Full Depth Reclamation of Asphalt Pavements Using Class F Fly Ash

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ABSTRACT

This study demonstrates the use of Class F fly ash in combination with lime or lime kiln dust in the full depth reclamation (FDR) of asphalt pavements. FDR is a process of pulverizing a predetermined amount of flexible pavement that is structurally deficient, blending it with chemical additives and water, and compacting it in place to construct a new stabilized base course. With funding from the Ohio Coal Development Office, two existing failed asphalt pavements in the fastest growing counties of Ohio were rehabilitated in summer of 2006 with Class F fly ash in combination with lime and lime kiln dust. After the construction, relationships for the service performance and structural behavior of the FDR pavements were monitored to determine how the fly ash sections compared to other more traditional pavement rehabilitation techniques. Service performance and structural behavior were determined with the use of sensors embedded in the road and Falling Weight Deflectometer (FWD) tests. Results of the FWD tests conducted up to 3 months after road reclamation show that Class F fly ash can be used successfully in combination with lime kiln dust or lime for FDR work to obtain resilient modulli values ranging from 500 to 750 ksi or more. Long-term monitoring of the pavement response will be carried out till December 2008.

INTRODUCTION

In the United States many of the almost two million miles of asphalt roadways are severely distressed and in need of repair or replacement. Over the last few decades, increasing traffic demands combined with decreasing funding for repairs, environmental concerns and an emphasis on safe, efficient, transportation systems have stimulated research and field demonstration projects to explore methods to reuse and recycle pavement materials.

In response to this need, the Department of Civil and Environmental Engineering and Geodetic Science at The Ohio State University (OSU) has partnered with the two fastest growing counties in Ohio (Delaware and Warren) to construct and monitor two county

roads in which sections of failing asphalt pavements were reclaimed and recycled. Class F fly ash generated from Ohio coal at the Zimmer power plant was used in the reclamation process.

At both locations the full depth of the asphalt wearing surface plus the base, subbase and a pre-determined amount of the underlying existing subgrade soil were uniformly pulverized, blended with chemical additives (Class F fly ash in combination with lime or lime kiln dust), and compacted to construct a new stabilized base course. An asphalt overlay was then placed over the newly reclaimed and stabilized base.

The Class F fly ash provides the silica and alumina needed for cementitious reaction with lime to increase the strength, stiffness, and durability of the stabilized base layer. In addition fly ash acts as a mineral filler to fill the voids in the granular pulverized pavement mix, reducing the permeability of the FDR stabilized base layer.

Figure 1: Blending fly ash with pulverized base material

OBJECTIVE AND GOAL

The overall objective of this work is to demonstrate the effective use of Class F fly ash in combination with lime or lime kiln dust in the full depth reclamation (FDR) of asphalt pavements. The goal of the proposed program is to establish field-verified relationships for the service performance, structural and environmental behavior of FDR pavements constructed using lime-activated fly ash.

Two highway pavements were constructed and instrumented in 2006, and will be monitored for two years. This project will demonstrate that when fly ash in combination with lime or lime kiln dust is properly incorporated into FDR reconstruction of a flexible pavement, its use can be economically attractive while offering increased structural and service performance,

DELAWARE COUNTY PAVEMENT

Delaware County (located 20 miles north of Columbus) is the fastest growing county in Ohio. In collaboration with the Delaware County Engineer's Office, Section Line Road between State Route 42 and Home Road was selected for FDR reconstruction in 2006.

The section of the road selected for study measured 4.1 miles in length. Roadway width is 20 feet with minimal shoulders, with an asphalt surface thickness ranging from 5.25 to 14 inches (average of 10.28 inches). The original pavement was underlain by a base course ranging from 1 to 11 inches (average of 5.18 inches) thick.

The pavement sampling and design was the responsibility of EDP Consultants in collaboration with OSU. Nine sections were constructed using the following six mixes:

- 4-percent lime with 6-percent fly ash, 8-inch stabilization depth (0.7 mile)
- 5-percent lime kiln dust with 5-percent fly ash, 8-inch stabilization depth (0.6 mile)
- 3-percent lime kiln dust with 1.4 gallons per square yard emulsion, 8-inch stabilization depth (0.7 mile)
- 5-percent cement, 12-inch stabilization depth (0.8 mile)
- 2-percent cement with 1.6 gallons per square yard emulsion, 8-inch stabilization depth (0.3 mile)
- 5-inch mill and fill (two 0.1-mile sections at the north and south ends of the project, and a 0.7-mile as well as 0.1-mile sections near the middle of the project).

The FDR rehabilitation of Section Line Road began in August, 2006. Strawser Paving first milled and removed 5 inches of the existing pavement. Base Construction then pre-pulverized the remaining pavement materials to the appropriate depth as listed above.

Figure 2: Compaction of the FDR base layer in Delaware County.

The pulverized pavement materials were then treated with the design admixtures. Water was added to the mix and it was compacted immediately (see Figure 2). Pavement

resurfacing with 5 inches of hot mix asphalt followed a specified curing interval. All work was completed by mid-October.

WARREN COUNTY PAVEMENT

Warren County, near Cincinnati, is the second fastest growing county in the state. The Long Spurling Road (County Road 171) located in the southeastern part of the county in Harlan Township between SR132 and the north driveway to the LM Animal Products Plant was chosen by the Warren County Engineer's Office for FDR construction. The failing pavement was 0.4 miles in length, 20 to 21 feet in width with minimal shoulders and a 2-inch asphalt layer on top of 4 to 6 inches of chipsealed pavement.

As was the case for the Delaware County project, EDP Consultants designed the new pavement system in collaboration with OSU. Two sections were constructed:

- 4-percent lime with 6-percent fly ash, 12-inch stabilization depth (0.32 mile)
- 5-inch mill and fill (0.08 mile)

The FDR rehabilitation of the Long Spurling Road was begun in July, 2006. Strawser Paving milled and removed 4 inches of the existing pavement asphalt surface. Base Construction pre-pulverized the remaining pavement materials to a depth of 12 inches. Lime and fly ash were added to the pulverized pavement materials to a depth of 12 inches. Water was added to the mix and it was compacted immediately. Resurfacing the pavement with 4 inches of hot mix asphalt (see Figure 3) was completed by mid-September.

Figure 3: Resurfacing with hot mix asphalt in Warren County.

PAVEMENT INSTRUMENTATION AND MONITORING

During construction, the Delaware and Warren pavement sections were instrumented with the following structural and environmental monitoring devices:

- Strain gauges at bottom of asphalt layer (see Figure 4)
- Pressure cells at bottom of stabilized base layer (see Figure 5)
- Pore pressure devices at bottom of stabilized base layer (see Figure 5)
- LVDTs for measuring vertical deflections of pavement (see Figure 5)
- Lysimeters installed within the stabilized base to monitor leachate quality.

Data collection from the above monitoring devices is being carried out on a quarterly basis.

Figure 4: Placement of the strain gauge at the top of the FDR layer in Delaware County.

Falling Weight Deflectometer (FWD) tests (to measure pavement load deflection behavior and calculate the insitu resilient modulus of pavement base) are being carried out by the Ohio Department of Transportation. FWD tests were conducted immediately before construction, directly after construction, and will be carried out twice a year to determine the longer-term elastic moduli of the various sections constructed in this project.

Figure 5: The OSU pavement instrumentation installed at the bottom of the FDR layer (left to right) — pressure cell, pore pressure device and LVDT base — in Warren County.

FWD RESULTS

Falling Weight Deflectometer (FWD) tests were carried out before pavement rehabilitation and within three weeks of paving for both the Warren County site and the Delaware County site. Additionally FWD tests were carried out at 3 months after paving at the Warren County site.

The FWD test data was processed using MODCOMP[3], a popular FWD back calculation software, to determine the elastic modulli of base layers. MODCOMP uses the FWD deflection profile along with theory of elasticity and an iterative process to fit elastic moduli to the layers of the flexible pavement. The required inputs to the program are the FWD data (including deflections, sensor spacing, etc.), layer thicknesses (determined from borings), and Poisson's Ratio of the layers (usually from 0.35 to 0.45).

Figure 6 and 7 summarize the base layer resilient modulus values back-calculated using FWD field data for Delaware and Warren counties, respectively. It can be seen that pavement sections stabilized with fly ash showed large increases in stiffness compared to pre-reclamation base stiffness modulli values.

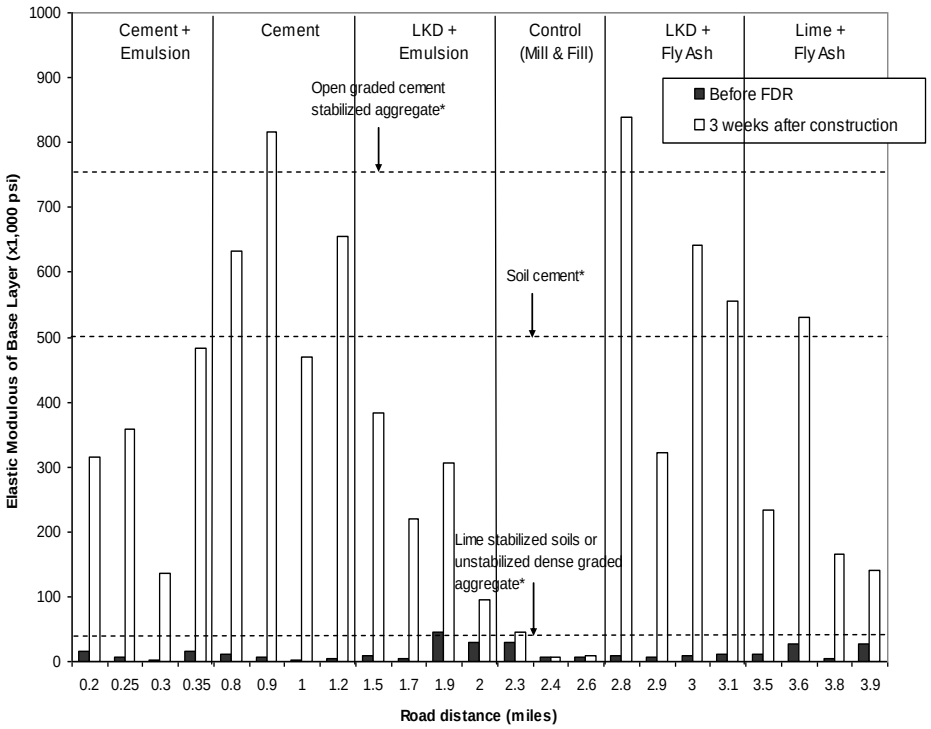

Figure 6: Delaware County resilient modulus vs. road distance
(Note - Typical resilient modulus values are from Mechanistic Empirical Pavement Design Guide 2004, FHWA[4])

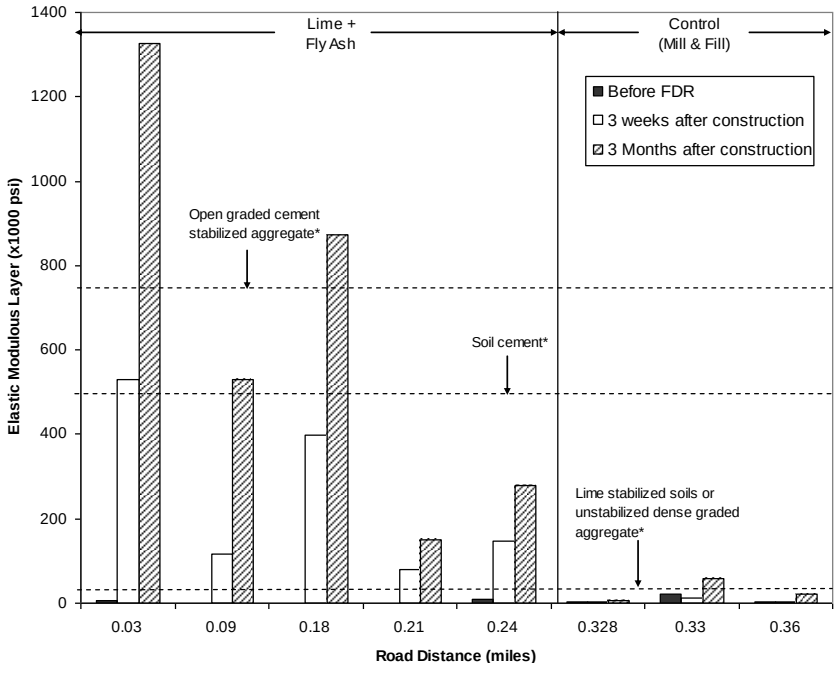

Figure 7: Warren County resilient modulus vs. road distance
(Note - Typical resilient modulus values are from Mechanistic Empirical Pavement Design Guide 2004, FHWA[4])

Figure 6 for Delaware County pavement site gives a comparison of six different mixes. It can be observed that shortly after construction was completed, the fly ash+LKD section modulli values were comparable to those of the cement section. The fly ash+lime resilient modulli values were slightly lower than that for fly ash+LKD. The cement+emulsion and LKD+emulsion sections exhibited lower stiffness values. The control section base layers saw little or no increase in modulli values (as expected). In general, the resilient modulus values obtained were comparable to typical values for soil cement (500 ksi) to open graded cement stabilized aggregate (750 ksi).

Figure 7 shows the back-calculated resilient modulus values for Warren county pavement site before construction, within three weeks after construction, and 3 months after construction was completed. As in Delaware County site, the fly ash+lime section elastic modulli values were in the range of 100 to 500 ksi. The 3-month resilient modulli values for the lime+fly ash stabilized section were more than twice that at three weeks due to curing of the section with time.

CONCLUSIONS

In this research project two test roads were developed to determine how Class F fly ash combined with lime or lime kiln dust (LKD) can be used in Full Depth Reclamation (FDR) of asphalt pavements. Two Ohio counties, Warren and Delaware, partnered with The Ohio State University to develop two test pavements. These pavements consisted of an asphalt layer, a stabilized base, and a subbase. In Warren County, a pavement section using Class F fly ash and lime was reclaimed, while in Delaware county five different pavement sections (using cement and emulsion, cement, LKD and emulsion, Class F fly ash and lime, and Class F fly ash and LKD) were constructed. Analysis of FWD test data carried out on the pavement sections soon after reclamation shows that Class F fly ash can be used successfully in combination with lime kiln dust or lime to obtain resilient modulli values ranging from 500 to 750 ksi or more.

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