NEW ENGLAND TRANSPORTATION CONSORTIUM
QUARTERLY PROJECT PROGRESS REPORT

A. PROJECT NUMBER AND TITLE: NETC 15-3

B. PRINCIPAL INVESTIGATOR(s) & UNIVERSITY(s): Eshan V. Dave, University of New Hampshire

C. WEB SITE ADDRESS (*If one exists*):

D. START DATE (*Per NETC Agreement*): 8/1/2016

E. END DATE (*Per NETC Agreement*): 7/31/2018

F. **ANTICIPATED COMPLETION DATE: 7/31/2018**

G. PROJECT OBJECTIVES:

1. Evaluate good and poor performing asphalt mixtures in New England and determine mechanisms responsible for poor performing mixtures
2. Determine impacts of remedial measures (anti-stripping additives and hydrated lime) in reducing moisture susceptibility of poor performing mixtures
3. Assess impacts of moisture induced-damage on pavement performance and service life
4. Recommend an evaluation framework consisting of appropriate test procedure(s), specification, analysis procedure verified with field performance data that is reliable and suitable for moisture susceptibility testing of asphalt mixtures used in New England

H. REPORT PERIOD: 10/1/2017 – 12/31/2017

I. ACCOMPLISHMENTS THIS PERIOD:

The majority of the work performed this quarter was focused on production of laboratory specimens and conducting laboratory tests. As of the writing of this report, all of the specimen production and fabrication (which includes indirect tensile strength (ITS), Hamburg wheel tracker, dynamic modulus, semi-circular bend (SCB), and disk-shaped compact tension (DCT) specimens for a total of almost 300 specimens) has been completed.

In terms of laboratory testing, progress was made on completing the ITS evaluation as five mixes were tested for ITS with MiST conditioning and two mixes were tested in the unconditioned and AASHTO T283 conditioned state. The only ITS testing that remains is the last two mixes with MiST conditioning, which is expected to be completed in the upcoming quarter. Progress was also made towards the dynamic modulus testing goals as well. In this quarter, the unconditioned dynamic modulus was measured on an additional seven mixtures as well as dynamic modulus with MiST conditioning being measured on three mixtures. Currently, the remaining seven mixtures are undergoing the MiST process and are expected to be finished during the upcoming quarter. Figure 1 shows the measured dynamic modulus data from the three Vermont mixtures that have been tested both unconditioned and MiST conditioned. The left side of the figure shows the unconditioned and MiST conditioned dynamic modulus master curves for the three mixes while the right side shows the dynamic modulus ratio, which represents the ratio of the MiST conditioned stiffness to the unconditioned stiffness at certain frequencies along the master curve. It can be seen that dynamic modulus appears to be able to clearly distinguish the difference between the poor and good performing mixtures in terms of both the relative drop on the master curve as well as the dynamic modulus ratio. It also appears to show a difference between the poor mixtures with and without anti-strip additives. Further dynamic modulus testing and analysis will be performed this quarter.

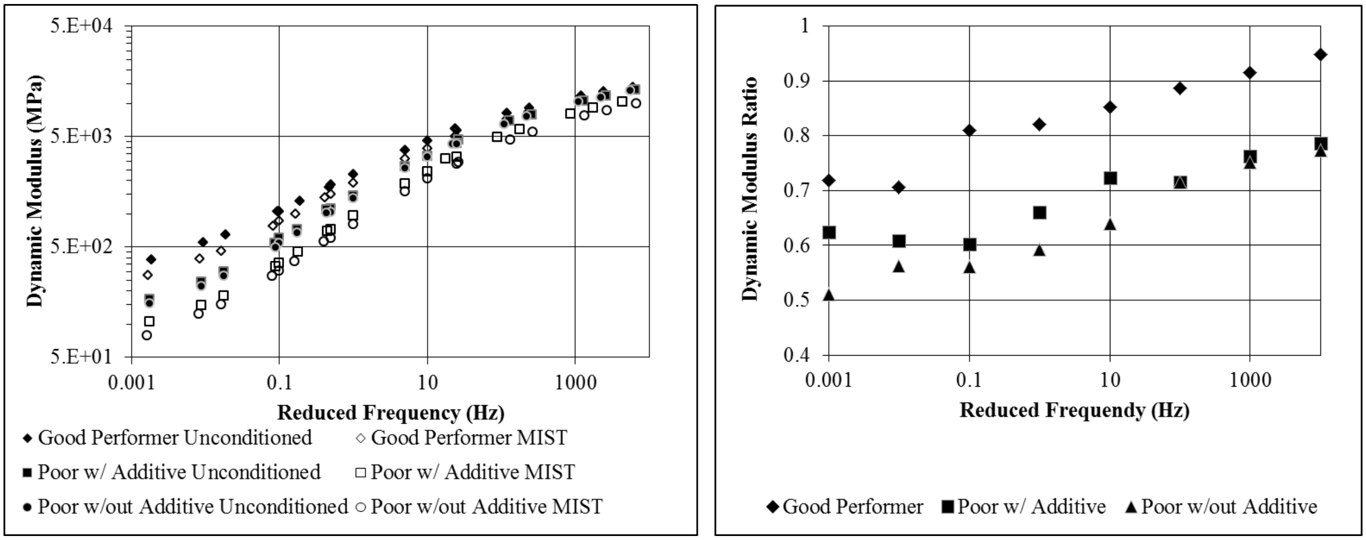


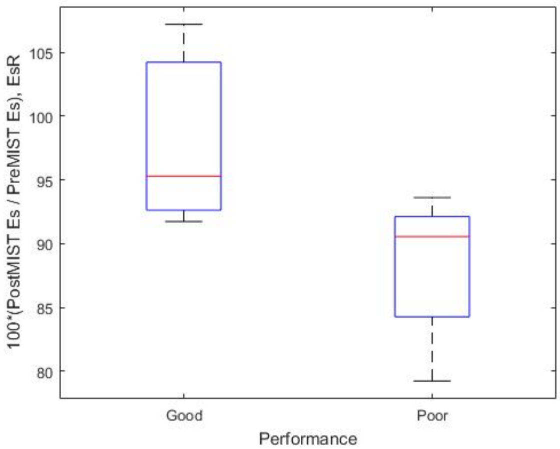
Figure 1: Dynamic Modulus Master Curve and Dynamic Modulus Ratio Results for the Vermont Mixtures

Another significant accomplishment of this quarter was that all of the fabrication and testing for the Hamburg wheel tracker testing has been completed by the MaineDOT materials lab. All of the results have been received by the research team and further data analysis will occur in the upcoming quarter.

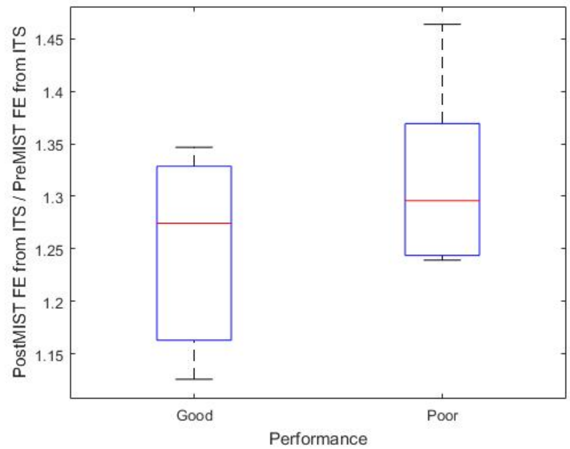
Significant progress has been made on sample fabrication and completing the seismic modulus (Es) testing on the majority of samples. The results are shown in Figure 2. The seismic modulus ratio (EsR) was estimated as the ratio of post MiST Es to the pre MiST Es. It can be seen that there is a large difference in EsR between the good performing (VTG1, MEG1, MEW1) and the poor performing mixes (VTP1, VTP2, MEP1, MEM1 and CTG1). The only seismic modulus testing pending is the last two mixes with MiST conditioning which is expected to be completed in the upcoming quarter.

Further analysis on calculating fracture energy (FE) from ITS test results were carried out and presented in this quarter (Figure 2b). Fracture Energy –ITS ratio has been calculated by taking the ratio of post MiST fracture energy from ITS test results to pre MiST ITS results. It can be seen that there is variation between good and poor performing mixes.

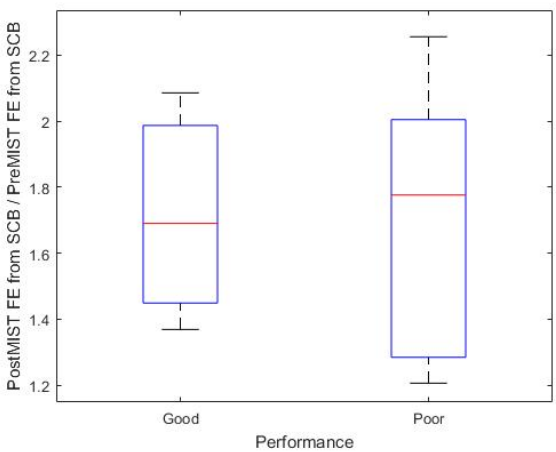
In this quarter semi-circular bending (SCB) tests were carried out with MiST conditioning at 60^{o}C and parameters such as fracture energy and flexibility index (FI) for all eight mixes were found out (The ratio of post MiST to pre MiST of FE and FI are shown in Figure 2c and 2d respectively). The hypothesis made (in the last quarter) due to the increase in fracture energy after moisture conditioning at high temperature was checked by testing one set of poor and good performing mix after MiST conditioning at 25^{o}C. The SCB testing was conducted after MiST conditioning at 25^{o}C. The poor performing mix followed similar trend showing an increase in FE whereas FE decreased for a good performing mix. A few more testing and updating of testing and conditioning plan are required which are expected to be completed in the next quarter.



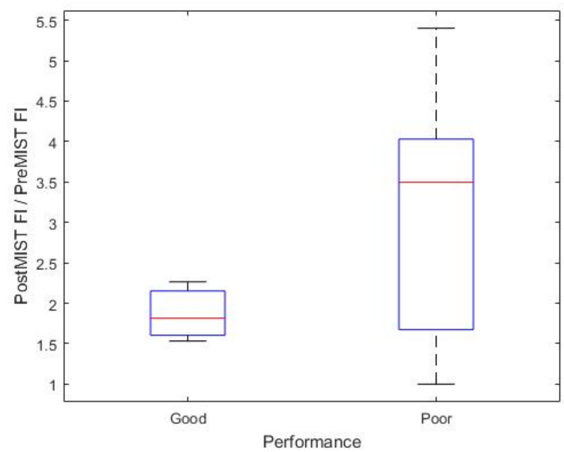
a) Seismic modulus (Es) ratio



b) Fracture Energy –ITS ratio



c) Fracture Energy –SCB ratio



d) Flexibility index ratio

Figure 2: Test results for good and poor performing mixes from Vermont

Lastly, preliminary work for the proposed freeze-thaw conditioning procedure was performed this quarter. As of the writing of this report, an environmental chamber capable of simulating freeze-thaw cycling has been selected and tested using thermocouple specimens. Further testing of the environmental chamber will occur in the coming weeks to verify that specimens inside the chamber are experiencing the freeze-thaw cycling is occurring at the temperatures and durations that the environmental chamber is programmed for. Additionally, climatic data analysis has been performed to determine a representative annual freeze-thaw cycle for each of the mixes in this study. This includes writing a macro in excel to determine the average annual number of freeze-thaw cycles as well as the average high and low temperatures during those freeze-thaw cycles based off of historic climate data outputs (in the form of pavement temperature) from PavementME. Ultimately, these parameters will be determined for each mixtures in the study (based off of the climatic data from the station nearest to the location of the plant the mixes were sampled at) and used to perform the freeze-thaw conditioning procedure. The freeze-thaw conditioning will be paired with DCT and SCB specimens, which is expected to occur (including testing) during the upcoming quarter.

Lastly, Table 1 gives an overall summary of the current state of laboratory production and testing. It is expected that all laboratory testing will be completed during the upcoming quarter.

Table 1: Summary of Testing Progress

	Mix:	VTG1	VTP1	VTP2	MEG1	MEW1	MEM1	MEP1	MEP2	CTG1	NHG1
Test Procedure	Performance Description:	Good	Poor w/ AS	Poor w/out AS	Good	Good	Poor	Poor w/out AS	Poor w/ AS	Poor w/ AS	Good
	Sampled?:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ITS	Unconditioned	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	T283	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	MIST@ 60C	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
	MIST @ 25 C	No	No	No	Yes	No	No	Yes	No	No	No
Dynamic Modulus	Unconditioned	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	MIST @ 60C	Yes	Yes	Yes	No	No	No	No	No	No	No
	MIST @ 25C	No	No	No	No	No	No	No	No	No	No
SCB-WPI	Compaction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Unconditioned	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	MIST @ 60C	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	MIST @ 25C	No	No	No	Yes	No	No	Yes	No	No	No
	Freeze-Thaw	No	No	No	No	No	No	No	No	No	No
UPV	Compaction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Unconditioned	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	MIST @ 60C	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	MIST @ 25C	No	No	No	Yes	No	No	Yes	No	No	No
DCT	Compaction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Unconditioned	No	No	No	No	No	No	No	No	No	No
	Freeze-Thaw	No	No	No	No	No	No	No	No	No	No
Hamburg	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Green indicates samples have been prepared and tested

ellow indicates that specimens have been prepared and possibly conditioned, but not teste

Red indicated specimens have not been produced yet

J. PROBLEMS ENCOUNTERED (If any):

No significant problems were encountered during this quarter.

K. TECHNOLOGY TRANSFER ACTIVITIES:

No activity to report.

L. STATUS BY TASK:

Task 1: State of the Practice and Literature Review: All work for Task 1 has been completed. A report for this task was submitted with a previous quarterly report.

Task 2: Identify and Inspect Moisture Susceptible Mixes and Develop Testing Plan: All of the work for Task 2 has been completed.

Task 3: Laboratory Testing: Significant amounts of laboratory testing was completed during this quarter. For all ten mixtures that have been sampled, compaction characteristics and volumetric testing has been completed. All ten of these mixtures have been tested for indirect tensile strength with both unconditioned specimens and specimens conditioned using AASHTO T-283 as well as eight of the mixtures having been tested for indirect tensile strength with MiST conditioning. Most of the mixtures have been tested for dynamic modulus in an unconditioned state while a few have been tested with MiST conditioning. In addition, all of the Hamburg wheel tracker testing and preliminary work for the freeze-thaw conditioning has been completed. Seismic modulus testing has been carried out for eight of the mixtures with unconditioned and MiST conditioned specimens. Most of the mixtures have had semi-circular bending tests with unconditioned and MiST conditioned samples conducted.

Task 4: Final Report and Recommendations: This quarterly report serves as the deliverable for the reported calendar quarter. No other activity is reported.

M. PERCENT COMPLETION OF TOTAL PROJECT: ____67_____%

N. ACTIVITIES PLANNED FOR NEXT QUARTER:

- Complete the remaining laboratory testing:
  - Conditioning: MiST (at both 25 and 60˚C) and Multi-cycle Freeze-Thaw; Mechanical Characterization: Indirect tensile strength, dynamic modulus, seismic modulus, and fracture parameters from the semi-circular bend (SCB) and disk-shaped compact tension (DCT) tests.
- Continue conducting data analysis on laboratory results to assess changes in mechanical characteristics of mixtures due to laboratory moisture conditioning. Begin comparative evaluation of mixtures in terms of test results.
- Conduct Pavement life evaluations using both PavementME and IlliTC to determine potential loss of life due to moisture damage.
- Develop preliminary recommendations for the lab procedure to be used by New England DOTs for screening of moisture susceptible asphalt mixtures.

O. FINANCIAL STATUS:
As of: *12/31/2017*
Total Project Budget: $ 150,000
Total Estimated Expenditures: $ 99,000

<u>Note: This report should not require more than 2-3 pages & should be e-mailed to the NETC Coordinator so as to arrive no later than three (3) working days after the end of each calendar quarter.</u>