WHRP (0092-14-20)

TPF-5 (302)

Modified Binder (PG+) Specifications and Quality Control Criteria:

Project Extension Work Plan

The purpose of this document is to present a one-year extension work plan for Transportation Pooled Fund (TPF)-5 (302): Modified Binder (PG+) Specification and Quality Control Criteria. The work plan is based on conversations between the Principal Investigator (UW-Madison) and the partner states before and during the presentation of the final report of the original work plan. The extension research topics originally proposed included four working tasks:

1. Evaluating the effects of RAP and RAS on linear blending charts including PG+ and developmental binder test methods.
2. Evaluating effects of low temperature binder modification using oils (also called softening or rejuvenators) on results of PG+ and developmental binder methods.
3. Expansion of the current binder database to validate the criteria limits proposed in the final report of the original work.
4. Expansion of mixture database to include low and high performing mixtures to validate proposed PG+ specification limits.

After presenting each of the four proposed research topics above, it was found that the investigation of RAP and RAS blending and low temperature binder modification (Tasks 1 and 2) were of more interest to the member states. Therefore, the extension work plan will focus on only these 2 tasks, as presented below.

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

Nearly all new asphalt mixtures produced in the United States contain a percentage of recycled asphalt materials (RAM). Implications of adding RAM into asphalt mixtures in pavements is an increase in rutting resistance with a potential reduction in cracking resistance at both intermediate and low temperatures. The decrease in cracking resistance is attributed to the heavily aged binder that coats the recycled aggregates. In response, DOTs often specify that softer grades of asphalt binder should be used with high RAM mixtures to offset the negative consequences of the aged recycled binder.

To estimate the performance implications of RAM, designers use simple blending charts to interpolate the effects of recycled materials on blended binder properties (AASHTO M323, Appendix X1). These charts have been proven effective for RAP materials and using standard Superpave PG test methods (G*, S-value, m-value, etc.) during the NCHRP 09-12 study. However, research has shown that the charts may not accurately predict blended binder properties for RAS binders, particularly at low temperature (Bonaquist, 2011). In addition, initial data generated in support of this research extension by UWM suggests that the effects of RAM on PG+ test methods are not predictable and could not follow assumptions of linear blending.

The experiment for this Task is designed to investigate the effects of blending between RAM and polymer modified virgin binders on selected PG+ and developmental test methods proposed in earlier phases of this research project. The experiment is divided between two subtasks: Subtask 1.1 will be an evaluation of selected PG+ and developmental methods using artificially produced RAM materials in order to limit the amount of binder extraction/recovery required. Subtask 1.2 will incorporate RAM materials supplied by member states to expand the testing matrix and provide direct information to the partners.

Subtask 1.1: Proof of Concept

Two potential base asphalts from separate crude sources will be used to produce 'artificial' RAP materials (A-RAP). If instead reclaimed shingle binder can be procured from a commercial company dealing in this material, then this material will be used in place of one of the A-RAP materials. Artificial RAP materials will be produced by exposing virgin binders to 2 full cycles (40 hrs.) of PAV aging. Two polymer modified base asphalts will be sampled from partner states for blending with the aged material. Each combination will be blended at up to five ratios (PMA/RAM): 100%/0%, 80%/20%, 60%/40%, and 0%/100%. These ratios are expected to encompass typical usage rates of RAM (~20% PBR) as well as include higher ratios to establish/confirm linearity or non-linearity in the blending charts. The proposed testing matrix of materials will take the following form:

Factor	Level	Description
Aged Binder	2	A-RAP_1, and either A-RAP_2 or RAS
Polymer Modified Binder	2	PMA_1 PMA_2
Blending Ratios	4	PMA/RAM 100%/0% 80%/20% 60%/40% 0%/100%.

* 16 combinations to be tested with 5 tests and 2 replicates= 160 tests

Each combination will be tested with a selected suite of testing encompassing the recommendations made by the research team during the original project and shown below:

Temperature Range	Selected Test Method	Response
High Temperature	MSCR	$Jnr_{3.2}$ $\%R_{3.2}$ %Jnr Diff.
	ER-DSR	%R
Intermediate Temperature	BYET, IT PG	Strain at Peak Stress $BYE_{2500\%}$
	LAS, IT PG	Cycles to Failure, Nf
Low Temperature	BBR-SENB (for a selected subset)	Failure Energy

Based on a two replicates for each combination and test method, the maximum number of total tests for Subtask 1.1 is 160 individual binder tests. The analysis of the results could lead to the development of non-linear blending models or verification that the error, if any, from using the standard linear models is not significant. The models developed in Phase I can be then verified in Phase II using actual RAM materials and fresh modified binders.

Subtask 1.2 : Validation using RAMs from Partner States

During this phase (which can begin concurrently with subtask 1.1), RAM materials from Partner States will be requested for evaluation. At least one RAS material will be included in these materials. RAM will be extracted and recovered and tested in a similar fashion as the Phase I work plan. It is expected that the

findings in Phase I will direct the amount of testing required for Phase II; it is anticipated, for example, that few blending ratios may need to be evaluated in Phase II. It is presently contemplated that the testing matrix will include at least the following:

Factor	Level	Description
RAM	5	RAP from Four Partner States RAS from One Partner State
Modified Asphalt (PMA)	4	*One unique PMA binder will be evaluated for each Partner State (supplied by State) and combined with one RAM for every Partner State
Blending Ratios	4	PMA/RAM 100%/0% 80%/20% 80%/15%RAP/5%RAS **60%/40%. (RAP Only)
Test Methods	5	As above

*80 total tests x 2 replicates = 160 total tests

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

As an alternative to using a softer base binder grade for mixtures containing RAM in cold climates, using a low temperature (LT) modifier, such as an oil or rejuvenator, is becoming more common. In addition, demand of the PG grades of PGxx-28 and PG xx-34 is increasing as more concerns about cracking are being raised. Although many of the binders using oil modification continue to meet PG specifications, observations from field performance have indicated an increasing number of pavement failures that could be attributed to asphalt binder. Additional testing in this Task will focus on understanding the implications of oil modification on binder properties using selected PG+ and the new damage characterization testing methods. In addition, this topic can be tied to RAP/RAS extension to help understand how oil modification affects the blending of recycled and fresh asphalts.

To accomplish this task, partner states will be asked to identify low temperature modifiers (oils/rejuvenators) that are being widely used in their region. Modifiers identified by member states will be collected and blended with 'standard' asphalt binders at MARC laboratories. MARC has done extensive testing with oils and has identified test methods that may distinguish between the performance of different types of low temperature modifiers. This information will be compared against unmodified soft binders produced by refineries in order to make recommendations to partner states regarding what test methods/properties of oil modified binders can indicate high or low pavement performance. At a minimum, the following test matrix is proposed:

Factor	Level	Description
LT Modification	3	Petroleum Based Plant/Animal Based "Bio-Oil" Recycled/Reclaimed
Base Asphalt	2	PG 58-34 Neat PG 58-34H (SBS) or Similar produced with LT Modifier to achieve LT Grade
Aging Level	3	One PAV, double PAV, and Triple PAV
Test Methods	5	As above

*90 combinations at 2 replicates = 180 total tests

Results will be summarized and best methods for estimating the effects of RAM with the new test methods will be defined. In addition, the best methods to control quality of oil modification on the performance of binders will be also identified.

Task 3: Submission of the Final report

Based on the findings from Tasks 1 and 2, the final project report and closeout presentation will be drafted and submitted during this task. In addition to the final report, a presentation conference call will be scheduled during the last quarter of the project to provide a summary of all deliverables.

Time Requirements/Schedule

The total project extension duration is 15 months, consisting of 12 months for research and an additional 3 months for review and approval of final project deliverables. The anticipated start date is January 1, 2017 and the anticipated end date is March 30, 2018. Based on this timeframe, the project schedule is provided in the following table. The proposed schedule for conference calls and submission of deliverables are denoted by the codes D and M. In addition to the deliverables provided in the schedule, the research team will submit quarterly reports according to WisDOT guidelines.

Project Extension Schedule

Task	Quarter				
	1	2	3	4	5
	1/17-3/17	4/17-6/17	7/17-9/17	10/17-12/17	1/18-3/18
1.1 Proof of Concept	M1				
1.2 Validation Testing		D1	M2		
2. Effects of low temperature modifiers on binder performance				D2 and M3	
3. Final Project Deliverables and Closeout					D3 and M4

Summary of Deliverable and Meeting Codes:

- **M1:** Project kick-off conference call held with Project Partners
- **D1, M2:** Project memorandum on RAM results (D1) and interim presentation at Project Partners (M2).
- **D2, M3: Project** memorandum on Oils and interim presentation on results of Task 2.
- **D3, M4:** Draft final reports (D3) and Project closeout presentation to Project Partners.