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	$255,702.96	75 %

Quarterly Project Statistics

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$6,089.75 and 1%	$6,089.75	78.5%

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:

- Progress for Task 1 - *Subtask 1.1* of the project.

- Two asphalt binders commonly used in the Mid-West region of the United States were selected to produce 'Artificial' Reclaimed Asphalt Pavement (A-RAP) materials. The materials include an unmodified (neat) PG 64-22 binder (A-RAP_1), and a polymer modified asphalt (PMA) PG 70-28 binder (A-RAP_2). The A-RAPs were produced by exposing the virgin binders to extended cycles of aging in the Pressure Aging Vessel (PAV) (40 and 60 hours for A-RAP_1 & A-RAP_2, respectively).
- The A-RAP_1 & A-RAP_2 were tested following the original project plan, which included the Multiple Stress Creep and Recovery (MSCR), Elastic Recovery in the DSR (ER-DSR), Binder Yield Energy Test (BYET), and the Linear Amplitude Sweep Test (LAS).
- The blending of the A-RAP materials (A-RAP_1 & A-RAP_2) with polymer modified asphalts sampled from partner states was completed. The two PMAs are WI 70-28 and KS 64-34, which were nominated PMA_1 and PMA_2, respectively.
- 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 MSCR, ER-DSR, and BYTE testing of the twelve asphalt binders were performed.
- After the analysis, blending charts for each of the selected tests were generated for verification of the effects of recycled materials on blended binder properties.

- Progress for Task 1 - *Subtask 1.2* of the project.

- Three RAP samples were received from partner states (Kansas, Colorado and

Wisconsin).
  - A recycled asphalt shingle (RAS) sample was also collected for the subtask 1.2 of the project.
  - All four sources of recycled asphalt materials (three RAP and one RAS source) will be used for binder extraction, recovery and testing in a similar fashion as the subtask 1.1 work plan.
  - The binder extraction process is expected to be concluded by the beginning of August.

- **Work progressed for Task 2 of the project.**
  - Three low temperature modifiers (oils/rejuvenators) that are 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 Bio- 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 modifiers plus an elastomeric polymer in order to achieve PG 58-34H.

Anticipated work next quarter:

The work planned for next quarter is as follows.

- Task 1 – *Subtask 1.1*:

  - Blending charts for LAS and SENB tests will be generated for the twelve asphalt binders combinations prepared by blending the two PMAs with the two A-RAPs at four ratios (PMA/A-RAP). The blending charts will allow the verification of the effects of recycled materials on blended binder properties, considering the selected PG+ and developmental methods suggested by the research team during the original project.

- Task 1 – *Subtask 1.2*:

  - Extraction and evaluation of the recycled asphalt materials (RAP and RAS) received from Partner States.
  - A total of eighteen asphalt binders' combinations will be prepared by blending two PMAs (WI 70-28 and KS 64-34), one RAS material, and three RAP sources at following ratios (PMA/RAP/RAS): 100%/0%/0%, 80%/15%/5%, 80%/20%/0%, and 60%/40%/0%.
  - The eighteen prepared samples will be RTFO and PAV aged. After aging, the samples will be tested for MSCR, ER-DSR, BYET, and LAS.
  - To complete the subtask 1.2, blending charts for each proposed test will be generated for the eighteen asphalt samples.

- Task 2:

  - A PG 70-28 asphalt binder will be modified with three different oils/rejuvenators, to achieve a final performance grade of 58-34H.

- A project call update with the partner states will be schedule sometime in mid-late August, once the work for Task 1 of the project is finalized.

Significant Results:

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 by means of MSCR, ER-DSR, and BYTE testing results. The summary of results for this quarter is as follows.

- Elastic Recovery (ER-DSR) blending charts:

- Results indicated that the effect of increasing RAP binder content is linear regarding Elastic Recovery (ER).
  - It is observed that a decrease of the elastic recovery is achieved with an increase of RAP content.
  - For agencies wishing to set a minimum limit for ER with a factor of safety, a sample set of representative RAP materials could be tested, and the rate of change in ER could be calculated. A minimum limit could then be selected based on typical RAP usage in the referring State.
- It is also observed that the rate of change in the elastic recovery is dependent of the RAP source.
  - For all tested samples, the observed changes in elastic recovery after the increase of the A-RAP_2 content were smaller than the changes observed after increasing the A-RAP_1 content. This behavior can be explained by the fact that the A-RAP_2 material was prepared from a polymer modified binder (WI 70-28 aged for 40h in PAV).

- MSCR blending charts:

- Results indicated that linear blending analyses can be applied to J_{nr} results. Please note that the J_{nr} results were plotted in a log scale, since the values ranged from a minimum of 0.007 to a maximum of 0.460 kPa^{-1}.
  - Since a lower J_{nr} is perceived as favorable in terms of rutting resistance and in terms of being conservative for state agencies, there would not be necessary to adjust limits.
- Results indicated that the effect of increasing RAP binder content is a non-linear function of MSCR % Recovery.

- BYET blending charts:

- Results indicated that linear blending analyses can be applied to Yield Energy results.
  - In accordance with the data collect, the behavior observed for the yield energy parameter is mostly controlled by the polymer modification type, rather than by the RAP source in use.

- Both $ARAP_1$ and $ARAP_2$ when blended with PMA_1 show an increase in the yield energy as the RAP content in the blend increased from 0% to 100%. A different trend, however, was observed when both RAP materials were blended with PMA_2: the yield energy of PMA 2 decreased with the increase of the A-RAP content.

- Regarding the measured strain at peak stress parameter, it is observed that the results for both $ARAP_1$ and $ARAP_2$ materials blended with PMA_2 (KS 64-34) are much higher than the strain observed when PMA_1 (WI 70-28) was used in blending.

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).

Dr. Raquel Moraes has been added to the Research team and will lead coordination of the experimental testing program. She has replaced Mr. Erik Lyngdal who accepted a new position outside of the University. No impact on budget or time is expected.

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.