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Project Title

Field Performance of Asphalt Pavements at Low and Intermediate Temperatures

University

University of Utah

Principal Investigators

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Research Needs

Within its current practice, state transportation agencies are using aggressive rutting and stripping testing to qualify asphalt mixes for use in highway construction. This practice was in response to the typical distresses found in pavements from the late 1980s and early 1990s. In most states, this has generally resolved rutting issues, but has led to a detrimental effect on cracking and raveling behavior in the pavements. This one-dimensional approach has been recognized as a challenge to be addressed within the mix design process and highway agencies have been looking for practical tests to provide a performance balance and increase mix durability. Asphalt mixes now contain Recycled Asphalt Pavement (RAP) and less asphalt binder, both virgin and total, in an attempt to resist rutting and save on materials. Furthermore, with the high cost of asphalt binder and the increase in available substitutes and modifiers, asphalt binder testing alone is no longer adequate to predict pavement performance thus mix performance testing at all temperatures is becoming increasingly important. Building a mix to avoid both rutting and cracking requires a balance of priorities because these behaviors are often in direct conflict with each other. However, in the absence of practical tests, mix design and acceptance programs currently favors rutting resistance, leaving a clear imbalance and skewed performance. As the practice continues, these effects are becoming more pronounced; should current practices continue without adjustment for durability performance, constructed pavements will continue to exhibit early age cracking (both thermal and fatigue) and the performance of the pavements will be significantly affected, leading to a significant loss of investment by highway agencies.

A new test to evaluate low temperature performance of asphalt mixtures was developed with previous funding assistance from the MPC. This test uses the existing Bending Beam Rheometer (BBR) to test asphalt mixes. Test protocols were created for both cores and laboratory compacted samples and the relation to pavement performance was determined. This test was voted as an AASHTO provisional specification (TP-125) and could soon be adopted as a requirement for asphalt mix design. In a parallel effort, the Semi-Circular Bending/Fracture Energy test (SCB) was determined as a feasible test for intermediate temperature performance and was also voted as an AASHTO provisional specification (TP-126). By using these two tests (BBR and SCB) mixes can be evaluated for cracking potential in regards to RAP content, asphalt binder content, binder modification, etc., resulting in a complete performance-related specification.

However, adoption of any pavement performance specification requires an understanding of ALL aspects of mixture design including factors like: How will the new requirement affect the binder content? How will the new requirement affect the durability of asphalt pavements? How will the requirement affect current rutting tests (i.e., Hamburg WTD results)? How do all of these tests complement each other? This research will attempt to answer these questions by evaluating selected asphalt mixtures for low temperature cracking, intermediate temperature fracture energy, and high temperature deformation (rutting) to ensure that the addition of a low temperature test will not affect the high temperature performance or the durability of pavements. This work will allow for better optimization of mixes and reduction of poor performance potential of highway assets. Therefore, this work will have relevance at a regional and national level.

Research Objectives

1. Determine the intermediate temperature properties of representative asphalt mixtures produced in the state of Utah
2. Determine the low temperature properties of representative asphalt mixtures produced in the state of Utah
3. Compare the laboratory measured properties of asphalt mixtures and their material design to their corresponding short-term field performance
4. Present results at a national level

The overall objective of this work is to determine if the BBR and the SCB test, based on AASHTO TP125 and 126, respectively, can be used to predict the short-term (first year) low- and intermediate-temperature field performance of asphalt mixtures (i.e., cracking). At the conclusion of this project, we will be able to know if these tests could be used as practical alternatives to screen, or even eliminate, asphalt mixtures that result in poor cracking performance once placed in the field.

Research Methods

Evaluation of field materials for asphalt mixture performance testing involves collecting asphalt mixtures from paving projects across the state of Utah, compacting these asphalt mixtures in the lab, and then testing them using the BBR and the SCB tests. The specific steps to be followed include:

Sample Collection – Using the same resources currently used as part of the quality control process, asphalt mixtures will be collected in the field from the windrow prior to the paver. The asphalt mixtures will be stored in sealed metal buckets and transported to the laboratory. Projects from different regions, different traffic levels, and different materials will be sought.

Sample Preparation – The asphalt mixtures will be collected from a central storage facility at the Utah Department of Transportation and brought to the laboratory to be re-heated and compacted using the Superpave gyratory compactor (SGC). One SGC sample will used to create samples for BBR testing and two SGC samples will be used to create samples for SCB testing. This SGC samples will provide enough replicates to obtain accurate results.

Sample Testing – The SGC samples will be cut using established procedures to create the specimens with the required dimensions for testing in the BBR (small beams) and the SCB (semi-circle with a notch in the middle). Testing of the beams in the BBR will be done at 2 temperatures: PG +10 and PG +4, where PG is the performance grade temperature for the specific location of paving project according to the Long Term Pavement Performance Software LTPPBind. Testing in the SCB will be done at 25 ºC as per established protocols. The specific testing protocols to be followed are described in the corresponding AASHTO Provisional Standards.

Data Analysis – The results from BBR and SCB testing will be analyzed. Modulus and m-value at 60 and 120 seconds will be used as performance parameters for the BBR. Flexibility Index will be used as performance parameter for the SCB.

Field Performance Evaluation – The field performance of the sections where the corresponding asphalt mixtures were collected will be monitored for early cracking using Roadview Explorer (http://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:53,77013). Roadview Explorer is an online resource that allows to visually inspect the condition of any road in Utah without having to travel to the site ensuring both safety and conservation of resources. The quality of the image will easily allow for the identification of any cracks. Sections with early cracking will be noted. The images are usually updated every other year and are expected to be available for 2018.

Test evaluation – A comparison will be made between the results from the data analysis and the field performance to determine the ability of the BBR and SCB testing results to predict early distresses. High temperature mix properties from the Hamburg Wheel Tracking Device (WTD), available from the mix design process, will be analyzed to complement the low and intermediate temperature properties. Future funding might allow for long-term evaluation of these sections.

Expected Outcomes

The expected outcome of this work will be a practical understanding of the current low and intermediate temperature properties of mixtures produced and how they relate to the current mix design practices. Potentially, this will allow highway agencies to transition to performance-based materials specifications that would ensure optimal performance throughout the complete temperature range expected in the road. Such approach will allow for innovation and introduction of new materials by practitioners while minimizing the risk to the highway agencies. The impact of such specification would be significant economic savings; for example, extending the life of a road surface by just one year could results in at least a 10% savings in maintenance budgets which directly translates into millions of dollars.

Specific deliverables will include:

1. Report with project locations and mixture performance parameters (stiffness, m-value, flexibility index, and reported Hamburg WTD rut depth) of at least 5 projects.
2. Summary of property values and mix designs
3. Development of potential thresholds for the BBR and SCB tests based on short-term performance
4. Final Report on the effect of BBR and SCB testing on the performance specifications of asphalt mixtures

Relevance to Strategic Goals

State of Good Repair is one of the strategic goals of the USDOT. The results from this project will help develop new resources to help improve and sustain the conditions of the pavement infrastructure. The concepts developed from this project will allow highway agencies and industry partners to optimize the design of asphalt mixtures to improve its longevity and thus minimize the life cycle cost of the system.

This work focuses on two main goals of the MPC: 1- improve infrastructure design by allowing new performance based designs that reduce pavement damage and 2- increase infrastructure longevity by allowing advanced technologies and innovative materials that results in better pavement performance. As described in the outcomes, results from this project will reduce early pavement failures resulting in increased longevity.

Educational Benefits

At least one graduate student and one undergraduate student will be funding through this project. Students will be involved in all aspects of the project including sample preparation, sample testing, and data analyses. Beyond the obvious acquisition of knowledge, by being involved in the research they will have to present results and write journal articles on their discoveries, thus greatly improving their communication skills. At the end of their studies, these students will join the workforce as knowledgeable practitioners.

Tech Transfer

The main objective of this work is to allow for a balanced, longer lasting, asphalt mix design by means of performance testing. Technology transfer will be an integral component of this project since this work is part of a large project with partners both from state highway agencies (i.e., UDOT), and contractors (i.e., CME Material testing). There is already a UDOT advisory committee who would guide the process and ensure the technology will be applicable to the state department of transportation. Furthermore, the work will include publication in the leading journals and presentation in conferences such as the Transportation Research Board Meeting that occurs every January. The PI will work with MCP staff to advertise the results so that other interested parties can benefit from the technology being developed.

Work Plan

1. Sample Collection: Asphalt mixtures will be collected from windrow prior to the paver and stored in sealed buckets and transport to central location.
2. BBR sample testing: Prepare samples (compaction, cutting, conditioning) and test at 2 temperatures (PG + 10 and PG + 4) using the BBR. Report mix characteristics (stiffness and m-value)
3. SCB Sample testing: Prepare samples (compaction, cutting, conditioning) and test samples at 25 ºC using the SCB test. Report mix characteristics (flexibility index)
4. Short-Term Field Performance: Based on the location where the original samples were collected, evaluate the surface condition using Roadview Explorer looking for signs of cracking. Compare observed field performance to measured properties.
5. Final Report Document: Summarize data and present findings at national/international forums (e.g., TRB) and develop final report. Store data in a proper location as described in the data management plan.

Evaluation of field materials for asphalt mixture performance testing involves collecting asphalt mixtures from paving projects across the state of Utah then preparing mixture samples and testing them using the BBR and the SCB tests. The steps listed in the Research Methods section will be accomplished through a phased approach. The major tasks outlined have the corresponding duration (in months) and the expected completion data (measured from the start of the project). Note that some tasks will run concurrent.

Task 1 - 6 months - 6 months

Task 2 - 7 months - 9 months

Task 3 - 7 months - 10 months

Task 4 - 3 months - 13 months

Task 5 - 3 months - 16 months

Project Cost

Total Project Costs:	$180,000
MPC Funds Requested:	$ 60,000
Matching Funds:	$120,000
Source of Matching Funds:	Utah Department of Transportation

References

Romero, P.: "Using the Bending Beam Rheometer for Low Temperature Testing of Asphalt Mixtures." Report UT-16-09. Utah Department of Transportation, July 2016

VanFrank, K., VanMilligen, M., and Biel, T.:"Intermediate Temperature Cracking in HMA: Phase I, Semi-Circular Bending Practicality Evaluation." Report UT-17-01. February 2017