



Project Summary Report 7-4920-S
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Project 7-4920: Improving Long-Term
Flexible Pavement Performance

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Improving Long-Term Performance of Cement-Treated Aggregate Base Materials

Recent research projects at the Texas Transportation Institute (TTI) have focused on methods of improving the long-term performance of cement-treated bases. These methods primarily address proper selection of optimum cement contents through laboratory testing and innovative construction techniques in the field.

Most problems with cement-stabilized base layers in pavements stem from the fact that current design practices are based only on strength, without consideration of long-term durability or performance. For example, many state departments of transportation require sufficient cement to achieve a minimum unconfined compressive strength as high as 750 psi after seven days. While this level of cement results in a very stiff aggregate layer

characterized by a high resilient modulus, it does not necessarily guarantee acceptable long-term pavement performance.

In many roadways, for instance, shrinkage cracks within heavily cement-stabilized base layers reflect into the surface treatments and appear as transverse cracks spaced between 3 ft and 60 ft, as shown in [Figure 1](#). Although the cracks themselves may not present a structural problem, they often accelerate deterioration of the pavement by allowing water to enter lower pavement layers. Several documented cases demonstrate the ability of moisture to disintegrate underlying base materials, causing a reduction in pavement support and a corresponding increase in pavement roughness that often leads to unacceptable ride quality.

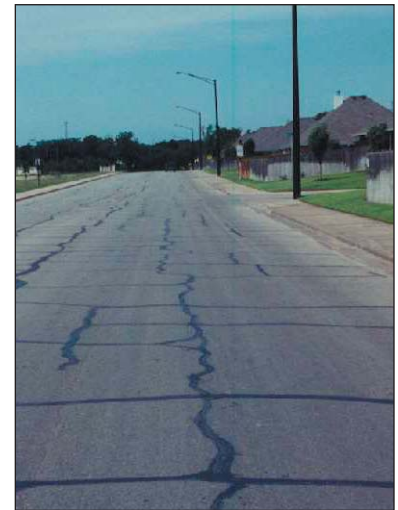


Figure 1. Cracking from Shrinkage of Cement-Stabilized Base Layer.

While the use of excessive cement frequently results in very stiff bases that shrink and crack, insufficient amounts of stabilizer may not provide adequate durability under imposed traffic loads and environmental conditions. Effectively balancing strength and durability requirements is necessary in a successful mixture design, and construction techniques that minimize the effects of



shrinkage cracking should be utilized.

What We Did...

Researchers performed a literature review to document the development of current specifications for selecting cement contents for stabilizing aggregate base materials. They also investigated the availability of additional tests for assessing other properties of cement-stabilized aggregates that could be used to more accurately predict field performance and more appropriately select optimum cement contents. Construction methods for mitigating shrinkage cracking were also identified in the literature search.

Based on this review, researchers designed a laboratory test sequence to evaluate the consequences of reduced cement contents on the performance of two aggregates, limestone and recycled concrete, typically used in the Texas Department of Transportation (TxDOT) Houston District. Researchers determined the mineralogy of each material, and the performance of the aggregates in their untreated conditions was documented to study the impacts of three levels of cement stabilization. Samples treated with 1.5, 3.0, and 4.5 percent Portland Type I

cement were tested for strength, shrinkage, durability, moisture susceptibility, and stiffness characteristics in the laboratory. Test results were then compared to specifications proposed for each test.

The research team measured strength with the Soil Cement Compressive Strength Test (TxDOT Test Method Tex-120-E) and developed a linear shrinkage test to assess shrinkage properties. Durability was evaluated using the South African Wheel Tracker Erosion Test (SAWTET), and moisture susceptibility was assessed with the Tube Suction Test (TST). Modulus values for the limestone were obtained through the Standard Method of Test for Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials (AASHTO T292-91) and the free-free resonant column method developed at The University of Texas at El Paso.

Based on recent experience with new construction of cement-treated base layers in a residential subdivision in College Station, Texas, TTI also developed a pre-cracking procedure that is recommended for further evaluation. The procedure is based on limited data obtained during experimental construction of base layers treated with

6 to 8 percent cement. Construction occurred in the fall with an air temperature ranging between 75°F and 80°F.

What We Found...

Both the limestone and recycled concrete aggregates were comprised of some percentage of smectite which, even in small quantities, can negatively impact the overall behavior of these materials. Preliminary strength and moisture susceptibility testing of the aggregates in their untreated conditions yielded poor performance, requiring stabilization of the aggregates to achieve acceptable properties necessary for use as base materials.

The results of the laboratory tests indicate that the limestone and recycled concrete aggregates yielded acceptable performance with additions of 3.0 percent and 1.5 percent cement, respectively. At these levels, samples of both aggregate types exhibited improved strength, adequate durability, and markedly reduced moisture susceptibility. However, specifications for maximum allowable shrinkage were generally exceeded for both aggregates. Also, instrumentation and measurement difficulties and possible variations in material constituents produced relatively



high variability in results obtained in the shrinkage and durability tests.

Modulus values obtained with the Standard Method of Test for Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials were adversely influenced by end effects. The seismic method was used to measure Young's modulus and the shear modulus of elasticity for the limestone samples. The implications of these parameters on materials quality and expected pavement performance are under ongoing investigation at The University of Texas at El Paso.

From the construction viewpoint, effective retention of moisture in cement-treated materials is especially important for promoting cement hydration and corresponding strength gain while reducing shrinkage. Some researchers suggest that the impacts of drying shrinkage can be combated by application of a curing emulsion immediately after construction of the cement-treated base layer and by delaying placement of the surface for as long as practical afterwards.

Additional efforts to further delay appearance of shrinkage cracks at the surface are manifest

in design of the "upside-down" pavement section. An untreated granular layer between the cement-treated base and the surface layer is added to disrupt crack growth into the surface. Saw-cutting has also been used to control the occurrence of cracks. In addition, pre-cracking of cement-treated materials within one to three days after placement has been utilized in construction activities, where heavy traffic or vibratory rollers can be used to create networks of microcracks within the base layer that eliminate the development of larger shrinkage cracks.

The Researchers Recommend...

Cement contents of 3.0 percent and 1.5 percent should be used for the limestone and recycled concrete aggregates, respectively, presuming that variances in mineralogy, gradations, or other important physical or chemical properties are not significant between samples tested in this project and aggregates proposed for use in actual highway construction.

For future testing of aggregate base materials to determine optimum cement

contents, the joint utilization of the Soil Cement Compressive Strength Test and the TST is recommended. Sufficient quantities of cement should be added to tested samples to obtain minimum unconfined compressive strengths of 300 psi in the former and maximum average surface dielectric values of 10 in the latter. The minimum amount of cement necessary to satisfy both criteria should be recommended for pavement construction.

Further development and evaluation of the linear shrinkage test and the SAWTET used in this project are necessary before their use can be recommended.

In the field, pre-cracking is a viable method for reducing reflection cracking through surface layers placed over cement-treated bases. The provisional specification provided in Report 7-4920-2 is recommended for further evaluation. Additional research is needed to evaluate possible adjustments to this specification necessitated by different layer thicknesses, lower unconfined compressive strengths, or construction during seasons substantially colder or warmer than conditions present in this project.



For More Details...

This research project is documented in [Report 7-4920-2, *Selecting Optimum Cement Contents for Stabilizing Aggregate Base Materials*](#).

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TxDOT Implementation Status—January 2005

Some of the recommendations from this research are being implemented by the Houston District. A formal implementation project is not envisioned at this time.

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Disclaimer

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