TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 7-2966-S

Project 7-2966: Durability of Surface Treatments as the Wearing Course Placed on Crushed Fly Ash and Long-Term Performance of Crushed Fly Ash for Flexible Base

Author: Cindy K. Estakhri

PROJECT SUMMARY REPORT

Performance of Fly Ash as a Base Material on Six Test Pavements in the Atlanta District

The Atlanta District first began evaluating crushed fly ash, or hydrated fly ash, as a base material in 1990. Hydrated fly ash is produced by allowing a Class C powder fly ash (ASTM C 618) from coal-fired power plants to cure with moisture. The hydrated (cured) fly ash becomes a stiff material that can be crushed to form a synthetic aggregate. When properly processed and compacted to optimum moisture content, the hydrated fly ash continues to gain strength after placement as a base material.

Based on early promising test results from the district's laboratory investigation and from the successful construction of a test section on the power plant haul road, six test pavements were constructed throughout the district:

- Loop 390,
- IH 20 (FR),
- SH 154,
- FM 1326,
- FM 1520, and
- FM 560.

While district personnel were pleased with early performance characteristics of the test sections, long-term performance was in question. In addition, some problems occurred on some of the pavements soon after placement of a surface treatment whereby the surface treatment delaminated from the underlying fly-ash base material.

The objectives of this research were to: (1) evaluate and monitor the performance and changes in material properties for these six pavements over a five-year period (1997 through 2001) and (2) perform a laboratory investigation into the cause and cure for the failure of surface treatments on the hydrated fly-ash base courses.

What We Did . . .

Descriptions of the problems encountered when asphalt surface treatments were placed on crushed hydrated fly-ash bases indicated the potential for at least two types of failure mechanisms: type of prime material used and extent of base curing. It was thought

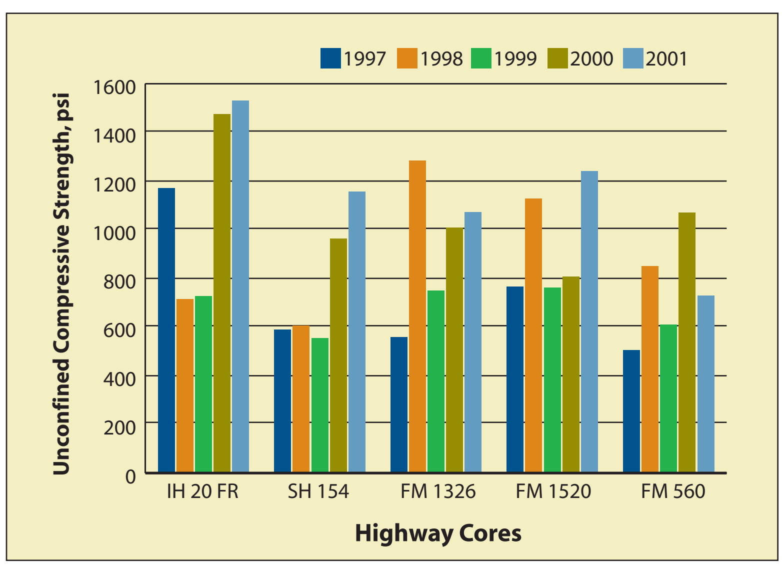

Figure 1. Compressive Strength of Highway Cores.

that either or both of these mechanisms could have had detrimental effects on the interface bond between the base and the surface treatment. Researchers designed a laboratory experiment to evaluate two variables: (1) prime materials and (2) curing conditions.

Researchers performed a laboratory experiment to evaluate different priming materials:

- no prime,
- MC-30,
- SS-1,
- CRS-2,
- HFRS-2p, and
- EPR-1.

Three types of curing conditions were simulated in the laboratory (all curing took place at 104°F):

- *Curing Condition 1* was an attempt to simulate field practice. The base samples were cured for 24 hours after the base was compacted. The primed base was cured an additional 24 hours prior to application of the surface treatment and then tested the following day.
- *Curing Condition 2* was the same as the first condition except that the base was cured for 72 hours prior to applying the prime (to allow a chance for some of the moisture to escape).
- *Curing Condition 3* was the same as the first condition except that the primed base was allowed to cure for 72 hours prior to application of the surface treatment.

The test procedure that was chosen to evaluate the bond strength between the prime material and the hydrated fly-ash base was a torsional shear test. This test was used to quantify interfacial strength at the prime coat interface.

It was also postulated that perhaps traffic on the seal might cause damage at the interface of the seal and the base. Texas Transportation Institute (TTI) researchers used the South African durability test to simulate traffic. For this test, the fly-ash base was compacted into a beam mold and cured for seven days at 160°F. The beam was then cut to a height of 2.0 inches, and the surfaces of the specimens were treated with the different prime materials, cured for 24 hours at 104°F, and topped with the Grade 4 surface treatment. The molded beam was then placed in the water bath of the erosion testing device. It was allowed to soak for 1.5 hours and then subjected to 5000 wheel load repetitions.

Evaluation of the field performance of the base materials was based on the following types of data which were collected annually by district personnel and researchers:

- visual evaluations of surface distress,
- nondestructive field testing (falling weight deflectometer), and
- compressive strength of field cores.

What We Found . . .

In the laboratory study of the bond between the base and surface treatment, the torsional shear test did not show any differences between the different prime materials used or the different curing conditions. A visual evaluation was done on samples for each prime material and curing condition, and there appeared to be a very good bond of the surface treatment to the base in all cases. The South African durability test, in which the samples were subjected to a water bath and trafficked under a loaded wheel for 5000 repetitions, revealed that all of the samples (produced with different prime materials) performed very well, and the bond strength of the surface treatment to the base material seemed to be very good. Curing condition was not a variable in this part of the experiment.

Based on laboratory activities, no confident solution can be provided to the problem experienced in the field regarding the surface treatment not bonding to the base material. Even though *curing time* of the base was a variable in the torsional shear test experiment, it may be that even the lowest level of curing in the laboratory was more than what was experienced in the field prior to construction of the surface treatment and application of traffic. Researchers believe that the curing time of the base prior to application of the surface treatment may be the key to achieving a good bond.

Findings of the field performance evaluations are as follows:

- All of the hydrated fly-ash test pavements have performed well throughout this research project. Cracking distress has been exhibited in four of the six test pavements; however, it is apparent to a significant degree in only two pavements: FM 1326 and IH 20. This significant amount of cracking has occurred in the final year of the study. For all of the pavements except FM 1326, the distress is generally in isolated areas, and the distress is not affecting the serviceability of the roadway.
- There has been little change observed in the performance of the six pavements since 1997. Four of the six hydrated fly-ash test pavements have exhibited distress that might

be attributable to deficiencies in the fly-ash base material. In 1997 Loop 390 exhibited a small amount of alligator cracking in an area where the falling weight deflectometer (FWD) data indicated the base was weak. However, by 1998 the surface had a new seal coat, and no further cracking distress has been evident. Loop 390 also previously exhibited some rutting, but it appeared that this rutting may have been within the hot-mix asphalt concrete layer. SH 154 has exhibited transverse cracking (which appears to be from shrinkage of the base), and the FWD data indicate this pavement is very stiff. This pavement was chip-sealed in 1999, and no distress is currently exhibited on the surface. IH 20 is beginning to exhibit some alligator cracking, which could be attributed to the base. In 2001, FM 1326 began to exhibit a significant degree of transverse cracking which would be attributable to the base.

- Year 2001 FWD data were compared to those taken in 2000, 1999, 1998, and 1997. Moduli of the fly-ash base materials were back-calculated from the FWD data. There is no indication of any significant weakening of these base materials with time. In the past year, there appears to be some weakening exhibited in FM 560 and FM 1520.
- Cores were taken on all of the test pavements except Loop 390. No intact core could be obtained from Loop 390 throughout the five years of this project. Compressive strengths for the cores from the other five test pavements were comparable to or greater than the strengths observed in the year 2000 and previous years as shown in Figure 1.
- The six test pavements evaluated in this project range in age from six to eight years. Based on visual evaluations, FWD data, and compressive strengths of cores, the hydrated fly-ash test pavements have performed well with only one pavement exhibiting a significant amount of distress, and that was in its eighth year of service.

The Researchers Recommend . . .

Based on five years of monitoring for these fly-ash test pavements, performance results are very promising. Pavement base materials have not exhibited any significant deterioration over the period. Researchers, therefore, can recommend use of such material in the applications and highway types used in the Atlanta District. Concern is warranted regarding fly ash material variability as exhibited in moduli values from FWD data; however, this variability has not adversely affected performance thus far. Methods used to *hydrate* the fly ash do not necessarily produce a consistent material.

Another concern regarding the use of this type of fly ash is that fly ash produced from one plant is not the same as that produced at another. The type of fly ash used for this project is known as a Class C fly ash. A fluidized bed ash should not be used in paving applications.

Inadequate bond of surface treatments to fly-ash base materials does not appear to be related to the type of prime material used. Researchers believe that the bonding problem is related to the curing extent of the base material. The fly-ash base develops strength with time, and care should be taken to ensure that adequate curing occurs prior to application of the surface treatment (especially on higher-traffic roadways). Once the base has been compacted at optimum moisture content, any additional water sprayed on the surface for finishing could weaken the base near the surface. If it is necessary to spray additional water on the surface for finishing, care should be taken not to trap any water (by an asphalt membrane) in excess of that needed for hydration.

For a better surface treatment bond to the base, researchers recommend the following modification to *Special Specification No. 2011 — Fly Ash Base*.

Article (7) *Curing* on page 3–4 shall be deleted as stated below:

(7) Curing. ~~*Immediately after the fly ash base has been brought to line and grade, an asphaltic membrane shall be placed on the fly ash base to prevent evaporation of water and provide curing. The asphalt used for curing shall be of the type and grade shown on the plans or as approved by the Engineer and shall be applied at the rate of approximately 0.1 gallons per square yard unless the plans require otherwise.*~~

~~*If there is a time delay prior to application of the asphalt membrane which is sufficient to cause surface drying, the Engineer may require the surface to be moistened.*~~

Article (7) should be replaced with the following:

Prior to placing the surfacing on the completed base, the base shall be cured to the extent as directed by the Engineer.

For More Details . . .

The research is documented in:

Report 2966-1, *Field Performance Evaluation of Hydrated, Fly Ash Bases in the Atlanta District — Year 1*
Report 2966-2, *Fly-Ash Bases in the Atlanta District: Evaluation of Surface Treatment Bond and Year-Two Field Performance Evaluations*
Report 2966-3, *Field Performance Evaluation of Hydrated, Fly Ash Bases in the Atlanta District — Year 3*
Report 2966-4, *Field Performance Evaluation of Hydrated, Fly Ash Bases in the Atlanta District — Year 4*
Report 2966-5, *Field Performance Evaluation of Hydrated, Fly-Ash Bases in the Atlanta District — Year 5*

Research Supervisor: Cindy K. Estakhri, P.E., TTI, c-estakhri@tamu.edu, (979) 845-9551

TxDOT Project Director: Miles Garrison, ATL, mgarr@dot.state.tx.us, (903) 799-1330

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TxDOT Implementation Status—April 2004

The changes to Special Specification No. 2011 recommended by this project have been implemented. At this time, we do not envision further implementation efforts.

For more information, contact Dr. German Claros, P.E., Research and Technology Implementation Office, at (512) 465-7403 or e-mail gclaros@dot.state.tx.us.

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Texas Transportation Institute/TTI Communications
The Texas A&M University System
3135 TAMU
College Station, TX 77843-3135