TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): **Wisconsin 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 # TPF-5(302)	**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: Modified Binder (PG+) Specification and Quality Control Criteria		
Name of Project Manager(s): Barry Paye	**Phone Number:** (608)246-7945	**E-Mail** barry.paye@dot.wi.gov
Lead Agency Project ID: 0092-14-20 (original/amendment)	**Other Project ID (i.e., contract #):**	**Project Start Date:** 9/30/2014
Original Project End Date: 03/31/2018	**Current Project End Date:** 3/31/2018	**Number of Extensions:** 1

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
$350,000	$295,857	85%

Quarterly Project Statistics

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$ 40,197 / 11.5%	$ 40,520	86%

Project Description:

This project was extended in January 2017 for 15 months with specific added tasks and a work plan approved by the partner states. The extension work plan was developed based on the stated needs and goals that were highlighted after the delivery of the final report of the original work plan. The extension work plan is focused on the following two tasks.

Task 1: Evaluating the Effects of RAP/RAS on PG+ and Developmental Test Blending Charts

- *Subtask 1.1: Proof of Concept of Using Blending Charts for New Tests.*
- *Subtask 1.2: Validation using recycled asphalt materials (RAM) from Partner States.*

Task 2: Effects of Low Temperature Modification Technologies on PG+ and Developmental Test Methods.

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

The following points represent summary of the progress during this quarter:

- Work progressed for Task 1 - *Subtask 1.1* of the project.

- This subtask is complete. Twelve asphalt binders' combinations were prepared by blending the two PMAs with the two A-RAPs at four ratios (PMA/A-RAP): 100%/0%, 80%/20%, 60%/40%, and 0%/100%. The blending charts for the results of the MSCR, ER-DSR, BYTE, LAS and SENB testing of the twelve asphalt binders were generated for verification of the effects of recycled materials on blended binder properties.
- The work on the report to summarize the findings have started and is expected to be completed next quarter.

- Work progressed for Task 1 - *Subtask 1.2* of the project.

- The three RAP samples received from partner states (Kansas, Colorado and Wisconsin), and one recycled asphalt shingle (RAS) sample were extracted and the binders from all 4 samples were recovered this quarter.
- The blending of the RAP materials (three RAP and one RAS source) with a polymer modified asphalt sampled from a partner state was completed. The PMA is WI 70-28, which was called PMA_1. A total of twelve blended asphalt binders' combinations (3 RAP sources, each at 4 percentages of recycling binder) were prepared by blending the PMA_1 (WI 70-28), one RAS material, and three RAP sources at following ratios (RAP/RAS/PMA): 0%/0%/100%, 15%/5%/80%, 20%/0%/80%, 40%/0%/60%, and 60%/0%/40%.
- After blending, the twelve prepared samples were both RTFO and PAV aged.

- For the blends prepared with the binder extracted from the Kansas RAP, the MSCR, ER-DSR, BYTE, LAS and SENB testing were performed, and blending charts for each of the selected tests were generated.
- For blends prepared with the binders extracted from the Colorado RAP and from the Wisconsin RAP, the MSCR, ER-DSR, BYTE, and LAS testing were performed, and blending charts for each of the selected tests were generated.
- Analysis of the results started this quarter and will be completed in the next quarter.

- **Work progressed for <u>Task 2</u> of the project.**
  - Three low temperature modifiers (oils/rejuvenators) that are currently widely used in the United States were collected for the Task 2 of the project: (1) an unmodified soft material produced by a refinery in the Mid-West; (2) A vegetal based "Bio-Oil", and (3) a re-refined engine oil bottom (REOB).
  - An unmodified asphalt binder PG 58-28 was selected to be blended with the above-mentioned oil modifiers plus an elastomeric polymer to achieve a target grade of PG 58-34H by varying amount of oil and polymer used. The preparation of the blends has started and testing will be completed next quarter.

Anticipated work next quarter:

The work planned for next quarter is as follows.

- Task 1 – <u>*Subtask 1.1*</u> and <u>*Subtask 1.2*</u>:

- The final report regarding the findings of both subtasks 1.1 and 1.2 of the project will be completed.

- Task 2:

- The three asphalt samples of the PG 58-34H will be prepared and aged in the RTFO and PAV. To simulate extended aging, each asphalt blend will be subjected to three different PAV cycles: 20 hours, 40 hours and 60 hours. After aging, the samples will be tested for MSCR, ER-DSR, BYET, and LAS.
- To complete the task 2, aging trends for each proposed test will be generated for the final nine asphalt samples.

Significant Results:

<u>Task 1 – *Subtask 1.1*</u>:

PG+ grading properties were measured for twelve asphalt binders' combinations prepared by blending the two PMAs with the two A-RAPs at four ratios (PMA/A-RAP): 100%/0%, 80%/20%, 60%/40%, and 0%/100%. The validity of linear blending analysis to combinations of A-RAP and

PMA was verified for the ER-DSR, MSCR (Jnr and %R), BYTE, LAS and SENB testing results. The detailed summary of findings for this subtask was submitted in the last Quarterly report except for the LAS and SENB. The results for these tests showed the following findings:

- LAS blending charts:

- For the set of binders tested in this subtask, the results indicated that the effect of increasing RAP binder content is non-linear regarding the parameters obtained through the Linear Amplitude Sweep (LAS) test.

- SENB blending charts:

- Similar to the LAS parameters, results indicated that the effect of increasing RAP binder content is non-linear regarding the parameters obtained through the Single Edge Notched Bending (SENB) Test.

Task 1 – *Subtask 1.2*:

The testing was completed for PG+ grading properties for twelve asphalt blended binders prepared by blending PMA_1 (WI 70-28), one RAS material, and binders extracted from three RAP sources (Colorado, Kansas and Wisconsin). The blends included the following ratios of (RAP/RAS/PMA) for each RAP source: 0%/0%/100%, 15%/5%/80%, 20%/0%/80%, 40%/0%/60%, and 60%/0%/40%. The validity of linear blending charts for the amount of RAP and RAS in the PMA_1 binder was analyzed by plotting the Jnr and % R from the MSCR test, the % ER from the ER-DSR test, the maximum stress and strain from the BYTE, the coefficients of fatigue from the LAS test, and the fracture properties from the SENB test. The summary of findings from the blending analysis for this subtask is as follows.

- Elastic Recovery (ER-DSR) blending charts:

- As previously observed for the blends prepared with artificial RAP, results collected for the blends prepared with binders extracted from three RAP sources (Colorado, Kansas, and Wisconsin) indicated that the effect of increasing RAP binder content is linear in terms of reduction in Elastic Recovery (ER) with increasing amount of RAP/RAS.
- The reduction in ER value at 60% RAP blending varied from the original ER of 61% to a low of 25% ER depending the source of the RAP.

- MSCR blending charts:

- Results indicated that linear blending analyses can be applied to J_{nr} results as a function of RAP/RAS content when the logarithmic scale of J_{nr} is used.
  - It is observed that J_{nr} decreases with the increase of the RAP content for the Colorado and Kansas RAPs, which is a similar trend to the blends prepared with artificial RAP.
  - However, for the blends prepared with the binder extract from the Wisconsin RAP, it was observed that J_{nr} increases with the increase of the RAP content because J_{nr} of this RAP is higher than the PMA_1 binder.
- For the changes in MSCR % Recovery, the trends are highly RAP source dependent; for the blends prepared with the binder extracted from the Colorado RAP, the effect of increasing RAP binder content is non-linear, while it is linear for the blends prepared

with the binder extracted from the Wisconsin RAP. For the binder extracted from the Kansas RAP, results indicate a linear increase in MSCR % Recovery with the increase in RAP binder.

- BYET blending charts:

- Results indicated that linear blending trends can be applied to Yield Energy results, and the yield energy increases with the increase of the RAP binder content.
- Regarding the maximum stress parameter, all RAP binders modified with PMA_1 showed an increase of the maximum stress with the increase of the RAP binder content in the blend.
- Regarding the strain at peak stress, for all RAP binders it is observed that the strain at peak stress value decreased with the increase of RAP binder content in the blend.

- LAS Parameters blending charts:

- For the set of binders tested in this subtask, results indicated that linear blending trend can be applied to LAS results. The blending chart linearity, however, was not observed for all of the tested RAP blends. Therefore, the validity of LAS linear blending analysis to combinations of RAP and PMA is mostly material dependent.

- SENB blending charts:

- Results indicated that the effect of increasing RAP binder content is non-linear regarding the parameters obtained through the Single Edge Notched Bending (SENB) Test.
- It is observed that the SENB results are not reproducible and getting good repeatability is extremely difficult for any of the blends. Based on this observation, the research team decided to stop the SENB data collection. Efforts will be focused on finding surrogate methods for the SENB test, in order to investigate the effects of RAP and oil modification on the low temperature fracture behavior of asphalt binders.

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).

None for this quarter.

Potential Implementation:

It is anticipated that the results can be used to quantify the effects of using heavily aged recycled binders, and softening oils (rejuvenators) on the criteria used by the Partner States for the PG + tests.