Impactful Resilient Infrastructure Science and Engineering (IRISE)

-Project Scope of Work-

(FY 2022-23 (IRISE Year 5) Annual Work Program)

SUMMARY PAGE

Project Title: Design and construction of two-lift concrete pavements for Pennsylvania

Person Submitting Proposal: Lev Khazanovich and Julie Vandenbossche

Proposed Funding Period: 10/01/2022 – 09/30/2024

Project Duration: 24 months

Project Cost: $209,999.99

PennDOT Work for Hire? No

Project Title: Design and construction of two-lift concrete pavements for Pennsylvania

Research Problem: Modern requirements for concrete pavement performance are often related to the pavement surface, which must be highly durable while providing adequate friction and ride quality. Meeting these requirements with conventional pavement construction requires the use of concrete mixes with high-quality natural aggregates for the entire layer. The use of high-quality concrete at the bottom of the layer is often expensive, unnecessary, and environmentally unfriendly. Two-lift concrete pavement construction, a technique that involves the placement of two wet-on-wet layers of concrete with different mixes, can balance the need for different materials in different depths of the concrete slab. In the two-lift technique, the top surface layer, usually 2 to 3 inches thick, consists of superior concrete composed of high-quality aggregates and cementitious materials. In contrast, the bottom layer, as thick as the design requires, is often composed of inferior concrete which tolerates the use of low-cost and recycled aggregates. The two-layer solution allows for a cost-effective combination of a high-quality surface layer and a sustainable bottom layer. The two-lift technique has been used successfully in Europe for many decades, becoming an attractive solution for cost reduction, improved surface quality and utilization in locations with scarce sources of high-quality aggregates. However, the design and construction aspects of two-lift concrete pavements can present challenges regarding the need for two pavers, two mixes, and potentially two plants as well as assuring the adequate bonding between the two layers.

Research Objectives: Our objective is to develop design and construction recommendations for two-lift concrete pavements for Pennsylvania conditions. This will involve testing appropriate concrete mixes for both top and bottom layers with a focus on the former's high-performance needs and the latter's economical and sustainable aspects.

Project Scope: The project will focus on the design, construction and evaluation of an experimental two-lift concrete pavement in Pennsylvania. We will develop the structural design for the concrete pavement as well as the mix design for both layers. Different concrete mixes for both the high-quality surface layer and the economical-sustainable bottom layer will be proposed and evaluated. We will document the construction of the experimental section focusing on the challenges of working consecutively with two pavers and two concrete mixes. A comprehensive evaluation of the bonding conditions between the two layers will be performed and documented using non-destructive methods. The potential cost saving and reduction in carbon footprint will be evaluated.

Task Statements:

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

Task A: Literature review of two-lift concrete pavement design, construction, and performance

We will conduct a comprehensive literature review on the two-lift wet-on-wet construction approach for concrete pavements. The review will include the literature on the European design and construction best practices as well as the available construction reports and performance data for the experimental sections constructed in the United States. We will identify the potential benefits of two-lift concrete pavements. In addition, we will also identify non-destructive testing methods available for evaluation of quality of two-lift construction, including the quality of the bond condition between the concrete lifts.

Task B: Laboratory testing of concrete mixes for two-lift concrete pavements

In this task, we will conduct laboratory testing of concrete mixes that are not typically used in conventional concrete pavements but can be potentially used in two-lift pavements. For example, concrete mixes with a smaller aggregate size and higher workability may have higher strength and durability than conventional mixes. In the top lift, such mixes may improve pavement smoothness and friction as well as decrease the noise level. However, their use in a single lift pavement may be cost-prohibited as well as result in poor joint performance due to lower aggregate interlock stiffness. At the same time, the lower lift surface does not need to be finished or provide good friction. It offers an opportunity for the use of lower cost aggregates with low polishing resistance, more sustainable concrete mixes such as with recycled aggregates, and mixes with a higher percentage of supplemental cementitious materials.

Two potential PCC mixes for the top lift and two potential mixes for the lower lift will be selected for laboratory testing after consultations with the Technical Panel. The following characteristics will be determined:

- The PCC compressive and flexural strength tests
- The coefficient of thermal expansion
- The shrinkage coefficient

Task C: Development of the design guidelines and design of experimental two-lift concrete pavement section

In this task, the web-based design tool, PittRIGID, will be modified to accommodate two-lift pavements. This will include accounting for the difference in the concrete strength, stiffness, thermal expansion, and shrinkage properties. In addition, the AASHTO-93 procedure will be adapted for two-lift pavements. Design guidelines will describe both adaptations of the design procedures mentioned above. These two procedures will be used to design the experimental test section.

Task D: Construction of experimental two-lift concrete pavement section

Based on the design developed in Task C, an experimental two-lift concrete pavement section will be constructed in collaboration with IRISE members. We will document each construction step, with special attention paid to consistency of delivery of uniform concrete to each paver and maintaining the required distance between the pavers.

Task E: Non-destructive evaluation of experimental two-lift concrete pavement section

Visual surveys and nondestructive ultrasonic testing will be conducted frequently to evaluate the early-age behavior of the experimental two-lift concrete section. The ultrasonic testing will also be performed to evaluate layer thickness, concrete quality, and especially, the bonding conditions between top and lower slab layers.

Task F: Draft final report

Results and observations from all previous Tasks will be compiled in a guideline format for the design, construction, and performance evaluation of two-lift concrete pavements considering Pennsylvania conditions. These guidelines, as well as the summary results of other project activities, will be included in a draft final report.

Task G: Final report

A Final Report taking into consideration comments that were received on the Draft Final Report will be prepared.

Deliverables:

The following deliverables will be provided based on completion of the above tasks:

- *Deliverable #1* – Task A: A memo report summarizing the literature review, due 5 months from the Notice to Proceed date.
- *Deliverable #2* – Task B: A memo report detailing the results of the laboratory testing, due 8+ months from the Notice to Proceed date.
- *Deliverable #3* – Task C: A memo report detailing the experimental section design, due 12 months from the Notice to Proceed date.
- *Deliverable #4* – Task D: A memo report describing experimental section construction, due 18 months from the Notice to Proceed date.
- *Deliverable #5* – Task E: A memo report summarizing the experimental section evaluation, due 21 months from the Notice to Proceed date.
- *Deliverable #6* – Task F: A draft final report, due 22 months from the Notice to Proceed date.
- *Deliverable #7* – Task G: Final report, due 24 months from the Notice to Proceed date.

Key Personnel:

Principal Investigator: Dr. Lev Khazanovich is to provide the technical expertise, project management, and oversight on all project activities.

Co-Principal Investigator: Dr. Vandenbossche is to provide the technical expertise on tasks B, D, E, F, and G of this project and assist the Principal Investigator in project management and oversight on all project activities.

Other Personnel:

Grad Assistant 1 (TBN) is a graduate student who will assist in tasks A through G
Grad Assistant 2 (TBN) will assist in literature review, experimental design, field and laboratory testing and report preparation.
Undergraduate student 1 (TBN) will assist in literature review, field and laboratory testing.
Undergraduate student 1 (TBN) will assist in field and laboratory testing.

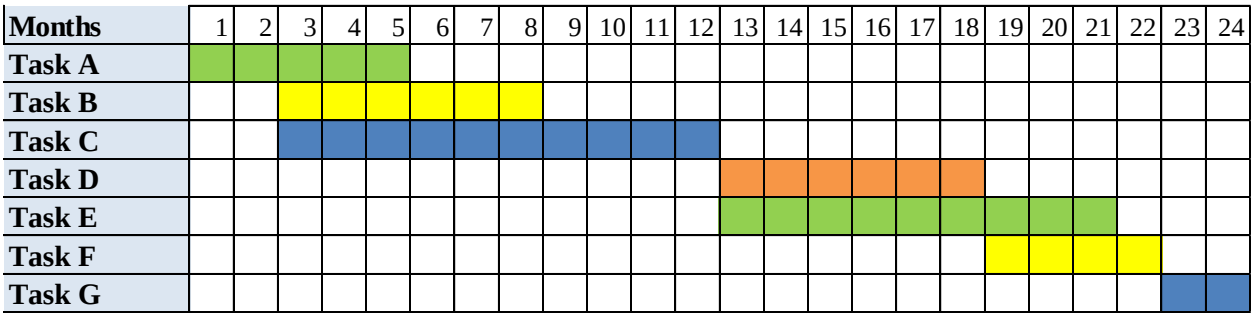
Supplies: The proposal budgets for the laboratory supplies required to conduct preparation, laboratory testing, and disposal of concrete mix specimens to be performed under Task B as well as filed testing under Task D. It includes a purchase and delivery of coarse and fine aggregates, admixtures, and cement; plastic molds for specimen preparation and capping materials; fees for disposals of tested specimens; thermal couples for lab and field testing; and personal protection equipment for lab and field testing.

Travel: Travel costs include trips to the concrete mix supplies to obtain samples of the course and fine aggregates or concrete specimens for the laboratory testing of concrete mixes in Task B as well as trips to the construction site for construction observation and nondestructive testing in Tasks D and E. The travel cost is estimated using the current mileage rate of $0.625/mile if traveled in a personal car or van/trailer rent cost.

Proposed Person-Hours by Task:

Team Member	Task A	Task B	Task C	Task D	Task E	Task F	Task G	Total
	Other Project Team Members, Estimated Hours Per Task							
Dr. Lev Khazanovich, PI	16	2	40	20	34	32	16	160
Dr. Julie Vandenbossche, co_PI		40	8	20		16	4	88
TBD, Grad Student 1	240	40	600	300	180	400	40	1800
TBD, Grad Student 2	80	320	100	360		100	40	1000
	Other Project Team Members, Estimated Hours Per Task							
TBD, Hourly Student 1	20	20	20	20	20	10	10	120
TBD, Hourly Student 2		77		42				119
Total	356	499	768	762	234	458	110	3187

Schedule:



Budget: The total project cost is $209,999.99.

Acknowledged By:

Lev Khazanovich

Lev Khazanovich, Ph.D.
Principal Investigator