No. 0092-04-10 Wisconsin Highway Research Program • www.whrp.org May 2010

PUTTING RESEARCH TO WORK

BRIEF

Fly Ash Stabilizes Roads at Competitive Costs

An important component of highway durability is the stiffness of the subgrade soils that support the upper pavement layers. One promising way of achieving this stiffness involves the use of fly ash, a byproduct of coal-burning power plants. Because fly ash has the property of self-cementing when it reacts with soil and water, it is useful for increasing the stiffness and strength of fine-grained subgrade soils, such as silty or clayey soils. As a waste material that would otherwise be sent to landfills, fly ash is also cost-competitive when compared to other methods of stabilizing subgrades such as the use of granular materials.

What's the Problem?

Fly ash stabilization of fine-grained subgrades is a developing and promising technology, and several states, including Minnesota and Kansas, have reported considerable success with the method. Further, many states have active programs promoting the recycling of fly ash and other high-volume industrial byproducts. However, there was little field research available on the effectiveness of stabilizing subgrades with fly ash in Wisconsin.

Research Objectives

The purpose of this effort was to document the performance of fly ash-stabilized subgrades in Wisconsin through short- and long-term monitoring of test sections. Another component of this research effort—accomplished in part through concurrent studies not funded through WisDOT—was to determine the environmental effects of fly ash by testing its leachate for contaminants such as arsenic and lead.

Methodology

Researchers monitored fly ash-stabilized sections on the following highway projects in Wisconsin:

- A 15.1-kilometer section of US 12 between Cambridge and Fort Atkinson, reconstructed from April 2004 to January 2005.
- A second project on WIS 32 near Port Washington, which was monitored only during construction.
- A third project on WIS 60 near Lodi, which researchers had monitored for seven years after its construction.

Prior to the reconstruction of US 12, researchers conducted California bearing ratio, resilient modulus and unconfined compression laboratory tests on subgrade soils. They also conducted field tests using the soil stiffness gauge, dynamic cone penetrometer, rolling weight deflectometer and falling weight deflectometer. During construction, subgrade soils were mixed with 12 percent Class C fly ash by dry weight, compacted and after seven days of curing, covered with a granular base course and a concrete pavement. After the construction, researchers repeated field tests twice between 2004 and 2007. Similar tests were conducted for WIS 32 during but not after its construction.

In 2009, researchers conducted a pavement distress survey on stabilized and unstabilized segments of US 12 as well as on a segment of WIS 60 that had been reconstructed in 2001 using a fly ash-stabilized subgrade. These surveys included 11 indicators of distress including different types of cracking, surface raveling and rutting.

To measure the environmental effects of fly ash, researchers installed pan lysimeters beneath fly ash-stabilized sections of the roadway and a control section. Then they tested the water that had percolated into these lysimeters for environmental contaminants that might have leached from the fly ash. They also simulated leaching behavior in laboratory column leach tests.

Project Manager

"Using fly ash to stabilize fine-grained subgrade soils provides the pavement structure support necessary and puts recycled materials to good use."

– Bob Arndorfer
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After fly ash is placed over a subgrade, a water truck moistens it and a road reclaimer blends it with the soil. After compaction, the soil gradually gains strength and stiffness as it cures over the next several dry weather days.

Results

Results suggested that fly ash stabilization of subgrades provides adequate support for the pavement structure and could increase the capacity and service life of pavements in Wisconsin.

For the ongoing project on WIS 32, all tests consistently indicated that the stiffness and strength of the subgrade were improved significantly by fly ash stabilization, and that once the fly ash had been mixed into the soil and compacted during a window of dry weather, the subgrade remained stiff during wet weather, facilitating construction operations.

For all sites, the use of fly ash to stabilize soils with moisture contents varying from 7 percent to 14 percent increased the stiffness and strength of soil by a factor of two to three. Further, pavement distress surveys of WIS 60 over eight years and US 12 after four years showed that fly ash-stabilized sections perform comparably to control sections stabilized with breaker run. Stiffness either remained about the same or improved over freeze-thaw cycles.

Environmental findings indicated that concentration levels of all monitored elements are expected to fall below Wisconsin environmental standards during percolation to the groundwater table.

Further Research

Researchers are continuing to monitor the US 12 and WIS 60 projects for the environmental effects of fly ash.

While results show that fly ash stabilization provides a stiffer subgrade layer irrespective of soil type, they also indicate that there is a complex relationship between base soil type, fly ash quantity and water content. Consequently, a careful mix design should be developed for fly ash stabilization involving all potential subgrade soils, although the greatest application of fly ash stabilization is for fine-grained soils.

This project is one of a series of fly ash studies being conducted in the region by the University of Wisconsin–Madison. The Wisconsin Highway Research Program sponsored a series of studies to explore different products including fly ash for subgrade stabilization. Additional work in this area is being funded by other states and the U.S. Department of Energy.

Investigator

"This study shows that we should use fly ash for stabilization at every opportunity—not just for wet subgrades, but to improve the performance of roads in general."

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Brief prepared by CTC & Associates LLC
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This brief summarizes Project 0092-04-10, "Monitoring and Evaluation of Fly Ash Stabilized Subgrade Constructed by the WisDOT," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

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