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):	**Phone Number:**	**E-Mail**
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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~~ Revised to 731,000	631,287	80%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	25,271	

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 three 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. Phase III is a laboratory study to isolate the effects of mixture variables without changing plant production variables.

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.):

During this quarter, the research team has focused on two tasks:

1. Phase III testing
2. Interim report summarizing the Phase I results

1. Phase III Testing Plan for the $100,000 FHWA Contribution

The research team finalized the Phase III testing plan (below) with the technical committee during a web meeting on May 17, 2013. The $100,000 FHWA contribution is still being processed.

UNH has acquired the raw materials for the mixtures and has begun fabricating specimens to send to the other laboratories for testing.

Phase III Testing Plan:

The testing plan proposed for Phase III consists of a laboratory study of 8-10 mixtures to evaluate the impacts of asphalt binder grade and asphalt content on the mixture properties. The laboratory study is proposed to allow for better control of production variables (temperature, gradation, short term aging). NH Phase I mixtures were selected for comparison with plant produced mixtures tested previously. The conditions to be tested are shown in Table 1. The impact of a combination of changing binder grade and adding additional asphalt cement (conditions in parenthesis) will only be evaluated after examining the results of changing binder grade and increasing asphalt content independently.

Table 2 shows the corresponding binder replacement values and equivalent percent credit given for the RAP binders for the different asphalt contents shown in Table 1.

Table 1. Laboratory Test Mixtures

Mixture	Asphalt content	RAP Content (total weight)		
		0	20	40
NH Pike Mixture from Phase I, 12.5 mm	optimum	PG 64-28	PG 64-28 PG58-28	PG 64-28 PG 58-28
	+0.5%	-	PG 64-28	PG 64-28 (PG 58-28)
	+1.0%	-	-	PG 64-28 (PG 58-28)

Table 2. Percent Binder Replacement and Percent RAP Credit Values

		Optimum	+0.5%	+1.0%
% binder replacement	20% RAP	16.8	15.5	-
	40% RAP	33.7	31.0	28.7
RAP credit	20% RAP	100%	47.9%	-
	40% RAP	100%	74.0%	47.9%

Laboratory Specimen Fabrication Procedures

All specimens will be fabricated in the UNH laboratory for consistency and to minimize shipping costs. Laboratory procedures are summarized:

- Aggregate stockpiles will be dried and sieved into individual size components for batching of individual specimen sizes.
- Aggregates will be heated to mixing temperature for at least 4 hours prior to mixing. The mixing temperatures used in the plant production will be used for heating the aggregate (approx. 330 F).
- Asphalt cement will be heated to mixing temperature; it will be discarded after 3 hours at mixing temperature and will not be reheated once it has been heated to mixing temperature.
- RAP will be air dried on a flat sheet for 24 hours prior to mixing.
- RAP will be heated to 60C for 2 hours prior to being mixed with the virgin aggregate and asphalt.
- RAP, virgin aggregate, and asphalt will be mixed together for 2 minutes using a bucket mixer.
- Mixtures will be short-term oven aged for 2 hours at compaction temperature.
- Mixtures will be compacted to create specimens of appropriate geometry and air void content using a Superpave Gyratory Compactor.
- Specimens will be cored to appropriate diameter prior to being shipped.
- Testing labs will trim specimens to appropriate height.

Testing

Table 3. Binder Testing (Virgin & Extracted)

Test/Test Parameter	Test Method/Reference	Title	Lab
Extraction and Recovery			Rutgers
Performance Grade	AASHTO R29 & AASHTO M320	Grading or Verifying the Performance Grade of an Asphalt Binder & Performance-Graded Asphalt Binder	Rutgers
Binder Modulus (G*) & Binder Master Curve			Rutgers
Critical Cracking Temperature	AASHTO R49-09	Determination of Low-Temperature Performance Grade (PG) of Asphalt Binders	Rutgers

Table 4. Mixture Testing			
Test/Test Parameter	**Test Method/Reference**	**Title**	**Lab**
SGC Compaction Volumetrics		Specimens compacted to design gyration level and measurement of volumetrics	UNH
Dynamic Modulus	AASHTO TP 62	Determining Dynamic Modulus of Hot Mix Asphalt Concrete Specimens	NCSU
Fatigue Test	Push-Pull Fatigue (S-VECD)	Proposed Standard Method of Test for Determining the Damage Characteristic Curve of Asphalt Concrete from Direct Tension Cyclic Fatigue Tests	NCSU
Permanent Deformation		Triaxial Stress Sweep	NCSU
Low Temperature Cracking		Thermal Stress Restrained Specimen Test (TSRST)	UMass

2. Interim Report

The research team is in the process of writing the interim report summarizing the Phase I testing results. During this process, the research team discussed concerns with the results from the testing on the extracted and recovered binders. During testing, both Rutgers and UMass Dartmouth laboratories suspected the presence of residual solvents in some of the materials based on a noticeable odor and visual sheen on the surface of the materials. Some of the original binder testing results do not follow expected trends with increasing RAP contents. Because of this, the research team decided that new extraction and recoveries should be performed to verify the results. Rutgers has recently acquired the necessary equipment for this work and is performing the extraction and recoveries on plant produced, plant compacted specimens (not reheated) and PG grading the material. To date, the testing on the NY and VT mixtures and the results have been completed and show some significant differences as compared to the original testing. The results are summarized in the following results section.

The research team will complete the analysis of the Phase I mixtures including all of the new binder testing for inclusion in the interim report. For this reason, the interim report will be submitted next quarter instead of this quarter, as originally planned.

Anticipated work next quarter:

1. Interim Report that includes data, analysis, and preliminary conclusions from the Phase I mixtures will be finalized and submitted to the technical committee for review
2. Finalize transition of $100,000 FHWA contribution to pooled fund
3. Finish specimen fabrication of Phase III test specimens
4. Begin testing and analysis of Phase III test specimens
5. Develop scope and budget for future tasks, formally add these tasks to the project and solicit funding
6. Continue testing remaining Phase II mixtures

Significant Results:

Significant results this quarter include the results of the testing of new extracted and recovered binders from the Phase I mixtures and the results of the survey sent to the contractors and states. These results are summarized in the two sections below.

1. New Binder Testing on Phase I Mixtures

During Phase I of this project, Pike Industries, Inc. performed the extractions and recoveries on the mixtures and the materials were shipped to Rutgers and UMass Dartmouth for testing. Pike also conducted testing on some of the extracted material following their own procedures in their lab. Both Rutgers and UMass Dartmouth laboratories suspected the presence of residual solvents in some of the recovered binders based on a noticeable odor and visual sheen on the surface of the materials. The resulting binder testing results did not follow expected trends with increasing RAP contents. Because of this, the research team decided that new extraction and recoveries should be performed to verify the results. Rutgers is performing the extraction and recoveries on plant produced, plant compacted specimens (not reheated) and PG grading the material. To date, the testing on the NY and VT mixtures have been completed and show some significant differences as compared to the original testing.

Figures 1-4 show the results of the high temperature continuous grading that was performed for the four sets of mixtures. There are three sets of results shown on each graph for each mixture:

- Pike Ex/RU Test: Extraction and recovery performed by Pike Industries, testing performed by Rutgers
- Pike Ex/Pike Test: Extraction and recovery performed by Pike Industries, testing performed by Pike
- RU Ex/RU Test: Extraction and recovery performed by Rutgers, testing performed by Rutgers

The Pike Ex/RU Test results are those that were originally performed in 2010/2011 and have been reported for this project to date and the RU Ex/RU Test results are those that have recently been completed. There are significant differences in the Pike Ex/RU Test and the RU Ex/RU Test for most mixtures, while the RU Ex/RU Test and RU Ex/RU Test results are more similar. This is likely due to the procedures used in each lab: Rutgers performed DSR testing on the extracted and recovered binders directly, while Pike laboratories RTFO age the extracted and recovered material as part of their standard procedure. If solvents were still present in the Pike Extracted materials, they would be removed during the RTFO process.

Figures 5-8 show the results of the intermediate continuous grading for each set of mixtures. Here, the results are closer as all materials were subject to PAV aging prior to testing.

The research team will be using the Rutgers extracted, Rutgers tested data moving forward in this project. All of the new binder results will be presented in the interim report.

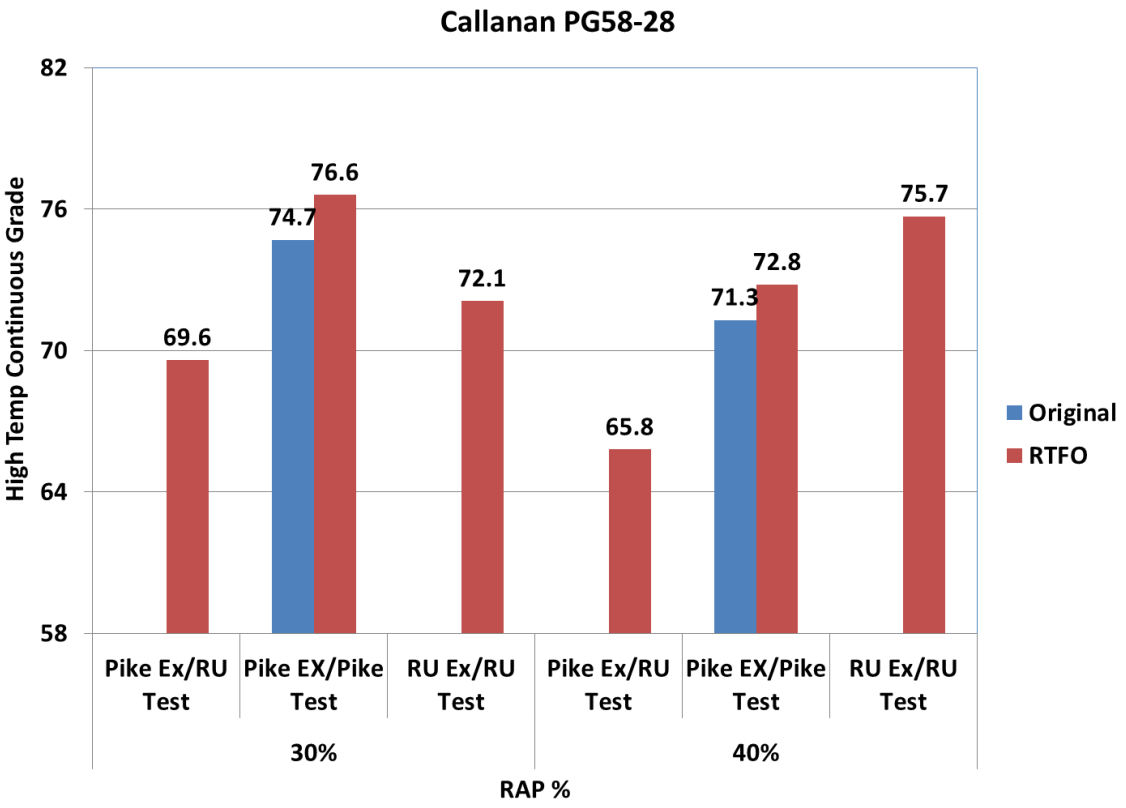

Figure 1. High Temperature Continuous Grade Measured for the NY PG 58-28 Mixtures

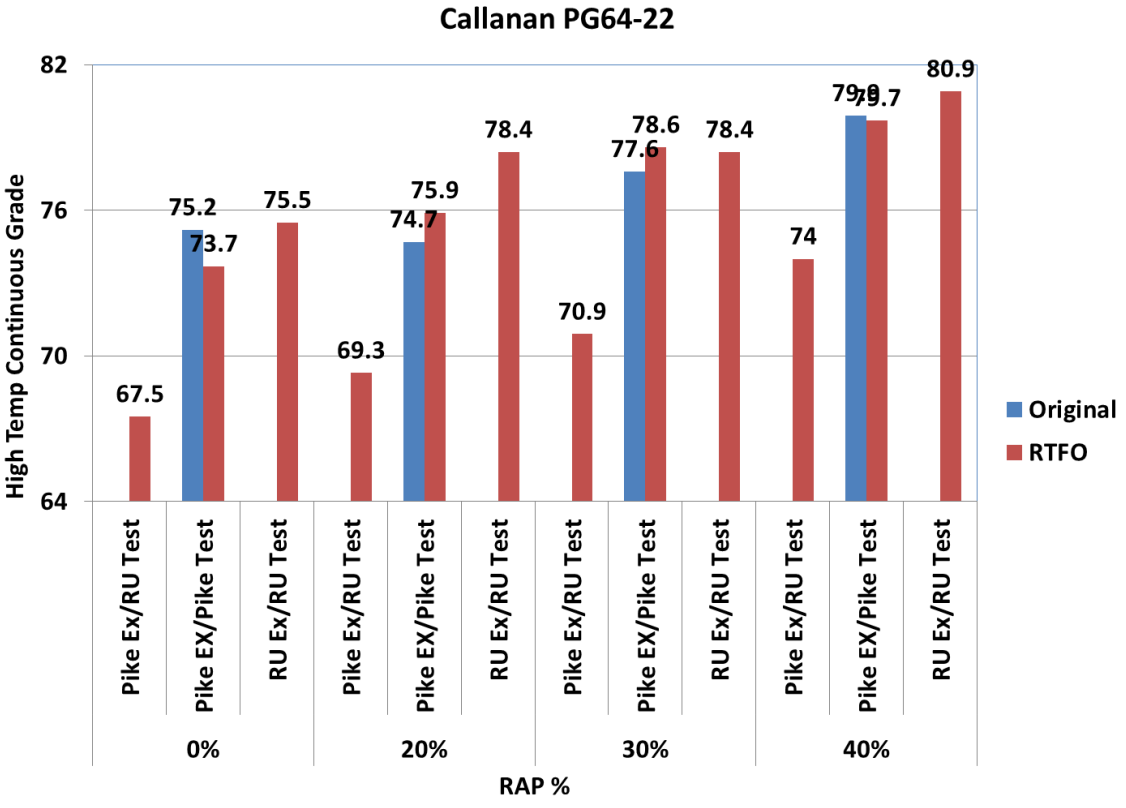

Figure 2. High Temperature Continuous Grade Measured for the NY PG 64-22 Mixtures

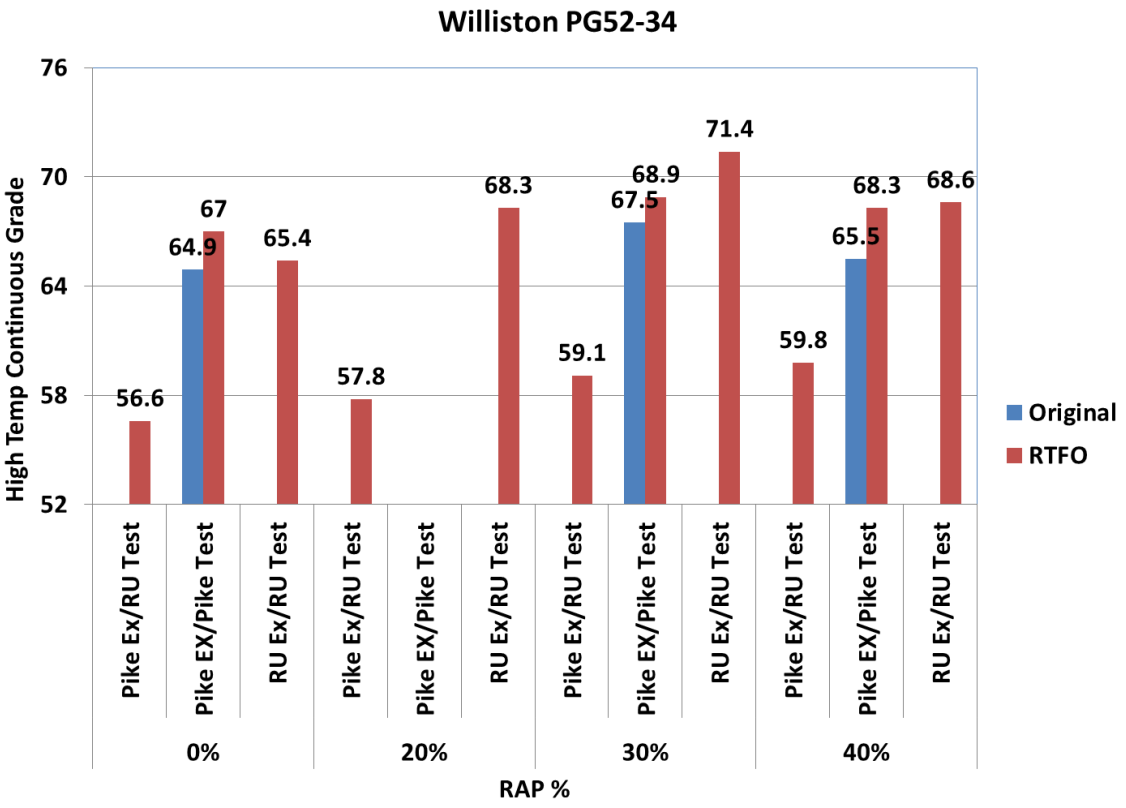

Figure 3. High Temperature Continuous Grade Measured for the VT PG 52-34 Mixtures

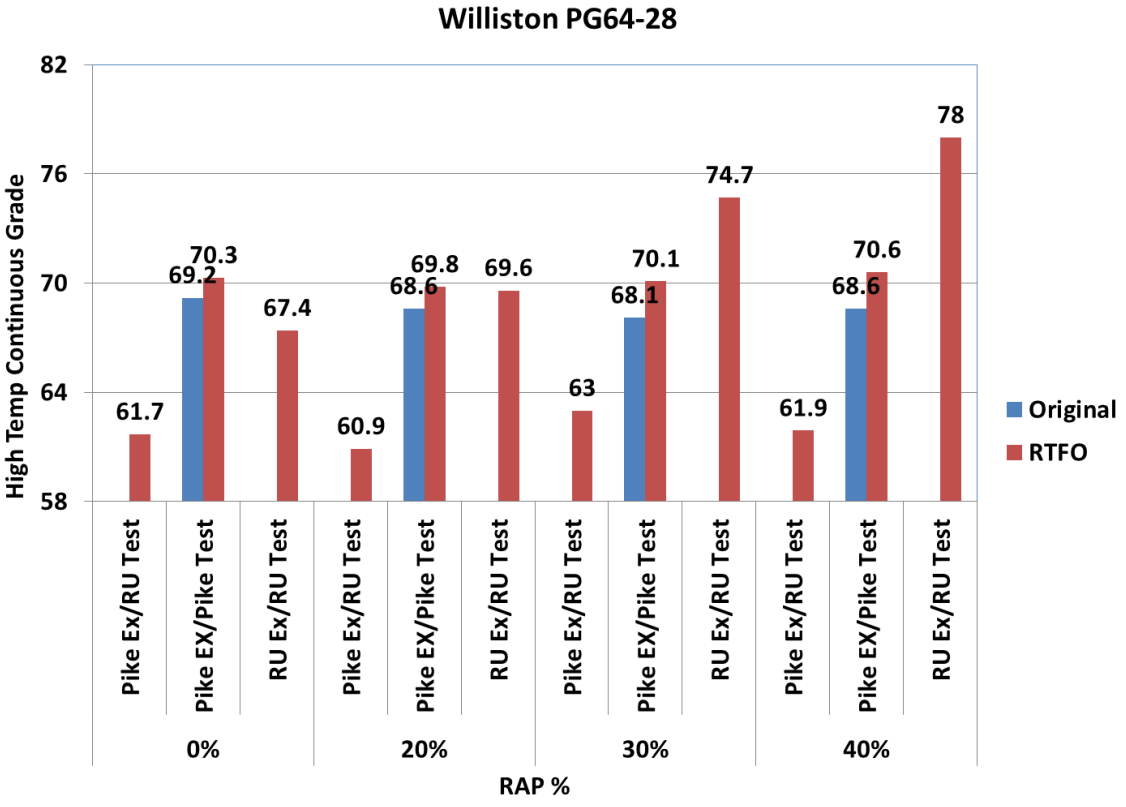

Figure 4. High Temperature Continuous Grade Measured for the VT PG 64-28 Mixtures

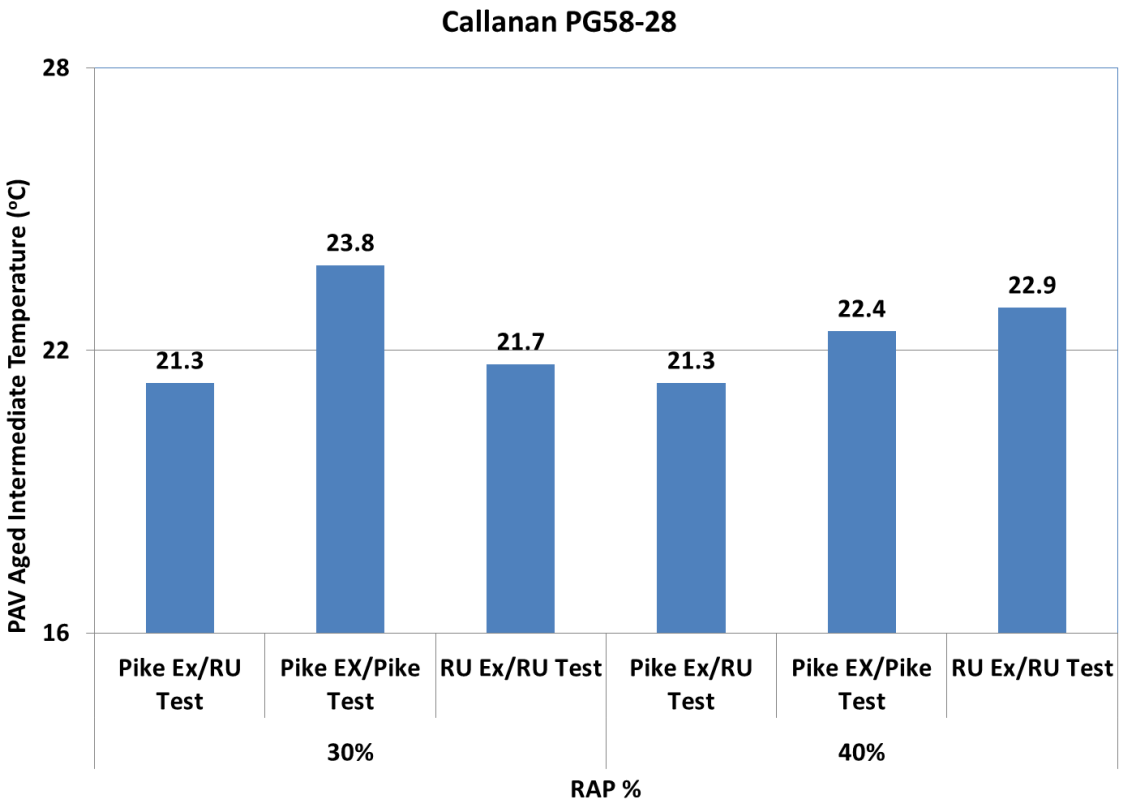

Figure 5. Intermediate Temperature Continuous Grade Measured for the NY PG 58-28 Mixtures

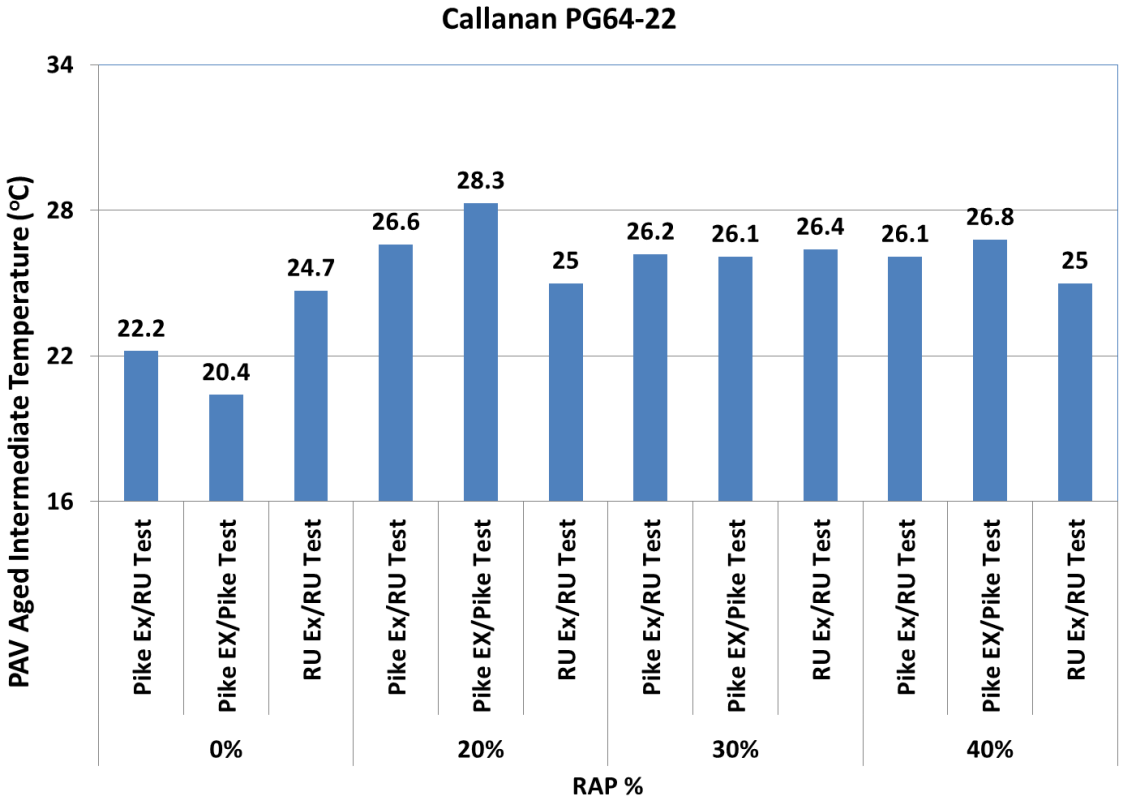

Figure 6. Intermediate Temperature Continuous Grade Measured for the NY PG 64-22 Mixtures

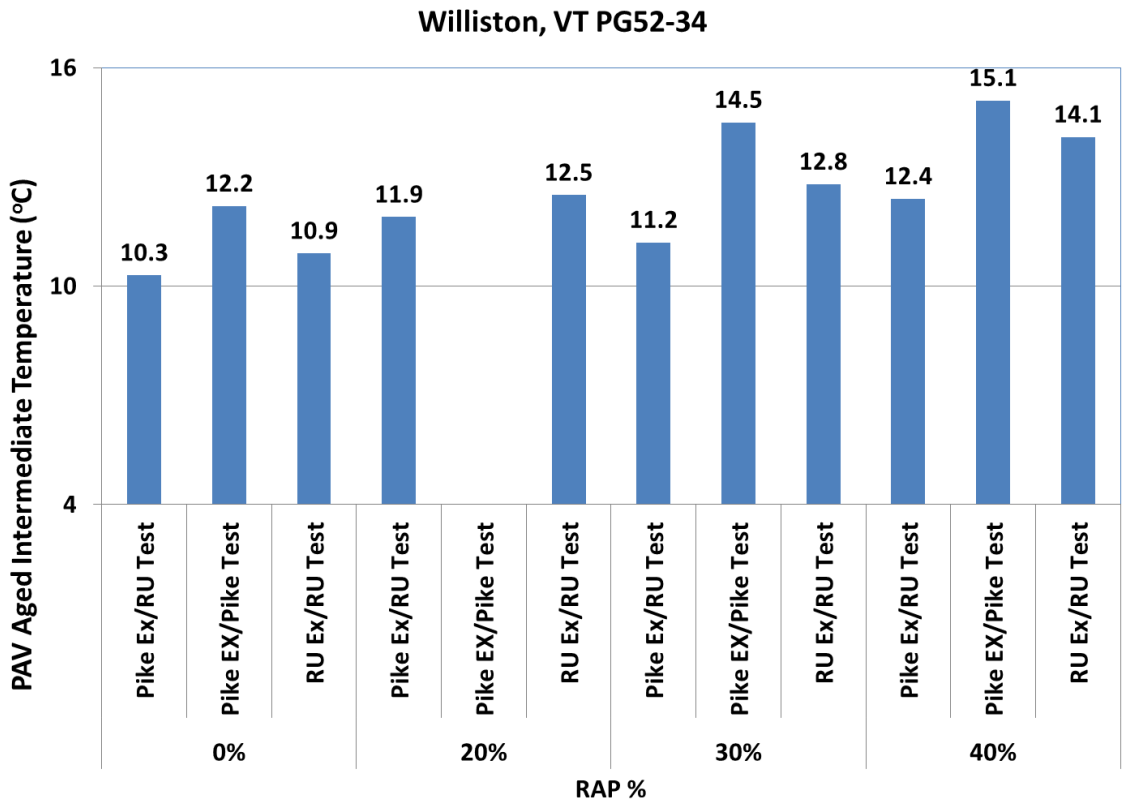

Figure 7. Intermediate Temperature Continuous Grade Measured for the VT 52-34 Mixtures

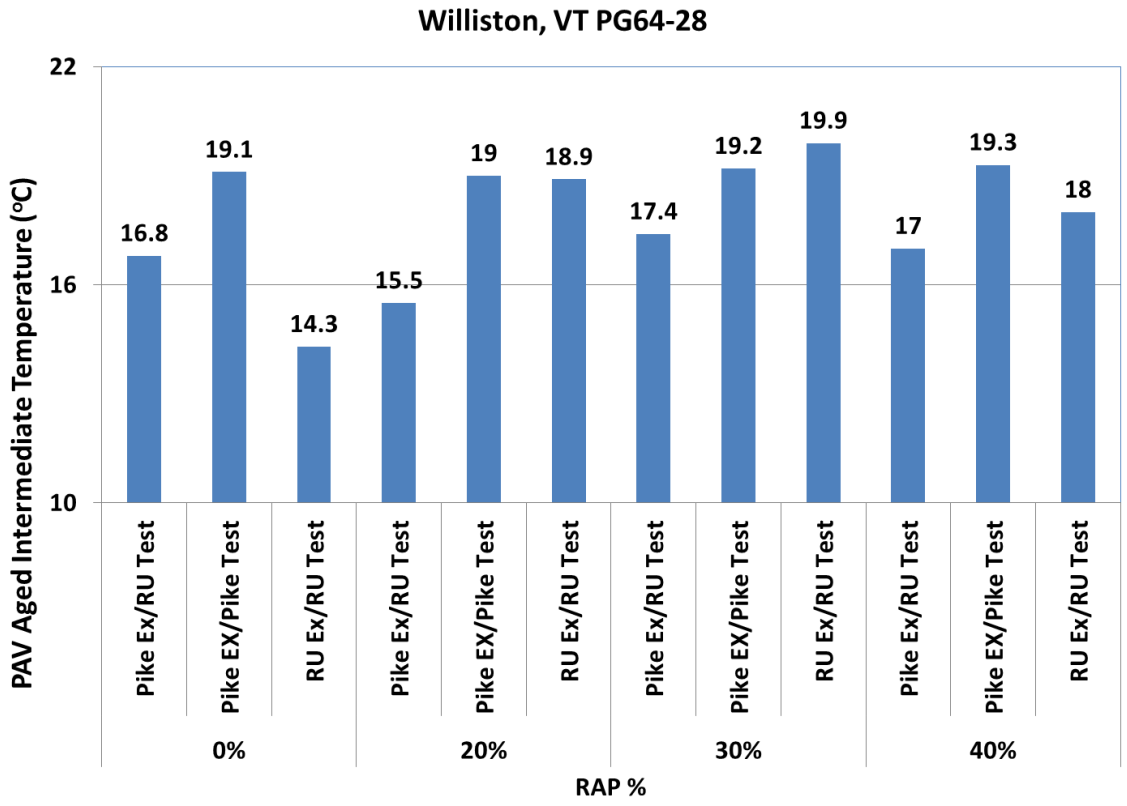

Figure 8. Intermediate Temperature Continuous Grade Measured for the VT PG 64-28 Mixtures

2. Summary of High RAP Usage Survey

In order to determine the concerns of state agencies and industry in the northeast with the usage of high RAP contents in the top lifts of flexible pavements, two internet based surveys were developed. One survey was developed for state agencies and consisted of fifteen questions. Another survey was developed for asphalt mixtures producers and consisted of eleven questions. The focus of the survey for the state agencies was to determine their main concerns in allowing high RAP contents in their surface mixtures while for the industry, the survey focused on production issues such as QC and mix design for RAP mixtures. The questions for state agencies were:

1. How much RAP do you allow in base, binder, and surface?
2. How did you determine these RAP limits?
3. Do you require changes in binder grade at certain limits?
4. If you answered “yes” to Question 3, how did you determine these limits?
5. Does your state agency verify RAP percent usage from suppliers? If so, what procedures are being used?
6. Does your mixture design process include RAP?
7. If you answered “yes” to Question 6, what mixture design process do you use to account for RAP in the mix (e.g. binder replacement, by total mass of the mixture, reducing RAP binder credit, etc)?
8. Do you currently have any concerns with using RAP in your asphalt mixtures? If so, please list these concerns.
9. Would you like to have more RAP used in the state?
10. What are your primary concerns with higher RAP levels?
11. What data/experience are these concerns based on?
12. What research, in your opinion, is needed to address these concerns?
13. Based on your experience to date, what method seems most likely to be adopted by your agency to increase RAP contents?
14. If you answered "Not Listed" to question 12, Please explain.
15. Do you have any additional comments that would help in developing the plan? If so, please explain.

Based on the responses received from state agencies that completed the survey, the following observations were made:

- The main concern with using high RAP content in the surface layers is premature cracking failure
- State agency follows AASHTO M323 in bumping down the binder grade when higher RAP contents are used
- State agencies are not opposed to the use of high RAP content if performance data yields favorable results

The questions for the industry were:

1. What limits the amount of RAP in state work? Private work?
2. How much RAP would you use if you could?
3. How do you currently process your RAP?
4. Do your mixture designs include RAP?
5. What QC procedures do you use with your RAP?
6. Do you bump binder grades or use different asphalt contents with higher RAP mixtures?
7. If you answered “yes” to question 6, how do you determine when to make the changes?
8. What are your primary concerns with higher RAP levels?
9. What data/experience are these concerns based on?
10. What research, in your opinion, is needed to address these concerns?
11. Do you have any additional comments that would help in developing the plan? If so, please explain.

Based on the responses received from producers that completed the survey, the following observations were made:

- Mix design is used when RAP is incorporated
- State specifications and current plant equipment is what limits the RAP contents
- Most producers bump down the binder grade depending on the amount of RAP used. However, the cost of a softer binder might limit the usage of high RAP contents
- Similar to state agencies, industry has the concern that mixtures with high RAP content might be susceptible to cracking and poor durability

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).

The anticipated $150,000 contribution from FHWA has not been received. FHWA will be contributing $100,000 to this project. It is expected that the transfer of these funds will be completed by the end of August. In the interim, the research team has been working with a reduced budget and scope.

Potential Implementation: