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	$319,576	92%

Quarterly Project Statistics

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$ 20,624 / 5.90%	$ 23,718	93%

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 progress for Task 1 - *Subtask 1.1* of the project.
- This subtask is complete.
- The first draft of the final report has been prepared and is currently being reviewed and revised.

- Work progress for Task 1 - *Subtask 1.2* of the project.
- Analysis of the results has been completed and the results have been summarized in the draft final report.

- **Work progress for Task 2 of the project.**
- 3 blends containing a base PG 58-28 with either bio-oil and REOB (re-refined engine oil bottom) were prepared, ratios are listed below. Initially a flux was also going to be included, however, the asphalt modified with the flux was not able to meet the -34 grade with blends containing feasible amounts of the flux (>25% by mass).
  - Blend 2 – Bio-Oil: 93.75% PG 58S-28, 3% SBS, 3.25% Bio-Oil
  - Blend 4 – Bio-Oil: 94.80% PG58S-28, 1% Elvaloy, 0.2% PPA, 4% Bio-Oil
  - Blend 3 – REOB: 89.50% PG58S-28, 2.5% SBS, 8% REOB
- A control blend was prepared using a base PG 52-34, PPA, a stiffing agent, and SBS, stiffening agent, ratios are listed below. A neat binder was not used as the aging effects of interest are those of the polymer modified binder, whereas the effect of the oil/rejuvenator is to be measured.
  - Control Blend: 96.85% PG 52S-34, 3% SBS, 0.15% Sulfur
- The control blend and 3 oil/rejuvenator modified blends were tested for PG true grade, as well as ER-DSR, MSCR, BYET, LAS at RTFO aged and 20, 40, and 60 hours in the pressure-aging vessel (PAV) to simulate long term aging performance of the binders. BBR was also performed with binders aged 20, 40, and 60 hours in the PAV.

- The work completed was summarized in the draft final report.

Anticipated work next quarter:
The work planned for next quarter is as follows.

- Task 1 – *Subtask 1.1* and *Subtask 1.2*:

- Completion of the final report regarding the data analysis for subtasks 1.1 and 1.2.

- Task 2:

- Completion of the final report regarding the data analysis for task 2.

Significant Results:

Task 1 – *Subtask 1.1*:

No New results last quarter.

Commented [AK1]: we need to restate this task?

Task 1 – *Subtask 1.2*:

No new results last quarter.

Task 2:

-MSCR Results

- Since Jnr spans several orders of magnitude for the blends, data is plotted on a log-linear scale as was done in earlier sections of this report for Jnr. As expected, Jnr decreases with increased aging in an exponential fashion. The difference in aging susceptibility (slope of fit line) is readily apparent from the data, with the control blend showing the greatest reduction in Jnr and Blend 4 exhibiting the least aging susceptibility.
- MSCR %R is shown to increase at a decreasing rate with aging for all of the blends using a %R Index. An increase in %R of over 220% relative to the %R of the RTFO residue is observed for all of the blends.
- Control Blend shows the greatest increase in %R for all aging conditions while Blend 4 shows the least increase except for the 60-hour PAV condition, where the %R Index for Blend 4 is very similar to Blend 3. This finding coupled with the observations made for the Jnr Index indicates a strong relationship between Jnr and %R must exist.

-ER-DSR Results

- For the control blend and blends 3 and 4, the ER-DSR decreases with aging, as expected. The bio-oil blend interestingly shows a slight increase between the RTFO and 20 hour PAV condition, almost no change between the 20 hour PAV and 40 hour PAV condition, and a decrease between the 40 hour and 60 hour PAV condition.
- It is clear that the percent recovery is driven by the maximum stress in a given blend, but not necessarily the relative change in maximum stress between aging levels for

the control and blends 3 and 4; it is hypothesized that the stress sensitivity of the polymer network is causing the apparent reduction in elastic response.

-BYET Results

- The Strain at Maximum Stress parameter has been shown to be a direct replacement to the ductility test. Since it is generally expected that asphalt binders would lose ductility with long term aging (embrittlement), it would be expected the Strain at Maximum Stress would also decrease. This is confirmed with all of the binder blends, and a reduction in this parameter of between 25% and 60% relative to the 20-hour PAV condition is observed, indicating a dramatic dependency on binder formulation.
- The binder Yield Energy parameter increases uniformly for three of the four blends. For Blend 3 – REOB, there appears to be a parabolic shape to the Yield Energy trend.

-LAS Results

- The rate of change in the B parameter is nearly linear with increased aging, but the rate is dependent on the binder blend.
- Blend 2 – Bio Oil shows the greatest rate and magnitude of change for the B parameter, while the Control Blend shows the lowest. The nearly linear relationship suggests evaluating the B parameter at two levels of aging is sufficient for prediction at other aging levels.

-BBR Results

- Although the binder blends in this study were all designed to have approximately equal effective low temperature continuous grades, they exhibit widely different aging susceptibilities.
- BBR or m-value index value, which is defined as the ratio of the critical temperature (for either S(60) or m-value) at any given level of aging relative to the critical temperature for the standard 20 hour PAV cycle. An index less than one indicates that the critical temperature has increased (closer to zero) for that aging condition, which would be viewed as detrimental to the low temperature performance of the asphalt binder.
    - For low temperature stiffness, all binder blends with the exception of Blend 4 at 40 hours exhibit a reduction in stiffness index with increased aging time. The same trend is observed for m-value, in this case for all four binder blends. For both the stiffness and m-value, the least reduction in indices occurs with Blend 4, and the greatest reduction for both stiffness and m-value occurs for Blend 3. For all binder blends, the increase in m-value continuous grade relative to the 20-hour PAV sample was greater (lower index) than the increase in stiffness continuous grade. That is to say that all binder blends became more m-value controlled with increased levels of aging.
- Three of the four binder blends are stiffness-controlled at the 20-hour PAV aging condition, whereas all are m-value controlled at the 60 hour condition. Blend 3, which contained the recycled/re-refined oil (REOB), shows by far the lowest ΔT_c for all three

aging conditions, and even at the 20-hour condition exhibited a ΔT_c of approximately 5 °C.

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.