Chapter 7

Fly Ash Stabilized Cold In-Place Recycled Asphalt Pavements, Stabilized Soils, and Stabilized Coal Ash

Introduction

We Energies conducted studies in cooperation with Bloom Consultants, LLC and the Center for Highway and Traffic Engineering at Marquette University in Milwaukee, Wisconsin to evaluate the potential application of fly ash in asphalt pavement construction. In a typical cold in-place recycled (CIR) application, existing hot mix asphalt (HMA) layers are pulverized, graded, compacted and used as a base layer for a new hot mix asphalt surface. In most CIR applications, the existing HMA layers are pulverized to the full thickness, and in some cases through the top 2" or 3" or the entire depth of aggregate base. The CIR material is sprayed with water to get the desired moisture content. The material is graded and then compacted with vibrating steel drums and pneumatic tired rollers.

In recent years, stabilizers have been added into the CIR materials to improve the structural capacity of the CIR layers. In these studies self cementing Class C fly ash was used to bond with CIR materials and the long-term performance of the final pavement section is being studied.

In addition, Class C fly ash was used by We Energies to stabilize a coal ash land fill to construct a commercial office building parking lot.

Case Study I: Highland Avenue, Mequon

A 1.5 mile long section of West Highland Avenue, between Wauwatosa Avenue and Farmdale Road, was resurfaced in 1997. The existing pavement had a 5½" thick asphaltic surface with an aggregate base varying in thickness from 7" – 18". This stretch of road is a two-lane cross section with an average annual daily traffic (AADT) of 1150. The pavement was constructed over a natural cohesive soil subgrade material.

Through a 1.5 mile length of the pavement was resurfaced, two 800 ft. long test sections were stabilized with a fly ash binder and an asphalt emulsion binder respectively. The project was undertaken in August of 1997. The existing HMA surface was pulverized to a total depth of 8", then graded and compacted using standard procedures.

The 800 ft. asphalt emulsion stabilized test section was constructed by repulverizing the upper 4" of the CIR base, and incorporating emulsified asphalt at a rate of 1½ gallons per square yard. The base was then graded and compacted. The 800-ft. length of fly ash stabilized CIR section was constructed by applying 35 lbs./yd^2 of Pleasant Prairie ASTM C618, Class C fly ash over the pulverized CIR base and repulverizing the top 5" of CIR base. The pulverized layer was shaped with the grader and moistened with surface applied water, at the rate of 8 gal/yd^2. The stabilized base was graded and compacted similar to the other test section.

The asphalt emulsion stabilized test section received a 3½" HMA surface, and the fly ash stabilized test section received a 4" HMA surface. The remaining portion of the pavement received a 4" HMA surface without repulverization of the base. Due to the lack of established procedures and equipment to transfer fly ash from the supply tank to the spreader truck and in spreading fly ash, some delays and dusting problems occurred. This problem has now been solved by using a vein feeder spreader for the fly ash and by addition of water to the reclaimer mixing chamber.

Pavement Performance

Representative sections, 500 ft. each in length, were selected from the asphalt emulsion stabilized, fly ash stabilized and control sections. Visual inspections performed on these three sections do not show any surface distress (i.e., cracking, rutting or raveling). Nondestructive deflection testing using the Marquette Falling Weight Deflectometer (FWD) was conducted prior to the construction, after initial pulverization, after one year, and after six years of service to establish structural integrity of each test section. This data was used to back calculate in-situ subgrade resilient moduli and the structural number of the pavement (53).

The preconstruction and post pulverization structural number (SN) results (back calculated) indicate general between section uniformity of the upper pavement layers. The post construction testing and back calculation of SN shows that the fly ash stabilized section gave an 8.6% increase in SN (2.53 vs. 2.33) when compared to the control section. Also the fly ash stabilized section gave a 4.6% increase in SN (2.53 vs. 2.42) compared to the asphalt stabilized section, after making adjustments for the difference in thickness of the HMA surface.

Using the back-calculated SN values of the pavement sections, the structural coefficients of the stabilized and unstabilized CIR base material were calculated. The structural coefficient was found to be 0.11 for the untreated CIR base layer, 0.13 for the asphalt emulsion stabilized layer and 0.15 for the fly ash stabilized base layer.

Based on the 1993 edition of the AASHTO Guide for Design of Pavement, an estimate of the allowable number of 18,000 lb. equivalent single axle loads (ESALs) was determined. In this calculation a design reliability of 85%, an overall standard deviation of 0.35 and a design serviceability loss due to traffic of 2.0 were used. Figure 7-1 shows the allowable ESALs vs. SN (structural number) for the range of subgrade resilient moduli exhibited within the test sections. By holding the subgrade resilient modulus constant and adjusting the asphalt layer coefficient to 0.44, the structural numbers were recalculated. The revised values of SN are as follows:

Control section = 2.65

Emulsion stabilized section = 2.74

Fly ash stabilized section = 2.85

The allowable traffic estimate based on the revised SN provided a more meaningful comparison. Based on the revised SN, the fly ash test section provided a 58% increase in the allowable traffic compared to the control section and a 28% increase in the allowable traffic compared to the asphalt emulsion test section. Long term testing of the pavement is required to understand its behavior. However from the studies completed to date, the fly ash stabilized CIR appears to have good potential.

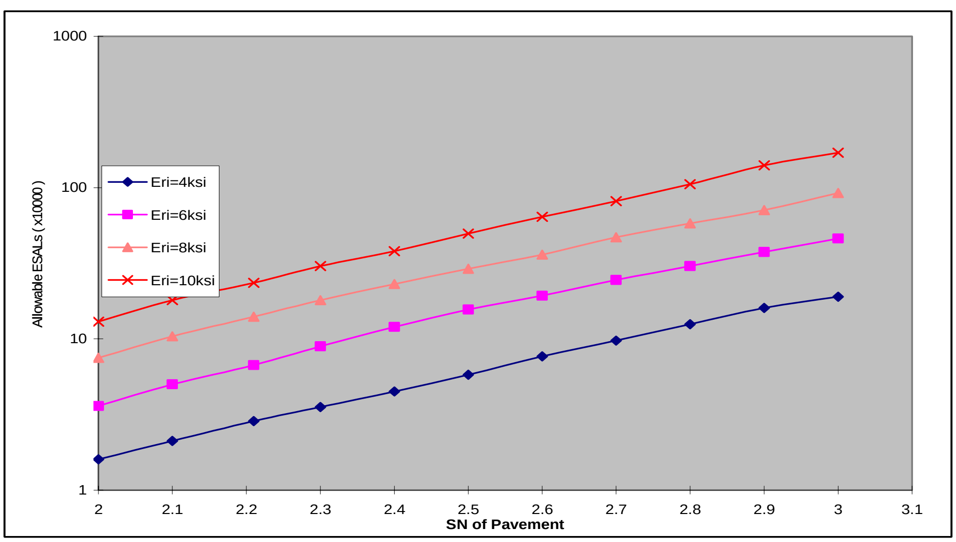

Figure 7-1: Allowable Traffic Estimates

Figure 7-2: Fly ash being placed uniformly on the pulverized pavement.

Figure 7-3: Pavement being repulverized after fly ash application.

Falling Weight Deflectometer tests were conducted again in October 2003, approximately six years after construction, within the control section, the emulsion stabilized section, and the fly ash stabilized section. Surface deflections were used to backcalculate subgrade and pavement parameters including the flexural rigidity of the upper pavement layers and the effective structural number of the pavement (54).

Figure 7-4 provides a summary of the backcalculated effective structural number (Sneff.) As shown, the Sneff of the fly ash stabilized section is greater than comparable control or emulsion stabilized sections with the exception of the westbound emulsion stabilized section with a stronger subgrade.

In general, after six years of service the structural integrity of fly ash stabilized section of Highland Road appears to be equal or better than both the control and emulsion stabilized sections. From a condition standpoint, all sections are performing well with no observed surface cracking.

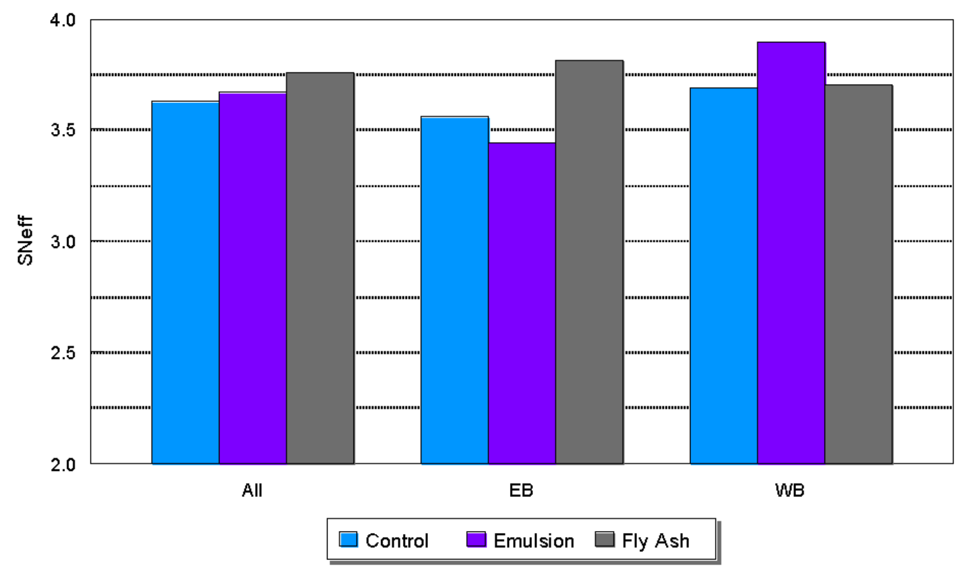

Figure 7-4: Comparison of Effective Structural Numbers (Sneff.) (54)

Case Study II: CTH JK, Waukesha

County Trunk Highway JK is located in Waukesha County, Wisconsin and the project segment runs between County Trunk Highway KF and County Trunk Highway K, with a project length of 3,310 ft. It is a two-lane road with an average daily traffic (ADT) count of 5,050 vehicles in year 2000 and a projected ADT of 8,080 in design year 2021. The existing pavement structure consisted of approximately a 5" asphalt concrete surface layer and a 7" granular base course.

The project scope included construction of a reinforced concrete pipe culvert. The contractor completed this task prior to starting the paving. The base course of the pavement section at the culvert for a length of approximately 50 feet was constructed using crushed aggregate, instead of fly ash stabilized CIR materials. Prior to construction of the road, undercutting was performed at places where severe pavement distresses existed. The pavement was excavated to a depth of 2 feet underneath the existing base course and was filled with breaker run stone. Initial pulverization started on October 9, 2001. The existing HMA pavement was first pulverized to a depth of 5”. After spraying water on the surface of pulverized materials, the pavement was repulverized to a depth of 12” and was graded and compacted by a Sheep’s Foot Roller.

Fly ash was placed on October 11, 2001. Fly ash was transferred from the supply tanker to the vein feeder spreader truck through a hose, which significantly reduced dusting. The vein feeder spreader truck applied the fly ash at an application rate of 8% by weight. The feed gates from the spreader truck provided a six ft. wide surface application. Water was sprayed to obtain the water content of the stabilized CIR materials to the desired 5.0% moisture content. The fly ash and moisture content was controlled by an operator, based on field experience. The mixing operation commenced immediately after distribution of fly ash over a length of approximately 100 feet and was completed within one hour, using the pulverizer. Compaction of the mixture began immediately after mixing and was completed within one hour following spreading of fly ash. The compaction of the base course included 6 passes of the Sheep’s Foot Roller followed by 2 passes of the Vibratory Drum Compactor.

A laboratory mix analysis to evaluate the stabilization potential of recycled pavement material with Class C fly ash was conducted. A field sample of existing asphalt pavement and underlying aggregate bases was obtained from CTH JK. The results of the grain size analysis on the CIR material indicated a sand and gravel mixture with trace fines. The analysis showed that the sample contained 68% gravel (larger than #4 sieve), 26% sand (between #4 and #200 sieves) and 6% silt (between #200 sieve and size of 0.005 mm) and clay (between 0.005 and 0.001 mm) size particles. Evaluation of fly ash stabilized CIR material was performed at two fly ash contents, 6% and 8% by dry weight of total mix. Laboratory analysis of the fly ash stabilized materials was in accordance with ASTM C593, where the Moisture-Density (ASTM D1557) and Moisture-Strength (ASTM D1633) relationship of specimens compacted in a 4” diameter mold was obtained. Results of the moisture density relationship test on the recycled asphalt pavement indicated a maximum dry density of 141.7 pcf at an optimum moisture level of 5.0%. In addition, moisture density relationship tests on the recycled asphalt pavement material with 6%and 8% fly ash added indicated a maximum dry density of 142.3 and 142.9 pcf at optimum moisture contents of 5.5%, respectively. A maximum unconfined compressive strength of 1250 psi and 380 psi at optimum moisture contents of 5% were also obtained after seven day curing, respectively.

Pavement Performance

Pavement performance of CTH JK was evaluated using the FWD test in October 2001, 2002, and 2003. The results of the testing indicate that the strength of fly ash stabilized CIR recycled asphalt base course developed significantly and the modulus increased from 179.7 ksi in 2001, to 267.91 ksi in 2002, and to 328.82 ksi in 2003. The layer coefficient of fly ash stabilized CIR recycled asphalt base course was 0.23 at time of FWD testing in 2002 and 0.245 in 2003, compared to 0.16 in 2001. No cracking and rutting was identified in the pavement distress survey. Compared to the pavement of CTH VV with untreated CIR recycled asphalt base course, the structural capacity of fly ash stabilized CIR recycled asphalt base course in CTH JK, with a layer coefficient of 0.245, is appreciably higher than that of untreated CIR recycled asphalt base course, with a layer coefficient of 0.13 (55). Figure 7-5 shows the structural number of CTH JK pavement since the construction.

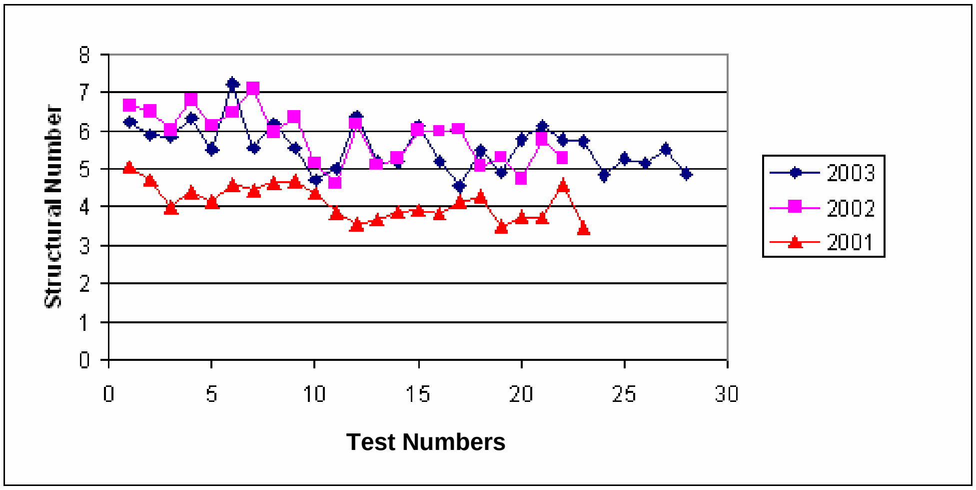

Figure 7-5: Structural Numbers of Pavement in CTH JK

Case Study III: Commercial Office Building Parking Lot

The surface parking lot is located at 3600 S. Lake Drive, St. Francis, Wisconsin. The lot area contained a capped coal ash fill. The coal ash was placed there more than 30 years ago by We Energies. The Class F fly ash and bottom ash were byproducts from the former Lakeside Power Plant operation. Due to the large quantity of coal ash, the cost and time to remove and transport the coal ash is prohibitive. Therefore, it was decided to build the parking lot on the existing coal ash fill. Because the coal ash fill did not contain any Class C fly ash, the coal ash was graded and stabilized with Class C fly ash to a depth of 12". Upon compaction, a 5" asphalt pavement was placed directly on top of the compacted self-cementing fly ash mixture, without the need to use crushed aggregate base course. For the parking lot ramp, a 12" Class C fly ash stabilized sandy clay was used as subbase directly underneath the asphalt pavement. The construction was done in August 2002.

A significant cost savings of approximately $400,000 was achieved by avoiding the costs associated with removal and hauling of the existing coal ash off site and the need to import crushed aggregate for base course. The life expectancy of the parking lot using the Class C fly ash stabilization is expected to be equal to or better than the standard practice of using a crushed aggregate base course material. The performance of the parking lot is monitored annually using a FWD. Figure 7-6 shows parking lot.

Figure 7-6: Commercial Office Building Parking Lot