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Project Summary Report 0-4358-S
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Project 0-4358: Materials, Specifications and Construction Techniques for High Performance Flexible Bases

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PROJECT SUMMARY REPORT

High-Performance Flexible Bases

Traditional Texas flexible bases, specified under Item 247, perform very well as long as they are kept dry. However, in documented forensic studies rapid and sudden failures have occurred when water enters these moisture-susceptible bases. As part of Project 0-4358, forensic investigations identified the cause of premature failure on two flexible pavement failures. In both cases water penetrated the base layer, and, as shown in Figure 1, the failures were rapid and severe.

Project 0-4358 evaluated the concept of non–moisture-susceptible high-performance bases. High-performance bases require tight control on the type and amount of fine material and the use of higher-strength rock. Bases with high fines contents can act like a sponge and soak up available moisture resulting in a loss of strength. A literature search found that of the states represented by the 12 agencies surveyed, Texas was the only state that does not regulate the amount of fines (minus #200 sieve) in its bases. One finding of this project indicated that fines contents of 5 to 10 percent appear to be optimum for typical Texas material, whereas it is not uncommon to find current bases with more than 20 percent fines.

Figure 1. Premature Failure of a Pavement Attributed to Moisture-Susceptible Base.

What We Did…

Texas Transportation Institute (TTI) researchers conducted laboratory and field studies on high-performance base materials. Figure 2 shows several of the bases used in this project.

The current Texas bases are shown on the left, and the high-performance (low-fines) bases are shown on the right. The fines in the Texas bases are often brought to the surface during the watering and compaction process, and this can lead to potential bonding problems with the surface layer. However, the current bases are relatively easy to compact, and they provide a smooth finish. This is important because in many areas the final surface is a surface treatment. In contrast, high-performance bases are more open and have a coarser surface finish. High-performance bases will not draw water by capillary action, and they are free-draining;

consequently, they are classified as non–moisture susceptible.

Laboratory investigations measured the physical properties and mineralogical composition of the bases shown in Figure 2. High-performance bases were incorporated into three Texas Department of Transportation (TxDOT) construction projects, and the construction sequence and initial performance data were monitored. Two new tests were evaluated during Project 0-4358. The tube suction test was proposed to measure the moisture susceptibility of granular base materials, and the free-free resonant column was proposed as a stiffness measuring test. Both of these tests have recently been incorporated in TxDOT standards (Tex Methods 144-E and 149-E).

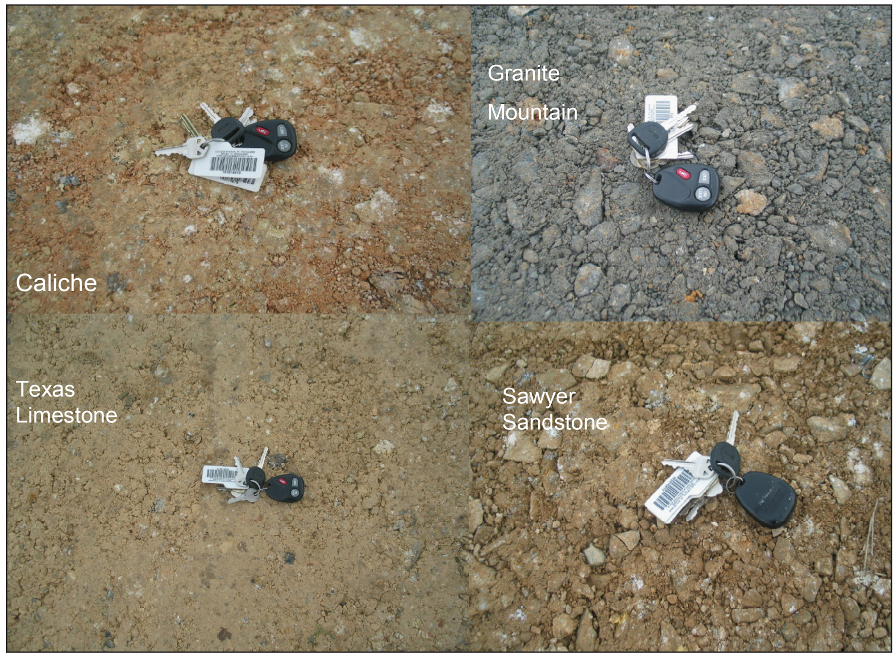

Figure 2. Visual Appearance of Existing (Left) and Proposed (Right) High-Performance Bases.

What We Found…

The source of the moisture susceptibility of the existing bases was found to be explained by the fine clay content of the base. In Project 0-4358 a comprehensive procedure was developed to identify the mineralogical composition of base materials. For the caliche material it was found that 2.3 percent of the base material was fine clay with the predominant component being smectite, which is a highly expansive clay mineral. In comparison, the Granite Mountain material has less than 0.06 percent clay.

Three TxDOT pavements containing bases that met the high-performance base specifications were monitored in this project. The long-term benefits of these low-fines bases could not be demonstrated in this short project since all the sections are new and performing well. However, as shown in Figure 3, the oldest section on FM 1810 in the Fort Worth District has higher long-term modulus than the control Item 247 base section.

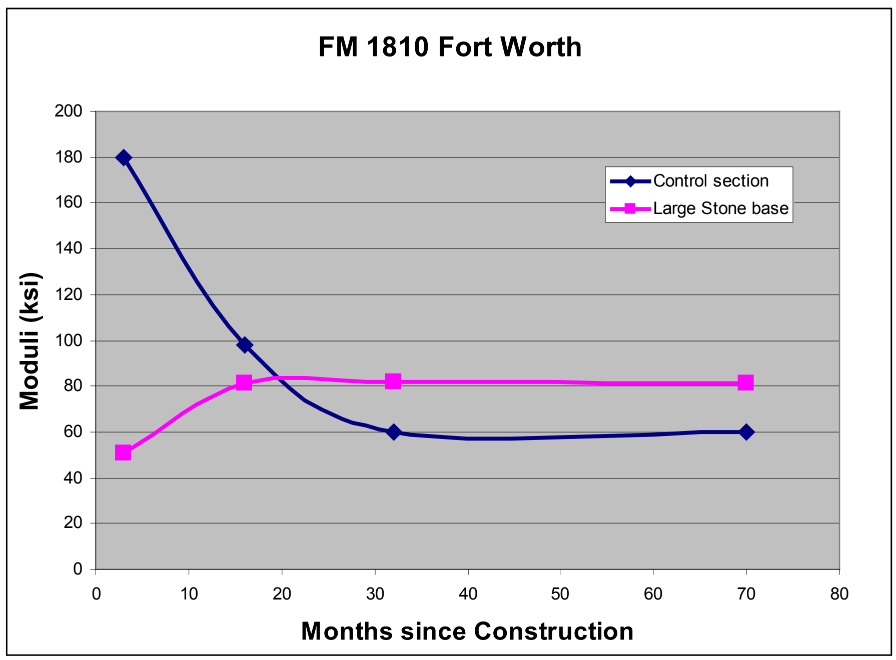

Figure 3. Backcalculated Moduli Values for the Low-Fines Base Experimental Sections.

The use of low-fines bases will require modifications to the laboratory testing, design, and construction specifications. New methods of compacting and handling the low-fines bases were evaluated in this project. From limited results it appears that moving from the drop hammer to a vibratory compactor system would produce bases that more closely simulate field compaction. A prototype vibrator compactor was built and tested in this project.

During field compaction, problems were reported with meeting density requirements for the high-performance material. In several cases the contractors were required to bring in larger vibratory rollers to achieve adequate compaction. However, issues were also raised about measuring density with the standard nuclear density gauge. In some cases it was found that driving the access rod in the nuclear gauge test disturbed the base excessively prior to taking the measurement. By comparison, the sand cone test provided densities on average 3 lb/cu ft higher than the nuclear test.

In the design area, since the new bases are more permeable, consideration should be given to avoid trapping moisture in them during construction. This consideration includes providing free lateral drainage on the shoulders and also ensuring that the sub-base layer is either non–moisture susceptible or sealed. It was found that the low-fines bases are more prone to segregation than traditional Texas bases. Base pavers similar to the one shown in Figure 4 are recommended to minimize segregation.

The Researchers Recommend…

The researchers conclude that TxDOT should continue to construct demonstration projects with high-performance bases, especially in east Texas. The long-term performance and cost/benefit effectiveness of using these bases should continue to be monitored. However, the full benefits of these bases will be realized only when moisture enters the layer (primarily through surface cracks), and this may take several years to document.

Appendix B of Report 0-4358-4 provides a draft construction specification for consideration for inclusion in future projects. An important part of that specification is the material requirements, the recommended values for which are shown in Table 1.

The new draft specifications also propose modified placement and quality control testing procedures, including the use of a pugmill and a base paver.

Figure 4. Base Paver Operation.

Table 1. Laboratory Test Results from Arkansas Granite SH 31.

Property	Test Method	Criteria Item 247	Granite Mountain
Master Gradation (% Retained)			
1 ¾ in.	Tex-110-E	0	0
1 ½ in.		0–15	
7/8 in.		10–35	10.7
3/8 in.		30–50	37.4
No. 4		45–65	54.3
No. 40		70–85	81.6
No. 200		N.A.	92.1
Plasticity Index	Tex-106-E	≤ 10	None Plastic
Wet Ball Mill, % passing	Tex-116-E	≤ 40	26.6
Max. Increase Passing No. 40,%	Tex-116-E	≤ 20	8.1
Texas Triaxial Class	Tex-117-E	1.0	1.0
Strength (psi) @ 0 psi Confining	Tex-117-E	≤ 45	54.1
Strength (psi) @ 15 psi Confining	Tex-117-E	>175	270.1
Maximum Dry Density, MDD (pcf)	Tex-113-E	–	138.6
Optimum Moisture Content, %	Tex-113-E	–	6.0—

For More Details...

This research is documented in the following reports:

0-4358-1, *Materials, Specifications, and Construction Techniques for Heavy-Duty Flexible Bases: Literature Review and Status Report on Experimental Sections*

0-4358-2, *Impact of Aggregate Gradation on Base Material Performance*

0-4358-3, *Heavy-Duty Flexible Bases: Year 3 Progress Report*

0-4358-4, *Heavy-Duty Flexible Bases: Field Performance and Draft Specifications*

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