LTRC

IMPLEMENTATION UPDATE: Research in Practice

Construction & Comparison of LA's Conventional and Alternative Base Courses Under Accelerated Loading

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INTRODUCTION

Cement-stabilized subgrade soils have been the primary load carrying material for most non-interstate flexible pavements on the very weak soils prevalent in central and south Louisiana. However, cracking in this material often reflects to the pavement surface, allowing moisture infiltration and subsequent pavement deterioration. Consequently, other materials and blending methods needed to be considered as potential replacements for standard mixed-in-place soil cement bases.

The Accelerated Loading Facility (ALF) device at the Louisiana Department of Transportation and Development (LADOTD) Pavement Research Facility (PRF) was used to evaluate the performance of alternate base materials and blending methods. One of only three of its kind in the nation, the 100-foot long, 55-ton ALF device compresses many years of road wear into just a few months of testing (Figure 1).

Figure 1
ALF Device

RESEARCH PERFORMED

Nine test lanes, with material configurations as shown in Figure 2, were constructed at the PRF. Each test lane consisted of a 3.5 in. layer of high-stability wearing and binder course placed over crushed limestone or a soil cement base that was either plant-mixed or mixed-in-place. The soil cement bases were classified as either **cement-treated** or **cement-stabilized**. The cement-treated bases had a 4 percent cement content and a design strength of 150 psi at 7 days, while the cement-stabilized bases had a 10 percent cement content and a design strength of 300 psi at 7 days. Each test lane's foundation was a 5 ft. layer of uniform embankment A-4 soil with a plasticity index less than 10 placed over existing natural soil. The lanes were loaded to failure using the ALF device, and the results were used to compare the performance of the various base materials.

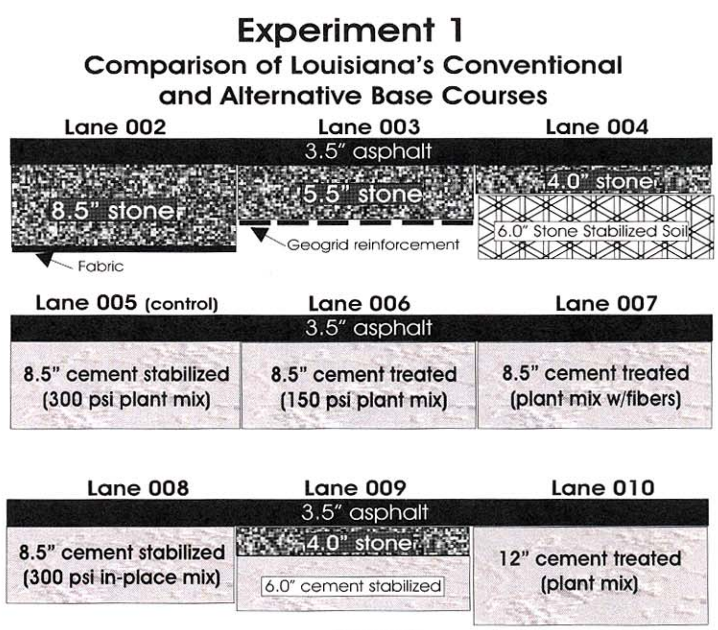

Figure 2

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Accelerated loading was applied on a single set of dual wheels (i.e., half an axle) with a tire pressure of 105 psi. The load was applied in one direction only, with a normal transverse distribution of 1.23 ft. Loading was applied in sets of 25,000 passes on each lane, which took approximately 3 days. Each lane had the same asphalt surface to ensure that failure would primarily be due to permanent deformation of the base, subbase, and/or subgrade.

Pavement condition was monitored by measuring surface deformation, cracking, and surface deflection, which was measured by Falling Weight Deflectometer (FWD) and Dynaflect equipment. Performance measurements were made at the end of each loading set. Moisture, ambient climate, and "in-pavement" temperatures were also monitored. Failure criteria was set as rutting of 0.75 in. and/or cracking of more than 50 percent of the loaded area with a crack density of 5 m/m^2. Loading ceased when a failure criterion was exceeded, or if, in the project manager's judgment, the lane had reached a condition where it would be rehabilitated under normal LADOTD practice.

RESEARCH RESULTS

The performance of the base and subbase material combinations was evaluated by comparing the development of rutting, roughness, and cracking observed during ALF loading for each test lane. Plots were prepared to graphically summarize performance and compare test lanes.

A criterion that can be used to evaluate the performance of a flexible pavement is its ability to carry loads before reaching a critical rut depth. The slower the rut development, the better the pavement structure performs. Figure 3 shows a summary of the rut depth for lanes 002 through 010 versus the number of equivalent single axle loads (ESALs). The ESALs were obtained by multiplying the number of ALF passes by an axle load coefficient obtained from Appendix D of the 1993 AASHTO guidelines.

To compare the relative performance of each lane, a common rut depth of 0.75 in. was used as the basis for comparison (Figure 4). Performance comparisons showed that stone bases performed as well as soil cement bases, and mixed-in-place bases performed similarly to plant-mixed bases. Furthermore, bases composed of stone over cement-stabilized or cement-treated soil performed better than either of these base materials used separately. Results showed that an increase in load-carrying capacity comes from an increase in base thickness, regardless of cement content.

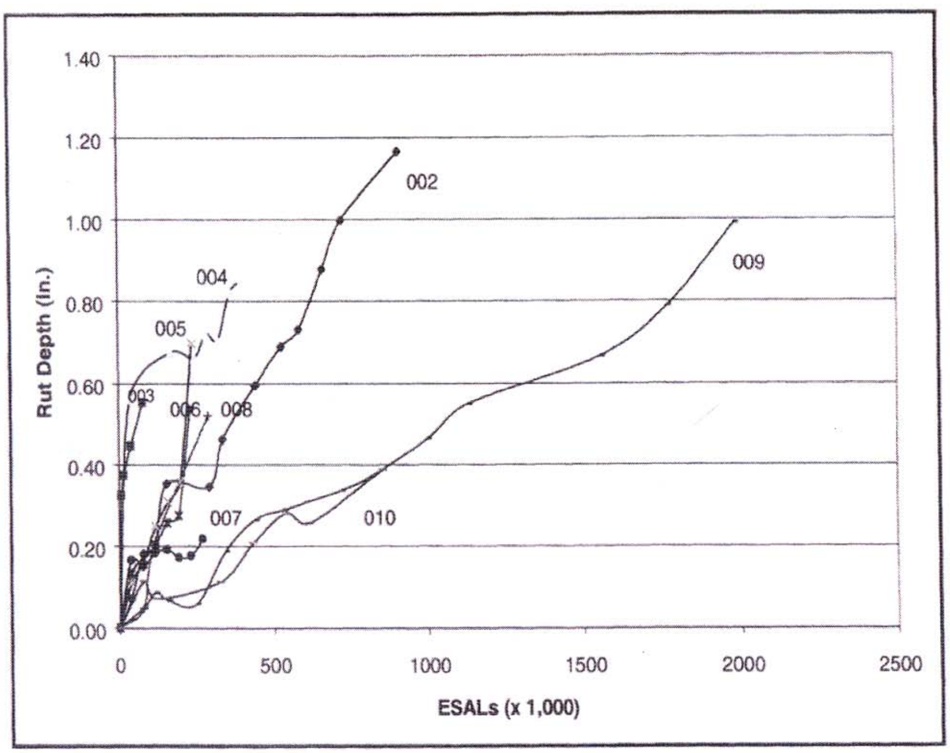

Figure 3 Average Rutting Development for Lanes 002 through 010

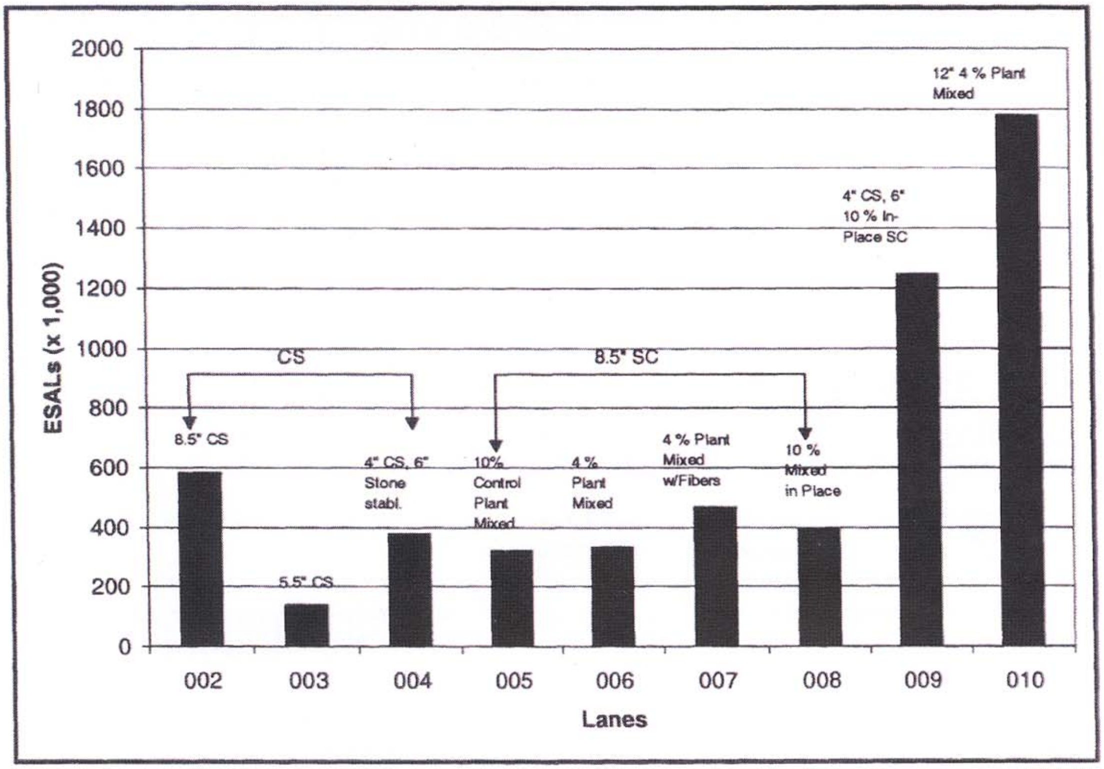

Figure 4
Comparison at a Rut Depth of 0.75 in. (19mm)

RESEARCH RECOMMENDATIONS

For pavement construction on low-volume roads in Louisiana, 12 in. thick mixed-in-place cement-treated bases are recommended in lieu of 8.5 in thick cement-stabilized bases.

Because of long term durability concerns, the cement-content-treated bases are recommended only for reconstruction of existing bases. For high volume roads, construction of new bases composed of stone over cement-stabilized soil, also known as "stone interlayer," is recommended.

IMPLEMENTATION FEASIBILITY

On **low volume roads** with 3.5 in. HMAC top layers, the initial pavement construction cost per lane-mile is slightly higher for 12 in. cement-treated bases than for 8.5 in. cement stabilized bases, as shown in Figure 5.

Based on LCA assumptions used in Louisiana's Alternate Design / Alternate Bid programs, a 30-year life cycle analysis was performed. This analysis assumed that future maintenance requirements would include the following: full reconstruction (base and HMAC) at the end of years 10 and 20 for the pavement with an 8.5 in. cement-stabilized base, and a one-time HMAC milling and overlay at the end of year 15 for the pavement with a 12 in. cement-treated base. Additional assumptions included a 4 percent inflation rate and zero salvage value at the end of year 30.

This life cycle analysis for low-volume roads revealed that using a 12 in. cement-treated base creates a 40 percent savings, as shown in Figure 5.

On **high volume roads** with 9 in. HMAC top layers, the initial pavement construction cost per lane-mile is higher for 12 in. stone bases than for 4 in. stone/8.5 in. cement-stabilized bases, as shown in Figure 6.

The 30-year life cycle analysis assumed the following future maintenance requirements: base rehabilitation, including removal and replacement of the HMAC, at the end of year 15 for the pavement with a 12 in. stone base, and milling of 2 in. HMAC and 3.5 in. HMAC overlay at the end of year 15 for the pavement with a stone interlayer base. Like the low-volume road analysis, a 4 percent inflation rate and zero salvage value at the end of year 30 were assumed.

This life cycle analysis for high volume roads revealed that using a stone interlayer base consisting of 4 in. stone/8.5 in. cement-stabilized

Since beginning implementation of cement-treated bases on LADOTD projects in 2001, the percentage of total projects using this concept increased from 41 percent to 94 percent. Based on the life cycle cost analysis presented, over $3.9 million was saved for 650 lane miles of roadway constructed in the first three years of implementation. This value of savings will continue to grow each year as full implementation is achieved.

The stone interlayer design was implemented gradually with the first new projects in 2003 and 2004. In 2005, LADOTD fully endorsed the concept and is now designing most new projects using stone interlayer bases in lieu of full depth stone bases. Life cycle savings in excess of $1 million can be credited on the 95 miles of completed projects during the first two years of implementation.

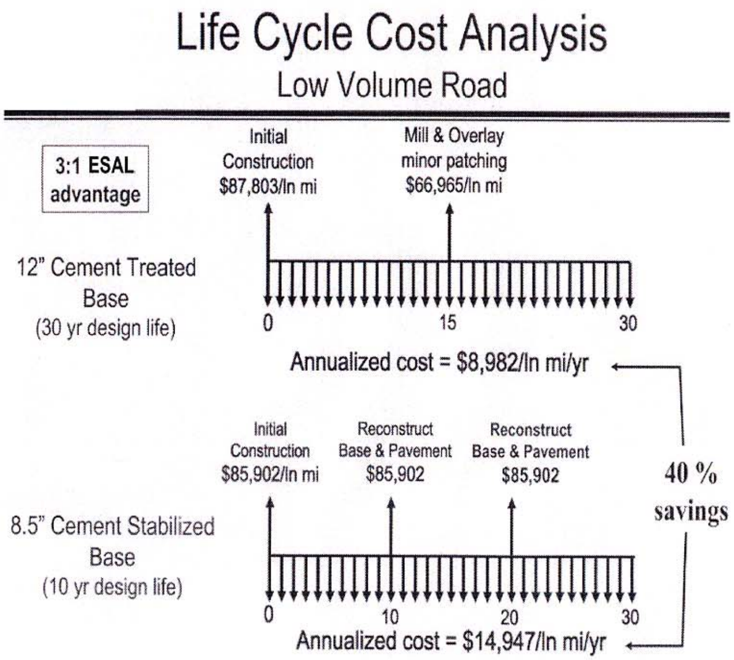

Figure 5

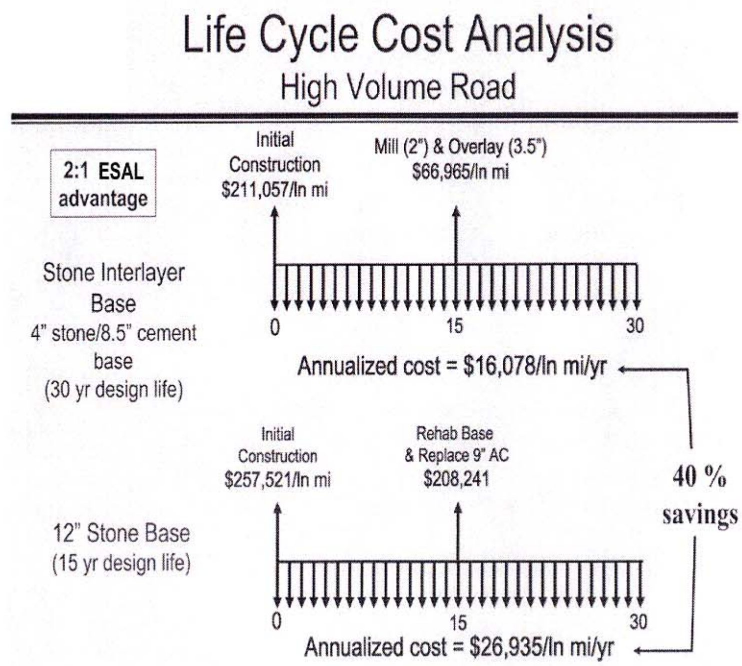

Figure 6