Impactful Resilient Infrastructure Science and Engineering (IRISE)

-Project Scope of Work-

(FY 2021-22 Annual Work Program)

SUMMARY PAGE

Project Title: Joint Design Optimization

Person Submitting Proposal: Julie Vandenbossche

Proposed Funding Period: 10/01/2021 - 09/30/2023

Project Duration: 24 months

Project Cost: $199,933.27

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Problem Statement: Long-term performance of the joints in jointed plain concrete pavement(s) (JPCP)s with minimal maintenance activities is essential to the sustainability of the pavement. The performance of the joint is dependent on the interaction between the individual elements of the pavement structure, such as load transfer, drainage, joint reservoir/sealant design, etc. Yet, traditionally, most of these individual elements are designed, without regards to these interactions. For example, the selection of the joint sealant type and the design of the sealant reservoir must consider the pavement structure (base type, load transfer, slab length, dimensional stability of the concrete, etc.), the anticipated level of traffic and the expected opportunities for maintenance. It is important to periodically assess the effectiveness of joint sealing and evaluate methods to optimize joint design, while limiting maintenance needs.

Project Objectives: The purpose of the sealant is to keep incompressible and moisture out of the joint. Current sealant types, reservoir designs and construction practices will be evaluated to determine the effectiveness of these practices and identify opportunities for improvement. The current reservoir design process was developed many years ago and is based on an empirical relationship established for conventional jointed plain concrete pavements (JPCP). With the availability of strain data from instrumented pavement structures currently in service, these old methodologies need to be re-evaluated and, if needed, new joint design strategies/guidelines will be developed.

Joint performance is also dependent on the ability of the dowel bars to function properly. For this reason, corrosion-resistant dowel bars are being used more commonly. Current design procedures do not account for the additional life achieved by using these long-life dowel bars. Corrosion models and dowel corrosion performance data will be identified and evaluated to determine which of these can be incorporated into models currently available for predicting faulting.

Project Scope:
The scope of this research will include evaluating the type, reservoir design, construction practices and performance of joint sealant in Pennsylvania and provide guidance on strategies for optimizing joint performance. The scope will also include incorporating the consideration of the potential for dowel corrosion into models for predicting faulting.

Task Statements:

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

Task A: Literature review
A literature review will be conducted to identify on-going and recently completed research in the area of joint performance with a focus on aspects of joints sealing/filling (including sealant type), joint reservoir design, dowel bar performance and corrosion models and, effects of drainage on joint performance for pavements in this state as well as others states with similar climates and pavement designs. This will

include potential new innovative sealant materials. Sources of instrumented pavement data that can be used to evaluate joint opening will also be identified.

Task B: Performance review

Information will be requested from Allegheny County, if available, the Turnpike and PennDOT to assess the performance of concrete pavements as it relates to joint performance and sealing. The following information: will be solicited:

Design

1. Posted speed limit
2. Traffic
3. Age
4. Slab thickness
5. Mixture design and aggregate type
6. Base type/thickness
7. if PCC overlay, Interlayer type/thickness,
8. Subgrade AASHTO classification
9. Dowel design
10. Joint spacing
11. Edge drains: yes/no
12. Sealant: type, age, reservoir design

Performance

1. Spalling
2. Lane/shoulder dropoff
3. Blow-ups
4. Faulting
5. Corner breaks
6. Longitudinal cracks

Maintenance/CPR

1. Partial depth repairs– Age performed/quantity
2. Dowel bar retrofits– Age performed/quantity
3. Joint resealing – Age performed/quantity

The data collected will be analyzed to assess the effectiveness of different joint sealants (including, asphalt, silicone and neoprene). Limited site visits will be made to help further investigate sealant performance after a review of the performance data is completed.

Task C: Joint reservoir design

The joint reservoir design for a formed in-place sealant is based on the allowable strain in the sealant and the width to depth ratio, which is referred to as the shape factor. The allowable strain is dependent on the properties of the sealant and is used along with the estimated joint opening to establish the width to which the reservoir should be sawed. The shape factor, which is also dependent on the sealant type, is then used to establish the necessary depth of the sealant. Therefore, an accurate estimate of the maximum joint opening is required for a proper joint reservoir design.

The use of preformed sealants requires an accurate estimate of the maximum joint opening as well as the maximum joint closure. This is to ensure the preform sealant is always sufficiently compressed so it stays in the joint but not compressed to the point that permanent deformation occurs. Current practices for estimating joint movement (opening and closing) will be evaluated with respect to materials/designs used in Pennsylvania. One specific aspect that will be evaluated includes the friction assumed between the bottom of the slab and the underlying layer. Traditionally, an empirical correction factor of 0.65 for slabs on stabilized bases, 0.8 for granular bases and 1 for subgrade to account for friction is used. The validity of these values will be examined using vibrating data from instrumented in-service pavements both locally and around the country (available data sources will be identified under Task 1).

There is not only a need to re-evaluate this empirical friction correction factors, but an additional need to better understand joint movement in JPCP overlays (un-bonded and bonded). In these pavements, every third to fourth joint can open wider than the others for a year or two until all joints activate. If these joints are sealed soon after paving when some joints are widened, both the widened joints are sealed as well as the narrow joints. After a couple of years when all joints have activated, the wider joints become narrower and the newly activated joints become wider. Therefore, some joints will have been “overfilled” with asphalt, which is then “squeezed out” as the wider joints close, and the newly activated joints have the potential to be under filled, which can result in a sealant failure. These types of factors must also be considered when evaluating joint sealant performance and establishing strategies for joint sealing.

Task D: Quantify the effects of corrosion on dowel performance
Joint design should consider additional factors such as the potential for corrosion of the dowel, corrosion resistant dowel materials, and exposure conditions (sealant performance would affect this). Information gathered as part of the literature review will be used to develop a laboratory study for quantifying the corrosion potential of various dowel bar materials. This information will be used to incorporate the corrosion potential of the dowel into the fault development prediction model.

Task E: Development of joint design strategies
Joints in a JPCP should be designed based on factors such as expected traffic levels and traffic speed, base and subgrade conditions, drainage design, presence of load transfer devices, anticipated maintenance practices, etc. Strategies will be developed to optimize joint performance, while limiting maintenance needs, based on the analysis of the performance data, site visits and joint reservoir design analysis.

Task F: Draft Final report
A draft final report will be prepared to document project activities, findings, and recommendations. The final report will also include recommendations for implementation of the mitigation strategies developed in this study.

Task G: Final report
A final report taking into consideration comments that are 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* – A technical memorandum summarizing the literature review (Task A) and the surveys of the pavement sections (Task B), due 6 months from the project initiation (assuming performance data is received within 1 month from the time of the request).
- *Deliverable #2* - A technical memorandum summarizing Task C and D, due 13 months from project notice to proceed.
- *Deliverable #3* – A draft final report, due 22 months from project notice to proceed.
- *Deliverable #4* – Final report, due 24 months from project notice to proceed.

Key Personnel:

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

Other Personnel:

Two students will contribute to the successful completion of this research effort as described below:

- Grad Assistant 1 (TBN)
- Undergraduate student (TBN)

Proposed Person-Hours by Task:

Team Member	Task A	Task B	Task C	Task D	Task E	Task F	Task G	Total
Key Project Team Members, Estimated Hours Per Task								
Dr. Julie Vandenbossche, PI	45	50	50	50	45	50	60	340
Other Project Team Members, Estimated Hours Per Task								
TBD, Grad Student	150	360	200	80	900	260	80	2040
TBD, Hourly Student	0	40	0	0	35	0	0	75
Total	195	450	250	130	980	310	140	2455

Schedule:

	FY21-22									FY22-23												FY23-24		
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Task A	■	■																						
Task B	■	■	■	■	■	■																		
Task C			■	■	■	■	■	■	■	■														
Task D							■	■	■	■														
Task E											■	■	■	■	■	■	■	■	■	■	■			
Task F																						■	■	
Task G																								■

Budget: The total project cost is $199,933.27.

Acknowledged By:

Julie M. Vandenbossche
Principal Investigator