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In-Place Cement Stabilized Base Reconstruction Techniques Final Report: "Construction and Eight Year Evaluation"

INTRODUCTION

Soil cement has been used internationally since 1935 to enhance the load distribution and durability of base courses and subbases. The Louisiana Department of Transportation and Development (DOTD) has been using portland cement to stabilize or treat soils either for base courses or subbases in excess of 50 years. Many of the older pavements have undergone either rehabilitation or reconstruction. Because of this, soil cement base courses on those pavements have been restabilized with cement as many as four times.

Soil cement has proven itself to be an excellent base course through the years in Louisiana; however, it is not without drawbacks. The major soil cement issue addressed in this study was shrinkage cracking. It is natural for cementitious materials to shrink as a result of the hydration and the curing process. Factors that can influence shrinkage in soil cement blends are cement content, moisture content, density, compaction, curing, and fine grain soils. Common methods to abate this are using lower cement contents (4 to 8 percent), controlling the moisture content to within +/- 2 percent of optimum, compacting the material in excess of 95 percent maximum density, applying a moisture barrier (curing membrane) over the soil cement, and selecting soils with a plasticity index (PI) of less than 25. In Louisiana, soils selected for base course cement stabilization or treatment must have a PI less than 15.

Reflective cracking in the asphaltic concrete (AC) pavement is often witnessed when soil cement base courses are used. Surface cracks increase roughness and decrease structural capacity by allowing water to infiltrate into the pavement, base course, and subgrade, thereby, weakening the entire pavement system over time. Mitigating reflective cracks entails abating shrinkage cracks as previously mentioned, utilizing crack relief layers (interlayers), and fiber reinforcing the base course to name a few.

An interim report was published in August 2002. Topics covered in that report were constructing test sections, a laboratory program, a two-year performance analysis, and a technical assistance study.

OBJECTIVE AND SCOPE

The purpose of this research was to evaluate the effectiveness of soil cement shrinkage crack mitigation techniques. Ten test sections were constructed on LA 89, State Project No. 397-04-0004. Each test section was 1000 ft. long. The shrinkage crack mitigation methods that were addressed included cement content, base thicknesses, fibers, interlayer, curing membrane, and curing periods.

After the test sections were constructed, their structural properties were assessed with the Dynaflect and falling weight deflectometer (FWD). Crack mapping was conducted by field technicians and the pavement management section with ARAN. The crack mapping of the field test sections continued for a period of 8 years.

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METHODOLOGY

This project was designed using the control section versus treatment method with no replicates. Since no replicates are available, robust statistical methods such as analysis of variance were not utilized. Instead, a simple comparison of measurement values was performed. In this experiment, the control section was cement stabilized soil (CSD), 8.5 in. thick. The treatment levels were cement treated soil (CTD,lower cement content); interlayers; polypropylene fibers; and curing duration. During the construction of the test sections, equipment problems occurred causing the CSD section to be constructed with

Table 1
Treatment levels

Treatment	Treatment levels	Test section number/ Location (Beg. & End Sta.)
Control section (CSD)	9% cement content – 8.5 in. thick	TS / 9 (85+00 to 95+00)
CTD	5% cement content – 12 in. thick	TS 4 / (Sta. 35+00 to 45+00)
Interlayers		
	Crack relief layer	TS 7 / (Sta. 65+00 to 75+00)
	E.A. curing membrane with sand	TS 8 / (Sta. 75+00 to 85+00)
Fibers		
	CSD with 0.1% fiber concentration	TS 2 / (Sta. 15+00 to 25+00)
	CSD with 0.05% fiber concentration	TS 3 / (Sta. 25+00 to 35+00)
	CTD with 0.1% fiber concentration	TS 5 / (Sta. 45+00 to 55+00)
	CTD with 0.05% fiber concentration	TS 6 / (Sta. 55+00 to 65+00)
Extended cure period	14 days < Cure period < 30 days	TS 10 / (Sta. 95+00 to 105+00)
CSD	9% cement content – 8.5 in. thick with random moisture content variations	TS 1 / (Sta. 5+00 to 15+00)
CSD - Cement stabilized design *,CTD - Cement treated design *, E.A. - Emulsified asphalt		

varying degrees of moisture content. Because of that, an additional CSD section was properly constructed and the CSD section with moisture variations was added to the experiment as a treatment. Table 1 presents the sections used in this experiment.

The purpose of the project was to assess the effectiveness of the treatments specifically on soil cement shrinkage crack mitigation and monitor their overall performance for a period of approximately 8 years. Past research has shown that shrinkage cracks from soil cement typically manifest as either transverse or block cracks in the asphaltic concrete pavement surface and were measured during the monitoring period of this project. In addition to measuring shrinkage and block cracks, longitudinal and alligator cracks, rutting, and roughness [international roughness index (IRI)] were monitored during the 8-year period as well.

The research team postulated the following:

1. With the exception of the CSD moisture variation treatment, each treatment selected would decrease the amount of transverse, longitudinal, and alligator cracks in the AC relative to the control section.
2. The addition of fibers to either CSD or CTD would increase its strength (resilient modulus) and could be demonstrated using the FWD.
3. The CSD and CTD sections would meet or exceed typical resilient modulus values for those sections in accordance with nationally accepted published data.

CONCLUSIONS

As expected, the CTD base courses generally produced less transverse cracks than the CSD base courses. Fibers generally did not reduce transverse cracks in either the CSD or CTD sections. As with the fiber sections, the treatments of interlayers and extended cure periods did not significantly mitigate transverse cracks. The maximum observed longitudinal cracking was in the CSD interlayer section with sand (test section 8). The CSD (control section) (test section 8) had significant longitudinal cracking as well. The remaining test sections had less than 42 ft. per 0.1-mile longitudinal cracks with some sections having no longitudinal cracks at all.

Test sections 5 and 10 had no alligator cracks and test sections 1, 4, 6, and 9 had minimal amounts of alligator cracks. For the alligator crack distress category, the CSD fiber sections (test sections 1 and 2) and interlayer sections (test sections 2, 3, 7, and 8) had significant amounts of alligator cracks relative to the control section.

IRI data indicated that the control section (CSD) had no deterioration over the 7.8-year review period, while (CSD) test section 1 had the highest deterioration rate. Because the control section had no change in IRI, all test sections had higher IRI deterioration rates than the control section, which made it difficult to truly gauge the IRI performance of the test sections relative to that of the control section. However, the IRI measurements indicated that test sections 1, 2, 3, 4, and 8 had higher rates of IRI deterioration than test sections 5, 6, 7, 9, and 10. In fact, the changes in the IRI for test sections 5, 6, 7, 9, and 10 are negligible and can be contributed to high speed measurement device variance.

At 7.8 years of service, all rut values were below 0.25 in., which can be attributed to AC densification. Each section was considered to have performed both equally and favorably within this distress category.

Treatment cost evaluations for each test section relative to the control section indicated that the extended cure period (test section 10) and CSD section with random moisture variation had similar costs to the control section. The CTD section costs approximately 7 percent more than the control section, while the interlayer sections (test sections 7 and 8) cost approximately 75 percent more to construct than the control section. The fiber sections cost ranged from 170 to 410 percent more than the control section. Of the sections evaluated in this study, the CTD section (test section 4) proved to be the most cost effective method option for mitigating cracking distresses.

The treatment M_r analysis indicated that the test sections met or exceeded design standards and were consistent with other projects in Louisiana. The addition of fibers to the soil cement base course did not contribute to increasing its modulus values; in fact, modulus values were generally lower in the fiber sections as measured with the FWD.

RECOMMENDATIONS

The results of this analysis show that cement treated bases perform structurally as well as cement stabilized bases and produce less distress cracks. DOTD should continue to utilize cement treated bases as a viable alternative to cement stabilized bases unless conditions warrant otherwise.

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