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Minimizing Shrinkage Cracking in Cement-Stabilized Bases through Micro-Cracking

INTRODUCTION

The Louisiana Department of Transportation and Development (DOTD) has been using cement-stabilized soil bases (so-called soil cement) in flexible pavement construction for more than 50 years. This type of base course, although known for having an excellent loading carrying capacity and durability, is also well-known for developing shrinkage cracks, which can reflect through the asphalt concrete surface and accelerate the deterioration of the pavement. Micro-cracking is a special reflective-cracking mitigation technique used for an asphalt pavement with a cement-stabilized base during the construction. Micro-cracking aims to produce a fine network of hairline cracks in the cement-stabilized base to relieve its contracting stress during the drying process and prevent it from forming of wider shrinkage cracks, which are more likely to be reflected to the pavement surface. Several recent research studies reported that micro-cracking does improve the field performance of pavement test sections with cement stabilized bases by reducing the crack width, crack length, or both, indicating a great potential of applying this technique on the soil cement pavement construction in Louisiana. A field experiment research was performed in this study to explore the implementation potential of micro-cracking technique in Louisiana.

OBJECTIVE

The objectives of this research were to (1) determine if the micro-cracking technique is suitable for implementing on pavements with soil cement bases in Louisiana and (2) evaluate the effectiveness of the micro-cracking technique in reducing the shrinkage/reflective cracking on pavements with soil cement bases.

SCOPE

Micro-cracked cement-stabilized or treated soil bases were constructed and monitored at LTRC's Pavement Research Facility (PRF) site and two selected state pavement projects. In the micro-cracking application, a vibratory roller compactor (at least 12-ton) was used to achieve a stiffness reduction of 30% to 50% of the cement bases. Pavement performance after micro-cracking was monitored through the in-situ non-destructive tests. Statistical analyses were performed based on the pavement performance data collected from both the control sections and the micro-cracked sections.

METHODOLOGY

To achieve the objectives, micro-cracking test sections were constructed on both the PRF site and two selected in-situ pavement project sites. As shown in Figure 1, the six PRF test sections were constructed with cement stabilized design (CSD) and cement treated design (CTD) according to DOTD's specification, but without the surface asphalt layer. The purpose was to directly evaluate the shrinkage cracking performance of CSD and CTD without the use of micro-cracking. Non-destructive tests including falling weight deflectometer (FWD), light FWD (LFWD), and Geogauge was used to determine the required micro-cracking roller passes during the construction.

LA 1003 and LA 599 were selected as field projects to investigate effectiveness of micro-cracking on pavements with CSD and CTD base layers. In LA 1003, a section of double layer structure with chip seal treatment was also included. Five and four test sections were included in each of these two projects and the length of each section was near 1000 ft. Various non-destructive tests (NDT) including FWD/HWD, road surface profiling, and crack survey were performed to evaluate the section performance w/o micro-cracking. The section arrangements of these two project are shown in Figure 2.

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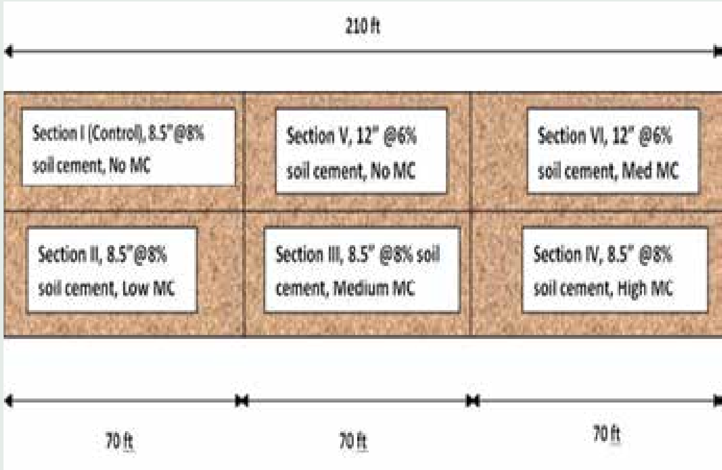

Figure 1
Layout of PRF sections

Figure 2
Section arrangment of LA 1003 and LA 599

CONCLUSIONS

In this study, a total of 15 micro-cracked and non-micro-cracked pavement test sections were constructed with different soil types, cement contents, and soil cement base designs. Various in-situ NDT tests were conducted during the micro-cracking process and the post-construction pavement monitoring. Based on the obtained in-situ performance results, the following observations and conclusions were made:

- No severe shrinkage cracks were found on any of three PRF test sections after three and half years of construction. Substantial amounts of hairline-type shrinkage cracks were first observed on all test sections during the early curing periods, but the surface cracks were all disappeared in approximately six months thereafter. Saw-cut beams showed no full-depth wide cracks along the beam thickness, indicating no hidden severe shrinkage cracks have been developed.
- The possible reasons for severe shrinkage cracks developed on PRF sections may be due to (1) sufficient curing time and less moisture loss due to covered by visqueen; (2) short section length (each section is only approximately 70-ft. long); (3) possible effect of micro-cracking; and (4) no traffic loading on PRF sections.
- The base stiffness increased with time for all PRF sections. This result indicates that the micro-cracking did not damage the base layer, and the base strength could fully regain after curing with time.
- Based on the results of the crack performance, high-speed pavement profile survey, and FWD testing, it was found that the sections with an 8.5-in. micro-cracked soil cement base layer generally performed similar to the control sections with an 8.5-in. non-micro-cracked soil cement base layer on both the LA 1003 and LA 599 testing sites. However, only limited cracks were found on both the control and micro-cracked sections and the pavements were in service for less than three years. Therefore, whether or not the micro-cracking technique is suitable for implementing on the 8.5-in soil cement pavement in Louisiana cannot be concluded at this time.
- From the performance in LA 1003 and LA 599, it may be concluded that micro-cracking seems not to be an effective method in the mitigation of reflective cracking for a 12-in. cement treated soil base layer in Louisiana. The dissatisfactory pavement cracking performance of the 12-in. cement treated soil base micro-cracked test sections may be partially attributable to its less cement content, non-uniformity of base after construction, and possibly differential settlement on a relatively weak subgrade.
- Based on the structural number analysis, it was found that the effective structural numbers of the micro-cracked sections were generally similar to or even slightly higher than the control sections, indicating the micro-cracking process might not weaken the pavement structures due to the extra compaction.
- The 8.5-in. CSD section with a double-layer AST on LA 1003 was compared to the 8.5-in. CSD control section. The double layer section did not show a better crack or rutting performance, even though its effective structural number was found greater than the control section.

RECOMMENDATIONS

Based on the observations from this study, the following recommendations are proposed:

- The micro-cracking technique is not recommended for implementing on the asphalt pavements containing a 12-in. cement treated soil base in Louisiana;
- Long-term pavement cracking performance of an 8.5-in. micro-cracked soil cement pavement could not be obtained from the current study. Whether or not the micro-cracking technique is suitable for implementing on the 8.5-in soil cement pavement in Louisiana still cannot be concluded.
- Continuously field monitoring of the constructed micro-cracked test sections on both the LA 599 and LA 1003 are recommended (i.e., once per year for at least another five years) in order to determine if the micro-cracking has any long-term benefits in the control of reflective cracking on the asphalt pavement with an 8.5-in soil cement in Louisiana.