**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: 1/1/2018 – 3/31/2018**

**I. ACCOMPLISHMENTS THIS PERIOD:**

The majority of the work performed this quarter was focused on the finalization of the laboratory testing and data analysis. As of the writing of this report, all of the indirect tensile strength, Hamburg wheel tracker, and semi-circular bend testing has been completed while a majority of the dynamic modulus and disk-shaped compact tension testing has been completed. A web-meeting was held for the project TAC on March 9th. Lab results and preliminary recommendations from the study were presented to TAC and feedback was obtained. The feedback is being utilized in the final stages of research activities as well as in preparation of final project deliverables.

In terms of laboratory testing, the most significant progress made during the last quarter was the beginning of the disk-shaped compact tension test (DCT) as well as conducting semi-circular bend (SCB) and ultra-sonic pulse velocity (UPV) testing for two mixes – MEP2 and NHG1. The DCT testing was paired with a simulative multi-cycle freeze-thaw conditioning protocol, which was also developed during this quarter. This conditioning protocol was intended to simulate the in-place temperatures a pavement would experience during the fall, winter, and spring months in various locations throughout New England. This was done by analyzing Enhanced Integrated Climatic Model (EICM) files to calculate the average annual freeze-thaw cycles as well as the average maximum and minimum temperatures of those cycles. These three parameters were then programmed into an environmental chamber, which simulated these cycles at an accelerated pace.

Another significant accomplishment during this quarter was the completion of the Hamburg data analysis. All of the Hamburg testing for this project was carried out by MaineDOT with their wheel tracking device. MaineDOT also provided their in-house spreadsheets to perform the traditional Hamburg data analysis, which were the final rut depth and stripping inflection point values. In addition to this, a relatively new method to analyze Hamburg results that was developed by researchers at the Texas Transportation Institute (TTI) was used. This method aims to split the damage accumulated during the Hamburg test into rut damage and stripping damage. This allows both to be analyzed separately, allowing fairer and more consistent comparisons between materials.

Figure 1 shows Hamburg results from seven mixtures. In both cases, mixes shown with red bars indicate this mix is considered a poor performer, orange indicates it is a poor-moderate performer, and blue indicates that the mix is a good performer. On the left, the results from traditional Hamburg analysis is shown. On the right are results from the TTI method. As can be seen, both methods appear to show clear distinction between good and poor performing materials. In addition, the results also indicate that the Hamburg is also able to distinguish between mixes with and without anti-strip additives (MEP1 vs MEP2, for example).

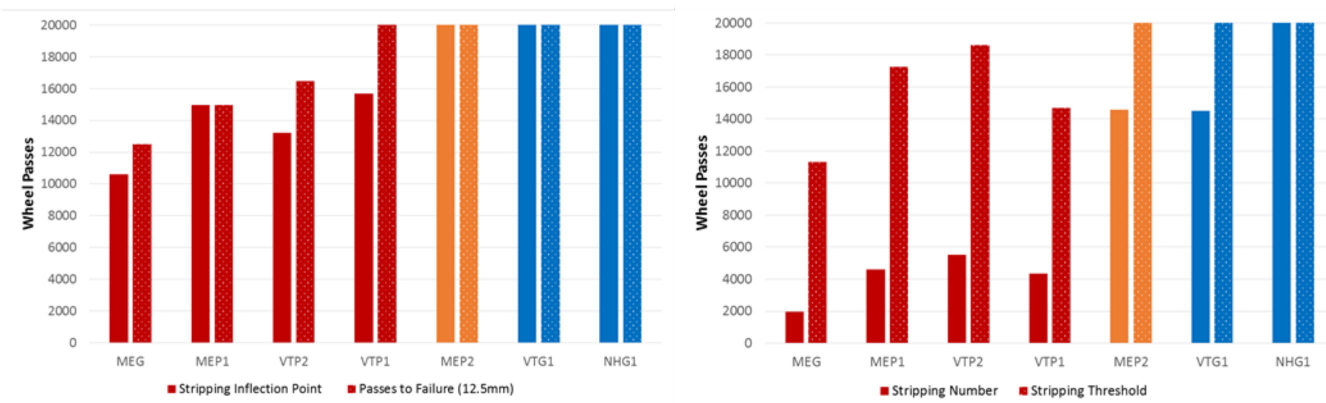


***Figure 1: Hamburg Wheel Tracker Results. (Left-Traditional Analysis, Right-TTI Method Analysis)***

A summary of SCB and UPV test results is presented in Table 1 and 2. As seen in results the currently used fracture energy and flexibility index measures for the SCB test did not discriminate the moisture conditioned state (specifically, both properties increased after moisture condition). At present, researchers are exploring additional measures that can be evaluated using fracture test results to determine if other measures are able to discriminate moisture conditioning in meaningful manner. Mix moduli values measured using UPV showed a reduction after MIST conditioning. This is in agreement with the dynamic modulus measurements.

Another significant accomplishment of this quarter was the beginning of PavementME analysis for the materials used in this study. This analysis was performed by using measured dynamic modulus values of unconditioned and moisture conditioned materials as input values for asphalt layers in the program. Two pavement sections (thin-low traffic, thick-high traffic) were analyzed with both conditioned and unconditioned materials. Analysis is still underway, but preliminary results suggest that the conditioned materials results in significantly shorter pavement lives and accelerated distress formation, particularly with rutting and bottom-up fatigue cracking.

Lastly, Table 3 gives an overall summary of the current state of laboratory production and testing.

***Table 1: Summary of SCB Results***

| Mix | Conditioning | Average or Standard Deviation (SD) | Fracture Energy- ($J/m^2$) | Flexibility Index (FI) |
|---|---|---|---|---|
| MEP2 | DRY SET | *Average* | 2005 | 26 |
| | | *SD* | 259 | 8 |
| | 60C Post-MIST | *Average* | 3077 | 69 |
| | | *SD* | 404 | 27 |
| | 25C Post-MIST | *Average* | 2480 | 28 |
| | | *SD* | 121 | 2 |
| NHG1 | DRY SET | *Average* | 1540 | 7 |
| | | *SD* | 205 | 2 |
| | 60C Post-MIST | *Average* | 2251 | 18 |
| | | *SD* | 125 | 2 |
| | 25C Post-MIST | *Average* | 1911 | 9 |
| | | *SD* | 176 | 2 |

***Table 2: Summary of UPV Results***

| MIST | Sample ID | Air Voids % | Avg. Travel Time (microsec) | | Unit Weight (pcf) | | Seismic Modulus (ksi) 25°C & 150kHz | | Design Modulus (ksi) 25°C & 150kHz | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pre-MIST | Post-MIST | Pre-MIST | Post-MIST | Pre-MIST | Post-MIST | Pre-MIST | Post-MIST |
| **Un-conditioned** | **MEP2-10** | 6.4 | 15.0 | NA | 141.5 | NA | 1767 | NA | 552 | NA |
| | **MEP2-8** | 6.3 | 15.3 | NA | 141.8 | NA | 1707 | NA | 534 | NA |
| | **MEP2-1** | 6.6 | 15.0 | NA | 141.3 | NA | 1774 | NA | 554 | NA |
| | ***Average*** | | | | | | ***1749*** | | | |
| | ***SD*** | | | | | | ***37*** | | | |
| **Conditioned (60°C)** | **MEP2-3** | 6.6 | 15.4 | 15.62 | 142.4 | 140 | 1683 | 1582 | 526 | 494 |
| | **MEP2-5** | 6.4 | 15.3 | 15.12 | 141.7 | 140 | 1722 | 1698 | 538 | 531 |
| | **MEP2-6** | 6.3 | 15.1 | 15.2 | 142.6 | 139 | 1753 | 1684 | 548 | 526 |
| | ***Average*** | | | | | | ***1719*** | ***1655*** | | |
| | ***SD*** | | | | | | ***35*** | ***63*** | | |
| **Conditioned (25°C)** | **MEP2-2** | 7.1 | 15.2 | 15.54 | 140.6 | 141.7 | 1720 | 1658 | 537 | 518 |
| | **MEP2-4** | 7.4 | 15.4 | 15.44 | 139.8 | 141.0 | 1683 | 1682 | 526 | 526 |
| | **MEP2-7** | 6.6 | 15.2 | 15.16 | 140.7 | 141.5 | 1727 | 1742 | 540 | 544 |
| | ***Average*** | | | | | | ***1710*** | ***1694*** | | |
| | ***SD*** | | | | | | ***24*** | ***43*** | | |
| **Un-conditioned** | **NHG-7** | 7.1 | 15.2 | NA | 141.2 | NA | 1716 | NA | 536 | NA |
| | **NHG-3** | 7.4 | 15.2 | NA | 140.8 | NA | 1711 | NA | 535 | NA |
| | **NHG-9** | 6.4 | 14.8 | NA | 141.8 | NA | 1818 | NA | 568 | NA |
| | ***Average*** | | | | | | ***1748*** | | | |
| | ***SD*** | | | | | | ***60*** | | | |
| **Conditioned (60°C)** | **NHG-2** | 6.9 | 15.2 | 15.28 | 141.2 | 143 | 1720 | 1713 | 537 | 535 |
| | **NHG-6** | 6.4 | 14.7 | 15.24 | 142.7 | 144 | 1848 | 1726 | 577 | 539 |
| | **NHG-8** | 7.1 | 15.0 | 15.88 | 141.6 | 143 | 1761 | 1576 | 550 | 493 |
| | ***Average*** | | | | | | ***1776*** | ***1671*** | | |
| | ***SD*** | | | | | | ***65*** | ***83*** | | |
| **Conditioned (25°C)** | **NHG-1** | 6.7 | 15.4 | 15.34 | 141.2 | 142.7 | 1674 | 1710 | 523 | 534 |
| | **NHG-4** | 7.5 | 15.4 | 15.34 | 140.7 | 141.5 | 1685 | 1698 | 527 | 531 |
| | **NHG-5** | 7.2 | 15.2 | 15.4 | 140.9 | 141.7 | 1708 | 1685 | 534 | 527 |
| | ***Average*** | | | | | | ***1689*** | ***1697*** | | |
| | ***SD*** | | | | | | ***17*** | ***12*** | | |

*Table 3: 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 @ 25C | No | No | No | Yes | No | No | Yes | Yes | No | Yes |
| 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 | Compaction | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Unconditioned | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | MIST @ 60C | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Freeze-Thaw | No | No | No | Yes | No | No | Yes | Yes | No | Yes |
| UPV | Compaction | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Unconditioned | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | MIST @ 60C | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | MIST @ 25C | No | No | No | Yes | No | No | Yes | Yes | No | Yes |
| 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 |
| Yellow indicates that specimens have been prepared and possibly conditioned, but not tested |
| 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, compaction characteristics and volumetric testing has been completed. In addition, a majority of the testing and data analysis has been completed. Only a select few tests remain to be completed (see Table 3 above), which are anticipated to occur during the beginning of the next quarter.

**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: ____80_____%

## N. ACTIVITIES PLANNED FOR NEXT QUARTER:

- Complete the remaining laboratory testing:
    - o Conditioning: MiST on remaining test samples; Mechanical Characterization: dynamic modulus, 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.
- Continue Pavement life evaluations using PavementME to determine potential loss of life due to moisture damage.
- Develop recommendations for the lab procedure to be used by New England DOTs for screening of moisture susceptible asphalt mixtures.
- Plan and schedule final TAC meeting for the project.
- Prepare final deliverables for NETC Technical committee

**O. FINANCIAL STATUS:**
**As of:** *3/31/2018*
**Total Project Budget: $ 150,000**
**Total Estimated Expenditures: $ 114,000**

***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.***