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Evaluation of Bonded Concrete Overlays over Asphalt under Accelerated Loading

INTRODUCTION

Bonded concrete overlay of asphalt (BCOA) is a pavement rehabilitation technique that involves the placement of a thin Portland Cement Concrete (PCC) overlay over a distressed asphalt concrete (AC) pavement. Typically, the AC pavement is milled and cleaned, which helps to create a bond between the existing AC pavement and the PCC overlay. The bond between the two layers promotes composite action of the pavement section and as a result has a direct impact on the performance of the BCOA pavements. Compared with unbonded overlays, bonded overlays have a sound bond between the overlay and the AC layer. The bond is maintained through some proper construction techniques so that the composite action takes advantages of the structural capacity of the existing AC layer and correspondingly allows for a reduced thickness of the overlay layer.

The proven durability and cost-effective construction method of BCOA pavements has created a great deal of interests from many states and local transportation agencies. Currently, the typical medium- to high-volume roadway in Louisiana consists of an existing asphalt concrete layer over a crushed stone or cement-stabilized soil base. Due to the increasing costs of roadway maintenance, the Louisiana Department of Transportation and Development (DOTD) has a great interest in determining if the thin bonded concrete overlay (usually 2-6 in.) is a suitable and cost-effective alternative to the current practice of roadway maintenance.

OBJECTIVE & SCOPE

The overall objective of this research was to evaluate the structural performance and load carrying capacity of BCOA pavement structures with different PCC overlay thicknesses through accelerated pavement testing (APT) and document the experience of mix design and construction practice of BCOA pavements for DOTD. Based on the APT results, potential benefits of using BCOA pavements were evaluated and recommendations were made for BCOA pavements in Louisiana.

METHODOLOGY

To achieve the objectives, researchers conducted an accelerated pavement testing experiment on full-scale BCOA pavement test sections. Three BCOA pavement test sections were constructed at the Louisiana Pavement Research Facility (PRF) site in Port Allen, Louisiana, using normal highway construction equipment and procedures.

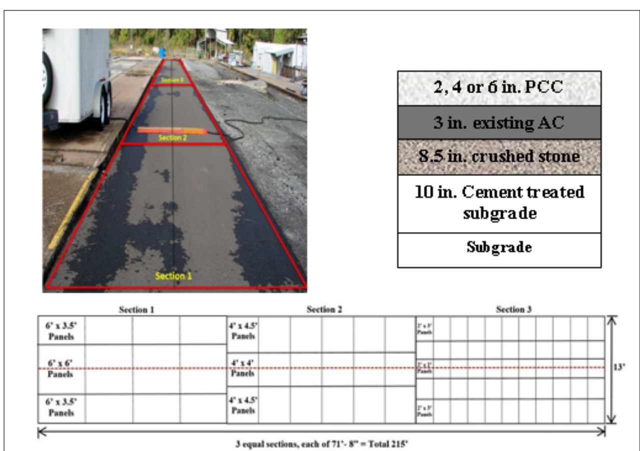

Figure 1
Existing AC test sections before overlay placement and BCOA pavement structure

Figure 1 presents the plan view and pavement layer thickness configurations of the test section. Each pavement section is 13 ft. wide and 72 ft. long. Saw-cut joints were prepared at a 2 × 2 ft., 4 × 4 ft., and 6 × 6 ft. panel spacing on the loading areas of the 2-in., 4-in., and 6-in. concrete overlays, respectively. The existing pavement consists of a 3-in. existing AC layer, an 8.5-in. crushed stone layer over a 10-in. cement stabilized subgrade. One inch of the existing AC layer was milled and the milled surface was thoroughly cleaned before the placing of the concrete layer.

The heavy vehicle load simulation device ATLaS30 was used in APT loading,

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which equipped with a dual-tire, half-axle load moving bi-directionally. Several pavement instrumentations were employed to monitor the load-induced pavement responses under the ATLaS loading. Various in-situ pavement testing (falling weight deflectometer (FWD) deflection tests, pull-off test, and surface texture and profile tests) was conducted during the APT testing. In addition, cracking survey and post mortem trench slabs were cut on failure areas of each test section after the APT testing to further evaluate the BCOA pavement performance. Figure 2 shows visual distresses of BCOA pavement test sections at the end of APT testing.

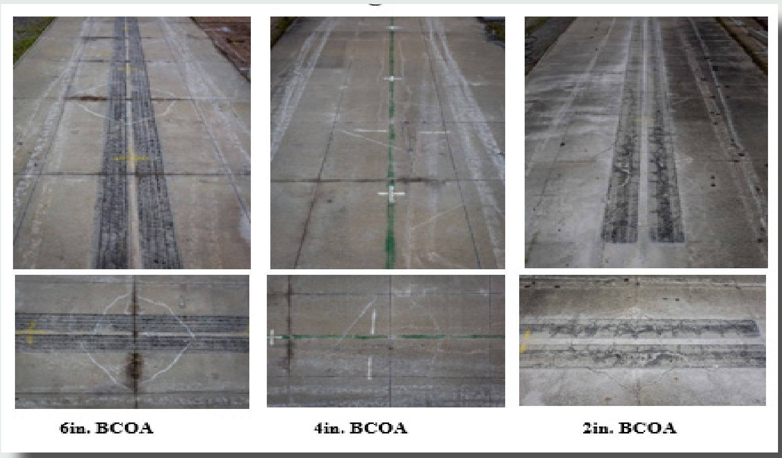

Figure 2
Visual distresses of BCOA pavement test sections

CONCLUSIONS

At the end of accelerated loading and field investigations on BCOA pavement performance, the following observations and conclusions were drawn:

- The predicted pavement lives for the 6-in., 4-in, and 2-in. BCOA sections were 8.9-, 3.5-, and 1.2- million ESALs, respectively. The 6-in. and 4-in. sections developed less severe cracking distresses. Therefore, the load carrying capacity of this pavements is greater than expected.
- Crack was first noticed on the 6-in. BCOA section after 1,090,000 load repetitions under the combination loads 9-kips and 16-kips. On the other hand, cracks started to show on the 4-in. and 2-in. BCOA sections only after 130,000 load repetitions and 110,000 load repetitions, respectively. This indicates that a 6-in. PCC overlay had a superior load carrying capacity compared to the 4-in. and 2-in. concrete overlays tested in this study.
- Fair to good bond strengths were found on all BCOA sections. The bond strength reduced with number of load repetition and potential debonding were also detected at the bottom of the PCC layer. A trench cutting investigation revealed that a good bonding was achieved on all the BCOA section, as seen in Figure 3.
- In terms of the failure criterion of 15% cracking slabs of all the slabs in the wheel path, the performance predicted by Pavement-ME is comparable to the in-situ performance of the BCOA sections in this study. However, Pavement-ME under predicts the BCOA design life in terms of fatigue cracking of 15% cracking slabs.

Figure 3
Forensic trenches of BCOA pavement sections

RECOMMENDATIONS

The following recommendations can be made based on the APT study:

- A slab panel size should not be more than half the lane width, which would result in a greatly reduced number of wheel loads on the slab corners. It will also reduce the loss of contact friction or debonding at the interface near the slab corner.
- Currently there is no specification for bond strength on BCOA pavement performance. Based on this experiment, it is recommended that the bond strength should be considered in the fatigue analysis for BCOA pavement performance and to quantify interface bonding failure.
- Based on the cracking survey results, a higher percent slabs cracked can be considered as a failure criterion for fatigue cracking instead of the current deign failure criterion of 15% slabs cracked to determine the true pavement life for BCOA pavement.
- Considering the BCOA pavement performance and cost-benefit analysis, it is recommended that a 6-in. BCOA pavement may be used in a medium- to high-volume pavement design where heavy and overloaded trucks are abundant, and a 4-in. BCOA may be suitable in a pavement rehabilitation project with medium-volume traffic. However, the 2-in. BCOA section did not perform well in this experiment. No recommendation could be made for a 2-in. BCOA section.