



**Transportation Infrastructure Precast Innovation Center  
(TRANS-IPIC)**

**University Transportation Center (UTC)**

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

UI-25-RP-05

Quarterly Progress Report  
For the performance period ending [March 31<sup>st</sup>]

**Submitted by:**

Nishant Garg, Associate Professor, [nishantg@illinois.edu](mailto:nishantg@illinois.edu)  
Department of Civil and Environmental Engineering  
University of Illinois Urbana-Champaign

**Collaborators / Partners:**

NONE

**Submitted to:**

TRANS-IPIC UTC  
University of Illinois Urbana-Champaign  
Urbana, IL

## TRANS-IPIC Quarterly Progress Report:

### Project Description:

#### 1. Research Plan - Statement of Problem

Durability and service life of concrete transportation infrastructure are strongly governed by the transport of water, chlorides, sulfates, and other aggressive agents through the pore network. Conventional test methods used to assess these transport properties, including ASTM C1585 sorptivity and AASHTO T 358 surface resistivity, are labor-intensive, time-consuming, and susceptible to operator variability. In addition, estimating long-term aging behavior and service-life-related durability parameters typically requires months of testing, which limits rapid decision-making for precast concrete production and quality assurance.

This project addresses the need for a rapid, automated, and reliable method to evaluate permeability-related durability in precast concrete. The proposed computer vision-based sorptivity method is intended to increase testing throughput, reduce human error, and provide early feedback on curing quality, permeability, and long-term aging behavior. Such a tool is especially important as the precast industry adopts newer cement systems and supplementary cementitious materials, for which traditional durability databases may be insufficient. By enabling fast and low-cost assessment of porosity, permeability, and curing performance, the project aims to support more durable precast elements, improved service life prediction, and reduced maintenance costs for transportation infrastructure.

#### 2. Research Plan - Summary of Project Activities (Tasks)

##### ***Task 1: Prediction of resistivity based on results of CV-based sorptivity test***

It is critical to link the sorptivity measured by our CV-based method to the durability of concrete. The first subtask 1.1 of this research task will use resistivity as a measure of permeability. An extensive dataset comprising approximately 20 concrete mix compositions will be developed, including different w/c ratios, cement type, SCM replacement ratios, and aggregate type and volume. The AASHTO T 358-15 surface resistivity measurement will be conducted to obtain the target of prediction. The second subtask 1.2 is to perform the CV-based sorptivity test on the same samples to obtain initial and secondary sorptivity. The relationship between these results and the resistivity will be explored. A preliminary test has been conducted using 4 different concretes specimens, and a strong correlation has been observed, which demonstrates the potential of this proposed approach. This proposed task, combining a more extensive dataset, will further validate the feasibility and reveal any potential barriers.

##### ***Task 2: Estimation of ageing coefficient based on sorptivity***

Task 2.1 will extend the curing duration from 28d to 56 and 90d. Longer time samples will also be prepared and tested in Phase II of this project to further improve the accuracy. The ageing coefficients determined based on sorptivity will be compared to those based on surface resistivity. This task will justify the application of the CV-based sorptivity test on the durability assessment of concrete specimens after long-term curing and also establish the sorptivity test as a new approach for service life prediction. Task 2.2 will utilize the advantage of this automated rapid test to improve the estimation of ageing coefficients. For a selected subset of samples, the sorptivity will be measured more frequently to generate full curves of permeability evolution over time. These results are expected to improve the accuracy and precision of ageing coefficients and allow prediction based on early-stage results.

### Task 3: Evaluation of curing using sorptivity

Task 3 will further explore the application of the CV-based sorptivity test as a method to evaluate the extent and quality of curing. Curing conditions more relevant to the production of precast concrete will be used and prepared for the scale-up of the proposed technology. Task 3.1 will verify the CV-based sorptivity test as an automated, rapid alternative method to the standard methods for concrete cured under different conditions. Submerged in water curing, different moisture conditions, and dry curing in air will be tested. The sorptivity obtained will be compared to ASTM C1585 to reveal the impact of curing conditions. Task 3.2 will explore the feasibility of using sorptivity to optimize the demolding time. Samples demolded after different initial curing durations and subjected to various post-curing conditions and durations will be tested. Resistivity and strength will be used to evaluate the sufficiency of curing, and to verify if the sorptivity obtained using our proposed method can be used as a measure of curing quality.

### Project Progress:

#### 3. Progress for each research task

Task 1 40% Completed

Task 2 0% completed to date

Task 3 0% completed to date

Task 1 focuses on establishing the relationship between sorptivity and electrical resistivity so that sorptivity can be used as a practical indicator of transport-related durability in precast concrete. As proposed, this task involves measuring surface resistivity using AASHTO T 358 and comparing those results with sorptivity obtained from the investigated concrete mixtures. This task is important because resistivity is being used as a permeability-related durability indicator and linking it with sorptivity is a key step toward validating the proposed computer-vision-based sorptivity approach for rapid durability assessment.

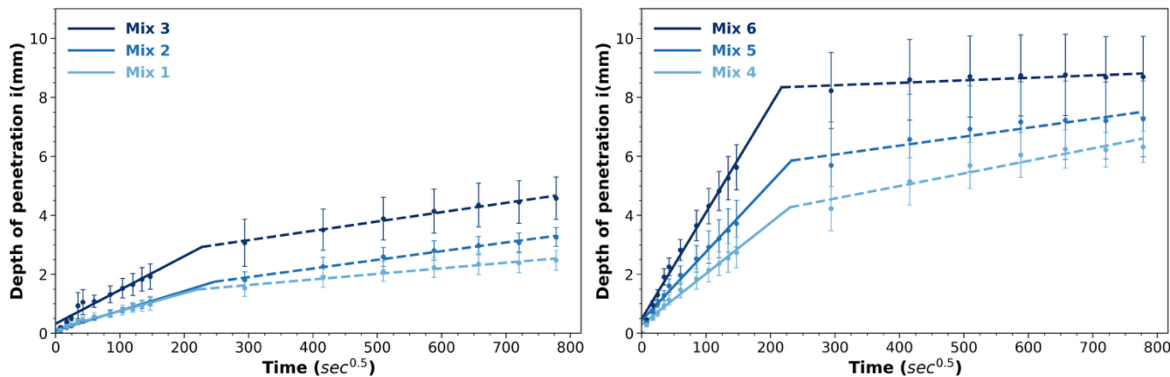


Fig.1 ASTM C1585 sorptivity test setup and experimentally obtained plots of depth of penetration,  $i$ , versus square root of time for Mixes 1- 6, used to determine the initial and secondary sorptivity coefficients.

During this reporting period, six concrete mixtures were tested to generate the initial dataset for this task. Sorptivity was measured in accordance with ASTM C1585, and companion specimens were tested for electrical surface resistivity using the four-point Wenner probe method according to AASHTO T 358. The mixtures represented a range of transport behaviors and included lower and higher water-to-cementitious ratio systems. The results showed clear differences among the mixtures. Mix 6 exhibited the highest initial sorptivity and the lowest resistivity, while Mix 1 showed the highest resistivity and comparatively lower sorptivity. In general, mixtures with higher capillary absorption tended to show lower electrical resistivity.

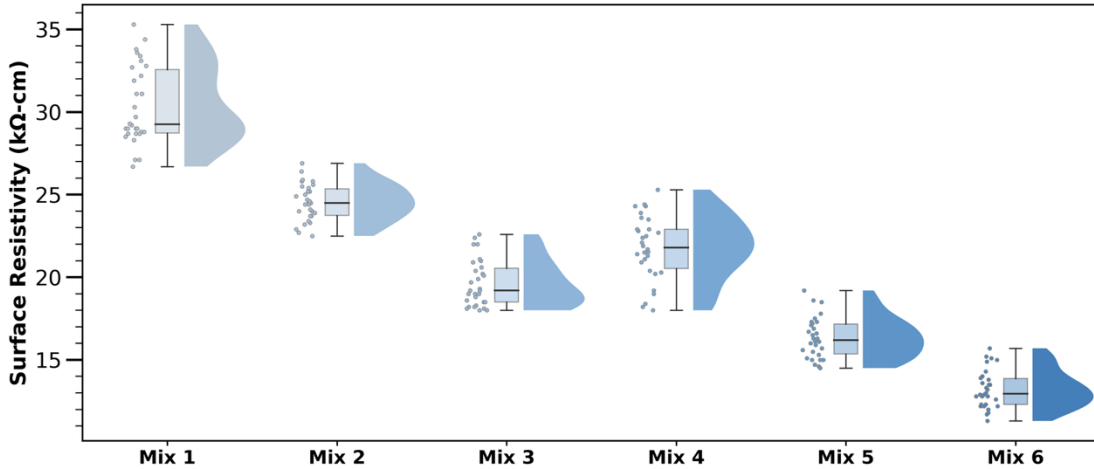


Fig.2 Measured surface resistivity values of Mix 1 to Mix 6, shown as scatter, box, and violin plots to capture dispersion and distribution characteristics.

Regression analysis further confirmed this relationship. Surface resistivity decreased as initial sorptivity increased, and the measured data produced a reasonably strong inverse correlation with an  $R^2$  of 0.78 and an RMSE of 12.4%. These findings provide the first direct validation within this project that sorptivity-based transport measurements can be used to estimate resistivity-related durability behavior. The completed work therefore demonstrates strong feasibility for Task 1 and establishes an important baseline for further development of predictive relationships using the computer-vision-based sorptivity method.

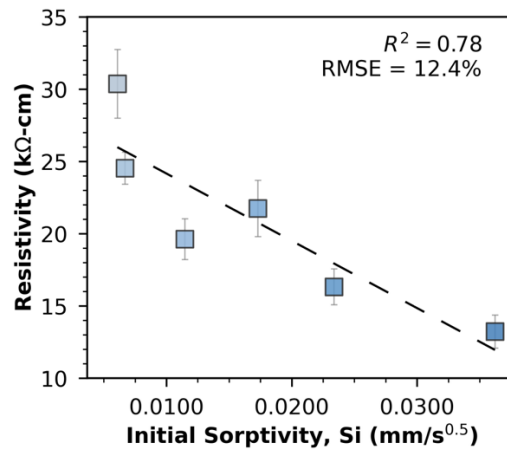


Fig.3 Relationship between surface resistivity and initial sorptivity,  $S_i$ , determined from ASTM C 1585 testing.

The next phase of Task 1 will focus on expanding the dataset to include additional concrete mixtures and integrating the computer-vision-based sorptivity framework more directly into resistivity prediction. This will improve the robustness of the model and further support the long-term goal of developing a rapid, low-cost, and automated durability assessment tool for precast concrete applications.

4. Percent of research project completed

15% of the project is completed in the 1<sup>st</sup> quarter.

5. Expected progress for next quarter

The next quarter will involve Tasks 1.2 and 2.1.

Task 1. Prediction of resistivity based on results of CV-based sorptivity test [100% completed]

Task 2. Estimation of ageing coefficient based on sorptivity [30% completed]

Task 3. Evaluation of curing using sorptivity [0% completed]

By the end of next quarter, 33% of this project is expected to be completed.

6. Educational outreach and workforce development

NA

7. Technology Transfer

NA

**Research Contribution:**

8. Papers that include TRANS-IPIC UTC in the acknowledgments section:

None

9. Presentations and Posters of TRANS-IPIC funded research:

None

10. Please list any other events or activities that highlights the work of TRANS-IPIC occurring at your university (please include any pictures or figures you may have). Similarly, please list any references to TRANS-IPIC in the news or interviews from your research.

None

**Appendix 1: Research Activities, leadership, and awards (cumulative, since the start of the project)**

- A. Number of presentations at academic and industry conferences and workshops of UTC findings
  - No. = 0
- B. Number of peer-reviewed publications submitted based on outcomes of UTC funded projects
  - No. = 0
- C. Number of peer-reviewed journal articles published by faculty.
  - No. = 4
- D. Number of peer-reviewed conference papers published by faculty.
  - No. = 3
- E. Number of TRANS-IPIC sponsored thesis or dissertations at the MS and PhD levels.
  - No. MS thesis = 0
  - No. PhD dissertations = 0
  - No. citations of each of the above = 0
- F. Number of research tools (lab equipment, models, software, test processes, etc.) developed as part of TRANS-IPIC sponsored research
  - Research Tool #1 (Name, description, and link to tool) = 0
  - Research Tool #2 (Name, description, and link to tool) = 0
  - Research Tool #3 (Name, description, and link to tool) = 0
- G. Number of transportation-related professional and service organization committees that TRANS-IPIC faculty researchers participate in or lead.
  - Professional societies
    - No. participated in = 2
    - No. lead = 1
  - Advisory committees (No. participated in & No. led)
    - No. participated in = 0
    - No. lead = 0
  - Conference Organizing Committees (No. participated in & No. led)
    - No. participated in = 0
    - No. lead = 0
  - Editorial board of journals (No. participated in & No. led)
    - No. participated in = 4
    - No. lead = 2
  - TRB committees (No. participated in & No. led)
    - No. participated in = 2
    - No. lead = 0
- H. Number of relevant awards received during the grant year
  - No. awards received = 1
- I. Number of transportation related classes developed or modified as a result of TRANS-IPIC funding.
  - No. Undergraduate = 0
  - No. Graduate = 0
- J. Number of internships and full-time positions secured in the industry and government during the grant year.
  - No. of internships = 0

- No. of full-time positions = 0

**References:**

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4. Kabir H., Garg N. (2023). 'Rapid prediction of cementitious initial sorptivity via surface wettability', *npj Materials Degradation*, 7, p. 52.
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