Quarterly Progress Report:
Project Number and Title: 2.1 Asphalt Mixtures with Crumb Rubber Modifier (CRM) for Longevity and Environment
Research Area: Thrust 2 NEW MATERIALS FOR LONGEVITY AND CONSTRUCTABILITY
PI: K. Wayne Lee, University of Rhode Island (URI), Civil and Environmental Engineering
Co-PI(s): George E. Veyera, Professor of Civil and Environmental Engineering, URI
Reporting Period: 1/1/20 to 3/31/20
Submission Date: 3/31/20

Overview:

*Provide **BRIEF** overview and summary of activities performed during the reporting period. This summary should be written in lay terms for a general audience to understand. This should not be an extensive write up of findings (those are to be included in the final report), but a high-level overview of the activities conducted during the last three months….*

The feasibility of using Crumb Rubber Modifier (CRM) in hot mix asphalt (HMA) was investigated by the team at the University of Rhode Island (URI) in the 1990s. By adding the CRM, asphalt mixture had same or better performance against rutting and cracking. Therefore, a comprehensive literature review was carried out to confirm the advantages of CRM and to establish the experimental design for this study. Tests were also conducted to determine Optimum Binder Content (OBC) for the baseline (or control) asphalt mixtures. The 1st step was selection of aggregates and asphalt binder. Typical Rhode Island (RI) aggregates and PG64-28 asphalt binder were selected for this study. In the 2nd step, 3 different gradation of aggregates were used based on Superpave aggregate requirements and RI Class I-1 gradation was selected. In the 3rd step, asphalt mixture specimens were prepared using four different asphalt binder contents to determine the OBC. The volumetric properties were plotted versus asphalt contents. The OBC was 6.3%, determined at 4.0 % air voids, as can be seen in Figure 1.

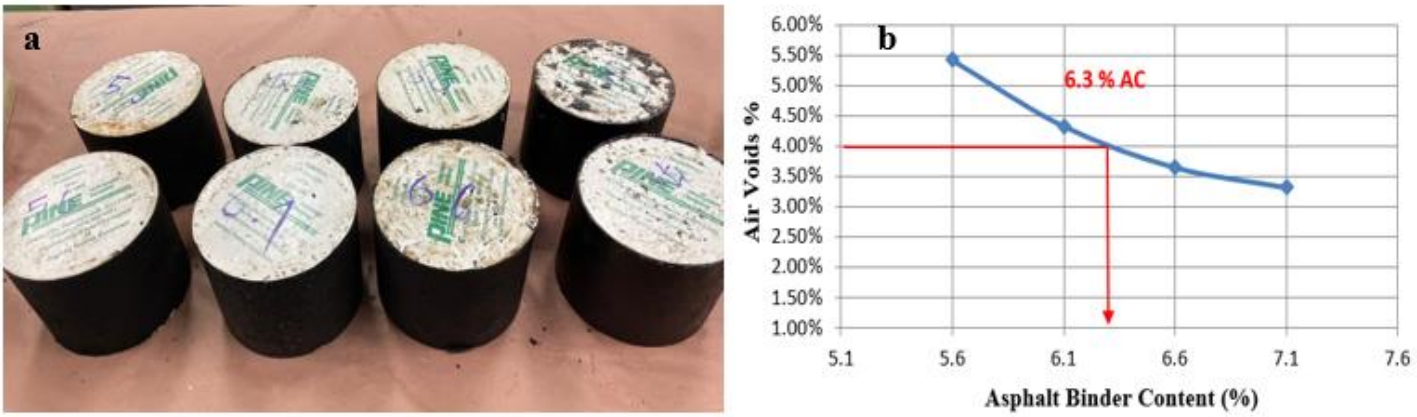

Figure 1. (a) Samples to determine OBC (b) Air voids versus Asphalt binder content

Provide context as to how these activities are helping achieve the overarching goal(s) of the project…

Producing high-performing asphalt mixtures with CRM is the main goal of the project. The first step was to secure a baseline of the performance with the asphalt mixture with RI Class I-1 gradation, which has been used in the surface layer. To prepare specimens for performance testing, OBC was first determined. Aggregate gradation effect on performance, e.g., rutting resistance needs to be studied. Binder content is one of important

parameters, e.g., thermal or low-temperature cracking resistance. A flowchart of the research project to fulfil the objectives is presented in Figure 2.

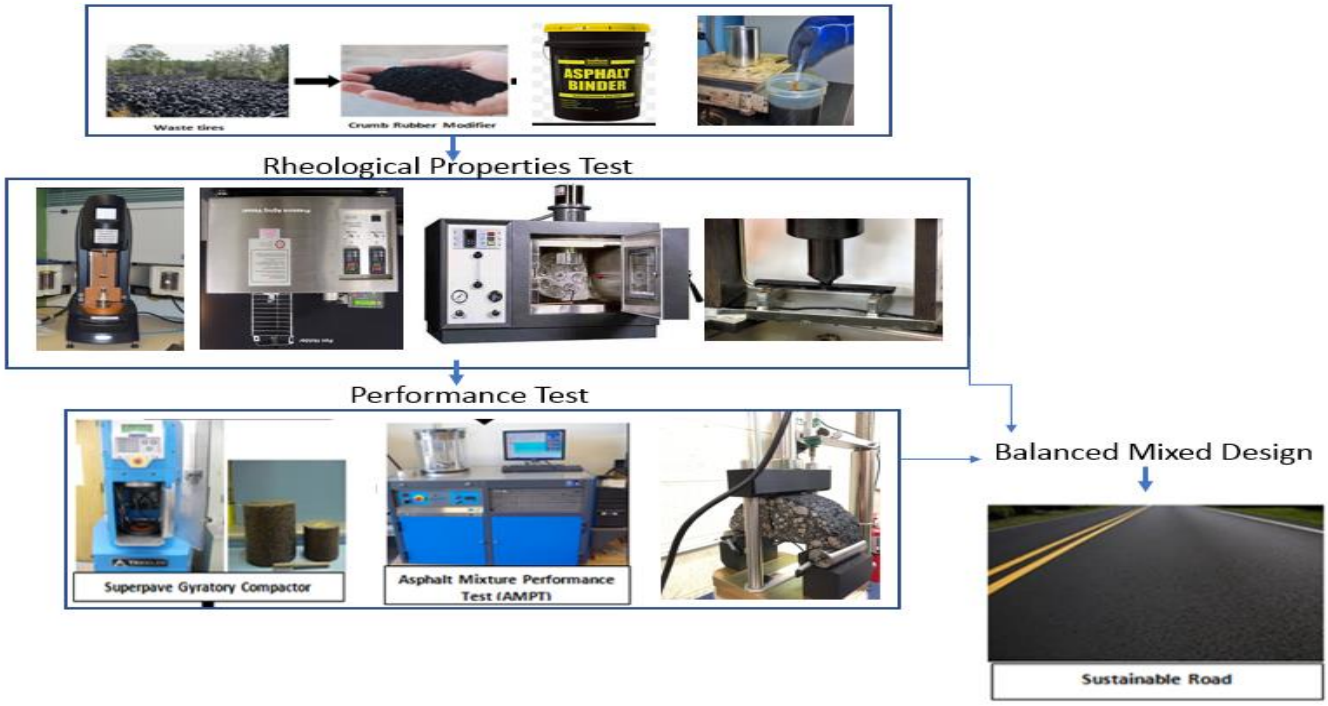

Figure2. Flowchart of the research project

Describe any accomplishments achieved under the project goals…

The best gradation of aggregates was selected to create asphalt mixture samples, i.e., RI Class I-1. In addition, OBC with RI Class I-1 gradation was determined using the Superpave asphalt mixture design, i.e., 6.3% as part of the baseline data.

The viscosity of the asphalt binder increases with the addition of CRM. Therefore, asphalt rubber mixtures should be compacted at higher temperatures. By using WMA instead of HMA the viscosity of asphalt cement reduces, as well as the mixing and compaction temperature. A preliminary study was therefore conducted with a WMA additive, i.e., Evotherm, to test whether the use of the additive develops both short-term and long-term pavement performance improvements compared with traditional asphalt binder. WMA and HMA specimens containing RAP were prepared for determination of the OBC. Results have shown that HMA mixtures have about 13% higher tensile strength than WMA with the same volume of RAP. Based on the results, the stiffness of the asphalt mixture increases in the WMA-RAP mixtures. Therefore, it could have improved rutting performance in comparison to the HMA mixtures with and without RAP.

Complete the following tables to document the work toward each task and budget (add rows/remove rows as needed)…

Table 1: Task Progress			
Task Number	**Start Date**	**End Date**	**Percent Complete**
Task 1:	10/1/18	3/31/19	95%
Task 2:	4/1/19	9/30/19	55%
Task 3:	7/1/19	12/31/19	55%
Task 4:	10/1/19	3/31/20	55%
Task 5	4/1/20	9/30/20	0%

Table 2: Budget Progress		
Entire Project Budget	**Spend Amount**	**Spend Percentage to Date**
$140,895	$85,000 (estimated)	60% (estimated)

Describe any opportunities for training/professional development that have been provided…

In August 2019 a graduate student, Ms. Neha Shrestha, successfully completed her MS thesis, entitled *"Performance Prediction of Warm Mix Asphalt Pavement Containing Reclaimed Asphalt Pavement in Rhode Island."* However, for personal reasons, she decided to take a one-year leave from the research program. Two new Ph.D. students, Mr. Ali Sharai and Mr. Mohammed Alotaibi, began working on this project starting 9/1/19. They will use the findings and results of the TIDC study in their Ph.D. dissertations in Civil and Environmental Engineering.

Describe any activities involving the dissemination of research results (be sure to include outputs, outcomes, and the ways in which the outcomes/outputs have had an impact during the reporting period. Please use the tables below for any Publications and Presentations in addition to the description of any other technology transfer efforts that took place during the reporting period.)… Use the tables below to complete information about conferences, workshops, publications, etc. ***List all other outputs, outcomes, and impacts after the tables*** *(i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings).*

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**
” Resilient Cold In-Place Recycling Asphalt Mixture and Pavement”	The ASCE Construction Institute (CI) Summit	Conference	Los Angeles, CA	2/20 to 2/23/20

Table 4: Publications and Submitted Papers and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
N/A				

Participants and Collaborators:

Use the table below to list all individuals who have worked on the project.

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
K. Wayne Lee	leekw@uri.edu	Civil Engineering	PI
George Veyera	gveyera@uri.edu	Civil Engineering	Co-PI

Use the table below to list all students who have participated in the project.

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Ali Sahraei Joubani asahraeijoubani@my.uri.edu		Ph.D.	Civil Engineering	GRA II
Mohammed Alotaibi		Ph.D.	Civilo Engineering	GRA II

Use the table below to list any students who worked on this project and graduated during this reporting period.

Table 7: Student Graduates			
Student Name	**Role in Research**	**Degree**	**Graduation Date**
N/A			

Use the table below to list organizations have been involved as partners on this project and their contribution to the project.

Table 8: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
N/A						

List all other outputs, outcomes, and impacts here (i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings). Please be sure to provide detailed information about each item as with the tables above.
None

Have other collaborators or contacts been involved? If so, who and how? (This would include collaborations with others within the lead or partner universities; especially interdepartmental or interdisciplinary collaborations.
Mr. Paul Petsching, RIDOT, Technical Champion
Prof. Hao Wang, Rutgers University

Changes:

Discuss any actual or anticipated problems or delays and actions or plans to resolve them…
None

Discuss any changes in approach and the reasons for the change…

Because Neha Shrestha took a leave of absence, new graduate research assistants were needed for the project. Fortunately, two Ph.D. candidates were found so they could continue the research based on Neha's findings. Also, since Neha used a chemical additive, the plan is to use foamed asphalt for comparative analyses in the 2nd year.

Unfortunately, to date it has not been possible to purchase the Laboratory Foamed Machine, mainly because of the cost of the equipment. Fortunately for the research program, the Maine DOT plans to lease the equipment to URI for up to 5 years. The arrangement details for the equipment loan are presently being sorted out by both legal departments of both institutions.

The URI research team also purchased two full versions of AASTHOware Pavement ME Design (PavementME) software, but the purchasing process was a little delayed.

Additionally, since it was observed that some results of the URI research in 1995 indicated that adding CRM in HMA with different percentages of extender oil by comparison with asphalt concrete showed decreasing rutting resistance and increasing the fatigue life, an additional study appears to be needed.

Planned Activities:

Description of future activities over the coming months (4/1/2020-6/30/2020).

Modified Superpave mix-designs will be performed for the RI WMA with and without RAP to establish the base line data.

CRM will be applied in different percentages to the HMA and WMA mixtures with and without RAP.

A series of performance tests will be conducted at various loading frequencies and temperatures using the AMPT, Semi-Circular Bending Test (SCBT), and Asphalt Pavement Analyzer (APA).

Then a preliminary BMD for WMA asphalt mixtures containing CRM and/or additives such as Evotherm will be developed for the comparative study. The URI research team will also investigate WMA using the laboratory-scale foamed asphalt plant. A series of comparative analyses will be carried out.

The prediction of pavement performance will be carried out using the AASHTOWare Pavement ME Design (PavementME) software and other performance models.