NEW ENGLAND TRANSPORTATION CONSORTIUM
RESEARCH PROBLEM STATEMENT

Due to netc@ctcandassociates.com by January 25, 2019

I. PROBLEM TITLE

Adaptation of the Semi-Circular Bend Test for New England Conditions

II. RESEARCH PROBLEM STATEMENT

Cracking – both environmental and load related - is a primary concern for asphalt pavements in New England. Cracking affects ride quality and allows water to penetrate from the surface to underlying soil layers, decreasing the life of the pavement and requiring more frequent maintenance or rehabilitation. Presently, New England DOTs primarily rely upon the performance grading of the binder to ensure the appropriate selection of materials to resist cracking in the field. Research has shown the importance of evaluating the mixture properties to include the effect of aggregate structure and minerology on cracking performance and various performance-related cracking tests are available for use.

The semi-circular bend (SCB) test has been gaining recognition over the last few years as a relatively simple and quick test that can be related to field performance. Several New England states have been investigating the Illinois method for the SCB test (I-FIT, AASHTO TP 124) as part of ongoing research and balanced mix design (BMD) efforts. However, the current SCB protocol was developed and validated using materials and conditions in the Illinois area, which are not necessarily representative of the conditions that exist in New England. Specifically, the test temperature and loading rate for this test may not be suitable for New England region as shown in previous research (Haslett et al. 2017, Chen et al. 2018). Additionally, the associated threshold values (flexibility index, FI) were developed only for short-term aged mixtures. Recent research (Haslett et al. 2017, Chen et al. 2018) has shown that the FI values obtained from the SCB test can change significantly after aging and that those changes are mix-dependent.

III. RESEARCH OBJECTIVES

The objectives of this project are to:

1. Gather existing SCB test data and field performance for New England mixtures; sample additional mixtures for testing to cover representative mixtures across all New England states.
2. Evaluate the current testing conditions (temperature and loading rate), analysis methods, index and threshold values for the I-FIT test for New England conditions.

3. Develop an aging protocol to use with AASHTO TP124 SCB test to identify crack susceptible mixtures for use in BMD approaches and/or performance-related specifications.
4. Develop a draft specification (adjustments to AASHTO TP 124) and suggested threshold values for SCB testing in New England conditions.

IV. COST ESTIMATE

$200,000

V. RESEARCH PERIOD

24 months

VI. URGENCY AND PAYOFF POTENTIAL

The results of this project will help New England DOTs improve the design specifications for asphalt mixtures to resist cracking, resulting in long term cost savings and better ride quality. The experimental study will provide agencies and industry with information on cracking characteristics of mixtures including different percentages of RAP, different binder grades, binder modifiers, and different aging conditions. Additionally, life cycle costs will be decreased as less frequent maintenance and rehabilitation will be needed. Improved ride quality will result in decreased fuel costs for users.

VII. PRELIMINARY LITERATURE SEARCH

Semi-Circular Bend (SCB) testing is gaining popularity as a cracking performance test within the asphalt industry. There have been many proposed testing protocols and analysis methods that utilize SCB geometry to evaluate the cracking performance of asphalt mixtures. For example, work conducted by Louisiana Transportation Research Centre (Mohammad et al., 2012), where analysis of the test results is accomplished using critical strain energy rate (J-integral) approach (AASHTO TP105). Work performed by Li & Marasteanu in 2005 investigated the use of SCB as a low temperature fracture test to determine fracture energy and the stress intensity factor. A third and more common testing protocol was developed by the Illinois Centre for Transportation, frequently referred to as the Illinois Flexibility Index Test (I-FIT) (Ozer et al., 2016).

The I-FIT test was originally developed with the purpose of discriminating the cracking performance of mixtures with varying amounts of recycled asphalt pavement/shingles (RAP/RAS) (Al-Qadi et al., 2015). To rank mixtures through I-FIT results, the fracture energies (area under the force-LLD curve divided by the ligament area) of different mixtures were compared. Due to poor discrimination between mixtures from fracture energy alone, other possible influential parameters from the force-LLD curve on the fracture process zone (FPZ) such as the peak load, the slope at the inflection point, and critical displacement were investigated (Al-Qadi et al., 2015). As a result, the flexibility index (FI), which is an engineering parameter, was developed to correlate the crack growth velocity and the brittleness of the mixtures. However, I-

FIT testing protocol was developed and validated using materials and conditions in the Illinois area, which are not necessarily representative of the conditions that exist in New England. Additionally, the associated threshold values (flexibility index) were developed only for short term aged mixtures.

Recent research has shown that the flexibility (FI) values obtained from the SCB test can change significantly after aging and that those changes are mixture dependent. Work by Chen et al., explored SCB testing on both short and long term aged asphalt mixtures to evaluate FI and its reliability as a fatigue resistance indicator. Results showed a significant reduction in FI fatigue resistance after long term aging and researchers determined that FI could not be used alone and as a sole indicator of fatigue performance but rather a combination of two indexes that incorporate mix toughness and ductility, and a strength or stiffness based index (Chen et al., 2018).

Furthermore, in many instances FI results in a relatively high coefficient of variation (COV) among the replicates, which can significantly reduce the practicality of using this parameter for routine use. The high COV results from the fact that the m-value is derived from the shape of the post-peak segment of the force-LLD curve and is highly sensitive to the gradation, density and air void distribution within the specimen, as well as other random variables such as operator variability etc. (Al-Qadi et al., 2015). For the same reasons, the FI may not be able to discriminate the performance of brittle or long- term aged mixture, as these mixtures may exhibit steep post peak curves resulting in indeterminate or quite low FI values (as low as 1) (Kaseer et al., 2018).

Other studies have also indicated that the FI may not be sensitive to variations in asphalt content (Zhou et al., 2017). In a similar study Li et al. (2008) investigated the use of SCB as cracking performance test and showed that the analysis from the experimental data indicates that fracture energy is strongly dependent upon temperature and significantly affected by type of aggregate and binder modifier (Li et al., 2008). In the current practice, test temperature and loading rate as recommended by I-FIT testing protocol may not be suitable for New England regions as shown by previous researchers (Haslett et al., 2017 and Félix et al., 2013).

Therefore, it is essential that the current AASHTO TP124 testing protocol be evaluated in terms of testing conditions (temperature and loading rate), analysis method, index and threshold values for typical New England Mixtures. Research as part of this study will build upon the current testing procedure and determine suitable threshold values for New England mixture properties to aid in the effort of incorporating SCB testing in BMD. It will also focus on the development and incorporation of a long term aging protocol to evaluate the field performance mixtures subject to New England climatic conditions.

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VIII. RESEARCH KEY WORDS

Semi-Circular Bend Test, Fracture Energy, Flexibility Index, I-FIT, Long-term aging

TWO DOT ENDORSEMENTS ARE REQUIRED (To be signed by separate individuals.)

IX. ENDORSEMENT BY THE SPONSORING DOT (To be signed by the DOT representative to the NETC Advisory Committee through whom the Problem Statement is submitted.)

By signing the endorsement, the DOT representative is certifying that:

1. *The Problem Statement follows the required format.*
2. *The required literature search has been conducted.*
3. *The Problem Statement addresses a transportation issue of relevance to NETC and does not duplicate another Problem Statement being submitted at this time.*

A EMILY PARICANY — Name

VERMONT AOT — DOT

A Emily Parkany — Signature

1/24/19 — Date

X. ENDORSEMENT BY A SECOND EMPLOYEE OF THE SPONSORING DOT who agrees to chair the project's technical advisory committee (TAC) if the Problem Statement is selected for funding. (To be signed by a DOT staff person who has technical knowledge of the project topic and is committed to the research outcome.)

DOT Technical Endorsement: *I agree to chair the project's Technical Advisory Committee if this Problem Statement is selected for funding by NETC.*

Aaron Schwartz — Name

Vermont AOT — DOT

Aaron Schwartz — Signature

1/24/2019 — Date

NOTE: To expedite the processing of Research Problem Statements, NETC requires submittal by e-mail (netc@ctcandassociates.com) by January 25, 2019.