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

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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	$161,766	85%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
95%	$36,338 (21%)	95%

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: Katie Haslett presented as part of the 3-minute student thesis competition at AAPT's Annual Meeting on September 15th, 2020. Research related to the reflective cracking modeling effort undertaken as part of this study was presented along with parametric analysis of fracture properties results. UNH researchers received updated field performance data including: distress surveys, IRI data from Pathrunner van and LISA, DPS and FWD data. Specific progress for the various study tasks are 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 and approved on June 10th, 2020.

Task 5 Developing Life and Performance Curves and Analysis of the Performance Monitoring: During this quarter, substantial effort was made to complete the Task-5 deliverable for submission to TAP members. Researchers continued to perform parametric evaluation of material properties on select MnROAD test sections as well as develop new finite element models of overlays sections with temperature loading from instrumented thermocouples. Different load transfer efficiencies and slab stabilization scenarios were also simulated in select finite element models. Lastly, with the procurement of additional field performance data from MnDOT, researchers revised and updates previous work related to DPS, IRI, distress maps, and field performance indices. Task draft deliverable was submitted to TAP on 10/2/2020.

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: Researchers have begun to collect life cycle cost analysis inputs in preparation for the development of the decision tree tool.

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

It is anticipated that during the upcoming quarter, researchers will make significant progress on the Task-6 deliverable focused on establishing the state of practice for PCC condition. Additionally, researchers plan to have a working framework for the decision tree tool to share with the TAP.

Based on the results from finite element analysis, promising overlay designs (materials and thicknesses) will be analyzed using AASHTOWare PavementME software. Results from these simulations will be used in the development of performance curves and subsequently in a life cycle assessment (LCA) and life cycle cost analysis (LCCA) as part of Tasks 6 and 7. It is also anticipated that the majority of the LCCA computations will be performed for 12 MnROAD test sections during this quarter.

Significant Results:
During this past quarter, researchers worked on updating field performance data and corresponding analysis. Researchers also revised Finite element (FE) models simulated using a historical critical thermal loading event, in addition to developing FE models of test sections that were instrumented with thermocouples to simulate the critical low cooling event since the time of construction (Sept 2017 to Jun 2020). Significant results and conclusions pertaining to the Task-5 deliverable are included below. However, more detailed results are included in the Task-5 submission that was provided to project TAP.

•After approximately 35 months in service reflective cracking performance ranked thicker overlay sections (4 inches) including Cell 987 and in-situ density sections (except Cell 991) as the best performers. In general this ranking agrees with simulated model results from PavementME and FE analysis.

•An increase in dielectric constant was observed among all test sections and there does not appear to be any concern of over densification of the in-situ density test sections (Cells 988-991). It was observed that the rate of densification increased sharply after approximately 3 million vehicle passes in both the diving and passing lanes as mixtures.

•Long term IRI performance shows comparable ranking of serviceability performance from both IRI collection measurement systems (PathRunner Van and LISA). However, ranking of test section performance based on serviceability (IRI) compared to the reported amount of reflective cracking differs. Percent discrepancy was used to further investigate the difference in ranking of test sections. The highest percent discrepancy in the driving lane was observed between PathRunner IRI, Δ IRI and %RC. Meanwhile Δ IRI and %RC produced the highest percent discrepancy in the passing lane.

•Refinement of FE models simulating a historical critical thermal loading event was undertaken in addition to developing models using temperature data acquired from instrumented thermocouples in select field test sections. Due to the relatively quick cooling rate of the simulated thermal event, all models reported fully formed macro cracks along the entire overlay thickness (100% damage ratio). This is not entirely surprisingly as field distress surveys from the corresponding winter period (2018) reported a sharp increase in reflective cracking amounts across all test sections. Furthermore, the AvgRC performance index was generally the highest between distress surveys that overlap with this specific thermal loading event (AvgRC from April 2019 survey date).

•There did not appear to be any significant correlation among lab performance test indices and observed field reflective cracking performance. Only parameter that combines both fracture energy and overlay thickness (fracture resistance of overlay) showed strong correlation to reflective cracking performance, indicating need for both material performance property and overlay structure in an overlay performance index. In general, there is fair agreement between the revised FE model results and field performance data. PavementME results continue to show good agreement between field ranking and total transverse cracking predicted in PavementME model test sections.

•A total of 36 life curves were constructed and the ranking of each curve based on when it reached an arbitrary threshold of 50% reflective cracking (will be able to change as part of decision tree tool) presented in this report. Ranking results showed that all 3 performance curves corresponding to cell 994 were clearly the worst performers irrespective of traffic lane. Recalling that Cell 994 was the only test section to undergo slab stabilization prior to overlay construction, this may indicate that it is not an effective pre-overlay treatment to mitigate reflective cracking. The best performers are Cells 987 and Cell 989, each achieving 42 months of service life before reaching the reflective cracking threshold.

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).

Due to the Covid-19 pandemic and continued impacts from it (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 significantly 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 (June 2020). This information can be implemented by NRRA member agencies in the interim while final project outcomes are being developed.