TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Minnesota Department of Transportation

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(341) http://www.pooledfund.org/Details/Study/590	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☒Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Developing Best Practices for Rehabilitation of Concrete with Hot Mix Asphalt (HMA) Overlays related to Density and Reflective Cracking		
Name of Project Manager(s): PI: Eshan V. Dave / PC: Debbie Sinclair / TL: Shongtao Dai	**Phone Number:** 603-862-5268	**E-Mail** eshan.dave@unh.edu
Lead Agency Project ID: NRRA LT1	**Other Project ID (i.e., contract #):** MnDOT Contract 1003326 WO 2	**Project Start Date:** 02/23/2018
Original Project End Date: 02/28/2021	**Current Project End Date:** 02/28/2021	**Number of Extensions:** 0

Project schedule status:

☒ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$169,970	$125,429	75%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
74%	$7,581 (4.5%)	81%

Project Description:
Asphalt overlays are commonly used to rehabilitate deteriorated Portland Cement Concrete (PCC) pavements; however, mechanically or thermally-driven movements at joints and cracks in the underlying pavement usually lead to the development of reflective cracks in the overlay. The formation and propagation of reflection cracking is controlled by the mechanical properties of the asphalt and the condition of the overlaid pavement. The current state of practice for asphalt overlay design is policy oriented and is lacking an engineered design approach. There is need for establishing state of practice in design of overlays as well as for assessment of PCC pavement condition and recommending improvements to existing pavement prior to overlay construction. The objective of the proposed study is to develop a simple decision tree based tool for selecting suitable asphalt mixtures and overlay designs to prolong overlay lives by lowering reflective cracking and improving in-situ density. This research will leverage the current National Road Research Alliance (NRRA) effort of constructing, instrumenting, and monitoring twelve MnROAD test sections, laboratory performance tests on asphalt mixtures from the test sections, and past field performance data. The proposed tool will incorporate field performance data, performance modelling, and life cycle cost analysis to develop best practices for rehabilitation of PCC with asphalt overlays.

Maintenance and rehabilitation of existing roadways uses a significant portion of available transportation funding. It is imperative for agencies to use the most effective tools and approaches to provide the required level of service and long term performance within the available resources. This research will provide specific guidance on the best materials and techniques to use in the rehabilitation of concrete pavements with an asphalt overlay. Recommended guidance from this study will incorporate consideration of constructability (time and effort), performance over time, and life cycle and cost-benefit analysis. It is anticipated that implementation of the tools and materials recommended from the results of this study will translate to savings in construction costs and time, improved serviceability of the roadways for users, and reduced life cycle costs.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):
General: Three project presentations were giving during this quarter. A project update was given during NRRA's Pavement Workshop by Eshan Dave on June 3rd, 2020. A presentation for NRRA's Long Term Research Pays Off Series was given by Eshan Dave and Katie Haslett on June 16th, 2020. Eshan Dave also presented at the NRRA virtual state visit with Missouri on May 14th, 2020. UNH researchers received thermocouple data from a select number of test sections (Cell 984, 989 and 992), MnROAD weather station data, distress maps for all test sections taken on March 2020, IRI data from November 2019, and Pathway distress data collected monthly since time of construction to 2019. Specific progress for various study tasks is provided below.

Task 1 Literature Review: This task is complete. Deliverable was approved by project TL on September 25th, 2018.

Task 2 Gathering Past Performance Data and Laboratory Testing: This task is complete. Deliverable was approved by project TL on August 7th, 2019.

Task 3 Mechanistic Analysis of HMA Overlay: This task is complete. Deliverable was approved by project TL on March 23rd 2020.

Task 4 A large portion of this quarter was dedicated to completing Task-4. The task deliverable was initially submitted on April 28th, 2020 for feedback from the TAP. The deliverable was then revised and re-submitted on May 27th, 2020. A brief summary of significant results from this task deliverable and updated cracking performance broken down by lane are included in a subsequent section.

Task 5 Developing Life and Performance Curves and Analysis of the Performance Monitoring: During this quarter, researchers have continued to perform a parametric evaluation of material properties on select MnROAD test sections; in addition, new finite element models of overlays with structures (3 lifts) and thicknesses other than those at MnROAD have been developed. In preparation to develop pavement performance curves, a TAP meeting was set up (June 25th, 2020) in order to receive feedback concerning what measures and types of performance curves would be most useful for agencies.

A summary of the key suggestions and recommendations made by project TAP members is included below:

- Use finite element models to perform a thickness sensitivity analysis (in ½ inch increments) up to 6 inch AC overlay total thickness.
- Importance of considering existing concrete condition in the development of decision tree tool and selection of rehabilitation treatment. Load transfer efficiency (LTE) taken prior to overlay construction will primarily be used and supplemented with computation models simulating different LTE and voids under slabs.
- Interest in seeing an additional finite element model that considers SMA on top of concrete.
- Performance curves will be developed primarily in terms of serviceability (IRI) measurements where agencies can then convert curves to another metric such as PCI or SR.
- When performing the life cycle cost analysis (LCCA) for each scenario, cost data will be used from MnDOT database. However, a limited sensitivity analysis will be done where cost will be adjusted (10% and 20%) higher and lower to provide agencies with a range in expected cost per rehabilitation treatment type.
- Consideration of thickness constraints (clearance issues) and to pavement shoulder construction cost when applicable included.

Task 6 Establish State of the Practice for PCC Condition: No progress to report.

Task 7 Establishment of State of Practice for HMA Mixtures and Their Effects on Reflective Cracking: No progress to report.

Anticipated work next quarter:
Key activities that will be undertaken in the upcoming quarter are the following:

A continuous effort to complete the parametric evaluation using the finite element model will be undertaken. Specifically, during this quarter researchers will focus on simulating different load transfer efficiencies and slab stabilization scenarios. Finite element models will also be revised using the provided thermocouple data for Cells 984, 989 and 992, to simulate critical cooling events between 2017-2020 rather than using historical thermal loading critical event data.

Based on the results from finite element analysis, promising overlay designs (materials and thicknesses) will be analyzed using AASHTOWare PavementME software. Additionally, all 12 MnROAD sections will be rerun in PavementME using MnROAD specific climate input data (from MnROAD weather station) rather than the default closest location (Illinois). Results from these simulations will be used in the development of performance life curves and subsequently in a life cycle assessment (LCA) and life cycle cost analysis (LCCA) as part of Task 6 and 7. It is anticipated that during this quarter the majority of the LCCA computations will be performed, meanwhile the goal and scope of the LCA will be defined and life cycle inventory data collected.

Significant Results:
Task-4 summarized and compared field performance results in terms of distress surveys, density profiling systems (DPS) and field cores with an emphasis on monitoring in-situ density sections (Cell 988-991). After the submission of Task-4, researchers received updated field performance data in terms of distress survey maps and IRI. Figures 1 through 3 show the updated percentage of reflective cracking (%RC) reported in each test section by lane (Driving and passing) and the combine performance of the two lanes. The red dashed box highlights the four density sections.

In general, Cells 989 (1.75 inch, 12.5 mm (5% AV) and 2.25 inch HMA, 19 mm) and 990 (1.75 inch, 12.5 mm (3% AV) and 2.25 inch HMA, 19 mm) are the best performers among the density sections. It is interesting to note that Cell 989 and Cell 990 switch ranking depending on which lane is being compared (driving or passing), however the combined performance of both lanes is similar at this point in time. Load transfer efficiency (LTE) of Cell 990 was substantially lower (22%) in the driving lane compared to Cell 989 (55%). Meanwhile the LTE in the passing lanes were closer while Cell 989 still reported a slightly higher value (59%) compared to Cell 990 (52%).

Cell 991 (1.75 inch, 9.5 mm (4% AV) and 2.25 inch HMA, 19 mm) is clearly the worst performer among the four density test sections. Another noteworthy test section is Cell 987 (1.5 inch, 9.5 mm (4% AV) and 2. 5 inch HMA, 19 mm) which also had a total lift thickness of 4 inches (equivalent to density sections) but the individual lift thickness varied. Performance ranking of all test sections as of the most current distress survey shows Cell 987 as a promising alternative design to Cell 989 and Cell 990 as they are all ranked the top 3 test sections in Figures 1 through 3.

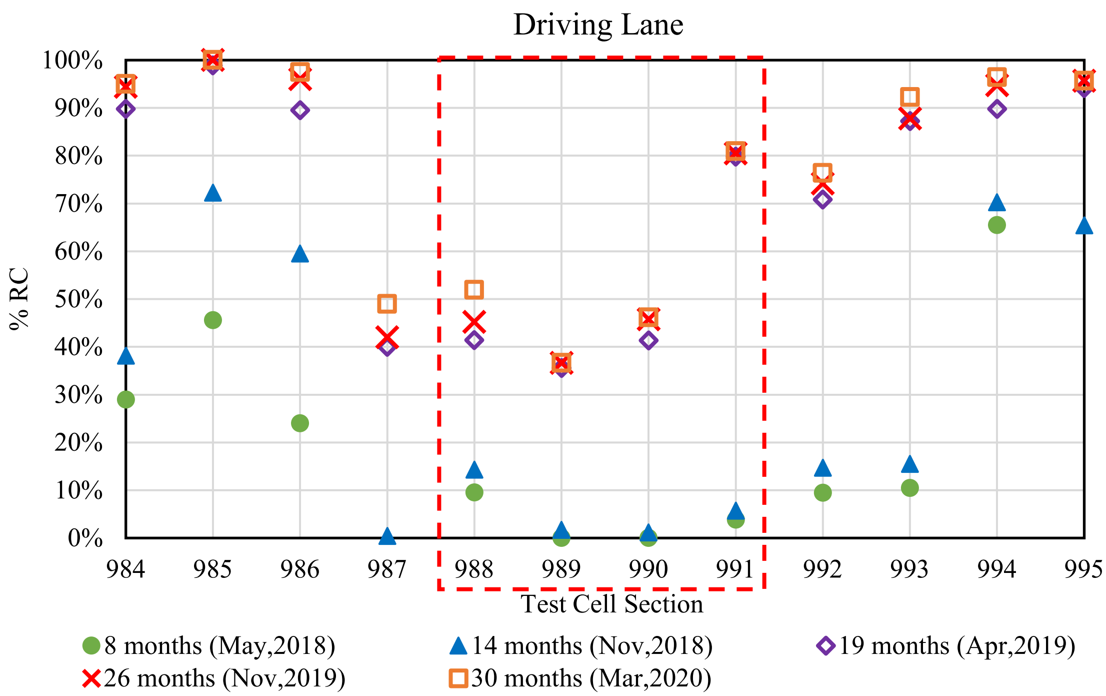

Figure 1: Percent reflective cracking by test section reported in driving lane only.

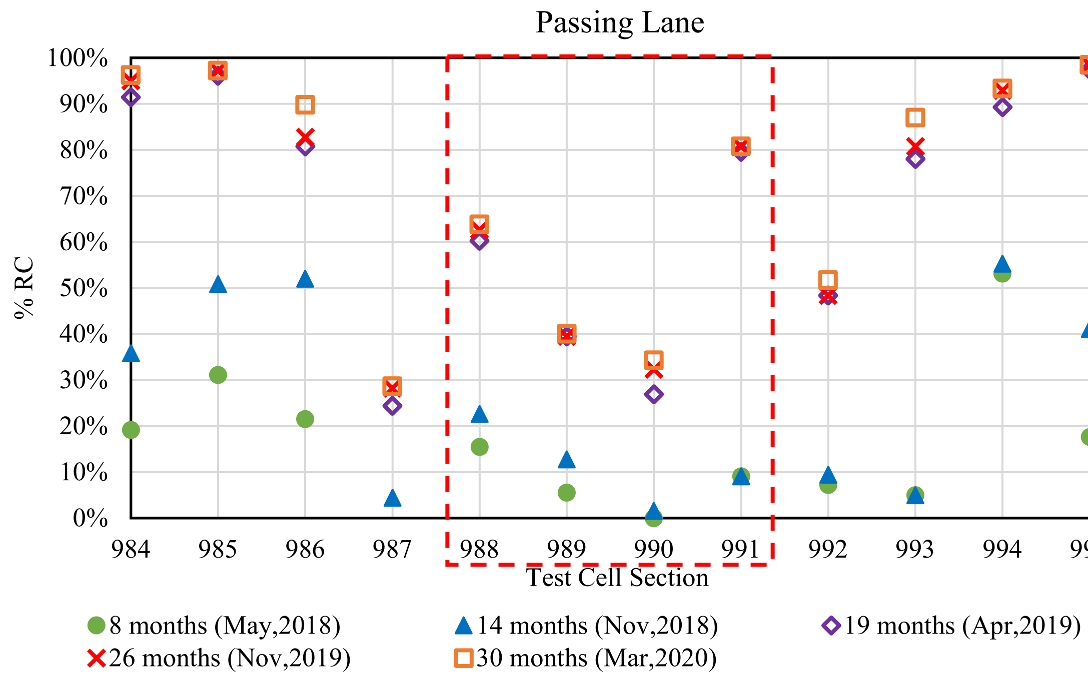

Figure 2: Percent reflective cracking by test section reported in passing lane only.

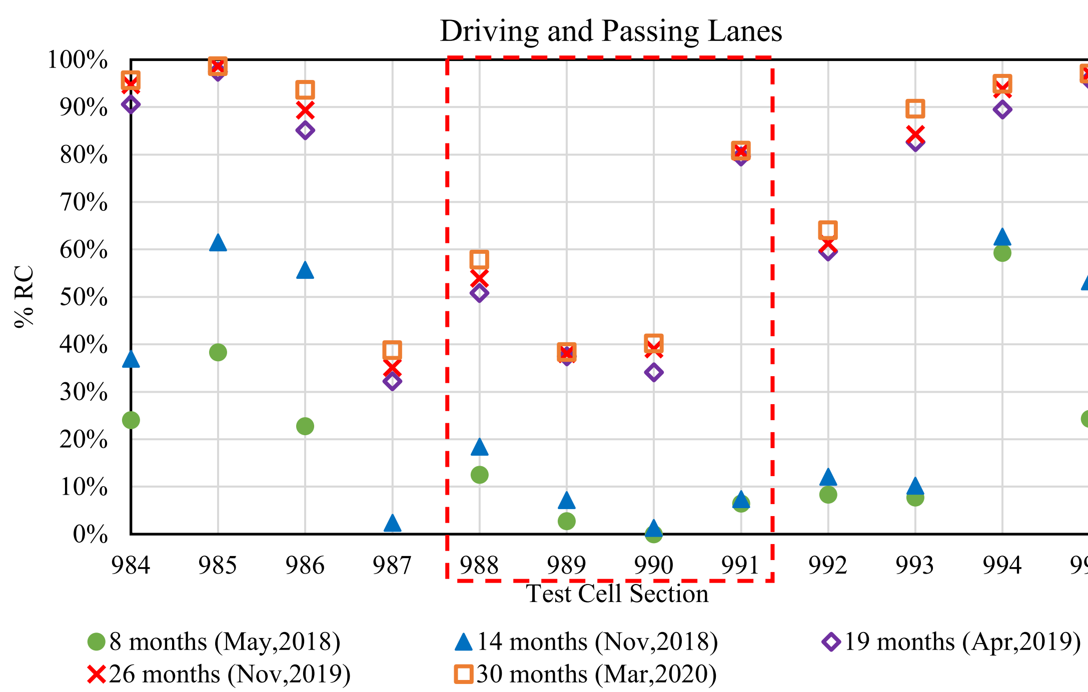

Figure 3: Percent reflective cracking by test section reported in both driving and passing lanes.

Researchers also received additional IRI measurements taken in November, 2019 (Figure 4). It should be emphasized that IRI measurements take in 2017 were prior to overlay construction and Cell 983 is the control test section (no asphalt overlay). It can be observed that Cell 994 does not experience a drop in IRI with the application of an asphalt overlay but rather IRI gradually increases over the past 2 years. This is due to the slab stabilization being performed using polyurethane compaction grouting and void filling prior to overlay construction. Pathway's distress data collected on a monthly basis since the time of construction was recently provided to the UNH research team. This data will be useful in providing a more in depth look at the change in IRI on a smaller scale (monthly rather than yearly) and the impact of seasonal temperature change on IRI measurements.

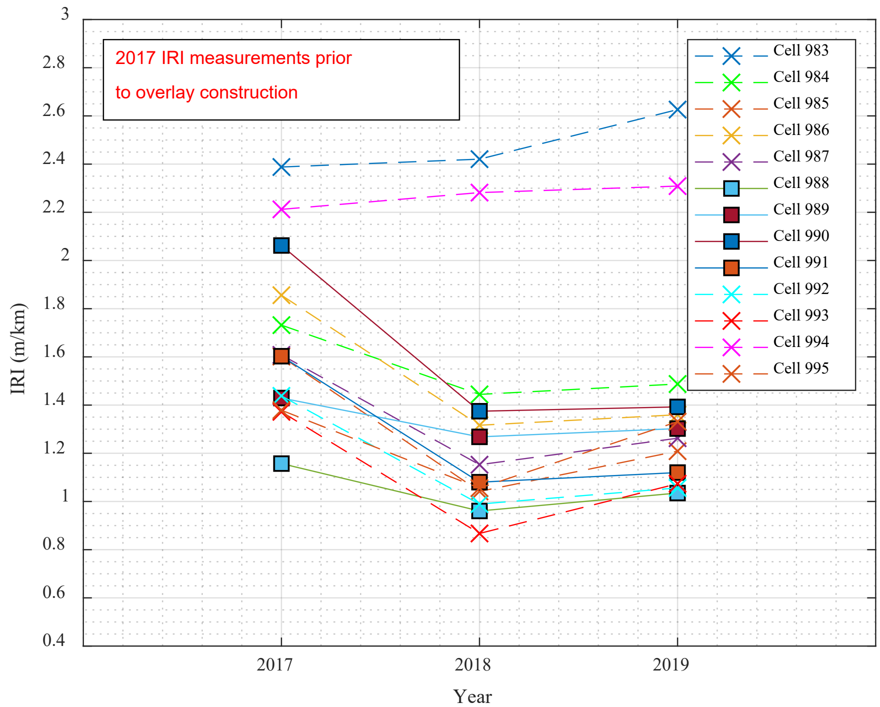

Figure 4: IRI measurements for all test sections.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Task 4 for the study was delayed. The main cause was the delay in receiving in-situ density data from MnDOT last Fall as well as the need for researchers to visit MnROAD to help collect data (which was not part of the work-plan for the study). This delay is not anticipated to cause delay to the other tasks or the overall project timeline.

Due to the Covid-19 pandemic and associated impacts (such as, requirements for remote working and restriction of personnel access laboratory and field facilities) there may be potential for delays in the future.

There has also been new data (pavement thermocouple histories, weather station data, and Pathway pavement performance data) provided to researchers. These datasets were not part of original work-plan, however their use is deemed important to improve reliability of research outcomes. Thus, task 5 (as well as tasks 6 and 7) are expected to take longer than anticipated. However, it is expected that these increased efforts are not going to impact overall timing of project end date.

Potential Implementation:
Initial recommendations with respect to wear mix types for 4-inch overlay designs as well as for interlayer based overlay designs have been presented at the NRRA Flexible Team online workshop session. This information can be implemented by NRRA member agencies in the interim while final project outcomes are being developed.