TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): New Hampshire DOT

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(230)	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ■Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 1 – December 31)

Project Title: **Evaluation of Plant-Produced High-Percentage RAP Mixtures in the Northeast**		
Name of Project Manager(s): **Jo Sias Daniel**	**Phone Number:** **603-862-3277**	**E-Mail** jo.daniel@unh.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:** **8/11/2010**
Original Project End Date: **12/31/2013**	**Current Project End Date:** **12/31/2013**	**Number of Extensions:** **0**

Project schedule status:

■ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
781,706	506,706	50%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	173,842	

Project Description:

Research Objectives

The objectives of this research project are to:

1. Evaluation the performance in terms of low temperature cracking, fatigue cracking, and moisture sensitivity of plant produced RAP mixtures in the laboratory and field.
2. Establish guidelines on when it is necessary to bump binder grades with RAP mixtures.
3. Provides further understanding of the blending that occurs between RAP and virgin binder in plant-produced mixtures.
4. Refine fatigue failure criteria for RAP mixtures that can be used in the simplified Viscoelastic Continuum Damage (S-VECD) model.

Research Plan

The research plan is broken down into two phases. Phase I will focus on evaluating the effects of binder grade and plant type on the properties of mixtures with various percentages of RAP. Phase II of the study will be geared towards evaluating the fatigue failure criteria in the S-VECD model.

The following tasks will be required to achieve the research objectives for both phases of this project:

1. Producing Plant Mixtures.
2. Testing and Analysis of Asphalt Binders and Mixtures.
3. Construction and Evaluation of Field Test Sections.
4. Reporting.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Testing of the Phase I mixtures has been completed and the majority of the analysis of the data has been done. Findings based on the analysis conducted to date are summarized in the Significant Results section below.

Dynamic modulus, fatigue, and TSRST testing of the Phase II silo storage study mixtures has been completed. Binder extraction and recovery was conducted by MTE Services, Inc. PG grading and G* master curves were done for the extracted binders. Findings of the analysis conducted to date are summarized in the Significant Results section below.

Controlled crosshead (CX) fatigue testing for the fatigue failure criteria study has continued.

Five tables showing the up-to-date status of all the binder, mixture and field cores testing are presented in Appendix A

A presentation on the silo storage study and Phase I results was given at the RAP Expert Task Group meeting in Arlington, VA on July 24. This presentation is attached in Appendix B of this report.

Anticipated work next quarter:

A. Binder Testing

All the binder testing relative to the Phase I and Phase II binders available (PIKE is still working on the extraction and recovery for the VA mixtures) will be completed.

The testing data will be accordingly reduced and analyzed.

B. Mixture Testing

Continued testing and analysis of Phase II mixtures, including new 0% RAP silo storage study mixtures once they are sampled.

A comparison study on low temperature creep and strength testing performed in uniaxial and IDT mode will be performed.

Complete the CX fatigue testing for all the Phase I VT mixtures (including VTe00LC, VTe20LC, VTe30LC and, VTe40LC) for all four temperatures (7°C, 13°C, 20°C and 27 °C). Begin the CX fatigue testing for the other plants' mixtures.

Additional mixtures from 2012 construction season will be gathered.

Significant Results:

Conclusions from the analysis conducted to date on the Phase I mixtures are summarized:

- Including higher RAP content in HMA generally decreases mixture compliance and increases dynamic and relaxation moduli.
- Using a softer binder grade may relatively increase mixture compliance and decrease dynamic and relaxation moduli.
- Plant production parameters such as silo storage time and discharge temperatures have an apparent effect on mixture properties.
- Many observed differences in relative behavior, while comparing different mixtures, were not statistically significant with the number of replicates used in this study.

- Including higher RAP contents in HMA mixtures generally leads to relatively warmer thermal cracking temperatures. Using softer binder grades can counteract this effect, but this was not observed for all mixtures.
- The fatigue behavior evaluated using the S-VECD approach does not show a clear trend with RAP content. For some mixtures, higher RAP contents and stiffer binder grades performed better than virgin mixtures. The relative ranking of different mixtures changes with the applied microstrain and/or stress level indicating the importance of considering the pavement structure in which the mixture is used.
- The cracking behavior evaluated using the overlay tester shows that higher RAP mixtures have a lower resistance to cracking.
- Specimens fabricated from reheated mix (lab compacted) were stiffer than those compacted hot at the time of production (plant compacted). There was an apparent effect of plant production and RAP on the amount of difference between plant compacted and lab compacted stiffnesses.

The findings to date from the silo storage study are summarized:

- The virgin mixtures showed a softening trend with storage time, which was later discovered to be a result of binder contamination. A new set of virgin silo storage study mixtures will be obtained.
- The 25% RAP mixtures show a trend of increasing stiffness and decreasing phase angle with time for both the plant and lab compacted specimens, however there are only statistically significant differences between the 0 hours and 10 hour curves at higher temperatures.
- Temperature Stress Restrained Specimen Tests (TSRST) testing shows an increasing (warming) trend in low temperature cracking values with silo storage time, but only the 0 hour and 7.5 hour times were significantly different.
- Extracted and recovered binder tests show stiffening with storage time for the G* master curves, high PG grade and low PG grade.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

In this quarter, the analysis of test results regarding the New York silo storage mixtures revealed a softening trend with respect to storage time for virgin mixtures. After binder grading and complex modulus testing revealed the same trend, the team sought additional production details from the Callanan (NY) plant. It was determined that PG 76-22 polymer modified binder had been mixed in with the PG 64-22 binder for the first several hundred tons of mixture. Therefore, the mixture sampled initially contained PG 76-22 asphalt while mixture sampled after several hours only contained PG 64-22 asphalt. A new set of virgin silo storage study mixtures will be collected.

Currently, the anticipated $150,000 contribution from FHWA has not been received. FHWA is working to get these funds for the pooled fund project, but the timeframe in which this will happen is unknown. In the interim, the research team is working with a reduced budget and scope. The research team will continue testing and analysis on the Phase I and 2011 Phase II mixtures. Mixtures will be collected for the 2012 construction season, but will not be tested until the budget situation is resolved.

Potential Implementation:

APPENDIX A

Phase I and Phase II Current Testing Status

(Binder, Mixtures and Field Cores)

Table A1. Phase I Binder and Aggregate Testing Status

Binder and Aggregate Testing																							
Test Description		Responsible Lab.	New York Mixtures							New Hampshire Mixtures					Vermont Mixtures								
			NYd00	NYd20	NYd30	NYd40	NYb30	NYb40	RAP	NHe00	NHe20	NHe30	NHe40	RAP	VTe00	VTe20	VTe30	VTe40	VTa00	VTa20	VTa30	VTa40	RAP
Binder Extraction and Recovery from Mixtures		Pike Ind.	Done	Done	Done	Done	Done	Done	In Progress	Done	Done	Done	Done	In Progress	Done	Done	Done	Done	Done	Done	Done	Done	In Progress
PG - grading (Including Critical Cracking Temp.)	Virgin Binders (Tank Supplied)	Rutgers	Done				Done		N/A	Done				N/A	Done				Done				N/A
	Ext.&Rec. Binders		Done	Done	Done	Done	Done	Done	In Progress	Done	Done	Done	Done	Not Started	Done	Done	Done	Done	Done	Done	Done	Done	In Progress
(ABCD) Asphalt Binder Cracking Device	Virgin Binders (Tank Supplied)	U-Mass	Done				Done		N/A	Done				N/A	Done				Done				N/A
	Ext.&Rec. Binders		Done	Done	Done	Done	Done	Done	Not Started	Done	Done	Done	Done	Not Started	Done	Done	Done	Done	Done	Done	Done	Done	Not Started
Binder Modulus (G*) & Binder Master Curve	Virgin Binders (Tank Supplied)	U-Mass	Done				Done		N/A	Done				N/A	Done				Done				N/A
	Ext.&Rec. Binders		Done	Done	Done	Done	Done	Done	In Progress	Done	Done	Done	Done	Not Started	Done	Done	Done	Done	Done	Done	Done	Done	In Progress
AASHTO T53 (Softening Point)	Virgin Binders (Tank Supplied)	Rutgers	N/A				N/A		N/A	N/A				N/A	N/A				N/A				N/A
	Ext.&Rec. Binders		N/A	N/A	N/A	N/A	N/A	N/A	In Progress	N/A	N/A	N/A	N/A	Not Started	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	In Progress

Table A2. Phase I Mixture Testing Status

Mixture Testing																						
Test Description		Responsible Lab.	New York Mixtures						New Hampshire Mixtures				Vermont Mixtures									
			NYd00	NYd20	NYd30	NYd40	NYb30	NYb40	NHe00	NHe20	NHe30	NHe40	VTe00	VTe20	VTe30	VTe40	VTa00	VTa20	VTa30	VTa40		
Dynamic Modulus (AMPT)	Lab Fabricated	Rutgers	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
	Plant Compacted		Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
Push-Pull Fatigue Test (S-VECD)	Lab Fabricated	UNH	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
	Plant Compacted	UNH	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
Low Temp. Creep Compliance and Strength	Lab Fabricated	UNH	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
AASHTO T283 (Moisture Damage)	Lab Fabricated	UNH	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
HWTD (Hamburg Wheel Tracking Device)	Lab Fabricated	U-Mass	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
Overlay tester	Lab Fabricated	Rutgers	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
TSRST	Lab Fabricated	U-Mass	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
Flexural Beam Fatigue	Lab Fabricated	Rutgers	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		
U-Mass Dartmouth Workability		U-Mass	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done		

Table A3. Phase II Binder and Aggregate Testing Status

Binder and Aggregate Testing																											
Test Description		Responsible Lab.	New Hampshire Mixtures							Virginia Mixtures					New York Mixtures										
			NHb00	NHb15	NHb25	NHa25	NHa30	NHa40	RAP	VAf00	VAf20	VAd30	VAd40	RAP	NYd00,0.0	NYd00,2.5	NYd00,5.0	NYd00,7.5	NYd25,0.0	NYd25,2.5	NYd25,5.0	NYd25,7.5	NYd25,10.0	RAP
Binder Extraction and Recovery from Mixtures		Pike Ind./MTE Services	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Not Started	Not Started	Not Started	Not Started	Not Started	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	Done	N/A
Binder Extraction and Recovery from Mixtures		FHWA	Done	Done	Done	Done	Done	Done	Done	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PG - grading (Including Critical Cracking Temp.)	Virgin Binders (Tank Supplied)	Rutgers	N/A							In Progress				N/A	N/A				N/A					N/A
	Ext.&Rec. Binders		N/A	N/A	N/A	N/A	N/A	N/A	N/A	Not Started	Not Started	Not Started	Not Started	Not Started	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	Done	N/A
PG - grading (Including Critical Cracking Temp.)	Virgin Binders (Tank Supplied)	FHWA	Done							In Progress				N/A	N/A				N/A					N/A
	Ext.&Rec. Binders		Done	Done	Done	Done	Done	Done	Done	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
(ABCD) Asphalt Binder Cracking Device	Virgin Binders (Tank Supplied)	U-Mass	N/A							Not Started				N/A	Not Started				Not Started					N/A
	Ext.&Rec. Binders		N/A	N/A	N/A	N/A	N/A	N/A	N/A	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started
Binder Modulus (G*) & Binder Master Curve	Virgin Binders (Tank Supplied)	U-Mass/MTE Services	N/A							Not Started				N/A	Not Started				Not Started					N/A
	Ext.&Rec. Binders		N/A	N/A	N/A	N/A	N/A	N/A	N/A	Not Started	Not Started	Not Started	Not Started	Not Started	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	Done	Not Started
Binder Modulus (G*) & Binder Master Curve	Virgin Binders (Tank Supplied)	FHWA	Done							N/A				N/A	N/A				N/A					N/A
	Ext.&Rec. Binders		Done	Done	Done	Done	Done	Done	Done	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AASHTO T53 (Softening Point)	Virgin Binders (Tank Supplied)	Rutgers	N/A							N/A				N/A	N/A				N/A					N/A
	Ext.&Rec. Binders		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Not Started	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Not Started

Table A4. Phase II Mixture Testing Status

Mixture Testing																									
	Test Description		Responsible Lab.	New Hampshire Mixtures						Virginia Mixtures				New York Mixtures										
				NHb00	NHb15	NHb25	NHa25	NHa30	NHa40	VAf00	VAf20	VAd30	VAd40	NYd00,0.0	NYd00,2.5	NYd00,5.0	NYd00,7.5	NYd25,0.0	NYd25,2.5	NYd25,5.0	NYd25,7.5	NYd25,10.0
	Dynamic Modulus (AMPT)	Lab Fabricated	Rutgers/UNH	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	Done
		Plant Compacted		In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	Not Started	Not Started	Not Started	Not Started	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	Done
	Dynamic Modulus (AMPT)	Plant Compacted	FHWA	Done	Done	Done	Done	Done	Done	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Dynamic Modulus (IDT)	Lab Fabricated	UNH	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started
		Plant Compacted		Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started
	Push-Pull Fatigue Test (S-VECD)	Lab Fabricated	UNH	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	Not Started	Not Started	Not Started	Not Started	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	Done
		Plant Compacted		In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started
	Low Temp. Creep Compliance and Strength	Lab Fabricated	UNH	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started
		Plant Compacted		Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started
	Overlay tester	Lab Fabricated	Rutgers	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress
	TSRST	Lab Fabricated	U-Mass	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	In Progress	In Progress	In Progress	In Progress	Done	Done	Done	Done	Done
	Flexural Beam Fatigue	Lab Fabricated	Rutgers	Done	Done	Done	Done	Done	Done	Done	Done	Done	Done	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress
	HWTD (Hamburg Wheel Tracking Device)	Lab Fabricated	U-Mass	Done	Done	Done	Done	Done	Done	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started
		Plant Compacted		Done	Done	Done	Done	Done	Done	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A5. Phase II Field Cores Testing Status

Field Cores Testing																						
	Test Description	Responsible Lab.	New Hampshire Mixtures						Virginia Mixtures				New York Mixtures									
			NHb00	NHb15	NHb25	NHa25	NHa30	NHa40	VAf00	VAf20	VAd30	VAd40	NYd00,0.0	NYd00,2.5	NYd00,5.0	NYd00,7.5	NYd25,0.0	NYd25,2.5	NYd25,5.0	NYd25,7.5	NYd25,10.0
	Dynamic Modulus (IDT)	UNH	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Low Temp. Creep Compliance and Strength	UNH	Not Started	Not Started	Not Started	Not Started	Not Started	Not Started	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

APPENDIX B

RAP Expert Task Group Meeting Presentation on Northeast RAP Pooled Fund Study (July 2012)