concrete composites identified during a detailed laboratory study and an equivalent conventional concrete. Laboratory tests on samples included compression, split tension, and flexure at various curing ages. In addition, tests were performed to determine resistance to freezing and thawing, and resistance to sulphate attack. The barriers are being used at an actual project site of IDOT in Thompsonville, Illinois. Monitoring of barriers under actual field conditions is in progress.

Within this reporting period of the project, most of the laboratory tests on concrete samples have been completed. Laboratory tests to determine resistance to freezing-thawing and sulphate attack, and field monitoring of barriers are in progress. Detailed results will be presented in the final technical report.

### **Laboratory Testing on Concrete Composites**

Based on previous studies performed at Southern Illinois University Carbondale (SIUC), two concrete composites and an equivalent conventional concrete were selected to conduct the laboratory testing and construct the barriers. The two concrete composites selected were: (1) 100 percent replacement of natural fine aggregate with PCC bottom ash (RB100); and (2) 50 percent replacement of natural fine aggregate with PCC bottom ash (RB50). Several samples were prepared and tested to determine strength, stiffness, and durability characteristics of concrete composites. Table 1 shows the mix designations with percent of different matrix constituents used to prepare the composites. Summary of laboratory test results is presented in this section. General Specifications used for all the mixtures are presented in Table 2.

**Table 1: Mixture Constituents**

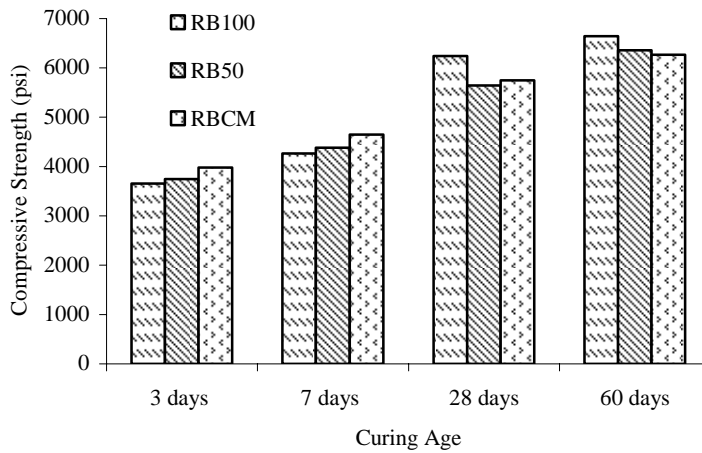
Mixture Designation	Binders (%)		Fine Aggregates (%)		Remarks
	Portland Cement	PCC Fly Ash	PCC Dry Bottom Ash	Natural Sand	
RBCM	100	0	0	100	Control Mix
RB50	100	0	50	50	
RB100	100	0	100	0	

**Table 2: General Specifications**

Description	Specification
Targeted Slump	4±½ in.
Targeted Air Content	7 %
Targeted 28 days Strength from the Lab Specimens (Prepared and Cured in lab under controlled conditions)	5000 psi
Targeted 28 days Strength from the Field Specimens (Prepared during construction and cured along with the barriers, i.e., not cured in water)	4000 psi
Water-to-cement ratio (w/c) used for all mixtures	0.39

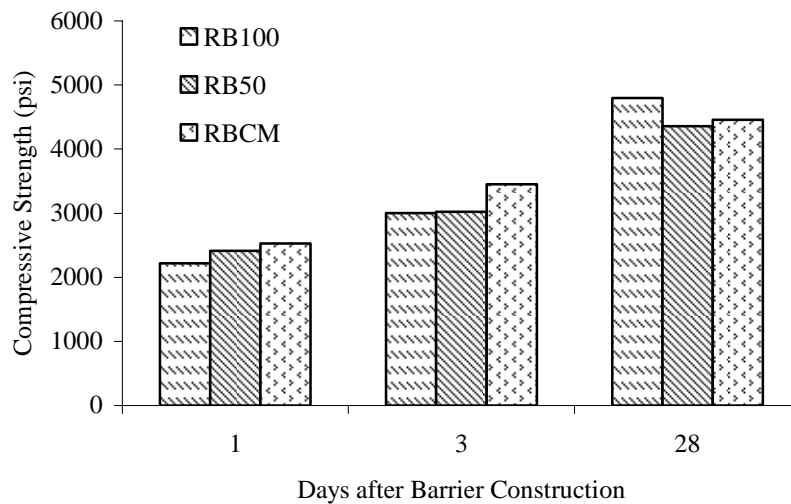
**Strength Characteristics from Laboratory Specimens.** Strength of concrete is commonly considered its most valuable property, although, in many practical cases, other characteristics, such as durability, may in fact be more important. Nevertheless, the compressive strength test usually gives an overall picture of the quality of concrete because strength is directly related to the structure of the hydrated cement paste. Moreover, the strength of the concrete is almost invariably a vital element of structural design and is specified for compliance purposes.

Figure 1 shows the influence of curing age on compressive strength of concrete composites and conventional concrete. In addition, Figure 1 shows the compressive strength of concrete composites compared to that of an equivalent conventional concrete at each curing age. From Figure 1 it is clear that compressive strength of the composites increased with an increase in curing age but the rate of increase in compressive strength reduced after 28 day. Results also show that the compressive strength of the concrete composites studied in the investigation was less than that of conventional concrete up to a curing age of approximately 7 days. However, after 7 days of curing, compressive strength of concrete composites made with Illinois PCC dry bottom ash was observed to be either higher than or almost equal to that of an equivalent conventional concrete.



**Figure 1. Compressive strength of concrete composites prepared and cured in the laboratory under controlled conditions**

Strength Characteristics of Field Specimens (not cured in water). Figure 2 presents the summary of compressive strength results obtained from 6x12 inch cylindrical specimens prepared and tested by Egyptian Concrete Co. from the concretes used to construct the barriers. These samples were left outside with the barriers and were not cured in water. The results presented in Figure 2 are the average of all specimens prepared and tested from each type of mix. Two specimens were prepared and tested at each curing age from each batch of mix which was used to construct 2 barriers. As shown in Figure 2, the average compressive strength of concrete composite with 100 percent bottom ash after 28 days is slightly higher than that of an equivalent concrete and the average compressive strength of concrete composite with 50 percent bottom ash is almost equal to that of an equivalent conventional concrete.



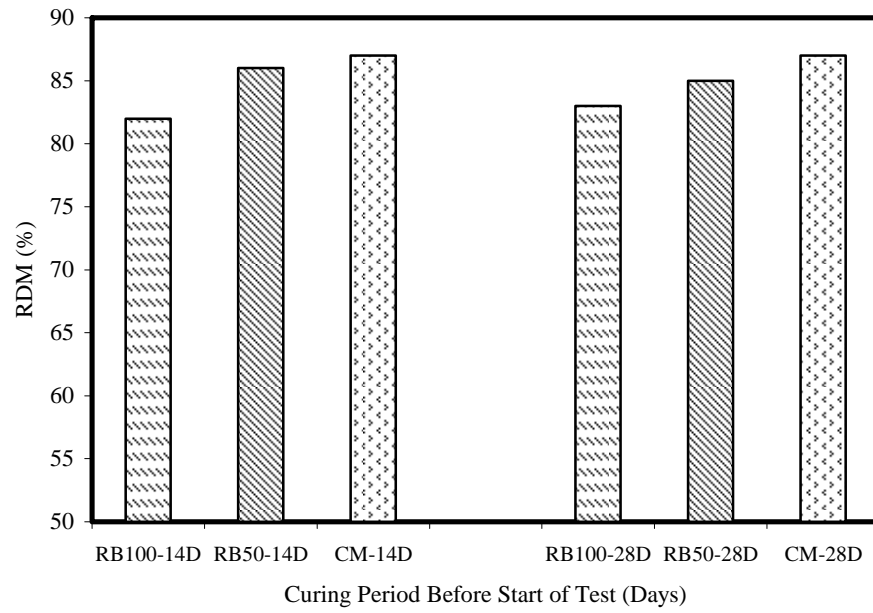
**Figure 2. Compressive Strength Results from Samples Prepared during Barrier Construction and Cured with the Barriers under Field Environmental Conditions (Samples Prepared and Tested by Egyptian Concrete Co.)**

## Freeze-Thaw Characteristics of Concrete Composites

Freeze-thaw tests were performed on specimens prepared using concrete composites and an equivalent conventional concrete. Tests were performed on two sets of specimens, i.e., specimens cured for 14 days before starting the tests and specimens cured for 28 days before starting the tests. Samples were prepared at SIUC and were tested by an independent testing agency, American Engineering Testing (AET). Table 3 presents the weight loss, length expansion, and relative dynamic modulus (RDM) of all the specimens tested after 302 cycles of freezing and thawing. Figure 3 shows the RDM of specimens of concrete composites compared to the RDM of specimens prepared from an equivalent conventional concrete after 302 cycles of freezing and thawing. The results presented in Table 3 show that the change in length of specimens prepared using Illinois PCC bottom ash is similar to that in the equivalent conventional concrete, except for RB100-28D which seems to be anomalous. Relative dynamic modulus of specimens prepared with Illinois bottom ash was observed to be slightly lower than that of the equivalent conventional concrete (Figure 3). However, RDM of all concrete composites was measured to be above 80 percent which represents good durability with regard to freeze-thaw resistance. The report prepared by AET indicates mortar flaking in samples prepared using Illinois bottom ash which caused higher weight loss of specimens having Illinois PCC bottom ash. Further investigation is needed to examine the cause of this flaking and its effect on field performance of the concrete composites.

**Table 3: Freeze Thaw Data after 302 Cycles (Tests Performed by AET)**

Description	Sample Number					
	CM-14D	RB50-14D	RB100-14D	CM-28D	RB50-28D	RB100-28D
Wt. Loss, %	0.230	0.346	0.502	0.230	0.350	0.962
Length Exp., %	0.024	0.027	0.025	0.024	0.025	0.052
RDM, %	87	86	82	87	85	83



**Figure 3. Relative Dynamic Modulus of Concrete Composites compared to an equivalent Conventional Concrete (Tests Performed by AET)**