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: 10/1/19 to 12/31/19
Submission Date: 12/30/10

Overview: (Please answer each question individually)

*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….*

A team at the University of Rhode Island (URI) carried out a research program in the 1990s to determine the feasibility of using Crumb Rubber Modifier (CRM) in hot mix asphalt (HMA). Results indicated that in contrast with conventional HMA, the addition of CRM to the paving asphalt mixtures offered similar or better performance in terms of rutting and fatigue cracking. Therefore, a literature review was carried out to confirm the advantages of CRM and to improve the experimental design. Tests were also carried out to evaluate the rheological properties of asphalt binder containing CRM and to compare it with straight asphalt binder. Since Reclaimed Asphalt Pavement (RAP) has become commonly added to paving mixtures, CRM has been added to HMA containing RAP. A pilot study was conducted using an Asphalt Mixture Performance Tester (AMPT), and master curves were developed. Moreover, CRM will be added to Warm Mix Asphalt (WMA) mixtures with and without RAP.

Provide context as to how these activities are helping achieve the overarching goal(s) of the project…
The goal of the project is to produce high-performing asphalt mixtures with CRM, thereby offering sustainable and durable pavements compared to traditional ones with HMA. Therefore, the URI team started to explore a new generation of asphalt mixtures with CRM to enhance the longevity of the pavement. Figure below shows that the WMA containing CRM and RAP to improve sustainable and durable asphalt pavements.

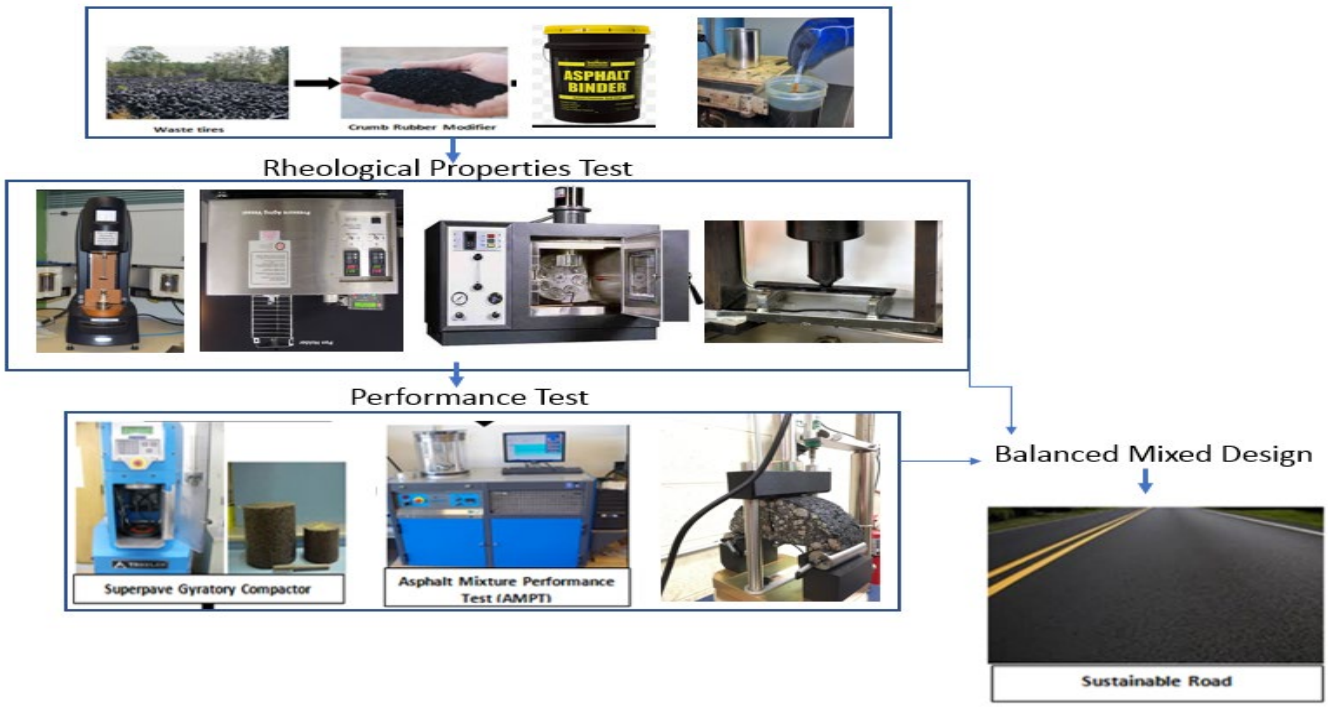

Figure1. Flowchart of the research project

Describe any accomplishments achieved under the project goals…

The addition of CRM to the asphalt binder increases the viscosity. Therefore, the compaction temperature of the asphalt rubber mixture must be higher. However, it was found that WMA was shown to reduce the viscosity, as well as the compaction and mixing temperatures. 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 compared to the traditional asphalt binder. Evotherm is a promising additive approved by New England Asphalt User and Producer Group (NEAUPG). WMA and HMA specimens containing RAP prepared in the Optimum Binder Content (OBC) and Indirect Tensile (IDT) strength tests. Results have shown that HMA mixtures have about 13 percent higher tensile strength than WMA with the same volume of RAP. The HMA and WMA samples with and without RAP were prepared to predict asphalt pavement performance utilizing dynamic modules and master curves. The results indicated that the WMA-RAP mixtures would increase the stiffness of the asphalt mixture and provide better performance in terms of rutting resistance by comparison with the HMA mixtures with and without RAP. It has also been found that WMA mixtures without RAP displayed weak rutting resistance by contrast with HMA with and without RAP.

Moreover, in 2015, two RI Rt. 102 sections were rebuilt using WMA-RAP mixtures, and since then, the research team has been carefully analyzing field performance for both HMA and WMA sections. No apparent pavement distresses have been found to date, and it appears that both sections are performing similarly.

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:	7/1/18	12/31/18	90%
Task 2:	1/1/19	6/30/19	50%
Task 3:	4/1/19	9/30/19	50%
Task 4:	7/1/19	12/31/19	50%
Task 5	1/1/20	6/30/20	0%

Table 2: Budget Progress		
Entire Project Budget	**Spend Amount**	**Spend Percentage to Date**
$249,368	$125,000 (predicted)	50% (predicted)

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." Nonetheless, 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 have thus started to work on this project from 9/1/19. They are using 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)**
"Balanced Mix Design for Sustainable Pavement with Warm Mix Asphalt"	The 11th International Committee on Pavement Technology (ICPT)	Conference	Seri Pacific Hotel, Kuala Lumpur, Malaysia	7/11/19
"Investigation on Rheological Properties of Warm Mix Asphalt"	The US-Korea Conference on Science, Technology, and Entrepreneurship (UKC 2019)	Conference	Chicago, IL	8/15/19
"Asphalt mixtures with Crumb Rubber Modifier for Longevity and Environment"	The 32^{nd} Rhode Island Transportation Forum	Conference	Kingston, RI	10/25/19

"Performance Prediction of Warm Asphalt Pavement containing Reclaimed Asphalt Pavement in Rhode Island"	The 32^{nd} Rhode Island Transportation Forum	Conference	Kingston, RI	10/25/19

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
Competition paper	"Determining the Effect of Climate and Loading on Fatigue Cracking and Roughness of Asphalt Pavement Using InfoPave"	2018–2019 T&DI/ASCE-LTPP International Data Analysis Contest	7/1/19	Submitted
Conference paper	"Implementation of Warm Mix Asphalt contained Reclaimed Asphalt Pavement in Rhode Island"	The 99th TRB Conference	8/1/19	Submitted

Encouraged to add figures that may be useful (especially for the website)…

Insert figures here

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
Neha Shrestha	neha_shrestha@my.uri.edu	Master	Civil Engineering	GRA I
Masoud Farahmarzi	mfaramarzi@my.uri.edu	Ph.D.	Civil Engineering	GTA II
Ali Sahraei Joubani asahraeijoubani@my.uri.edu	asahraeijoubani@my.uri.edu	Ph.D.	Civil Engineering	GRA II
Mohammed Alotaibi	malotaibi@my.uri.edu	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**
Neha Shrestha	Conducted pilot experimental study	M.S.	8/31/19
Matthew Schryver	Assisted GRA for experimental study	B.S.	10/30/19

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**
		Mark the appropriate contribution with an "x"				

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

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 was taking a leave of absence, new graduate research assistants need to be employed. Fortunately, two Ph.D. students were found so they could continue based on findings of Neha. Also, since Neha used a chemical additive, the plan is to use foamed asphalt for comparative analysis in Phase II.

But currently, it was not possible to purchase the Laboratory Foamed Machine, mainly because of prices. Fortunately, for the research program, the Maine DOT plans to lease the equipment to URI for up to 5 years. With both legal departments, the arrangement details for the equipment loan are presently being sorted out.

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 URI research in 1995 indicates 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 (1/1/20 to 3/31/20).
Final Superpave Mix-Design will be performed with RI HMA with and without RAP to establish the baseline.

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

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

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

Then 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 analysis 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.