

Research Approach

Work Plan/Experimental Design

AAT's proposed approach to this project is designed to achieve all project objectives, within the specified budget and schedule. The proposed project consists of five tasks which are described in the sections that follow.

Task 1: Develop Laboratory Testing Plan

A detailed experimental design for the laboratory testing and analysis will be prepared in Task 1. The detailed experimental design will be a modification of the preliminary experimental design presented in this proposal. Based on the available budget approximately 16 mixtures can be evaluated. AAT proposes to use a subset of the mixtures included in WHRP Project 0092-08-06, *Wisconsin Mixture Characterization Using the SPT on Historical Aggregate Structures*. These mixtures are also being used in WHRP Project 0092-09-01, *Evaluation of Flow Number F_n as a Discriminating HMA Mixture Property*. Table 1 summarizes the mixtures that are recommended for this project. By using the same mixtures used in WHRP Projects 0092-08-06 and 0092-09-01 a database containing dynamic modulus, flow number, low temperature compliance, and low temperature strength will be assembled.

Table 1. Recommended Mixtures for AASHTO T322 Testing.

Mix Number	Source	NMAS, mm	Design Traffic Level	Binder Grade	Design VMA	Design VFA
1	Cisler	12.5	E-3	PG 58-28	14.3	72.0
2	Cisler	12.5	E-10	PG 70-28	15.8	74.7
3	Wimmie	12.5	E-3	PG 58-28	14.6	72.7
4	Wimmie	12.5	E-10	PG 70-28	15.1	73.5
5	Christian	12.5	E-3	PG 58-28	14.6	72.5
6	Christian	12.5	E-10	PG 70-28	15.4	73.8
7	Glenmore	19.0	E-3	PG 58-28	13.5	70.3
8	Glenmore	19.0	E-10	PG 70-28	13.2	69.7

Several experiments using 16 mixtures can be designed for mixtures shown in Table 1. To evaluate the effect of RAP on thermal fracture resistance, the 8 mixtures listed in Table 1 can be tested as shown and then with 20 percent of the binder replaced with RAP binder. To evaluate the effect of binder properties, the 8 mixtures listed in Table 1 can be tested using PG 58-28 binder, then the E-3 mixtures can be tested using PG 58-34 binder and the E-10 mixtures tested using PG 64-28 binder. Combination of these options and changes in volumetric properties can also be considered since Project 0092-09-01 will include changes in selected volumetric properties.

AAT will seek the guidance of the Technical Oversight Committee (TOC) to finalize the experimental design. A Draft Experimental Design will be prepared and forward to the TOC for

review and comment. A meeting with the TOC will then be scheduled to finalize the Task 1, the experimental design and mixture selection.

Task 2: Laboratory Testing

Task 2 includes procuring samples of the materials identified in the Experimental Plan from Wisconsin sources, and executing the testing plans developed in Task 1. The required input data for the thermal cracking analysis in the MEPDG is indirect creep compliance measurements at three temperatures, and indirect tensile strength measurements at one temperature (5). All of these compliance and strength measurements can be made on the same three specimens to minimize fabrication costs. This will also minimize the amount of material that must be shipped to AAT. Only 50 lbs of each mixture will be required including 50 percent waste. If the materials from WHRP Projects 0092-08-06 and 0092-09-01 are used as proposed, sufficient quantities of the base mixtures for this project will already be available at AAT and only additional binders and RAP will need to be procured and shipped to AAT. The budget for the project makes this assumption.

Testing will be performed in accordance with AASHTO T322 by qualified technicians. AAT routinely conducts AASHTO T322 tests on research and mixture evaluation projects. AAT's laboratory has been accredited since 1996 by AMRL for a wide range of binder, hot-mix asphalt, and aggregate tests. AAT's current accreditation can be found in the AASHTO R18 online directory at:

http://www.amrl.net/Portal/DesktopDefault.aspx?tabindex=99&tabid=49&LaboratoryID=fhNbpwkOyFs*V

Task 3: Data Analysis

In this task, the laboratory data collected in Task 2 will be analyzed. The following analyses will be completed:

1. **Compute Compliance and Strength Values.** AAT uses a spreadsheet developed by Dr. Donald Christensen, P.E. (8) to convert the raw data to creep compliance and strength properties. This spreadsheet performs the computations described in AASHTO T322 and fits a creep compliance model to the measured data. The goodness of fit statistics for the creep compliance model are a good indicator of the quality of the data. The database of compliance and strength measurements can be used with the MEPDG for thermal cracking analysis.
2. **Identify Relationships Between Mixture Composition and Compliance and Strength Properties.** This analysis will use graphical and statistical tools to identify relationships between mixture composition and compliance and strength properties. The data collected in this project will be supplemented with additional creep compliance and strength measurements made by AAT on other projects. For example in NCHRP 9-29, AAT performed compliance and strength testing on 16 mixtures that used four different aggregates and four different binders.
3. **Evaluate Current Wisconsin DOT Binder Selection and Mixture Design Criteria.** AAT will use the relationships between mixture composition and

compliance and strength to evaluate whether the Wisconsin DOT should consider changes to their mixture design and acceptance criteria.

Task 4: Prepare Tutorial

In Task 4 a tutorial that demonstrates how binder selection and mixture composition affect low temperature properties of mixtures will be developed. This tutorial is intended for use in training programs provided by the Wisconsin DOT for engineers and technicians involved in the design and acceptance of HMA.

Task 5: Compile Final Report

The final task, Task 5, includes the preparation and submission of the Final Report for the project, documenting all significant work completed during the project. The report will be prepared in accordance with the Wisconsin Highway Research Program requirements. A Draft Final Report will be compiled by the research team and submitted to the TOC for review and comment. The research team will address the comments, then compile and submit the required number of copies of the Final Report. An electronic database of the laboratory test results will be included with the Final Report. Task 6 includes a closeout presentation by the Principal Investigator to the TOC.

Expected Contribution From WisDOT Staff

The proposed research will require some assistance from the Wisconsin DOT staff to review the experimental design and the products of the work. The research team does not anticipate the Wisconsin DOT contributions will exceed the 30 hours identified in the request for proposals.

Anticipated Research Results and Implementation Plan

Research Results

There will be six primary research products completed as part of the proposed research:

1. A database of creep compliance and strength properties for typical Wisconsin mixtures. This database can be used to perform thermal cracking analysis of pavement sections using the MEPDG or to compare properties of new mixtures (for example high RAP content mixtures) with mixtures that are currently being designed and produced.
2. Relationships between mixture composition and low temperature creep compliance and strength properties. These relationships could be used to estimate compliance and strength properties for mixtures not included in the database.
3. An evaluation of current Wisconsin DOT criteria for mixture design and acceptance based on the relationships between mixture composition and low temperature creep compliance and strength properties.
4. Recommended modifications to current Wisconsin DOT criteria for mixture design and acceptance if warranted.

5. A tutorial demonstrating how binder selection and mixture composition affect low temperature properties of mixtures.
6. A final report thoroughly documenting the work completed in the project.

Implementation of the products from this study will result in improved HMA mixture design. The products will reduce the risk of premature failure of pavements from thermal cracking and will result in a cost savings to the public.

Implementation Plan

The intended audience for the products outlined above is engineers and technicians responsible for HMA mixture design and acceptance. Typically, these are entry to mid-level engineers and experienced technicians working for the Wisconsin DOT and HMA producers. The research team will keep the products produced during this project appropriate to these intended end-users.

Implementation of the products of this research will be straightforward and most can be implemented immediately. The analysis of current Wisconsin DOT mix design and acceptance criteria will either support these criteria or identify changes that should be considered. The database of creep compliance and strength properties for typical mixtures can be used in Wisconsin DOT's efforts to implement the MEPDG. The tutorial demonstrating how binder selection and mixture composition affect low temperature properties of mixtures can be included in training programs provided by the Wisconsin DOT for engineers and technicians involved in the design and acceptance of HMA. The most likely impediment to implementation will be resistance from HMA producers if changes to current mix design and acceptance criteria are recommended.

Time Requirements

Figure 1 present the proposed time schedule. The first three months will be used to develop the laboratory testing plan and meet with the TOC to finalize the mixture selection and laboratory testing. Nine months have been provided for the laboratory testing and data analysis, and one month for the preparation of the tutorial. The Draft Final Report will be submitted at the end of the 15th month of the project. Three months are provided for preparation and submission of the Revised Final Report. The close out presentation will be made in the 16th month of the project and comments from the close out presentation will be incorporated in the Revised Final Report

Task/Activity	Contract Month																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Task 1: Develop Laboratory Testing Plan	X	X																
Task 2: Laboratory Testing			X	X	X	X	X	X	X	X	X							
Task 3: Data Analysis				X	X	X	X	X	X	X	X	X						
Task 4: Prepare Tutorial													X					
Task 5: Compile Final Report													X	X	X	X	X	X
<i>Presentations</i>		X														X		
<i>Quarterly Reports</i>				X			X			X			X			X		
<i>Laboratory Testing Plan</i>	X																	
<i>Draft Final Report</i>															X			
<i>Revised Final Report</i>																		X

Figure 1. Project Schedule.

The project is estimated to require 568 man-hours of effort. Table 2 summarizes the level of effort by task and individual.

Table 2. Planned Effort by Task.

		Level of Effort					
Individual	Role	Task 1	Task 2	Task 3	Task 4	Task 5	Total
Bonaquist	Principal Investigator	24	20	80	20	40	184
Jack	Lab Manager	0	96	0	0	0	96
Bennett	Senior Technician	0	96	0	0	0	96
D. Tederick	Senior Technician	0	96	0	0	0	96
P. Tederick	Technician	0	96	0	0	0	96
Total		24	404	80	20	40	568