

Exhibit D

Research Project Submission Template

Recipient/Grant (Contract) Number: University of Illinois Urbana-Champaign / Grant No.: 69A 355 234 8333

Computer Vision-Based Sorptivity Test for Automated Durability Assessment and Service Life Prediction of Precast Concrete

Center Name: Transportation Infrastructure Precast Innovation Center (TRANS-IPIC)

Research Priority: Improving the Durability and Extending the Life of Transportation Infrastructure

Principal Investigator(s): Nishant Garg

Project Partners: N/A

Research Project Funding: \$121,911 (\$69,957 Federal and \$51,954 Non-Federal)

Project Start and End Date: 01/16/2026 – 01/15/2027

Project Description:

Moisture transport and ingress of harmful external ions critically influence the durability and service life of concrete transportation infrastructure. Existing ASTM & AASHTO assessment methods—such as water adsorption or electrical resistivity tests—are slow, manual, and prone to operator error. Building on our preliminary work, we propose to deploy a computer vision-based sorptivity test that yields rapid, automated estimates of permeability, curing quality, and long-term aging behavior in precast concrete. Our objectives include (i) correlating sorptivity with resistivity and permeability, (ii) extracting aging coefficients from frequent sorptivity monitoring, and (iii) applying the method as an online quality control tool for curing of precast structural elements. Expected outcomes include predictive models for resistivity and ageing, real-time curing assurance, and reduced material/cure overdesign. Ultimately, this tool would enable precast concrete producers to ensure durability and service life at lower cost, with minimal human intervention.

US DOT Priorities:

Durability of concrete infrastructure is often controlled by how fluids, ions, and aggressive species penetrate the pore network. Permeability and diffusivity are thus fundamental metrics in durability design. However, conventional standard methods such as ASTM C1585 (sorptivity) and AASHTO T358 (surface resistivity) are labor-intensive, time-consuming, and subject to human variability. Furthermore, predictions of long-term aging (via aging coefficients) typically require months or years of testing, and the scatter across labs, operators, and test methods undermines confidence in lifetime estimates.

By developing an automated, computer vision-based sorptivity method, one can (a) increase testing throughput (allowing more frequent monitoring), (b) reduce operator error and inter-lab variation, and (c) provide early feedback in precast production for curing and mix optimization. Reliable early-stage estimates of permeability and ageing allow producers to avoid over-curing (and associated cost) or underperformance (leading to premature deterioration).

Moreover, as the precast industry increasingly adopts blended cements (such as Type II) and includes emerging Supplementary Cementitious Materials (SCMs), traditional durability databases may no longer apply. Without improved, accessible tools for quality and long-term performance prediction, the adoption of newer concrete mixes may be slowed. An affordable, automated permeability surrogate can help unlock sustainable mix designs without sacrificing reliability.

This proposal aligns with TRANS-IPIC / USDOT goals by directly addressing infrastructure life extension, improved durability, and cost-effective monitoring in precast concrete systems.

Outputs:

The anticipated research deliverables include a comprehensive database of sorptivity and permeability measured using our proposed test and standard methods for various precast concrete sample compositions, ages, and curing conditions. The research results include validated predictive models for resistivity/permeability from sorptivity, demonstrated methodology to extract aging coefficients from early sorptivity data and make reliable predictions of long-term permeability, and a Proof-of-concept QA tool for curing quality based on sorptivity in a precast environment.

This approach will lead to a rapid, scalable methodology for assessing the durability of precast concrete, reducing reliance on tedious traditional tests and enabling efficient quality control. By CV-based automation, the proposed method will minimize operator-dependent variability and enable the collection of large datasets. This technology will not only improve the assessment of durability and prediction of service life, but also provide feedback for producers to optimize mix design and curing process. The improved quality control and the optimized products will improve the durability and extend the life of transportation infrastructure.

Outcomes/Impacts:

The anticipated research results directly demonstrate the feasibility of using the proposed CV-based approach for permeability assessment, service life prediction, and quality assurance of curing. This approach provides rapid, objective measurements, reduces labor and operator error, and applies low-cost equipment (<\$200) suitable for jobsite deployment. The method can be standardized and replace traditional complex, expensive, and time-consuming methods. The proposed technology will enable optimization of mix design and curing, improve quality control and assurance, and reduce unneeded investments.

Provided that the feasibility is justified in this phase I of this project. In Phase II, large-scale concrete specimens will be used to verify the possibility of scale-up. We will also collaborate with precast plants for field tests and explore more industrial curing conditions, like steam curing.

Final Research Report: URL link to the project's final report will be provided upon the completion of the project.