Impactful Resilient Infrastructure Science and Engineering (IRISE)

-Project Scope of Work-

(FY 2022-23 Annual Work Program)

SUMMARY PAGE

Project Title: Prediction of dowel corrosion and effect on performance of concrete pavements

Person Submitting Proposal: Julie Vandenbossche

Proposed Funding Period: 10/1/2022 – 9/30/2024

Project Duration: 24 months

Project Cost: $249,999.87

PennDOT Work for Hire? No

Project Title: Prediction of dowel corrosion and effect on performance of concrete pavements.

Problem Statement: Corrosion of metallic dowel bars is a significant issue that leads to decreased long-term performance of jointed plain concrete pavements. Dowel bars are susceptible to corrosion because of high chloride exposure from deicing agents coupled with moisture penetration at transverse joints. Corrosion of the dowels decreases load transfer across the joint, which causes faulting. Additionally, the expansive byproduct of corrosion can prevent the joint from freely opening and closing. Many states have identified that this seizing of the joint is a significant problem. It is difficult to identify or predict dowel corrosion before major distresses develop, and repairs to distressed joints are costly and disruptive to traffic. Corrosion development is a complex phenomenon affected by both pavement design and climatic features. Current pavement performance prediction models are unable to account for dowel corrosion due to the limited understanding of this. Many long-life pavements are being constructed and the dowels are expected to perform for greater than 60 years. Unfortunately, the effect of the long-term corrosion resistance of the various types of dowel bars on increased performance life is not well quantified. This makes it a challenge to justify the additional expenses associated with longer-life bars.

Project Objectives: 1) Determine corrosion mechanisms and critical factors in dowels using currently available models and databases, 2) Experimentally investigate corrosion development in a novel accelerated load test to quantify resulting loss of dowel performance, 3) Build predictive performance models using modeling and experimental results, which will be validated with field data, 4) Create a set of guidelines based on the results to inform pavement design and management practices.

Project Scope: In this project, the development of corrosion on metallic dowels in concrete pavements will be quantified as a function of critical environmental and design parameters. Current corrosion models will be employed to identify the mechanisms of corrosion development and to identify current limitations in corrosion understanding. Critical factors identified through modeling will be used to design a laboratory investigation that will evaluate the loss of dowel performance as a function of corrosion development. The accelerated test will consist of doweled beam specimens that are subjected to both mechanical and environmental loading conditions. Pavement design parameters will be considered, including pavement thickness, dowel diameter, dowel material (carbon steel, stainless steel, fiber reinforced), and coating (epoxy, zinc-clad, galvanized). An accelerated testing program will be designed to simulate realistic corrosion conditions based on available field data. To determine the loss of pavement performance as a function of corrosion development, the corrosion of the doweled specimens will be measured and correlated to the increased pavement deflection under loading. . The force required to open the joint will be measured to evaluate the potential damage caused by the expansive byproducts of corrosion. Results from the laboratory investigation will be used to develop predictive performance models that account for critical parameters affecting corrosion development. The database of laboratory results will supplement available corrosion data. These algorithms will establish underlying relationships between critical design and exposure parameters and loss of joint performance due to corrosion development. The performance models will be validated with available

performance data from in-service doweled concrete pavements. The results from the computational and experimental analyses will be used to identify critical conditions for corrosion development and the corresponding loss of dowel performance. Guidelines for pavement design and management will be developed that address the critical parameters for corrosion development. This work will improve joint performance by considering corrosion, which is a common cause of failure in doweled pavements.

Task Statements:

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

Task A: Literature Review Review current understanding and mitigation strategies for corrosion development in doweled concrete pavements. Gaps in knowledge will be identified to inform computational modeling (Task B) and laboratory investigation (Task C). State deicing practices and climate patterns will be evaluated to design the accelerated corrosion program. Current databases and corrosion models will be evaluated to establish critical criteria for dowel corrosion development. Field data will be compiled from in-service doweled pavements which exhibit poor performance due to corrosion. This data will be used to validate the performance model in Task D.

Task B: Database Evaluate corrosion models identified in Task A and select the model that best captures the critical mechanisms for corrosion development in dowel bars. Evaluate available material corrosion databases and identify the corrosion parameters readily available in these database(s) for use in the corrosion model selected as well as the missing parameters that will need to be established experimentally in Task C. Develop and populate a material corrosion database that will be used to validate/calibrate the corrosion model to be developed.

Task C: Laboratory Study Design and conduct a laboratory investigation to quantify loss of joint performance due to the coupled effects of corrosion of dowel bars and socketing of the concrete directly adjacent to the bar due to vehicle loads. An accelerated test will be performed to subject doweled samples to both mechanical and environmental loadings, which will simulate the mechanisms for concrete joint deterioration. Increased pavement deflections will be measured to quantify the loss of dowel performance caused by corrosion of the dowel. Key parameters considered will be: 1) dowel bar material, type, coating, and diameter; 2) exposure to corrosive conditions; and 3) pavement features.

Task D: Model Development The results from Tasks B and C will be used to develop a predictive model that will determine damage accumulation in the concrete surrounding the dowel from fatigue, as a well as damage of the dowel from corrosion, as a function of factors such as load, dowel diameter and material, pavement parameters, exposure to deicers, etc.

Task E: Final Report Issue a Final Report containing suggestions and guidelines for corrosion mitigation. Guidelines will be based on results from experimental tests, field reports, and numerical modeling. These results will be used to quantify the effect of environmental conditions and dowel designs on corrosion development.

Deliverables:

1. Summary of the exposure conditions identified in Task A (3 months from the Notice to Proceed date).
2. Summary of the laboratory investigation plan to be executed in Task C as well as the corrosion models selected under Task B (6 months from the Notice to Proceed Date).
3. Summary of laboratory study completed in Task C (18 months from the Notice to Proceed Date).
4. Completion of the corrosion model (20 months from the Notice to Proceed date).
5. Draft Final and Final report and guidelines developed under Task E (22 and 24 months from the Notice to Proceed date).

Key Personnel:

Principal Investigator:

Julie Vandenbossche

Co-Investigator:

Alessandro Fascetti

Other Personnel:

Grad Students:

1x Graduate Student (Tasks A, B, C, D, E)

1x Graduate Student (Tasks A, B, C, D, E)

Undergrad Students:

1x Undergraduate Student (Task B, C, D)

Supplies: The proposal budget include the cost of supplies and disposal fees required to conduct the laboratory study to be performed in Task C.

Proposed Person-Hours by Task:

Team Member	Task A	Task B	Task C	Task D	Task E	Total
Key Project Team Members, Estimated Hours Per Task						
Julie Vandenbossche	66	55	80	60	85	346
Alessandro Fascetti	8	0	0	8	0	16
Graduate Student 1	35	64	200	294	100	693
Graduate Student 2	200	260	800	480	338	2078
Undergrad	0	25	98	22	0	145
Total	309	404	1178	864	523	3278

Schedule:

Months	2022	2023				2024		
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Task A: Lit Rev 3 months								
Task B: Database 3 months								
Task C: Lab Study 12 months								
Task D: Model Develop. 6 months								
Task E: Guidelines 3 months								

Budget: The total project cost is $249,999.87.

Acknowledged By:

Julie N Vandenbossche

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