Research Project Work Plan

For
SPR 782

HMAC LAYER ADHESION THROUGH TACK COAT

Submitted by

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for

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Research Unit
555 13th Street NE, Suite 2
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1.0 Identification

1.1 Organizations Sponsoring Research

Oregon Department of Transportation (ODOT)
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1.2 Principal Investigator(s)

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1.3 Technical Advisory Committee (TAC) Members

Larry Ilg, ODOT
Cole Mullis, ODOT
Chris Harris, ODOT
Anthony Boesen, FHWA
Keven Heitschmidt, Albina
Huachun (Dave) Zhai, Idaho Asphalt
Troy Tindall, Blueline Trans

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Larry Ilg, ODOT

2.0 Problem Statement

Tack coats are the asphaltic emulsions applied between pavement lifts to provide adequate bond between the two surfaces. The adhesive bond between the two layers helps the pavement system to behave as a monolithic structure and improves the structural integrity. The absence, inadequacy or failure of this bond result in a significant reduction in the shear strength resistance of the pavement structure and makes the system more vulnerable to many distress types, such as cracking, rutting, and potholes (Tashman et al. 2006).

Tracking, the pick-up of bituminous material by construction vehicle tires, reduces the amount of tack coat in certain areas and creates a non-uniform tack coat distribution between the two construction lifts. This non-uniform tack coat distribution creates localized failures around the low tack coat locations and reduces the overall structural integrity of the pavement structure. In addition, tack coat type, residual application rate, temperature, and existing surface condition (cracked, milled, new, old, or grooved) are the other factors that affect the tack coat performance. By considering all these factors, a quality-control and quality-assurance process need to be developed to maximize tack coat performance during the design life. Although Louisiana Tack Coat Quality Tester (LTCQT) (Mohammed et al. 2006) can be used to predict in-situ tack coat performance, high cost of LTCQT ($40,000) may restrict its widespread use in overlay construction projects in Oregon.

3.0 Objectives of the Study

The major objective of this study is to develop a low cost test method to predict the after-construction bond performance from the tests conducted on the tack coat. In addition, the factors that influence the bond strength, such as existing surface condition, residual application rates, tack coat type, moisture, and temperature, will also be investigated to recommend revisions to current methods and practices. Using lab measurements, regression equations will be developed for different tack coat types to predict tack coat set times that can be used during construction to minimize tracking.

4.0 Implementation

The output of this research study will be a low cost in-situ tack coat testing apparatus, a quantitative process for tack coat performance evaluation, a model to determine tack coat set times (to avoid tracking), and a test apparatus to evaluate the long term tack coat performance of ODOT pavement sections. The process will include step-by-step procedures that can be implemented by ODOT when deciding tack coat type and residual application rates for pavements with different textures. The process is expected to be implemented by ODOT Maintenance and outside contractors hired by ODOT. A final research report will be prepared and submitted to ODOT for publication. It is expected that the final report will be a public document, ready for publication by ODOT Research. In addition, one or more papers will be written for publication in a journal and/or presented at a national transportation conference.

5.0 Research Tasks

This section presents the tasks that will be undertaken to conduct the entire research study. The order in which the tasks will be conducted and their timing are shown in Section 6.0. The timing and duration of the data collection on the field sites will depend in part on the construction projects available to, and selected by, the research team and TAC. All reports will be produced in the standard ODOT Research Group report format unless another format is deemed to be more appropriate as a supplement to the ODOT format.

Task #1: Literature Review and Assessment of Tack Coat Test Procedures and Tack Coat Materials

A literature review will be conducted to evaluate the effectiveness of LTCQT (Mohammad et al. 2012), torque bond test (Walsh and Williams 2001), and Texas pull off test (Deysarkar 2004) for tack coat performance measurements. Although LTCQT can be used to conduct both torque bond and Texas pull off tests and can provide reliable results for both milled and old HMA surfaces with its polyethylene foam attachment on the loading platen, high cost of LTCQT ($40,000) may restrict its widespread use in overlay construction projects. On the other hand, a low cost torque or tension tester can be developed by using a simple metal frame and a digital torque wrench ($3,000 to $5,000) (Tashman et al. 2006). By attaching polyethylene foam to the loading platen of the torque and pull off testers, tack coat test results that are comparable to LTCQT can be achieved at a much lower cost.

In this task, the state of the knowledge in tack coat types, residual application rates, construction methods, and lab testing will also be investigated.

Time Frame:	4 months (January 2015 – April 2015)
Responsible Party:	Oregon State University
Cost:	$25,811
Deliverable:	Interim report describing the results of Task 1.
TAC Decision/Action:	TAC meeting with the Principal Investigator to discuss literature review, affirm the research objectives, tasks, and timeframe, and confirm the ODOT construction projects on which to conduct the field data collection.

Task #2: Identify Materials and Test Procedures

In this study, Texas pull off and torque bond tests will be used for in-situ tack coat performance evaluation. Lab shear, rotational viscosity, and softening point tests will also be conducted to determine the reference (ground truth) tack coat shear resistance which will be used to determine the effectiveness of in-situ tack coat tests. The effectiveness of the use of torque bond test on overlays in monitoring the long term tack coat performance will also be investigated. CSS-1 and CSS-1h emulsions (commonly used in Oregon) will be used in this study.

Evaluation of Tack Coat Set Time and Tracking – Lab Testing

Tack coat set times for CSS-1 and CSS-1h emulsions will be determined in the lab. Emulsions will be applied at different residual application rates to the surface of the cores taken from field sections. Reduction in core weight with time will be continuously recorded to determine the time point at which weight reduction stops (the time point at which evaporation stops). This time point can be considered as the tack coat set time. By conducting this experiment at different temperatures and residual application rates for different tack coat types and surface textures, the relationships between tack coat type, residual application rate, temperature, surface texture, and set time can be modeled using regression. Developed regression equations can be used in the field to determine the in-situ tack coat set times. By avoiding construction vehicle traffic before the calculated set time, tracking can be minimized. Developed lab equations will be validated and calibrated during the field tests. The increase in shear and tensile strength with time after tack coat application will also be measured by pull off and torque bond tests.

Three Dimensional Finite Element Model to Evaluate the Effect of Structural Characteristics on Tack Coat Shear Stresses

A 3D viscoelastic finite element (FE) model will be developed to evaluate the effect of structural characteristics, such as layer stiffnesses, thicknesses, material properties etc., on tack coat shear stresses. The tack coat shear stress and strain levels for different rolling truck tire loads and speeds will be determined using this theoretical investigation. The impact of overlay thickness on required tack coat strength will also be determined by using the 3D FE model results.

Evaluation of Tack Coat Test Methods and Procedures – Field and Lab Evaluation

The research team will work with ODOT personnel to identify potential field projects that can be used to assess different emulsion types and testing equipment. Field sections will be divided into two segments and different residual application rates will be applied on every segment. CSS-1 and CSS-1h tack coats will be used in this study. Three field test sections with old, milled, and new HMA surfaces will be used for testing. Tack coat temperature will be controlled using an infrared heater. The factorial for field testing is given in Table 1.

Table 1. Factorial for field testing and sample collection

Variables	**Content**
Pavement surface type	Old HMA, milled HMA, new HMA
Tack coat material	CSS-1 and CSS-1h
Residual application rate	New AC: 0.035 and 0.070 gal/yd^2 Old AC: 0.055 and 0.110 gal/yd^2 Milled AC: 0.055 and 0.110 gal/yd^2
Test type	Torque bond, Pull off, weight
Temperature	30, 50 and softening point ^{o}C
Number of test locations (replicates)	6

The following steps will be followed during the field tests to determine the correlations between in-situ tack coat experiments and lab measurements. Summary of task steps and outcomes are shown in Figure 1.

1. Before the construction, surface texture will be measured using a sand patch apparatus to be able to evaluate the effect of texture on bond strength.
2. Tack coat samples will be collected to perform rotational viscosity and softening point tests in the O.S.U. lab.
3. Distributor truck residual application rates will be measured and validated by placing papers at random locations along the test sections. Papers will be weighed after curing to determine ground truth residual application rates and calculate deviation from the target residual application rates.
4. After spraying, torque bond and pull off tests will be conducted at 6 different locations along every segment with different residual application rates (Table 1). Exact test locations will be determined and cores for lab shear testing will be collected (step 6) close to these locations in order to minimize the effect of spatial variability on lab vs. in-situ measurement comparisons.
5. Cores will also be collected before overlay construction. Tack coat amount measured in step 3 will be applied on 6 in. cores and the weight of the core will be continuously measured in the field to determine the time point at which reduction in weight stops (tack coat set time). The correlation between tack coat set time and strength measurements from torque bond and pull off tests will be determined using the results of the experiments.
6. After construction (a couple weeks, 3 months, 6 months and 9 months after), cores will be collected close to the locations that the torque bond and pull off tests are conducted. Shear tests will be conducted on collected cores using the test equipment available at O.S.U. Results of shear tests will be considered as reference (ground truth) data to evaluate the effectiveness of torque bond and pull off. Results of the emulsion rotational viscosity and softening point tests will be compared to the shear test results to determine the effectiveness of using simple emulsion tests for bond resistance characterization. Shear tests with saturated field cores will also be performed to determine the effect of moisture on tack coat performance.
7. After construction (a couple weeks, 3 months, 6 months and 9 months after), torque bond tests will also be conducted on overlays. Results will be used as reference (ground truth) data to evaluate the effectiveness of torque bond and pull off tests. In this test, the pavement is cored deeper than the interface of interest and is left in place. A core diameter of 2 and 4 inches will be used in order to reduce testing time and achieve breakage. If results of this test are correlated with lab shear tests, torque bond test can be adapted as a test to evaluate the long term tack coat bond performance for ODOT projects.

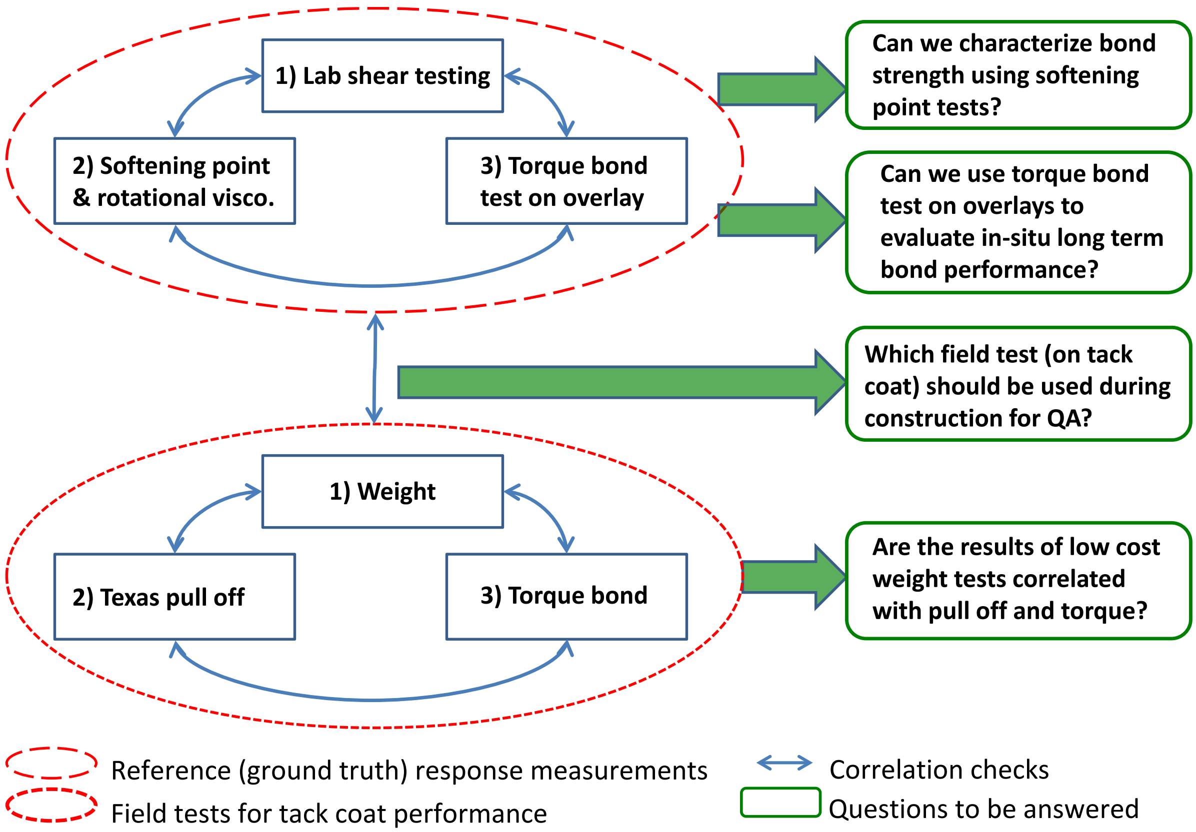

Figure 1. Summary of task steps and outcomes.

Time Frame:	15 months (February 2015 – April 2016)
Responsible Party:	Oregon State University
Cost:	$81,497
Deliverable:	Interim report describing the results of Task 2.
TAC Decision/Action:	TAC meeting with the Principal Investigator to discuss results of this task, and provide comments and feedback on the deliverable and on future research tasks.

Task #3: Final Report and Deliverables

A draft final report will be developed and submitted to ODOT for review. Following this review, a final report will be developed, incorporating the ODOT comments, to document the findings of the research. The output of this research study and the final deliverables will be an in-situ tack coat testing apparatus, a quantitative process for tack coat performance evaluation, a model and procedure to determine tack coat set times (to avoid tracking), and a test apparatus to evaluate the long term tack coat performance for ODOT pavement sections. The process will include step-by-step procedures that can be implemented by ODOT when deciding tack coat type and residual application rates for pavements with different textures.

Time Frame: 5 months (April – August 2016)

Responsible Party: Oregon State University
Cost: $32,692
Deliverable: Final report describing the results of the research study, in-situ tack coat testing apparatus, a quantitative process for tack coat performance evaluation, a model and procedure to determine tack coat set times, and a test apparatus to evaluate the long term tack coat performance for ODOT pavement sections.
TAC Decision/Action: TAC meeting with the Principal Investigator to discuss results of this task, and provide comments and feedback on the deliverable.

6.0 Time Schedule

This section specifies the time line for the project, listing the task headings and showing monthly and/or quarterly time blocks in which each task will be accomplished. Also shown are interim and final deliverables.

Task	2015												2016							
	FY 2015						FY 2016													
	Jan - Mar			Apr - Jun			Jul - Sep			Oct - Dec			Jan - Mar			Apr - Jun			Jul-Aug	
1. Literature Review and Assessment of Tack Coat Test Procedures and Tack Coat Materials (4 months) Deliverable: Interim report describing the results of Task 1.				† *																
2. Identify Materials and Test Procedures (15 months) Deliverable: Interim report describing the results of Task 2							† *									† *				
SUBTASK **2a.** *Evaluation of Tack Coat Set Time and Tracking – Lab Testing (6 months)* Deliverable: Interim report describing the results of Task 2a and 2b.							† *													
SUBTASK **2b.** *Three Dimensional Finite Element Model (6 months)* Deliverable: Interim report describing the results of Task 2a and 2b.							† *													
SUBTAS **2c.** *Evaluation of Tack Coat Test Methods and Procedures (13 months)* Deliverable: Interim report describing the results of Task 2c.																† *				
3. Final Report (5 months) Deliverable: Final report describing the results of the research study.																		† R		F

*Deliverables; † = TAC meeting; R - Draft report submitted for ODOT review.; F - Revised report submitted to ODOT for publication. End of contract.

7.0 Budget Estimate

An itemized budget for the project is included here, showing expenditures for each item by fiscal year and in total. A more detailed budget spreadsheet is also submitted with this work plan.

		FY--2015	FY--2016	Total
Personnel	PI	$ 10,909	$ 13,971	$ 24,880
	GRA (+tuition)	$ 20,794	$ 37,492	$ 58,286
Total Salaries		$ 31,703	$ 51,463	$ 83,166
Fringe Benefits	PI	$ 5,564	$ 7,405	$ 12,968
	GRA	$ 1,800	$ 3,498	$ 5,298
Total Fringe Benefits		$7,364	$ 10,903	$ 18,267
Total Personnel Costs		$ 39,067	$ 62,366	$ 101,433
Travel		$ 2,500	$ 2,500	$ 5,000
Services and Supplies (detailed list attached)		$ 10,000	$ 158	$ 10,158
Total Direct Costs		**$ 51,567**	**$ 65,024**	**$ 116,591**
Total Indirect Costs		**$ 10,712**	**$ 12,697**	**$ 23,409**
Total Project Costs		**$ 62,279**	**$ 77,721**	**$ 140,000**

8.0 References

Deysarkar, I. (2004). *Test Set-Up to Determine Quality of Tack Coat*. Master's Thesis, Department of Civil Engineering, The University of Texas at El Paso.

Mohammad, L.N., M.A. Elsifi, A. Bae, N. Patel, J. Button, and J.A. Scherocman (2012) *Optimization of Tack Coat for HMA Placement*. NCHRP Report 712, Transportation Research Board, Washington, D.C.

Tashman, L., K. Nam, and T. Papagiannakis (2006). *Evaluation of the Influence of Tack Coat Construction Factors on the Bond Strength between Pavement Layers*. Report Prepared for Washington State Department of Transportation # WCAT 06-002.

Walsh, I.D., and J.T. Williams (2001). *HAPAS Certificates for Procurement of Thin Surfacing*. Highways and Transportation, July/August 2001.