Impactful Resilient Infrastructure Science and Engineering (IRISE)

-Project Scope of Work-

(FY 2024-25 (IRISE Year 7) Annual Work Program)

SUMMARY PAGE

Project Title: Concrete Mixtures with Half the Carbon Footprint

Person Submitting Proposal: Dr. Julie Vandenbossche

Proposed Funding Period: 01/01/25 – 06/31/2026

Project Duration: 18 months

Project Cost: $155,000

Concrete Mixtures with Half the Carbon Footprint

Research Problem

Concrete is the most commonly used construction material in the world. It is durable, low maintenance, easy to cast into shape and cost effective. The release of CO_2 with the production of cement is well known and a large range of solutions for reducing the carbon footprint associated with the use of concrete have been proposed. Many of these solutions have not been properly vetted. Also, various early-age and long-term concrete properties associated with these solutions might make them poor alternatives for use in concrete paving.

Research Objectives

The objective of this research is to identify and evaluate alternatives that could be used to reduce the carbon footprint of a PennDOT concrete paving mixture in half.

Project Scope

In this project, the use of more sustainable concrete paving mixtures will be investigated. Locally available industrial by-products that could potentially be used in the concrete mixture will be investigated for potential inclusion in the study along with PLCs. First, an extensive literature review will be performed to identify novel materials that have the potential to be implemented in a concrete paving mixture. We will focus on materials readily available within the state that would be cost effective and abundantly available. Second, a series of mixture designs will be developed and evaluated in the laboratory. The performance of these materials will be compared to current standard materials using PennDOT specifications to ensure comparable performance. Pavement ME will then be used to predict the performance of a concrete pavement constructed with these mixtures and a comparison will be made with that of the performance of a pavement constructed with a standard PennDOT mixture. A life cycle cost analysis will then be performed for each of the pavement structures. The carbon reduction associated with each novel mixture design will be quantified as well. This scope defines what will be performed during Phase I. Upon the successful completion of Phase I, a pilot study can be initiated under Phase II to facilitate implementation if the IRISE Consortium members deem the newly developed materials/mixtures feasible.

If it is decided that Phase II will be pursued, and a pilot study is to be carried out, the project team will work with the IRISE partners (paving contractor and asset owners) to incorporate the low carbon concrete in a demonstration project. Additional funding will be pursued from FHWA through the Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change (Section

60506 Low-Carbon Transportation Materials Grants) to help cover additional construction cost that might be accrued as a result of the incorporation of the new material into the paving process.

Task Statements

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

Phase I Tasks:

Task A: Literature Review and Material Selection: A literature review will be conducted to identify current locally available industrial by products that have the potential to be used in concrete. Previous applications of these materials and PLCs will be reviewed along with typical mixture designs, material properties and field performance data. Life cycle assessment tools that can be used to quantify the embodied carbon of different materials will be identified. Based on this literature review, materials for inclusion in this study will be identified and mixture designs will be developed to be investigated in the laboratory component of the study under Task B and a plan for the laboratory study will be developed. This will include the number of mixtures to be evaluated, testing to be performed on each constituent in the concrete as well as the fresh and hardened concrete properties to be measured.

Duration: Task due 3 months after the start of the project.

Deliverable: Memo summarizing the literature review and the laboratory test plan.

Task B: Laboratory Performance Evaluation: The materials identified under Task A will be obtained and processed (crushed/milled to the appropriate size), if necessary. Material characterization will be performed on each of the constituents to be included in concrete mixtures in accordance with the test plan developed under Task A. Properties for consideration of inclusion include particle size distribution, heat of hydration, initial/final set, etc. The critical fresh and hardened concrete property testing defined in the laboratory test plan under Task A will be performed. Task C is due 13 months after the start of the project.

Duration: Task due 10 months after the start of the project.

Deliverable: Memo summarizing the laboratory study.

Task C: Perform LCC and LCA: The material properties established in Task B will be used to determine the predicted performance life for a section of roadway using PavementME. This will be compared to the performance of a pavement constructed using standard PennDOT pavement mixture. A life cycle cost analysis and a life cycle assessment will then be performed to compare the estimated costs and reduction in CO_2 associated with pavements constructed with the low carbon mixtures established in Task B to that of pavements constructed with the standard PennDOT mixtures.

Duration: Task due 12 months after the start of the project.

Deliverable: Memo summarizing the *LCC and LCA* based on the pavement life estimated using Pavement ME.

Phase II: Pilot Study

Upon the successful completion of Phase I, a pilot study can be initiated to facilitate implementation if the IRISE Consortium members deem the newly developed materials/mixtures feasible. If it is decided that Phase II will be pursued, and a pilot study is to be carried out, a budget and proposed scope of work can be developed at that time.

Task D: Final Report: The results from all tasks will be summarized and documented.

Duration: Task due 16 months after the start of the project.

Deliverable: Final Report.

Deliverables:

1. Task A: Memo summarizing the literature review and the laboratory test plan.
2. Task B: Memo summarizing the laboratory study.
3. Task C: Memo summarizing the *LCC and LCA* based on the pavement life estimated using Pavement ME
4. Task D: Final Report

Key Personnel:

Principal Investigator:

Julie Vandenbossche, P.E., Ph.D.

Vikas Khanna Ph.D.

Other Personnel:

Undergraduate Student:

To Be Named Undergraduate Student Researcher

Graduate Students:

To Be Named Graduate Student Researchers

Proposed Person-Hours by Task:

Team Member	Task A	Task B	Task C	Task D	Total
Julie Vandenbossche	40	35	25	73	173
Vikas Khanna	8	0	0	20	28
Graduate student 1	85	840	0	114	1039
Graduate student 1	0	0	246	100	346
Undergraduate Student	0	156	0	0	156
TOTAL	133	1031	271	307	1742

Schedule:

	2025												2026											
Task	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
A																								
B																								
C																								
D																								

Budget: The total project cost is $155,000.

Acknowledged By:

Julie M Vandenbossche

Julie M. Vandenbossche, P.E., Ph.D.
Principal Investigator