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Evaluation of Pavement Service Life Extension Due to Asphalt Surface Treatment Interlayer over Soil-Cement Base

INTRODUCTION

A considerable portion of flexible pavements have a soil-cement base course in Louisiana. Although such bases are popular due to its ease of construction, repeated traffic load bearing capacity, and inexpensive nature, they develop shrinkage cracks that reflect to the surface layer thus reducing the pavement service life. To mitigate these reflective shrinkage crackings, the Louisiana Department of Transportation and Development (DOTD) has been using asphalt surface treatment (AST) interlayers between the soil-cement base and surface hot mix asphalt (HMA) layer. The performance of AST interlayer to mitigate reflective cracking for soil cement base and its cost-effectiveness has not been studied. The pavement service life (SL) and SL extension or gain in SL of pavement due to such practice is also not known. Such practice to construct AST interlayers varies among DOTD districts, and there are currently no official DOTD guidelines or policies on this practice. In this regard, DOTD initiated this study to evaluate the performance, practice, and cost-effectiveness of AST interlayer as a reflective crack mitigation technique.

It should be noted that DOTD uses two types of soil-cement design processes. The first type is a cement-treated design (CTD) with 150 psi unconfined compressive strength (UCS) at 7 days. The second type is a cement-stabilized design (CSD) with a 7-day 300 psi UCS. Historically, DOTD has used CSD base as a traditional soil-cement base, and the CTD base was introduced in the early 2000s as another mean to mitigate shrinkage crack. Hence, this study also evaluated the performance of CTD bases as a reflective crack mitigation technique. Several available stone interlayer projects performances were also reported in this study for comparison.

OBJECTIVE

The overall objective of the study was to evaluate DOTD's current AST interlayer practice, measure its performance in terms of service life extension, and assess its cost-effectiveness. The study also included the development of statistical performance prediction models for each distress type of flexible pavement with and without AST interlayer over soil-cement bases. Developing guidelines and recommendations for use of AST interlayers were also one of the major objectives.

METHODOLOGY

The state-of-the-practice of AST interlayer construction was evaluated by published DOTD specifications and district engineers survey through a survey questionnaire. From the DOTD mainframe database, candidate soil-cement pavement projects were selected, and those project's historical data were gathered. Tracking of Projects (TOPS), Letting of Projects (LETS) and Highway Needs Study (NEEDS) files provided all critical historic information regarding soil-cement projects with or without AST interlayers. All selected projects' distress data [International Roughness Index (IRI), rut, transverse (TC), longitudinal (LC) and alligator cracking (AC)] was acquired from the DOTD PMS database. Every project consisted of several 1/10th-mile sections in Louisiana. For each soil-cement project with and without AST, all five distresses data were collected from 1997 to 2017 with a two-year collection interval. Hence, each 1/10th-mile section of a project had one data point for each two-year interval from 1997 to 2017.

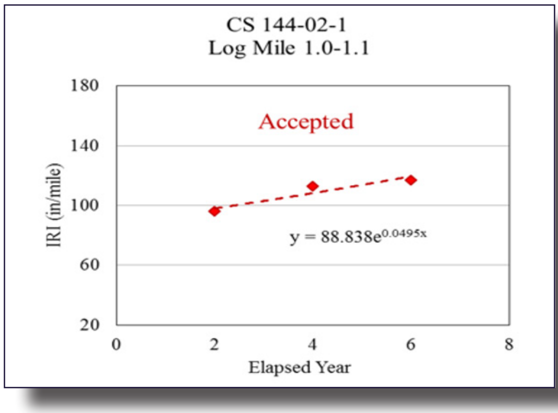

Figure 1: Acceptance criteria illustration

All candidate projects were categorized by four major groups as: AST CSD (CSD base pavements with AST interlayers), AST CTD, No AST CSD (CSD base pavements without any interlayer) and No AST CTD. All these projects had an ESAL range of 0-30,000 per year and thickness of overlying HMA as 2-4 in.

For each category, every project was divided into multiple 1/10th-mile long pavement sections, where each section had five-distress data point per two years. These time series distress data (TC/ LC/ AC cracking, rut, and IRI) could be modelled by any algebraic function. Here in this research, the best-fit curve for cracking, rut, and IRI were constructed by logistic, power, and exponential functions, respectively.

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Five to seven years of data were used for curve-fitting and those 1/10th-mile sections with an upward trend were only accepted for analysis. Those sections that did not have minimum three distress point or upward trend were rejected for analysis. Thus, the service life of every pavement section was calculated for all cracking, rut, and IRI data using aforementioned functions for accepted sections. For the service life calculations, thresholds for TC, LC, AC, IRI, and rut were considered as 1056 ft., 1056 ft., 1267 ft2, 200 in/mile, and 0.5 in. in this study. Maximum service life for any sections were allowed to be 20 years. For each category, all pavement sections' service lives are thus calculated and averaged for determining the "Service Life" for that category for each distress type. Thus, No AST CSD pavements SL were compared to AST CSD pavements for the performance of AST interlayers. The study also determined cost-effectiveness by calculating benefit-cost (B/C) ratios for each category and compared them. For the benefit-cost ratio B/C (SL) calculation, SL was considered as the benefit, and total monetary spending of pavement for the 1/10th-mile section was considered as "cost." There was another benefit-cost ratio utilized in this study calculated from normalized benefit area (NBA), where normalized area underneath the performance curve for any distress was considered as "benefit." Net B/C ratios were determined by averaging the five distress types benefit-cost for each category of projects for comparison. Accepted sections for these four categories consists about 70 miles, 178 miles, 148 miles, and 35 miles of data for AST CSD, No AST CSD, No AST CTD, and AST CTD pavements. Simultaneously, this study also developed prediction models for all four categories of pavements for five distress types for any future prediction of pavement performances.

Based on the above methodology, Service Life (SL) of No AST CSD category (reference category) was found to be 11.6 years for TC. As SL for AST CSD category was found to be 14.3 years for TC, the difference of SL for these two categories (2.7 years) was considered as gain SL by AST interlayer for TC. The AST interlayer also found to have a gain SL of 2.2 years for AC. But, AST interlayer projects had significant loss of service life of 3.2 years for rutting when compared to No AST projects. Rut service life for AST and No AST CSD pavements were 16.8 and 20.0 years, respectively. Moreover, No AST CTD pavements provides -0.9 years of Gain SL for TC and 0.9 years of Gain SL for AC. No AST CTD did not create any unwelcomed rutting unlike AST interlayer. IRI and LC remained largely unaffected by both AST CSD and No AST CTD pavements.

CONCLUSIONS

As TC is the major outcome of reflective shrinkage crack and it was found controlling distress type, it could be concluded that AST interlayer increased the service life of pavements by 2.7 years on average by mitigating reflective cracks. But AST interlayer also created significant unwanted rutting in the pavement by reducing rut SL of 3.2 years.

From the benefit-cost analysis, it was found that AST interlayer was the least cost-effective option due to its higher cost, marginal Gain SL for TC, and negative Gain SL for rutting.

No AST CTD pavement was found to be the most cost-effective option in mitigating reflective cracking. It happened as CTD base pavement has similar Gain SL for TC but not extra rutting was developed. Also, CTD was inexpensive due to its lower cement content.

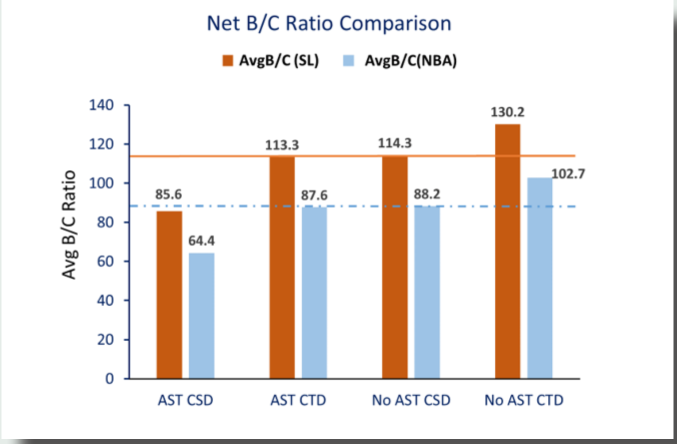

Figure 2: Net B/C ratios comparison

RECOMMENDATIONS

As CTD base became the most cost-effective option, it is recommended that DOTD continue CTD bases for flexible pavements.

Since the AST interlayer of all soil-cement became the least cost-effective option and creates unwanted rutting to the pavement, it is recommended that DOTD carefully consider its use as an interlayer over soil-cement base flexible pavements to minimize the reflective cracking.

Some stone interlayer projects over soil-cement bases were also analyzed in this project. As stone interlayer projects performed very well to mitigate reflective cracking (6.7 years of Gain SL for TC), it is recommended that DOTD continue researching stone interlayer as it may have the potential to be an effective interlayer in future.