Impactful Resilient Infrastructure Science and Engineering (IRISE)

-Project Scope of Work-

(FY 2021-22 Annual Work Program)

SUMMARY PAGE

Project Title: Material Compatible Repairs Evaluation

Person Submitting Proposal: Steven Sachs

Proposed Funding Period: 10/01/2021 - 09/30/2026

Project Duration: 60 months

Project Cost: $ 144,224.00

Notes:

- Traffic control and coring will be provided by PennDOT as per discussion with District 12 staff.
- The total project cost is $168,252.97. The last year of project funding ($26,028.97) is not included in Invoice #3. The Invoice #3 amount (as shown above) is $142,224.00.

Project Title: Material Compatible Repairs Evaluation

Problem Statement: Partial-depth repair of concrete pavements and bridge decks is a rehabilitation technique that restores localized surface distresses in the upper one-third to one-half of a concrete slab depth. With proper design and construction, partial-depth repair should last as long as the surrounding concrete pavement making it a cost-effective and sustainable alternative to more costly and invasive rehabilitation options. Past studies have identified two major reasons for premature failures of partial depth repairs: (a) inability to achieve and keep adequate bond between the repair and the existing pavement due to improper repair material selection; and (b) incorrect repair dimensions.

To address the incompatibility issues between in-situ concrete and repair material, a previous research project entitled "Material Compatible Repairs (MCR) for Concrete Pavements and Bridge Decks" was conducted as part of IRISE's first year program. Based on laboratory studies, the research shed light on the importance of using MCRs and best practices to develop a performance engineered repair material (PERM) to be used for the MCR. Computational modeling was also performed to assess the potential performance of MCRs. However, extensive and comparative testing is needed to validate and demonstrate the results of this previous research in the field. During the field implementation, it will be important to define the repair area accurately, so that the quality of the repair material can be assessed without the confounding effects. Traditionally, the repair size is determined by sounding techniques like steel rod and chain dragging. However, these methods are subjective and can only detect shallow distresses. More accurate and objective methods for determining the size and depth of concrete distresses are needed.

Project Objectives: Assess the performance of partial depth repairs made using the recommendations in the research report in comparison with partial depth repairs made using other methods in similar settings. Concurrently, for the same repairs, investigate the ability of ultrasonic tomography testing to provide reliable information for required partial depth repair dimensions and evaluate bond condition after repair placement.

Project Scope: Working with IRISE members, maintenance project locations involving partial depth repairs will be identified. PERM will be used for some of the partial depth repairs according to the recommendations in the research report. Standard repair materials will be used for other partial depth repairs so that comparisons can be made. Ultrasonic tomography testing using the device MIRA will be conducted prior to performing the partial depth repairs to evaluate the concrete condition and propose repair dimensions. The proposed repair dimensions will be compared to the same recommendations obtained from traditional sounding techniques. The in-situ concrete for all the locations will be identified/analyzed through a combination of coring and non-destructive testing as well as any existing project records. Four cores will be pulled so that the thermal coefficient, elastic modulus and compressive strength can be measured. This information will aid in developing a PERM for the project. In addition, the cores will be used to validated MIRA testing results. Specimens will be cast in the field using the repair materials to measure these three properties, along with drying shrinkage, for both the PERM and the standard repair material. MIRA testing of the repairs will be conducted prior to opening

of the concrete pavement to traffic to evaluate both the repair and bond conditions. The performance of the repairs will be monitored for a period of four-years at a frequency of one observation per year. Along with the performance evaluation, photos will be taken, and updates provided over the course of the monitoring period. If it is possible during these yearly evaluations, additional MIRA testing will be conducted. A final report will be prepared containing results and recommendations.

Task Statements:

The objectives of this project will be realized through the completion of the following tasks:

Task A: Project Selection and Evaluation

The first task will be to find suitable PCC rehabilitation projects where partial depth repairs are to be performed. Candidate sites will be evaluated and chosen based upon the project, which best fits the timeline of this project. If a suitable project does not fit the desired window, we will reevaluate the timeline based upon upcoming scheduled rehabilitations. Historical construction records from the project will be collected in addition to 4 cores from the roadway. The cores will be used to evaluate the coefficient of thermal expansion (AASHTO T336), elastic modulus (ASTM C469), and compressive strength (ASTM C39). This data will be used to develop a PERM for the project using the results from the year one MCR project. A technical memorandum will be compiled documenting the results from the core testing and other relevant project data. The mixture design for the PERM to be used on the project will also be specified.

Task B: Ultrasonic Tomography Testing of Concrete Pavements Prior to Partial Depth Repair

This task will evaluate the viability of ultrasonic tomography testing to provide information for required repair dimensions. MIRA testing will be conducted in the areas of the repair projects selected in Task A prior to the repair placement. The analysis of the testing will result in recommendations for the dimensions (both horizontal and vertical) of the repair which will be compared to the recommendations proposed by conventional sounding methods. The cores performed in Task A will be used to validate the MIRA testing. A technical memorandum will be prepared documenting the results of the testing.

Task C: Partial Depth Repair Construction

Once the PERM for the project has been established, this mixture will be specified for use on the project along with a standard repair material. The repair locations will be marked out and prepared for the repair placement. The repairs will then be placed using the two mixtures in a randomized pattern using, approximately, an equal number for each mixture. The same placement and curing methods will be specified for both repairs. Companion specimens will be cast with both the PERM and standard repair material to measure coefficient of thermal expansion (AASHTO T336), elastic modulus (ASTM C469), compressive strength (ASTM C39), and drying shrinkage (ASTM C157). The exact location and type of repair will be diligently recorded for reference during performance monitoring. A technical memorandum documenting the entire construction process will be prepared.

Task D: Performance Monitoring

Once the construction has been completed, performance monitoring will be conducted. The performance of the repairs will be monitored for a period of five-years at a frequency of one observation per year. Along with the performance evaluation, photos will be taken and updates provided over the course of the monitoring period. A yearly technical memorandum documenting the findings from the performance monitoring will be prepared.

Task E: Ultrasonic Tomography Testing of Partial Depth Repairs

This task will evaluate the viability of ultrasonic tomography testing to evaluate the strength development of the repair and the bond between the partial depth repair and the existing concrete slab. MIRA testing will be conducted in all repairs constructed under Task C prior to traffic opening. The data analysis will be conducted to evaluate uniformity of the partial depth repairs and degree of bonding between the repair and the existing concrete (unbonded, fully or partially bonded). Ultrasound device SURFER will be used to measure velocity development with time for one partial depth repair with conventional material and one partial depth repair with the PERM. In addition, 18 – 6 inch by 12 inch cylinders will be cast for both conventional and material compatible concrete mixes. Compressive strength will be measured for three cylinders after 5 hours, 1 day, 3 days, 7 days, and 28 days after casting and at SURFER measurements will be made for all available cylinders. Maturity measurements will be made in the lab and the field.

Task F: Final Report

A final report will be prepared that summarizes all project activities, results, and recommendations.

Deliverables:

Deliverables will include technical memoranda for each task as follows:

Task A – due 6-months from project notice to proceed

Task B – due 6-months from project notice to proceed

Task C – due 12-months from project notice to proceed

Task D – due 24, 36, 48 and 60 months from project notice to proceed

Task E - due 24, 36, 48 and 60 months from project notice to proceed

A draft and final report summarizing all project activities, results, and recommendations will also be prepared. The draft will be delivered 58-months from project notice to proceed and the final will be delivered 60-months from project notice to proceed.

Key Personnel:

Principal Investigator: Steven Sachs

Co-PI: Julie Vandenbossche
Co-PI: Lev Khazanovich

Other Personnel:

One postdoctoral associate, two graduate students, and two hourly students (both to be named) will be assigned to the project.

Proposed Person-Hours by Task:

Team Member	Task A	Task B	Task C	Task D	Task E	Task F	Total
Key Project Team Members, Estimated Hours Per Task							
PI: Steven Sachs	40	0	40	0	0	80	160
Co-PI: Julie Vandenbossche	10	9	0	0	8	0	27
Co-PI: Lev Khazanovich	0	0	0	20	20	10	50
Postdoctoral Associate	0	320	0	0	225	40	585
Graduate Student 1	480	0	480	480	0	160	1600
Graduate Student 2	0	0	0	80	180	68	328
Hourly Student 1	160	0	160	160	0	0	480
Hourly Student 2	0	20	0	0	20	0	40
Total	690	349	680	740	453	358	3270

Schedule:

	2021	2022				2023			
Task	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task A: Project Selection and Evaluation									
Task B: Ultrasonic Tomograpy Testing of Concrete Pavements Prior to Partial Depth Repairs									
Task C: Partial Depth Repair Construction									
Task D: Project Monitoring									
Task E: Ultrasonic Tomography Testing of Partial Depth Repairs									
Task F: Final Report									

	2024				2025				2026			
Task	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task A: Project Selection and Evaluation												
Task B: Ultrasonic Tomograpy Testing of Concrete Pavements Prior to Partial Depth Repairs												
Task C: Partial Depth Repair Construction												
Task D: Project Monitoring												
Task E: Ultrasonic Tomography Testing of Partial Depth Repairs												
Task F: Final Report												

Budget: The total project cost is $168,252.97.

Acknowledged By:

Steven G. Sachs

Steven Sachs

References

AASHTO T336, *Standard Method of Test for Coefficient of Thermal Expansion of Hydraulic Cement Concrete*, American Association of State Highway and Transportation Officials, Washington D.C., 2015.

ASTM C157, *Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete*, ASTM International, West Conshohocken, PA, 2017.

ASTM C39, *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*, ASTM International, West Conshohocken, PA, 2020.

ASTM C469, *Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression*, ASTM International, West Conshohocken, PA, 2014.