Temporary road barriers are used to channel traffic during construction and maintenance of highway structures. SIUC recently completed a research project to demonstrate utilization of Illinois PCC bottom ash in construction of temporary road barriers. Viable concrete composites utilizing Illinois PCC bottom ash were developed in this study and temporary road barriers were constructed using these concrete composites. The barriers constructed during this study are being used by IDOT on actual project sites as part of the research project so that they are subjected to actual field environmental conditions. In order to develop performance data, the current project was initiated to monitor these road barriers. The objective of the project was to evaluate the performance of the road barriers under actual environmental conditions and field stresses. This objective was accomplished by continued examination of the barriers made with Illinois PCC bottom ash concrete composites and comparing their performance with the performance of road barriers made with equivalent conventional concrete which are also being subjected to similar field conditions.
EXECUTIVE SUMMARY

The main objective of the project was to evaluate the performance of road barriers constructed as a part of a research study recently completed at SIUC under actual environmental conditions and field stresses. These barriers were constructed with two concrete composites using Illinois PCC bottom ash and an equivalent conventional concrete as a control mix. The intended objective was accomplished by visually examining the barriers made with Illinois PCC bottom ash concrete composites and comparing their performance with the performance of road barriers made with equivalent conventional concrete which are also being subjected to similar field conditions. In addition, samples were cored from the concrete blocks prepared during construction of the barriers and tested to evaluate their compressive strength characteristics. The concrete blocks were also subjected to actual field environmental conditions.

Composition of Barriers

The barriers are made of two concrete composites and an equivalent conventional concrete. The two concrete composites used to construct the barriers are: (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). Table 1 shows the mix designations with percent of different matrix constituents used to prepare the composites. General Specifications of mixtures used to construct the barriers are presented in Table 2.

<table>
<thead>
<tr>
<th>Mixture Designation</th>
<th>Binders (%)</th>
<th>Fine Aggregates (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Portland Cement</td>
<td>PCC Fly Ash</td>
<td>PCC Dry Bottom Ash</td>
</tr>
<tr>
<td>RBCM</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>RB50</td>
<td>100</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>RB100</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2: General Specifications

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

Currently, almost half of the barriers are being used for a bridge replacement project in Anna, Illinois. The barriers were inspected visually on a regular basis to observe visible signs of any discoloration, scaling, spalling, cracking etc. Figure 1 shows a barrier made with concrete composite, RB100. Based on visual observations, performance of the barriers made with concrete composites, RB100 and RB50, appears to be similar to those made with an equivalent conventional concrete.

Figure 1. Road barrier made with concrete composite, RB100, after being subjected to actual field conditions for a period of approximately 18 months

Strength of Concrete Composites

Concrete blocks were prepared from each of the two concrete composites and an equivalent concrete at the time of construction of the barriers. The blocks were kept outside and were subjected to actual field environmental conditions similar to the conditions to which the barriers are being subjected. Samples were cored from the blocks at various curing ages and tested in compression. Figure 2 shows the results of compression strength tests from the samples cored from the block made from concrete composite, RB100.
Figure 2. Compressive strength of concrete composite, RB100- samples cored from the blocks made at the time of construction

Test results presented in Figure 1 show that the compressive strength of the concrete composite, RB100, increased with the age after construction up to approximately 21 months. Compressive strength appears to have stabilized as there is insignificant difference in the compressive strengths measured at 21 and 27 months of age.
OBJECTIVES

Use of coal combustion products (CCPs) in construction of temporary road barriers has not been reported in the available literature which indicates that these products have not been used for construction of barriers. This is primarily due to the lack of technical data to convince the engineering community that coal combustion products could be used in construction of temporary road barriers without jeopardizing their field performance. SIUC recently completed a research project to demonstrate utilization of Illinois PCC bottom ash in construction of temporary road barriers. Viable concrete composites utilizing Illinois PCC bottom ash were developed in this study and temporary road barriers were constructed using these concrete composites. The barriers constructed during this study are being used by IDOT on actual project sites as part of the research project so that they are subjected to actual field stresses and environmental conditions. In addition, samples were cored from the concrete blocks prepared during construction of the barriers and tested to evaluate their compressive strength characteristics. The concrete blocks were also subjected to actual field environmental conditions.

The objective of the current project was to evaluate the performance of the road barriers constructed as a part of the research study recently completed at SIUC under actual environmental conditions and field stresses. This objective was accomplished by continued examination of the barriers made with Illinois PCC bottom ash concrete composites and comparing their performance with the performance of road barriers made with equivalent conventional concrete which are also being subjected to similar field conditions.

INTRODUCTION AND BACKGROUND

Several million tons of fly ash, bottom ash, and boiler slag are currently produced annually in Illinois by coal burning power-generating plants. The largest volume of coal combustion products in Illinois consists of fly ash and bottom ash. Typically, most of these ashes are disposed off by dumping in ash ponds or hauling to landfills. Because of the increasing costs associated with coal combustion ash disposal and the environmental regulations in place; the federal, state and local agencies, as well as the private sector have been taking an active part in sponsoring and promoting a growing number of programs and research studies to develop alternate methods for profitable and environmentally safe uses of these products.

Fly ash has long been recognized as a construction material used frequently in Portland cement and concrete products, structural fills, embankments, and road bases/subbases. Several projects have progressed over the last few years for large volume use of fly ash and bottom ash to make value-added marketable products, e.g., ceramic tiles, fiber-reinforced cement composites, bricks, piles, and other building materials. Coal combustion products have not been used in construction of road barriers mainly due to the lack of technical data to convince the engineering community that coal combustion products could be used in road barriers without jeopardizing long-term performance and
structural integrity of the barriers to resist the anticipated forces. SIUC recently completed a research project, which was funded by Illinois Department of Commerce and Economic Opportunity (DCEO) Office of Coal Development through Illinois Clean Coal Institute (Project Number 03-1/6.1B-2), to demonstrate utilization of Illinois PCC bottom ash in construction of temporary road barriers. Viable concrete composites utilizing Illinois bottom ash were developed in this study and temporary road barriers were constructed using these concrete composites. The barriers constructed are being used by IDOT on actual projects sites as part of the project so that they are subjected to actual field stresses and environmental conditions.

From the funding made available under Project Number 03-1/6.1B-2, the performance of the barriers under actual field conditions was monitored for a period of less than 6 months. However, in order to develop sufficient performance data, continuous monitoring and evaluation of these road barriers is required. Therefore, the objective of this project was to evaluate the performance of road barriers under actual environmental conditions and field stresses. SIUC teamed up with City Water Light and Power, Springfield, Illinois (CWLP), 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 construct and test the barriers.

**EXPERIMENTAL PROCEDURES**

The barriers are made of two concrete composites and an equivalent conventional concrete. The two concrete composites used to construct the barriers are: (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).

**Inspection of Barriers (Task I)**

Currently, almost half of the barriers are being used for a bridge replacement project in Anna, Illinois. The barriers were inspected visually on a regular basis to observe visible signs of any discoloration, scaling, spalling, cracking etc. Figure 3 shows the barriers being used on a project site.

**Strength of Concrete Composites (Task II)**

Concrete blocks were prepared from each of the two concrete composites and an equivalent concrete at the time of construction of the barriers. The blocks were kept outside and were subjected to actual field environmental conditions similar to the conditions to which the barriers are being subjected. Samples were cored from the blocks at various curing ages, cut to appropriate dimensions, and tested in compression. Figure 4 shows a sample being cored from concrete block and Figure 5 shows a sample being cut to appropriate dimensions before testing.
Figure 3. Barriers on a project site

Figure 4. Coring of a cylindrical sample from concrete block in progress
The cylindrical specimens cored from the blocks were tested for compression strength in general accordance with ASTM C 39 “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens”. To ensure the application of uniaxial compression loading, the surfaces of the upper and lower platens of the compression machine were cleaned and the specimen was placed on the hardened steel surface of the lower platen, aligning the specimen with the center of the upper spherically seated platens. The load was applied continuously at a rate of 22,500 lb/min until failure.

RESULTS AND DISCUSSION

Task I

Task I of the project consisted of inspecting the barriers for visible signs of any discoloration, scaling, spalling, cracking etc. every other month. Currently, almost of half of the barriers are being used for a bridge replacement project in Anna, Illinois. The barriers were inspected visually on a regular basis to observe unusual visible signs of any discoloration, scaling, spalling, cracking etc. related to the quality of the concrete composites. Figure 1 shows a barrier made with concrete composite, RB100. Based on visual observations, performance of the barriers made with concrete composites, RB100 and RB50, appears to be similar to those made with an equivalent conventional concrete.
Figure 1. Road barrier made with concrete composite, RB100, after being subjected to actual field conditions for a period of approximately 18 months (The same as presented in Executive Summary)

Task II

Task II of the project consisted of coring samples from the concrete blocks casted at the time of construction of the barriers, cutting the samples to required length, and testing the samples to evaluate strength characteristics.

Concrete blocks were prepared from each of the two concrete composites and an equivalent concrete at the time of construction of the barriers. The blocks were kept outside and were subjected to actual field environmental conditions similar to the conditions to which the barriers are being subjected. Samples were cored from the blocks at various curing ages and tested in compression. Figure 2 shows the results of compression strength tests performed on samples cored from the block made from concrete composite, RB100. Figure 6 and 7 show the test results from samples cored and tested from concrete composite, RB50 and an equivalent conventional concrete, respectively.
Figure 2. Compressive strength of concrete composite, RB100 - samples cored from the blocks made at the time of construction (The same as presented in Executive Summary)

Figure 6. Compressive strength of concrete composite, RB50 - samples cored from the blocks made at the time of construction
Test results presented in Figure 2 show that the compressive strength of the concrete composite, RB100, increased with the age after construction up to approximately 21 months. Compressive strength appears to have stabilized as there is insignificant difference in the compressive strengths measured at 21 and 27 months of age. Similar observations were made from Figures 6 and 7. Comparison of Figures 1 and 7 shows that the strength of concrete composite RB100 is almost equal to that of conventional concrete. However, comparison of Figures 6 and 7 shows that the strength of concrete composite RB50 is lower than that of conventional concrete. It is important to note that only two barriers were constructed in a day from a particular concrete mix. The concrete used to prepare the block from RB50 was observed to have lower strength than that from the other day’s mixes, probably because of mixing difficulties.

CONCLUSIONS AND RECOMMENDATIONS

- Based on the field observations made so far, it appears that the performance of barriers made with Illinois PCC bottom ash is similar to that of barriers made with an equivalent conventional concrete.
- No visual signs of unusual discoloration, scaling, spalling, cracking, etc., related to quality of the concrete were observed.
• Compressive strength of the concrete composites increased with the age after construction up to approximately 21 months and appears to have stabilized as there is insignificant difference in the compressive strengths measured at 21 and 27 months of age.

• Continuous field monitoring and evaluations of field performance of the barriers are required to access the long-term performance of the barriers. Therefore, it is recommended that field monitoring and evaluations be continued.

DISCLAIMER STATEMENT

This report was prepared by Sanjeev Kumar, Southern Illinois University Carbondale with support, in part, by grants made possible by the Illinois Department of Commerce and Economic Opportunity through the Office of Coal Development and the Illinois Clean Coal Institute. Neither Sanjeev Kumar, Southern Illinois University Carbondale, nor any of its subcontractors, nor the Illinois Department of Commerce and Economic Opportunity, Office of Coal Development, the Illinois Clean Coal Institute, nor any person acting on behalf of either:

(A) Makes any warranty of representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights; or

(B) Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring; nor do the views and opinions of authors expressed herein necessarily state or reflect those of the Illinois Department of Commerce and Economic Opportunity, Office of Coal Development, or the Illinois Clean Coal Institute.

Notice to Journalists and Publishers: If you borrow information from any part of this report, you must include a statement about the state of Illinois' support of the project.