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THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 0-4398-S
Project 0-4398: Develop Guidelines for Designing and Constructing Thin Asphalt Pavement (ACP) Overlays on Continuous Reinforcement Concrete Pavement (CRCP)
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PROJECT SUMMARY REPORT

Decision Tree for Thin Asphalt Concrete Overlays on Continuously Reinforced Concrete Pavement

This document summarizes the research work conducted for Project 0-4398, "Develop Guidelines for Designing and Constructing Thin Asphalt Concrete Pavement (ACP) Overlays on Continuously Reinforced Concrete Pavement (CRCP)," and it is the fourth report in the series for this project. As an introduction to the reader, a brief background is provided, followed by the objectives of the project. Then the two main aspects of this project—the decision tree, and the tack coat and asphalt concrete (AC) mixture evaluation—are presented.

Thin asphalt concrete (AC) overlays placed on existing portland cement concrete pavements (PCCP) have demonstrated their value as a cost-effective means for restoring the riding quality and extending the service life of deteriorated pavements. The Texas Department of Transportation (TxDOT) has been using this technique for 40 years. Even though it is acknowledged that a thin AC overlay is not applicable in all situations, decisions regarding the utilization of this kind of rehabilitation have been mostly based on experience because of a lack of established procedures for its implementation. The need to develop criteria and procedures to ensure that a thin AC overlay is implemented under ideal conditions for its success prompted TxDOT to develop Project 0-4398.

The primary objective of this project was to develop decision criteria to maximize the performance of CRCPs with thin AC overlays. This objective encompasses the following sub-objectives:

1. To evaluate the causes of the premature failures by the AC overlays and to mitigate their occurrences
2. To study the field performance of thin AC overlays on CRCP
3. To summarize the best practices for the utilization of thin AC overlays on CRCP
4. To provide recommendations to prevent the debonding phenomenon
5. To provide recommendations for tack coat performance testing and rutting resistance for thin AC overlays

What We Did...

When a pavement experiences failures and is in need of repair, it may need a major rehabilitation. The first step to remedy the problem is to select the best type of rehabilitation according to the type of failures, the origin of the problem, and the availability of resources to conduct such repairs. These decisions are made during the project selection stage. The solution as to how to approach the rehabilitation is not unique. An AC overlay is just one of the several rehabilitation alternatives and it is applicable only under certain conditions. If the conditions are not met, the AC overlay may perform poorly and may not fulfill the purpose of its implementation. Thus, an AC overlay is an optimal solution only in certain cases. The decision tree provides the steps to evaluate all the available alternatives and to select the one that will maximize performance. The decision tree includes these decisions: whether to conduct a rehabilitation with an overlay, whether to use an AC overlay or a PCCP overlay, and, if a PCCP overlay is chosen, whether to use an unbonded concrete overlay or a bonded concrete overlay (BCO).

To enable the selection of the most suitable type of rehabilitation for each case, three criteria have been developed, which constitute the backbone of the decision tree. These criteria analyze the current pavement condition and, depending on the results, indicate whether a thin AC overlay is adequate for the case in question. The decision criteria are the profile criterion, the condition survey criterion, and the deflection criterion.

Decision Criteria

Several tests on actual projects, along with abundant historic information from previous studies and experiences from other projects, were put together and analyzed to come up with these three decision criteria.

The profile criterion was deemed the decisive factor to ascertain the implementation of an overlay. The rationale behind this statement is that, regardless of the type of overlay, if a pavement exhibits profile problems, it is a candidate for overlay rehabilitation. The type of overlay will be determined subsequently by the structural conditions of the pavement, which will be evaluated by the condition survey criterion and the deflection criterion, both of which evaluate the struc-

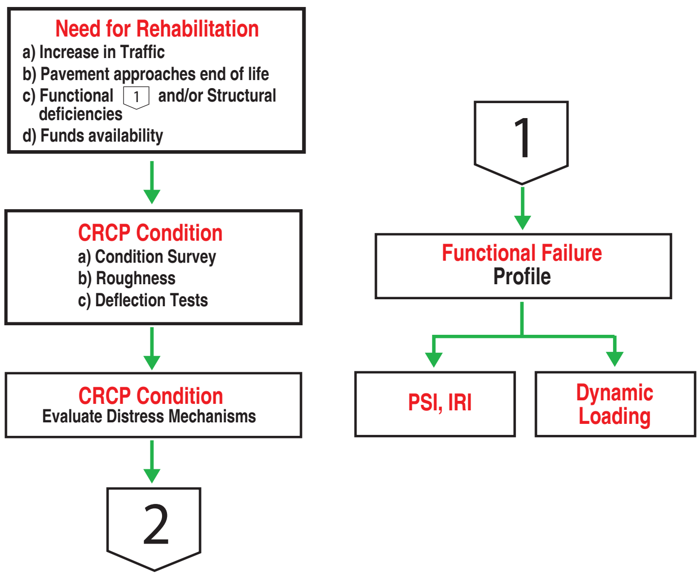

Figure 1.1: Flowchart of the Decision Tree (Part 1)

tural characteristics of the roadway.

Profile Criterion

The concept of pavement remaining life and the formulation of a dynamic load factor were the principles on which the profile criterion was developed. It has been demonstrated that when the pavement is subjected to dynamic loads, there may be a reduction in remaining life. The procedure to assess whether the structure may present such a reduction due to dynamic loading consists of computing a dynamic load factor. The remaining life of the pavement is related to the ratio of the pavement stresses when subjected to static and dynamic loads. The stresses in the pavement are assumed proportional to the load. Therefore, the ratio between the dynamic and static loads, which is called a dynamic load factor, can be used as a criterion to determine the need for pavement resurfacing. As investigated with actual profile data, the pavement structure prior to the new overlay showed more than about 10 percent higher load magnitudes due to the surface roughness. Therefore, it was recommended that the pavement be overlaid if the dynamic load factor is larger than 10 percent. In other words, if the remaining life of the pavement is less than 68 percent, which is the inverse of the fourth power of the load ratio of 1.1 (10 percent higher than the static load), resurfacing is needed.

As mentioned before, the other two criteria provide a structural evaluation of the existing pavement; therefore, these criteria will assess what kind of overlay is best for the structural conditions of the CRCP. The criterion that follows is the condition survey criterion.

Condition Survey Criterion

The primary structural evaluation of a pavement normally comes from the condition survey, a fundamental step in any rehabilitation project. The detection of failures and distresses by visual means will give an immediate indication of the structural soundness of the pavement. Its quantification, according to this criterion, is performed by two different approaches: namely, the pavement distress index (PDI) and the rate of failures per mile per year. The PDI is an index of pavement deterioration, and it can be used as a score to determine whether a section must be rehabilitated. The PDI considers various types of distresses, assigning them relative weights in an equation in which the computed index becomes the discriminant score. The original PDI equation, developed in the 1980s based on field data gathered across the state, was enhanced to include the incidence of spalling. A number of pavement sections were utilized to determine and calibrate a spalling coefficient to be included in the PDI equation.

The PDI equation developed for this purpose is as follows:

$$PDI = 1.0 - 0.0071\,(MPUNT) - 0.3978\,(SPUNT) - 0.4165\,(PATCH) - 0.2323\,(SPALL)$$

where

MPUNT= ln (minor punchouts per mile +1)
SPUNT= ln (severe punchouts per mile +1)
PATCH= ln (patches per mile +1)
SPALL= ln (spalls per mile +1)

A PDI value of zero or less indicates that the section needs an overlay. The PDI approach, much like the profile criterion, is not capable of determining what type of overlay is required by the pavement structure. The rate of occurrence of failures (the second approach of the condition survey criterion), however, can establish what type of overlay is more appropriate for the case in question.

The rate of occurrence of failures is essentially a measurement of where the pavement is in relation to its service life span. This measurement can be used as an intrinsic indicator of the feasibility and the timeliness not only of an AC overlay, but of different types of rehabilitation, namely, a BCO and an unbonded concrete overlay. The failure rate, computed from historic condition survey information, will signify what type of overlay is more conducive to addressing the current stage of structural decline of the pavement. The basic assumption behind this criterion is that any given CRCP at some point in its service life will first become an ideal candidate for an AC overlay. As time and traffic go by and the deterioration rate increases, if no treatment were applied in the first instance, then the pavement becomes an ideal candidate for a BCO. In a similar fashion, farther along in the life of the pavement, at a more advanced stage of deterioration, had no rehabilitation been applied, the structure would become an ideal candidate for an unbonded concrete overlay. The criterion establishes two threshold values of failures per mile per year that divide those three stages. The threshold values are two and three failures per mile per year, respectively, and are applied in the following manner. If a CRCP approaches a rate of failure development of two failures per mile per year, an AC overlay is likely to remedy the situation and deliver good performance. However, if the rate approaches three failures per mile per year, a BCO represents a better technical and economical strategy. If the deterioration rate has progressed beyond three failures per mile per year, the best solution is an unbonded concrete overlay; in this case, the section is already too damaged to be repaired by a BCO in an economic way. The cost to fix those distresses prior to the BCO placement will render this rehabilitation option too expensive, making it suitable for an unbonded concrete overlay.

Deflection Criterion

The third decision criterion is the deflection criterion. The measurement of deflections is a basic structural evaluation for an existing pavement. This criterion, very much like the aforementioned failure rate, establishes a boundary for the applicability of AC overlays with respect to other types of overlays. The idea is that if the deflection evaluation yields a structurally sound pavement, it may be successfully rehabilitated by a thin AC overlay. To perform this assessment, a theoretical analysis estimates how much a hypothetical overlay would have to contribute to the overall structural integrity of the pavement by means of a calculation of stresses. Therefore, this criterion encompasses a structural evaluation of the existing pavement, by means of the deflection measurements, in conjunction with a theoretical assessment of a future overlay and its structural contribution, with the computation of stresses.

The deflection criterion is integrated by two components, a deflection ratio and a stress ratio. The deflection ratio requires measurement of deflections both at the midspan and at cracks on the CRCP. The ratio of deflections at cracks to deflections at midspan is an indicator of the structural integrity of the existing pavement. An elastic layer theory calculation of stresses will provide information for the stress ratio, which measures the hypothetical structural contribution of the overlay, by comparing the stresses without the overlay to the stresses with the overlay. The deflection criterion will indicate whether an AC overlay would be a good solution, if both the deflection ratio and the stress ratio are close enough to 1, or if a more structural remedy is necessary. In general, a considerable departure from a value of 1 for both ratios implies that the pavement needs an overlay that can provide more structural benefits than an AC overlay.

The decision tree for the project selection of an AC overlay on CRCP integrates the application of the three aforementioned criteria in a flowchart, which summarizes in a simplified way the methodology proposed for the project selection stage. The decision tree is presented in Figures 1.1 and 2.1.

Tack Coat and AC Mixture Evaluation

This part of the project investigated the use of tack coats and the rutting resistance of asphalt mixtures for use as overlays on CRCP.

The shear strength performance of tack coats utilized to bond AC and PCC specimens was evaluated using a shear test developed as part of the research. Four influence factors were investigated as part of the experiment, including mix type, tack coat type, tack coat application rate, and Hamburg wheel tracking. Tack coat performance influence factors were investigated at three levels.

Mix types with finer gradations appear to enhance the shear strengths of tack coat interfaces. Overall, it appears that the procedure as developed is feasible to investigate the interface shear strength performance of tack coats, and that the total shear area as defined is the best parameter for investigating the significance of influence factors and corresponding interactions.

Based on the findings of the research, a methodology for evaluating the suitability of AC for overlays on CRCP is recommended. Interim criteria in terms of maximum shear strength and total area beneath the shear strength displacement curves (determined from direct shear testing) were developed to evaluate the performance of tack coats. Both the MMLS3 and Hamburg wheel-tracking tests highlighted the poorer relative performance of mixes with siliceous gravel aggregates.

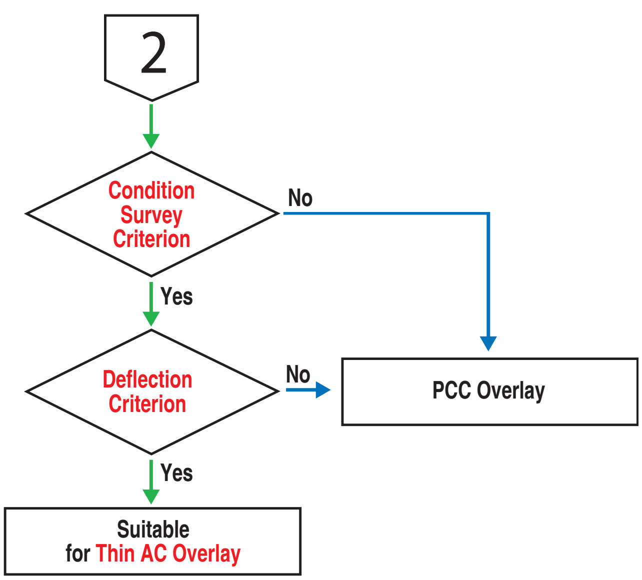

Figure 2.1: Flowchart of the Decision Tree (Part 2)

What We Found...

It is expected that the implementation of the criteria as the steps in the decision tree will ease the process of determining the adequacy of a thin AC overlay on CRCP by offering a more systematic approach. However, in some cases the solution may be too complex. In these cases, the decision may not be an obvious choice, because some of the criteria may indicate that this type of overlay is appropriate, while at the same time some other criteria may suggest otherwise. It should be kept in mind that the criteria, especially in cases like these, are not absolute. The decision, after all criteria have been analyzed, should come down to engineering judgment.

The Researchers Recommend...

Based on the results of the tests, it is recommended that the Superpave, CMHB, and Type C mixes be considered for use as overlays on CRCP pavements. Siliceous gravel aggregates should preferably not be used with these mixes. With respect to tack coats, the use of stiff binders (PG 76-22) and the addition of 1 percent lime to further stiffen the mixes and provide resistance to moisture susceptibility are recommended.

For future research, in terms of the decision criteria developed, it is advisable to apply the criteria to other existing projects in which it is known that AC overlays have been successfully applied, for the purpose of further calibration of the threshold values. The researchers have applied the values to every project for which the CRCP condition information was available, with positive results in all cases, but it is acknowledged that a shortcoming of some of those values may be that they were obtained from a limited number of cases.

In the case of tack coats, it is recommended that the interim criteria for maximum shear strength and total area beneath the shear strength displacement curves be evaluated in terms of actual shear stresses prevalent between AC and PCCP structures using layer theory. In addition, it is recommended that the direct shear strength experiment be expanded to investigate the influence of other variables, such as temperature and aggregate type. To further relate laboratory and field performance, it is also recommended that field cores from CRCP overlaid pavements be tested for shear strength.

For More Details...

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The research is documented in the following reports:

0-4398-1: Applicability of Asphalt Concrete Overlays on Continuously Reinforced Concrete Pavements
0-4398-2: Techniques and Procedures for Bonded Concrete Overlays
0-4398-3: Decision Tree for Asphalt Concrete Overlays on Continuously Reinforced Concrete Pavements

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