TACK COAT RESEARCH PROJECT STATEMENT

Funding: currently $60,000 from WSDOT and $20,000 from MnDOT. Potential funding from other SPTC states is possible.

Duration: August 2005 to February 2006 (approximately 6 months)

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PROJECT DESCRIPTION

A tack coat is a light application of an asphaltic emulsion between pavement lifts, particularly an existing surface and a newly constructed overlay. Its role is to provide adequate adhesive bond between pavement lifts so that they behave as a monolithic structure. The inadequacy or failure of this bond causes slippage between the pavement layers, which results in a significant reduction in the shear and tensile strength of the pavement structure, thus making it more susceptible to a variety of distresses, such as cracking, rutting, and potholes (WSDOT Tack Coat Tech Notes).

A tack coat is considered as a simple, relatively inexpensive, yet essential step in the pavement construction process; however, there is currently a lack of unified guidelines on the construction practice and quality control/acceptance (QC/QA) of tack coat. In a recent study conducted by Washington State Department of Transportation (WSDOT), field cores were extracted to analyze the cracking mode of failure. Approximately, one third of the cores that exhibited “top-down cracking” debonded at the interface between the existing pavement and the subsequent overlay during extraction of the core from the pavement. WSDOT requires tack coat on all hot mix asphalt (HMA) paving surfaces, but clearly these cores were not bonded adequately at the interface between the wearing course and the course beneath. These bond failures raise concerns about the adequacy of the adhesive bond achieved under current pavement construction practices.

It is therefore in the interest of WSDOT to develop a field test for both tack coat quality control (as performed by the contractor) and quality acceptance (performed by WSDOT). A protocol for tack coat application would also be critical. It is anticipated that this will contribute to improving the performance of the entire pavement structure by assuring a minimum adhesive bond is achieved between the pavement lifts. This will yield significant benefits in resisting early failure due to top-down cracking and other pavement stresses, both load and environmentally induced.

BACKGROUND

It is generally accepted that the quality of the tack coat bond depends on several factors including the following:

- Application rate

- Existing surface condition: surface texture
- Surface treatment: milling and cleaning the surface before the tack coat application
- Tack coat type
- Curing time and adequacy of the cure
- Presence of moisture

A recent study conducted by Florida DOT (Sholar et al., 2004) investigated the influence of some of these factors on the shear strength at the interface between the pavement lifts. For this purpose, FDOT developed a shear testing device to measure the shear strength of field cores and laboratory specimens at the interface between the lifts. The following conclusions can be drawn from this study:

- The presence of moisture on the tack coat surface significantly reduced the adhesive bond. This was consistently noticed in all their experimental results.
- There seems to be a minimum and an optimum tack coat application rate. Based on their testing results, a residual application rate of 0.091 L/m^2 (0.02 gal/yd^2) was selected as a minimum and 0.266 L/m^2 (0.06 gal/yd^2) as an optimum.
- Milling increased the shear strength at the interface and reduced the effect of the application rate. For milled section, it was noticed that using tack coat was not effective in increasing the shear strength at the interface.
- The type (texture) of the existing lift surface significantly influenced the shear strength at the interface. Coarse graded HMA mixes developed higher shear strength compared to fine grade mixes. Again, as the lift surface roughness increased, the influence of the tack coat application rate decreased. This is due to the interlocking between the aggregates, which seems to overshadow the adhesive bond provided by the tack coat.
- Increasing the curing time increased the shear strength. This was in agreement with the results by Hachia and Sato (1997).

It is anticipated that the adhesive bond at the interface will depend on the surface properties of the existing lift combined with other construction factors that can be controlled to improve the shear strength. These factors include the selection of the optimum tack coat application rate, tack coat type, curing time, cleanness of the surface (from dirt/dust), and absence of moisture. Parallel to the importance of the construction practice is the need to evaluate the quality of the tack coat in the field before and after paving (QC and QA testing). There are currently a few tests available for evaluating the quality of tack coat bond including the following:

- Texas DOT UTEP Pull-Off test, which is conducted on the tack coat before the construction of the overlay (QC test);
- “Attacker”, which has been recently developed by *Instrotek Inc.* to evaluate the torque and tensile strength of the tack coat (QC test);
- NCAT shear test performed on cores (QA test);
- Leutner test, originally developed in Germany (QA test);
- Torque Bond test, which was developed in the United Kingdom and can be used in the field after paving (QA test);
- Superpave Shear Tester (SST), which has been recently modified by Louisiana Transportation Research Center by building a shear mold assembly (QA test);

- FDOT shear test apparatus (QA test).

RESEARCH OBJECTIVE

The objective of this study is to investigate important factors that are known to influence the adhesive bond provided by the tack coat at the interface between pavement lifts while evaluating potential QC and QA test methods. The proposed study will aim at developing guidelines on the surface treatment of the existing pavement lift, selection of tack coat application rate, and developing/adopting a field (QC) and/or laboratory performance test (QA); the latter being the main focus of the study.

PROPOSED APPROACH

The following tasks will be executed to achieve the objective of the proposed study:

Task I: Literature Review
Conduct a literature review on the current practices for tack coat application and the performance tests used for its evaluation. The literature review will focus on field and laboratory tests for evaluating the tack coat bond. Information on the tack coat construction practices will be achieved through a questionnaire that will be sent out to personnel from Washington Pavement Association (WAPA) and region construction engineers.

Task II: Experiment
The experiment will take place in cooperation with the WAPA and *Woodworth & Company Inc*. It will consist of building 52 test sections with different tack coat construction practices and evaluating the tack coat bond with both QC and QA potential tests. QC testing will evaluate the Texas UTEP Pull-Off test and the *Instrotek* Attacker; QA testing will include the Torque Bond test (performed on cored, but not extracted, in situ field samples) and the FDOT shear test performed on extracted cores.

The field test sections will be built using different tack coat construction practices in order to investigate the influence of important factors on the shear strength at the interface between the existing surface and the newly constructed overlay. These factors include the application rate, tack coat type, surface treatment, and curing time. Table 1 shows the tentative experimental matrix proposed for this study.

This matrix will generate 52 different combinations of tack coat application. Twelve 6-inch field cores will be taken from each test section, of which three will be taken in each wheel path and three in the middle of the lane. Six field cores will be tested on site using the Torque Bond Test, and six in the laboratory using the FDOT Shear Test device to measure the shear strength at the interface. The Texas Pull-Off test and the *Instrotek* Attacker will be conducted on the tack coat before the construction of the new overlay.

Recently, there has been an interest from other state DOTs to partake in this project. The proposed experimental matrix will be modified to accommodate their needs if possible.

Table 1: Experimental Matrix#

FACTOR	**VARIABLE**			
Existing Surface Type	½" HMA			
Residual Application Rate	None	0.02 gal/yd^2	0.05 gal/yd^2	0.08 gal/yd^2
Tack Coat Type*****	CSS-1	CSS-1H or other as proposed by SPTC		
Surface Treatment	Milled		Un-Milled	
Cleanliness	Standard operation		Remove all dust	
Curing	Broken		Un-Broken	

This experimental matrix is tentative. The final one will depend on the participation of other states and the ability of Woodworth and Company to accommodate additional test sections.

***** Each additional tack coat type will require an additional 24 test sections.

<u>**Task III**: Data Analysis</u>

All sections will be tested using the Texas DOT UTEP Pull-Off test and the *Instrotek* Attacker prior to paving. After paving, six cores will be tested in the field using the Torque Bond test and six cores will be sent to FDOT to be tested using their Shear Test device. The laboratory results will be compared to the field test results in order to investigate the ability of the field tests to quantify the shear strength on site that correlates well with the laboratory measurements.

Analysis of Variance (ANOVA) will be used to statistically analyze the experimental data in order to determine the factors that significantly influence the shear strength at the interface between pavement layers.

<u>**Task IV**: Development of Tack Coat Guidelines</u>

The outcome of **Task III** will serve as the basis for the development of guidelines for tack coat construction practices and QC/QA test(s) (whether it is in the field, in the laboratory, or both) to assure an adequate adhesive bond at the interface between the lifts.

<u>**Task V**: Final Report</u>

A final report documenting the findings of this study will be submitted to WSDOT. It is also in the interest of the proposers to document the outcome of the proposed study in a manuscript that will be submitted for publication at a peer-refereed journal.

WSU Responsibilities

The PI's responsibility will be as follows:

1- Literature review (**Task I**);
2- Conducting the Torque Bond and the *Instrotek* Attacker tests (**Task II**);
3- Data analysis (**Task III**);

4- Development of tack coat guidelines (**Task IV**): this will be done collaboratively with WSDOT;
5- Final report (**Task V**).

WSDOT Responsibilities

The responsibilities of WSDOT will be mainly the experiment (**Task II**). This will include the following:

1- Overseeing the construction of the test sections by *Woodworth & Company Inc*.;
2- Conducting the Texas DOT UTEP Pull-Off test in collaboration with Texas DOT;
3- Field coring from the test sections;
4- Purchase of the Torque Bond testing device;
5- Shipping the field cores to Florida DOT and overseeing the testing of these cores using the FDOT Shear Test device. This will be done in collaboration with FDOT.
6- Modification to the proposed experiment to suit the needs of other interested DOTs.

RESEARCH SIGNIFICANCE AND POTENTIAL BENEFITS

Although tack coat application is considered an important aspect in pavement construction practices, the nation is currently lacking effective and efficient QC and QA tests to ensure that the tack coat provides the expected adhesive bond at the interface between the pavement lifts. The significance of the proposed study is the proof of concept of using field QC tests, field QA tests, and laboratory QA tests to ensure adequate tack coat bond. The use of these QC and QA tests would help eliminate early cracking failures due to debonding or top-down cracking. In addition, the proposed study will provide guidelines on the development of a construction protocol for tack coat based on the results from a comprehensive set of experiment that addresses important factors known to influence the tack coat bond.

DELIVERABLE PRODUCT AND IMPLEMENTATION

The deliverable of the proposed research will be the development of a tack coat protocol. The protocol will include guidelines for optimum tack coat application rate, construction practices, a field QC test, and a QA test. It is envisioned that this protocol will be implemented as a standardized WSDOT practice in the state of Washington.

REFERENCES

1- Sholar, G., Page, G., Musselman, J., Upshaw, P., and Moseley, H. (2004). "Preliminary Investigation of a Test Method to Evaluate Bond Strength of Bituminous Tack Coats." *Association of Asphalt Paving Technologists*. Vol. 73, p.p. 771-801.
2- Hachiya, Y., and Sato, K. (1997). "Effect of Tack Coat on Bonding Characteristics at Interface between Asphalt Concrete Layers." *Proceedings of the Eighth International Conference on Asphalt Pavements*, Vol. 1, p.p. 349-362.
3- WSDOT Tack Coat Tech Note. Website address: http://training.ce.washington.edu/WSDOT/Modules/07_construction/tack_coats.htm

4- Collop, A., Thom, N., Sangiorgi, C. (2003). “Assessment of Bond Condition Using the Leutner Shear Test.” ICE J. Transp., Vol. 156, No. 4, p.p. 211-217.
5- Raab, C., Partl, M. (2004). “Interlayer Shear Performance: Experience with Different Pavement Structures.” 3rd Euraasphalt & Eurobitume Congress Vienna, paper No. 081, p.p. 535-545.

WSU BUDGET ESTIMATE

The proposed budget is summarized on the following page. It represents the requested funds for WSU only. Brief justifications for each category are provided below.

Salaries and Wages

Support for this project is provided to the Principal Investigator (2/3 month), Co-PI (1/3 month), and one M.S. student for six months. The Department of Civil & Environmental Engineering at WSU will support the graduate student for another six months if needed. All pay rates are standard and include projected increases of four percent per year. Benefits are charged at 34% for the PI and Co-PI, and include tuition remission, health, and medical benefits for the graduate student.

Travel

The following trips are anticipated for this project:

1. One trip to a national conference for the PI ($1,200 estimate);
2. Two Trips to WSDOT headquarters in Olympia ($1,000 estimate).
3. Two field trips to conduct the in-situ testing ($1,000 estimate).

Indirect Costs

Indirect costs are computed at 46.8% of all project charges except the tuition for graduate students.

Budget detail attached.