Evaluation of Modified Performance Grade Binders in Thin Lift Maintenance Mixes, Surface Mix, and a Reflective Crack Relief Layer Mix.

Proposed Scope of Work
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I. Introduction

Pavement experts have long believed that a superior hot-mix asphalt (HMA) used in thin lifts can be prepared by using a high performance elastic binder. This type of HMA is essential for rehabilitation and maintenance purposes throughout the northeast United States. A mix with a high performance elastic binder can also be used in new pavement construction, like Open Graded Friction Course (OGFC) and Stone Matrix Asphalt (SMA).

Technological advances to chemically react rubber with asphalt were made at the Federal Highway Administration's (FHWA) binder laboratories in the mid 1990's. This technology is now in its second generation and can improve both the high and low temperature rheological properties of asphalt binders (1, 2). This technology results in a "homogenous" Chemically Modified Crumb Rubber Asphalt (CMCRA), which can be used to produce performance-graded asphalt binder. The process for preparing the CMCRA is different than the more widely known Charles McDonald Wet process where 18 -25 % rubber is used.

The rubber portion of the CMCRA is the integral part of the asphalt that greatly enhances the elastic recovery of the asphaltic system as well as serving as prevention of phase separation during storage. CMCRA has been tested in the lab for over four years and in the field for the last two years. Successful field trials were put in place in different states under different environmental and weather conditions. A successful placement of an overlay lift using this material was made in November 2000 under the supervision of RIDOT. The modified binder prepared for this field trail was a PG76-46 and had properties thought to retard reflective and low temperature cracking.

In this proposed research project, three (3) HMA mix designs with nominal maximum aggregate~~s~~ sizes (NMAS) of 4.75 mm, 9.5 mm, and 12.5 mm will be designed and evaluated by Umass Dartmouth using a CMCRA prepared using the technology previously outlined above. These mixes are the type that could be used for maintenance and rehabilitation. One (1) additional mix that could be used as a reflective crack relief layer (RCRL) will also be developed as part of this research. This mix will be used to prevent or mitigate reflective cracking.

Additionally, several modified asphalt binders currently being used by the pooled fund states for similar applications will be included. An attempt will be made to use the same base asphalt for all modified asphalt binders, unless an individual state has a specific modified asphalt binder that is preferred.

II. Objectives

The primary objective of this research project is to design and evaluate maintenance and rehabilitation HMA mixes as well as develop a reflective crack relief layer (RCRL) mix utilizing modified binders. Specifically thin lift mixes with a NMAS of 4.75 mm and 9.5 mm and a surface mix with a NMAS of 12.5 mm will be developed as maintenance and rehabilitation mixes using Superpave design methodology. These mixes will then be evaluated for their resistance to low temperature cracking and rutting. The secondary objective is to compare the performance of these modified mixes. Finally a RCRL mix will be developed and tested for its potential to prevent or mitigate reflective cracking.

III. Methodology

To achieve the objectives of these projects several sequential tasks must be accomplished. The means of conducting these tasks is outlined in further detail below. Figure 1 illustrates the experimental plan of the research project.

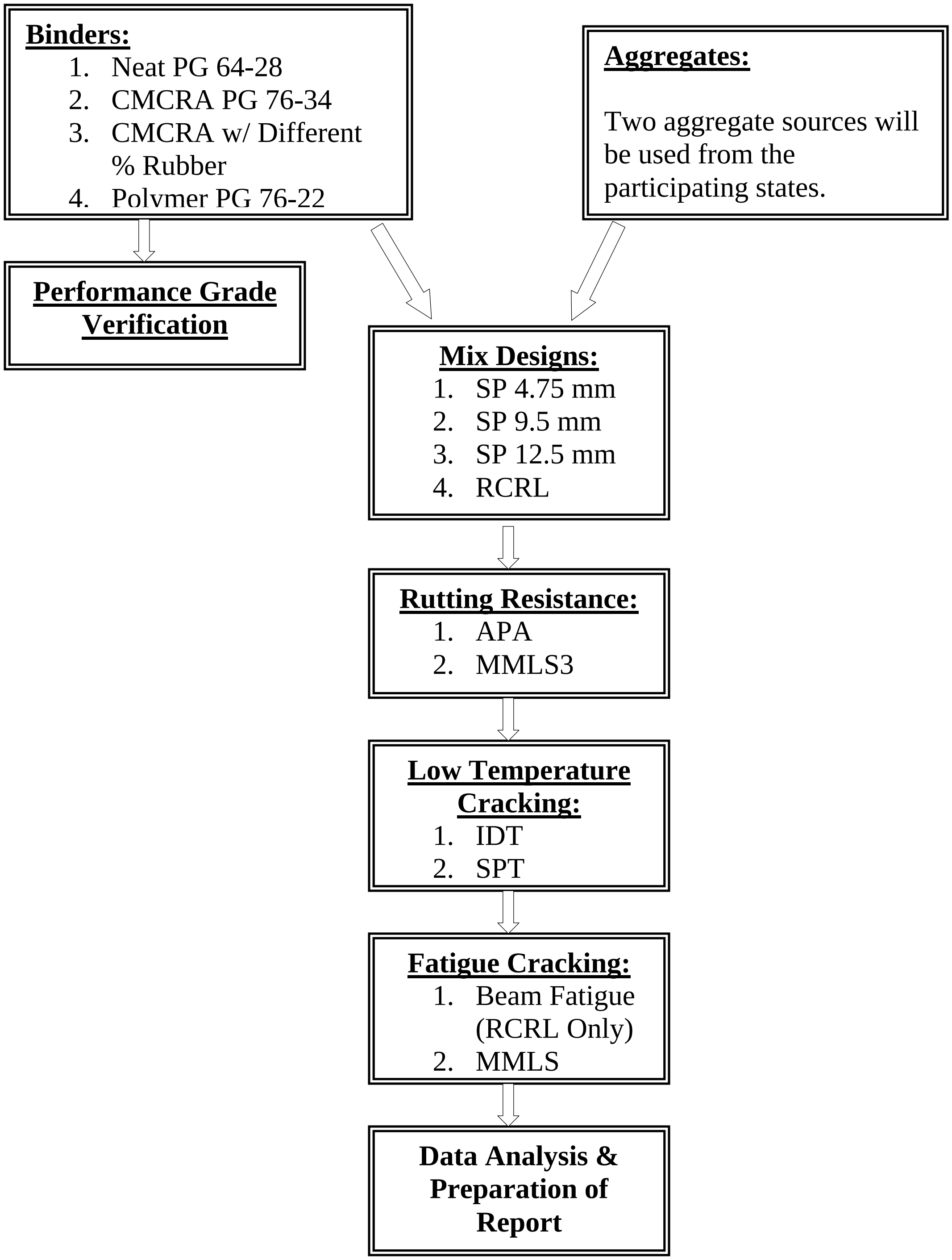

Figure 1: Experimental Plan

Task 1: ***Kick-Off Meeting***
In this task the PI will call a kick-off meeting to initiate the project. The meeting will take place after receipt of the notice to proceed. In addition to the PI, representatives from MassHighway and all other participating states will be invited. Also, Mr. Kevin Stuart, a consultant will be invited (Note: This proposal includes hiring Mr. Stuart to assist in adapting and evaluating the testing protocols for thin lift mixes versus conventional Superpave mixes). The PI at the meeting will present a review of the tasks and the experimental plan. At the meeting each state will provide Umass Dartmouth with its source of aggregates and the proper contacts to obtain the aggregates for this project In addition each state will also provide Umass Dartmouth with any Laboratory Trial Mix Formulas (LTMFs) with the NMAS of 4.75 mm, 9.5 mm, and 12.5 mm currently being specified.

Task 2: ***Literature Review***
A literature review will be conducted to obtain information on the development of maintenance and rehabilitation mixes prepared with modified binders using Superpave design methodology. Also, the differences between current methods to incorporate rubber in HMA and the method to make CMCRA will be explored. The experience using CMCRA in thin lifts as a rehabilitation and/or maintenance mix will be documented by sending a survey to each of the states that have reportedly used CMCRA. Also, this survey will be prepared to explore design and test methods for maintenance mixes as well as methods for their placement.

Task 3: ***Mix Designs***
The objective of this task is to design two thin lift mixes (NMAS 4.75 mm and 9.5 mm), a surface mix (NMAS 12.5 mm), and a RCRL mix using different performance grade modified binders as outlined in Table1. At the current funding rate, mixes will be designed using two aggregate sources in conjunction with current LTMFs that the participant states have for a mix of NMAS outlined for this study. If additional funding permits, more mixes could be developed from other aggregate sources or additional binders could be evaluated with the two aggregate sources outlined for this research.

	Aggregates Source	
Binder	**One**	**Two**
Neat PG 64-28	SP 4.75 SP 9.5 SP12.5	SP 4.75 SP 9.5 SP12.5
CMCRA PG 76-34	SP 4.75 SP 9.5 SP12.5 RCRL	SP 4.75 SP 9.5 SP12.5 RCRL
CMCRA with different % Rubber*	SP 4.75 SP 9.5 SP12.5 RCRL	SP 4.75 SP 9.5 SP12.5 RCRL
Polymer PG 76-22	SP 4.75 SP 9.5 SP12.5	SP 4.75 SP 9.5 SP12.5

*Percent rubber and PG to be decided at the kickoff meeting.
SP = Superpave RCRL = Reflective Crack Relief Layer

<u>Table 1:</u> Test Matrix for Task 3

Superpave aggregate consensus properties, required by Superpave, will be determined for each stockpile supplied. Control mixes will be prepared using a neat binder currently used by the participating states. These control mixes will be evaluated to obtain comparison results. The draft AASHTO Standard Specifications for designing a 4.75 mm mix (3) will be used.

Task 4:*Verification of Binder Performance Grade*
In this task all the binder tests included in the Superpave binder specification will be performed for verification of the performance grade. Since this study involves the use of chemically modified asphalt binders, both the conventional Superpave test methods and the methods presented in NCHRP 9-10 entitled *"Superpave Protocols for Modified Asphalt Binders"* will be explored for their relevance to this study by the consultant prior to commencement of testing.

Conventional Superpave asphalt binder tests are performed using the Dynamic Shear Rheometer (DSR), Bending Beam Rheometer (BBR), Direct Tension Device, and Rotational Viscometer. Aging of the binders is typically using the Rolling Thin Film Oven (RTFO) and the Pressure Aging Vessel (PAV). Typically AASHTO TP5-98 entitled *"Method for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer(DSR)"* and AASHTO TP1-98 entitled *"Method for Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)"* are performed.

Task 5: *Evaluation of Mixes Resistance to Low Temperature Cracking*
In this task nine (9) specimens per mix will be prepared at an air void level of 6 -8 percent. Three (3) specimens at the binder content obtained in Task 3, three (3) specimens at the binder content plus 0.4% binder, and three (3) specimens at the binder content minus 0.4% binder. Generally, the range of the percent binder content of HMA placed in the field is the binder content from design ±0.4%. All mixes will be tested for their resistance to low temperature cracking utilizing a MTS servo-hydraulic system in accordance with AASHTO TP9-94 entitled, *"Test Method for Determining the Creep Compliance and Strength of Hot Mix Asphalt (HMA) Using Indirect Tensile Test Device"* Umass Dartmouth will utilize the consultant for this task to help evaluate and adapt the current testing procedures to thin lift mixes. Also, the newly developed simple performance test (SPT) will be explored.

Task 6: *Evaluation of Rutting and Fatigue Resistance*
Maintenance mixes, excluding RCRL, will be tested for rutting resistance using two accelerated pavement testers (APT) noted as follows:
1. Model Mobile Load Simulator (MMLS)
2. Asphalt Pavement Analyzer (APA)

These mixes will also be tested for fatigue resistance using the MMLS. The same number of specimens at the same binder contents mentioned in Task 5 will be prepared. Umass Dartmouth will utilize the consultant for this task to help evaluate and adapt the current testing procedures to thin lift mixes.

Task 7: *Evaluation of the RCRL Resistance to Reflective Cracking*
Two tests will be conducted to evaluate the RCRL mix resistance to reflective cracking: 1) beam fatigue test, using high applied strain, to evaluate the susceptibility to flexural cracking, and 2) two concrete slabs will be placed in the MMLS mold and the RCRL mix will be placed at the top of the concrete layer followed by placing a dense mix at the top. Umass Dartmouth will utilize the consultant for this task to help evaluate and adapt the current Superpave testing procedures to thin lift mixes.

Task 8 : ***Data Analysis***
The data will be analyzed using the statistical package Statistica™. The analysis will determine if the modified binders did improve the resistance of the mixes to low temperature cracking and rutting significantly as compared to the control mixes. The analysis will show if the RCRL can alleviate reflective cracking.

Task 9 : ***Preparation of the Final Report***
A report documenting the findings of the study will be prepared. The report will include the mix designs and the results from evaluating the mixes. Recommendations on preparing thin lift HMA using CMCRA will be presented.

IV. Deliverables
Umass Dartmouth will supply monthly and quarterly progress reports to the administrator of the study. These reports may then be forwarded by the administrator to the individual states for their records. Each report will include a summary of the progress to date as well as budget expenditures for that time period. Based on these reports, meetings to discuss the progress of the study with the administrator and technical representatives from each state can be scheduled as warranted.

The final report for the project will be delivered to each technical representative within 3 months of completion of the study. This delivery will include ten (10) bound copies for each state as well as one (1) copy that is suitable for reproduction. Any deviation from the delivery schedule will be discussed with the technical representatives.

V. UMASS Dartmouth Materials Lab Facilities
The Umass Dartmouth Materials lab, located at the Advanced Technology and Manufacturing Center (ATMC) in Fall River Massachusetts, is AASHTO R18 accredited to perform various aggregate, binder and hot mix asphalt (HMA) testing.

The binder equipment located at the lab includes a Rotovap binder extraction device, Brookfield rotation viscometer, TA Instruments AR2000 Dynamic Shear Rheometer (DSR), Instron Direct Tension (DT) test device, and the Instron Bending Beam Rheometer (BBR). The lab is in the final stages of ordering the James Cox & Sons Rolling Thin Film Oven (RTFO) and Prentex Pressure Aging Vessel (PAV). All these binder equipment are necessary to perform Superpave Performance Grading (PG).

The lab is also equipped with two Superpave Gyratory Compactors (SGC's) (Pine Brovold AFGB1A and a Troxler 4140) and the other related testing equipment required to design or verify a Superpave mix. For HMA performance testing, the lab is equipped with the Asphalt Pavement Analyzer (APA) which is an accelerated pavement tester (APT). Also, a new MMLS3 system is available as the second APT located at the lab. This system includes the MMLS3 load simulator, test bed, profilometer, HMA slab compactor, environmental chamber, wet pavement heater, and dry heating and cooling unit. Finally, the lab is equipped with a MTS servo-hydraulic testing system required for indirect tensile, creep, and resilient modulus testing.

VI . Schedule

The schedule of activities is indicated in Table 2. The project will be completed in 24 months. This time includes time needed for project meetings, project evaluations and preparation of reports.

Task	Year 1												Year 2											
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								

<u>Table 2:</u> Schedule of Activities