

Use of Lime Activated Class F Fly Ash for Full Depth Reclamation (FDR) of Asphalt Pavements

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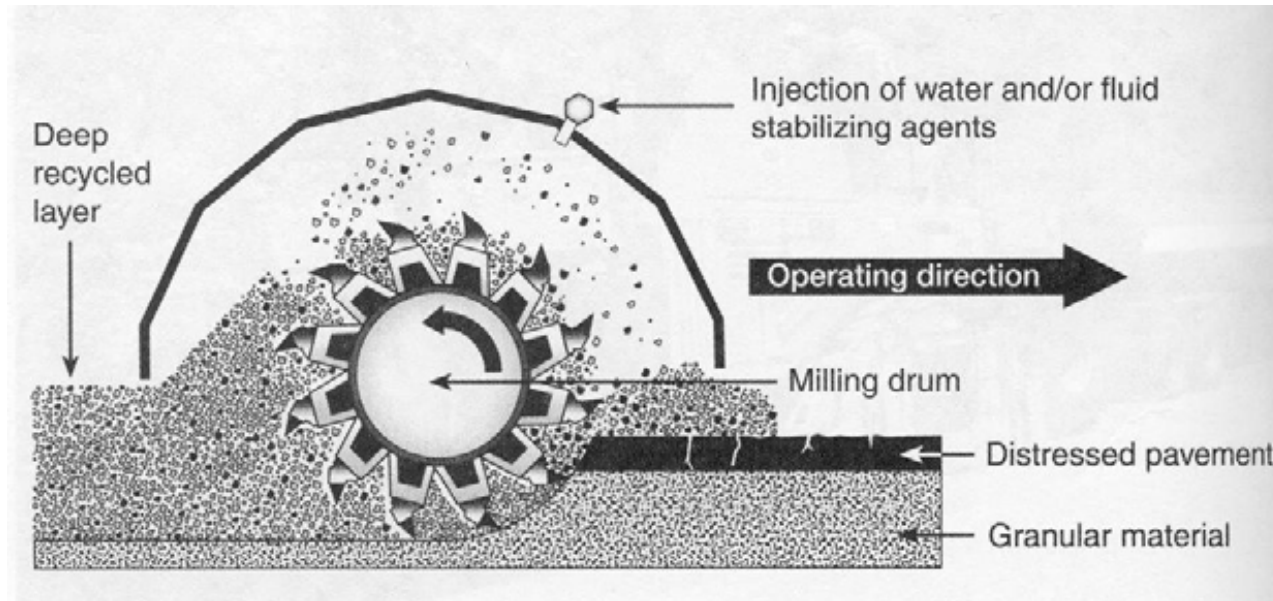


Asphalt Pavement Rehabilitation

- In last several decades:
 - increasing traffic demand (loads & volumes)
 - decreasing budgetary funds for repairs
 - continuing need for a safe, efficient, and cost-effective transportation system
- Roads are experiencing serious distress due to economic development, especially with rapid development of suburbs
- Choices:
 - Replace distressed road with new one based on limited funds available (fewer miles can be paved per year)
 - Replace distressed roads by recycling existing pavement and other by-products into a new pavement (large number of miles can be paved for a given budget)
- Recycling / reclamation of existing pavements is a priority



Full Depth Reclamation (FDR)



- FDR is a flexible pavement reclamation process in which the full pavement section, including the wearing surface, base / subbase, and a pre-determined portion of underlying soil are uniformly pulverized, blended with chemical additives (such as cement, fly ash, lime, etc.) and compacted to construct a new stabilized base. An asphalt overlay can then be placed over it.
- FDR is only cost-effective pavement rehabilitation procedure that corrects base / subbase problems short of conventional re-construction.

Coal Use Facts

Nationally:

- **52% of Electricity is Generated by Combustion of Coal**
- **1.1 Billion Tons were consumed in 2005.**

State of Ohio:

- **90% of Ohio's Electricity is Generated by Combustion of Coal**
- **Coal Use: 30 Million Tons/Yr. (Ohio Coal)**
30 Million Tons/Yr. (Non-Ohio Coal)
- **1.5 Tons of Coal Combustion By-products generated in Ohio / Person / Yr.**



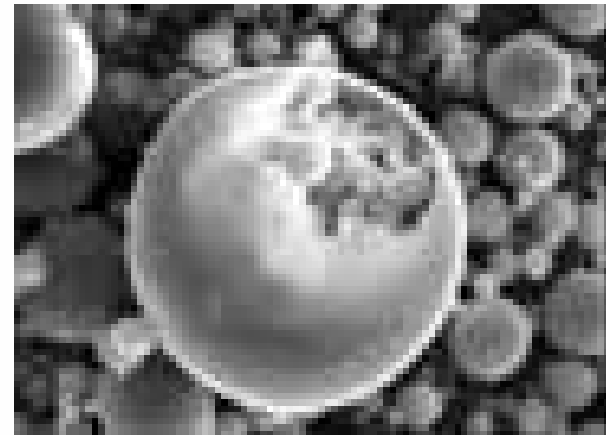
Fly Ash



Zimmer power plant in Moscow, Ohio.



Typical Fly ash



Fly ash particles at 2,000x magnification



Coal Fired Fly Ash Generating Power Plants



25 mile radius



50 mile radius

Objective

Demonstrate effective use of Class F fly ash in combination with lime or lime kiln dust (LKD) in FDR of asphalt pavements.

Role of Fly Ash in FDR Work

- Fly ash provides **Silica and Alumina** needed for cementitious reaction with lime to increase strength, stiffness, and durability of stabilized base layer.
- Fly ash act as **mineral filler** to fill the voids in the granular pulverized pavement mix, this reducing permeability of the FDR stabilized layer.





● FDR Sites

Failing Pavement at Warren County Site (Long Spurling Road CR-171)



Warren County Pavement Sections (0.4 miles)

Two sections were designed and constructed (2006):

- 4% Lime with 6% Fly Ash, 12 inch stabilization depth (0.32 mile)
- 5 inch Mill and Fill (0.08 mile)



Delaware County Pavement Sections (4.1 miles)

Nine sections were designed and constructed (2006) using the following six mixes:

- 4% Lime with 6% Fly Ash, 8 inch stabilization depth (0.7 mile)
- 5% Lime Kiln Dust with 5% Fly Ash, 8 inch stabilization depth (0.6 mile)
- 3% Lime Kiln Dust with 1.4 gallons per square yard emulsion, 8 inch stabilization depth (0.7 mile)
- 5% Cement, 12 inch stabilization depth (0.8 mile)
- 2% 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)



Milling of Asphalt Surface (Warren County)



Placing of Lime (Delaware County)



Train of equipment (front to back: water truck, mixer and compactor)



Teeth of Mixer (Warren County)



Placing of Fly Ash (Warren County)



Material before mixing (left) and after mixing (right)



Compaction of FDR base layer (Delaware County)



Final FDR base layer ready for asphalt overlay (Warren County)



Asphalt overlaying on South bound lanes of Section Line Road



Asphalt overlay (Warren County)



Introduction

Construction

Instrumentation

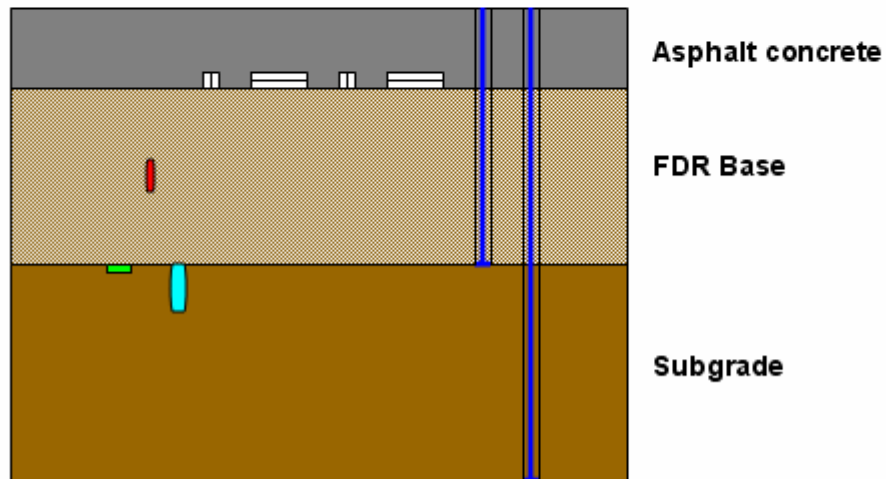
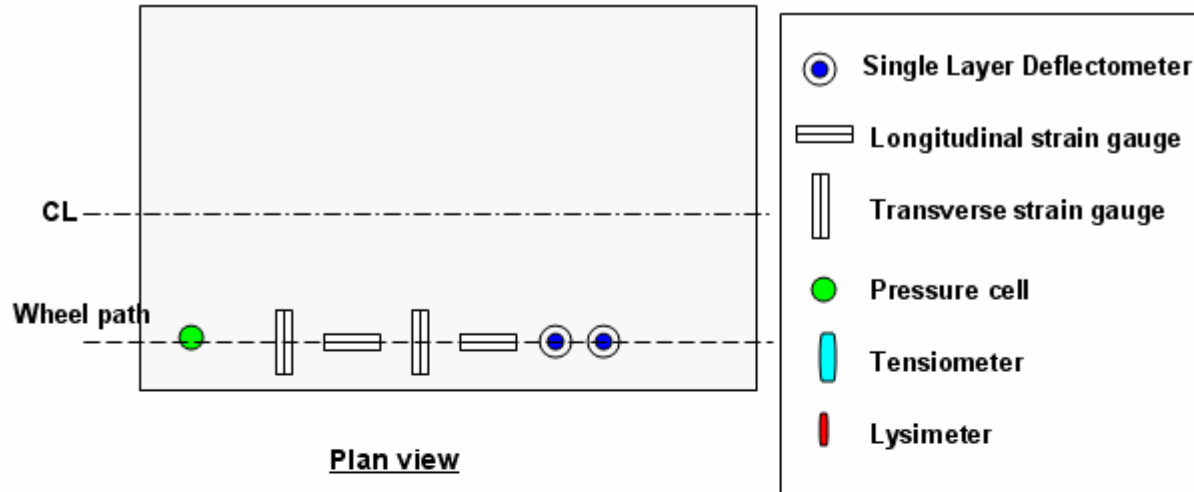
Monitoring

Conclusions

Final compaction of asphalt overlay (Delaware County)



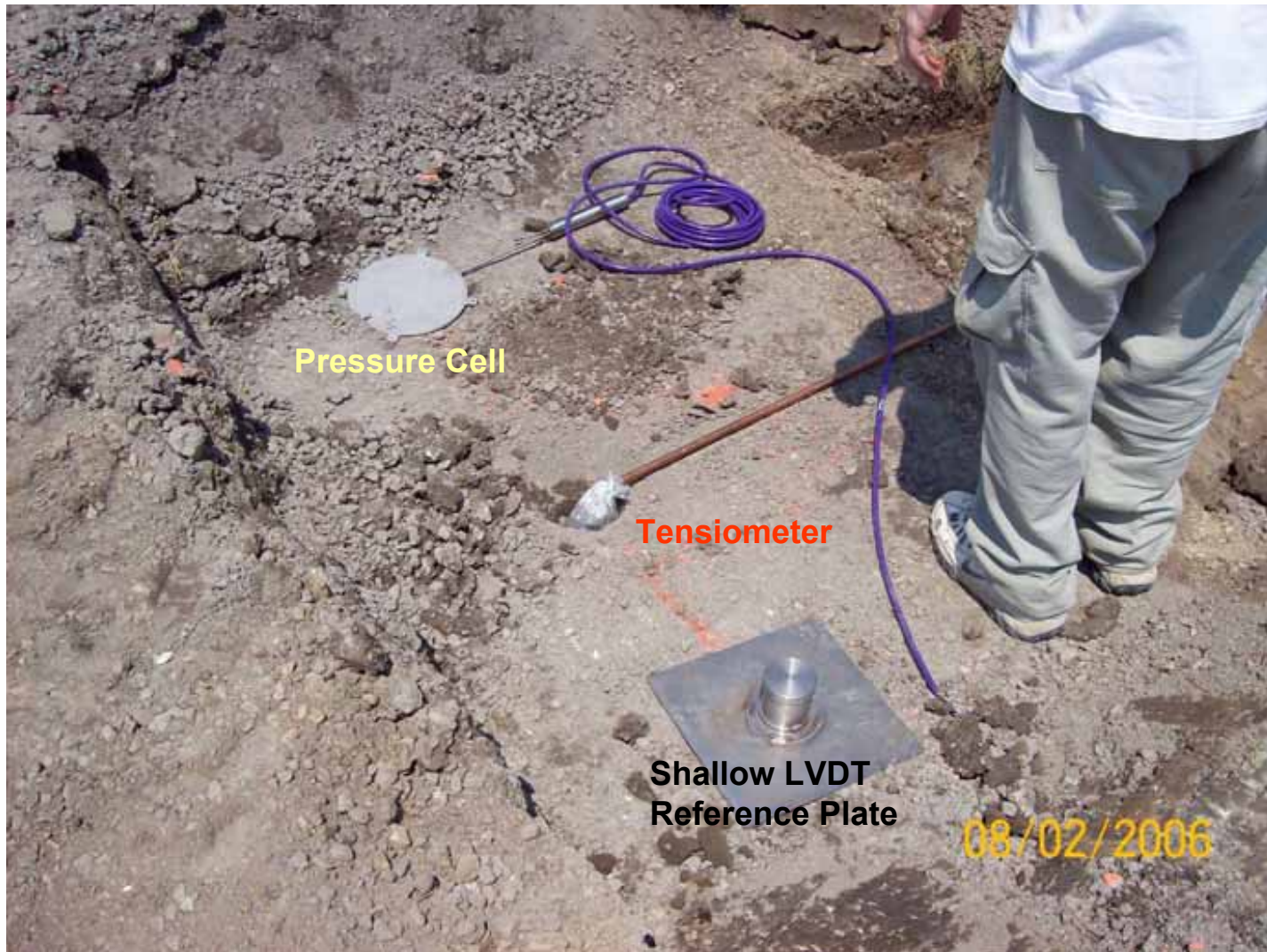
Pavement Instrumentation Plan



Not to scale



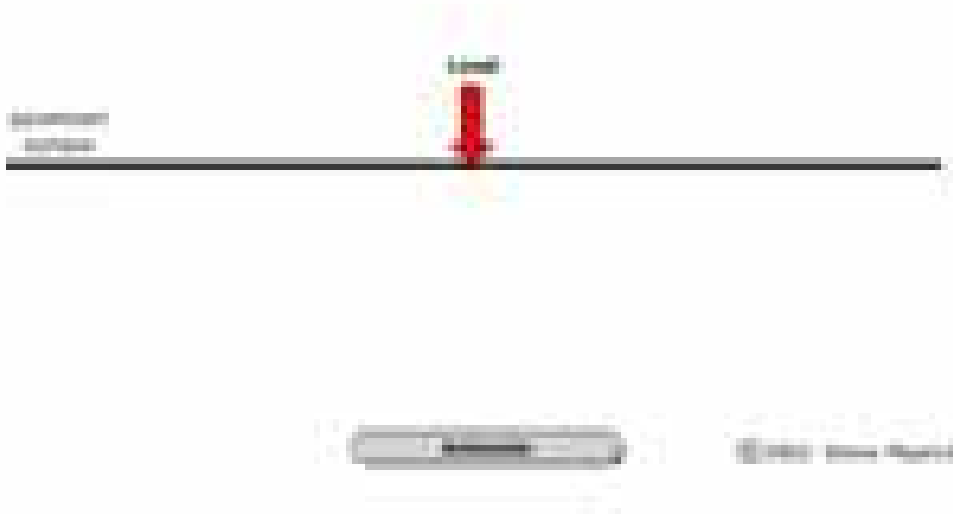
Pavement Instrumentation



Asphalt strain gauge



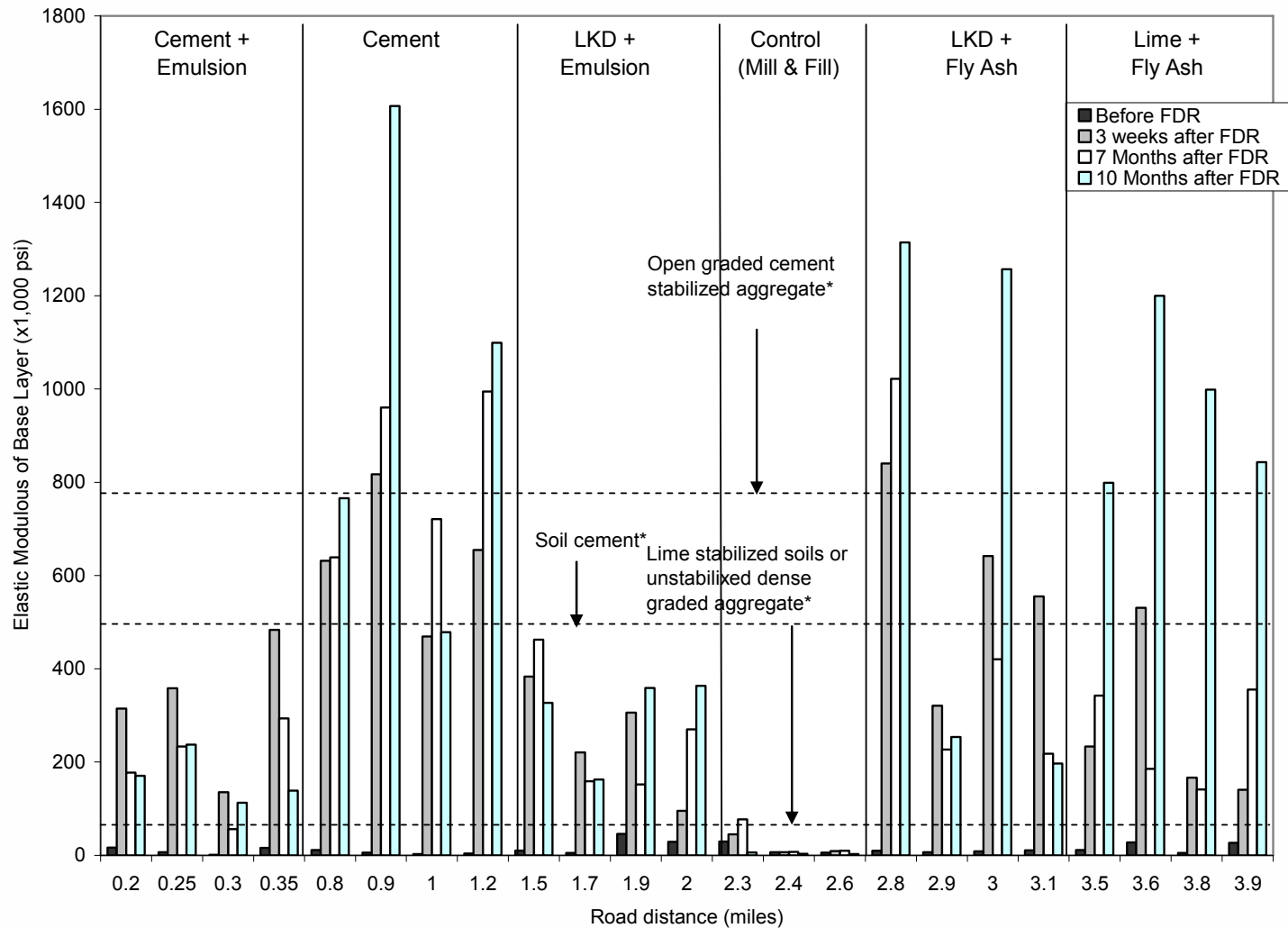
Falling Weight Deflectometer (FWD) Testing by Ohio DOT



Delaware site before FDR



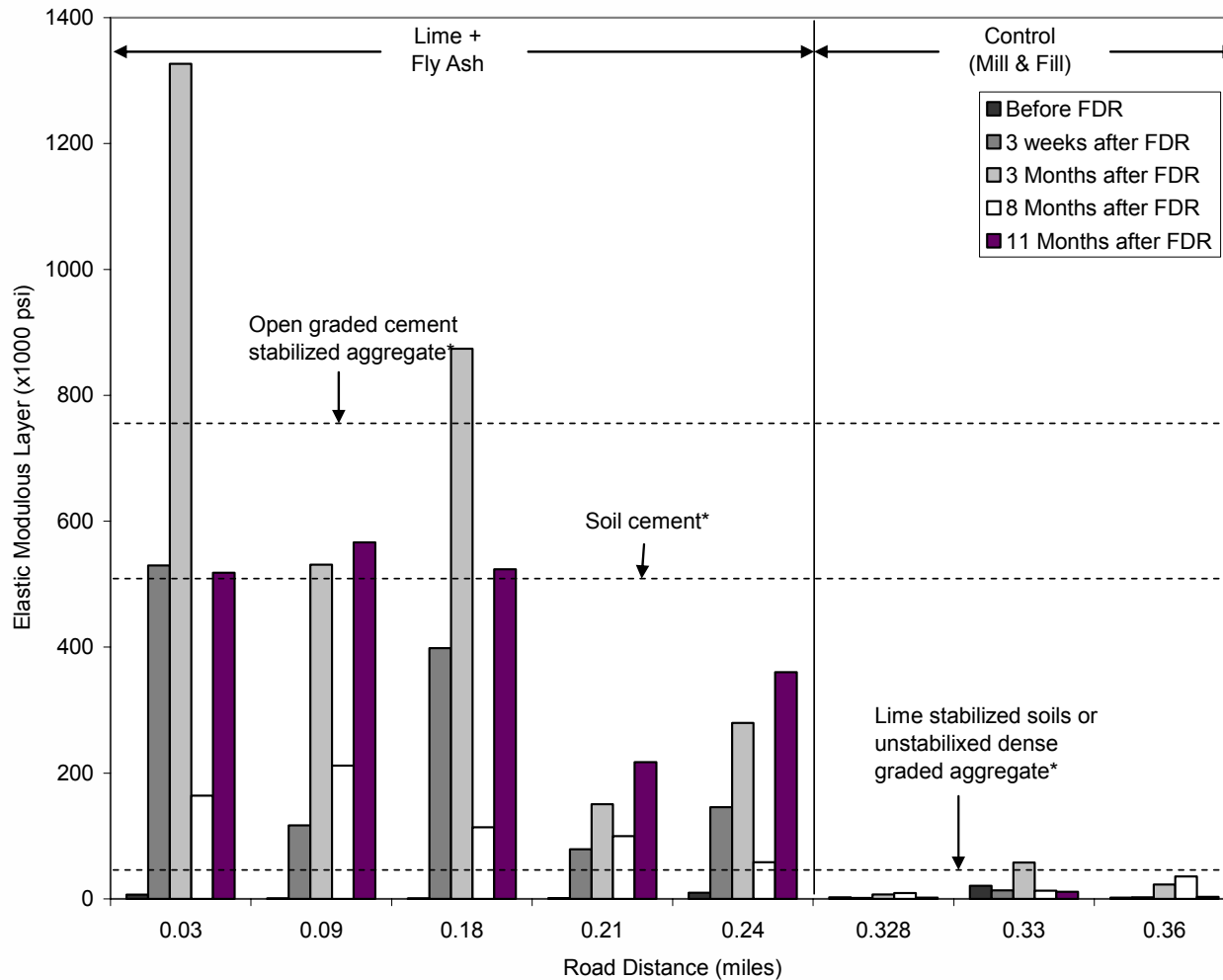
Backcalculated Moduli from FWD Testing (Delaware County)



* Typical Resilient Modulus values (Mechanistic Empirical Pavement Design Guide 2004, FHWA)



Backcalculated Moduli from FWD Testing (Warren County)



* Typical Resilient Modulus values (Mechanistic Empirical Pavement Design Guide 2004, FHWA)



2007 Zanesville Shoulder Reclamation: North Pointe Road (1,000 feet)

- Reclaimed 8 feet wide shoulder for 1,000 feet length using Asphalt Zipper reclaimer
- 5% LKD with 5% Fly Ash, 8 inch stabilization depth (1000 feet)
- Conditioned Fly Ash (m/c about 20%) – Glatfelter paper plant (Chillicothe)



2007 Zanesville Road Reclamation: Friendly Hills Road (2.2 miles)

Two sections were constructed (2007) using the following mixes:

- 5% LKD with 5% Conditioned Fly Ash (Conesville power plant), 8 inch stabilization depth (2.1 mile)
- 10% Fixated FGD material (Conesville power plant), 8 inch stabilization depth (0.1 mile)

Instrumented with pore pressure transducers just below FDR base. Chip and seal completed mid-September 2007



Fly Ash Section



Fixated FGD Section

Conclusions

- Pavement sections stabilized with fly ash (+LKD/lime) showed comparable stiffness and strength to the cement stabilized sections.
- The use of fly ash (with LKD or lime) as substitute for traditional cementitious additives in FDR can result in substantial cost savings as well as additional significant environmental benefits
- Fly ash can be easily mixed and compacted using standard FDR construction equipment
- Long-term testing data will be available from ongoing pavement performance and environmental condition data



Acknowledgements

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- **Headwater Resources**
- **Carmeuse NA**
- **Mintek Resources**
- **EDP Consultants**
- **Asphalt Recycling and Reclamation Association**
- **American Coal Ash Association**

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Case Study
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Rehabilitating Asphalt Highways:
Coal Fly Ash Used on Ohio Full Depth Reclamation Projects

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Rehabilitating Asphalt Highways: Coal Fly Ash Used on Ohio Full Depth Reclamation Projects

Much of the almost two million miles of asphalt roadways in the United States 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 Ohio State University (OSU) has partnered with the two fastest growing counties in Ohio (Delaware and Warren) to construct and monitor two pavement sections in which sections of failing asphalt pavements were recycled in 2006 using Ohio coal-generated Class F fly ash as a cementing agent.

"The value of this technology and demonstration project to the contractor is at a minimum two-fold," says Chris Anspengh, construction manager, Base Construction. "With the price of cementitious additives continuing to rise in price due to the substantial energy costs involved in producing them it would be of value to the contractor, from a competitive standpoint, to have alternative products available that will achieve the same end results.

"Secondly, the contractor needs testing data available that can be submitted to the owner to assure them that the product will perform as we are claiming," he continues. "This research will go a long way in providing that information." This project will demonstrate that when non-concrete quality fly ash in combination with lime or lime kiln dust are properly incorporated into FDR reconstruction of a flexible pavement, the use of fly ash can be economically attractive while offering increased structural and service performance, and should not lead to a degradation of environmental quality.

On this Full Depth Reclamation (FDR) research preservation project, the complete depth of the flexible pavement section consisting of the asphalt layer, 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 stabilized base. Class F fly ash in itself is not self-cementing. It needs additional lime to undergo a cementitious reaction. It's important to note that fly ash, when used in combination with lime or lime kiln dust, performs two important functions in FDR work:

1. 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.
2. 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.



Material before mixing (left) and after mixing (right). Note the fly ash on the left side.

- USEPA – C2P2 Case Study 16, Fall 2007