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New Jersey Department of Transportation
Bureau of Research, Innovation & Information Transfer

Research at a Glance

Technical Brief

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Bureau of Research, Innovation & Information Transfer

Extend Service Life of Concrete Bridge Decks with Internal Curing

Research Problem Statement

Proper curing of concrete during the hydration process plays a vital role in the durability and extending the service life of concrete structures. Conventional curing techniques generally adopted for bridge decks are applied externally using wet-burlap with plastic sheeting, and/or applying curing compound. These external curing methods are not always effective in providing sufficient moisture to support the hydration of the concrete cementitious matrix, particularly in HPC formulations, which have characteristic low water cement ratio and dense microstructure that reduces permeability and subsequently reduces external curing effectiveness.

During the hydration reaction, the cementitious material reacts with and consumes available pore water. Desiccation within the pore microstructure results in negative pore pressures that cause concrete self-shrinkage, also called autogenous shrinkage. When a high degree of autogenous shrinkage occurs under the restrained conditions typical of highly reinforced bridge decks, cracking can occur due to the localized stress accumulating around reinforcement. The ingress of chloride ions into cracks due to salt usage leads to corrosion of the steel reinforcement, increased maintenance costs, and overall reduction in the service life of the bridge deck or pavement.

High Performance Internally Curing Concrete (HPIC) is produced by incorporating highly absorbent materials, such as pre-wetted Light Weight Fine Aggregate (LWFA) or Super Absorbent Polymers (SAP). These materials readily release water into the cementitious matrix during hydration, refilling microstructure pores, and promoting increased hydration. This additional reservoir of water significantly reduces autogenous shrinkage and consequently decreases early age cracking. With early age cracking mitigated, HPIC can reach its full potential by providing a highly durable and cost-effective concrete that is resistant to the harsh conditions typical of NJ bridge decks and pavements.

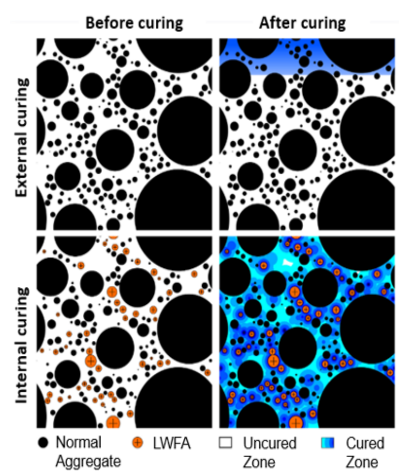


Image: FHWA EPIC2 Fact Sheet

Research Objectives

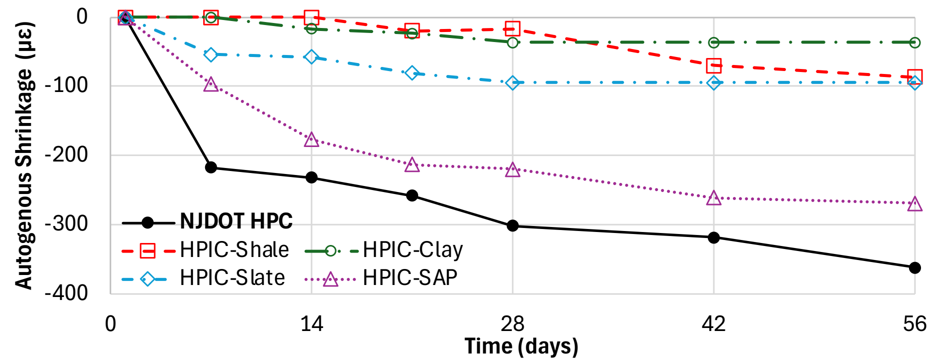
To evaluate the efficiency of internally cured concrete for New Jersey bridge structures, this research is organized into two main phases. Phase I consisted of an extensive review of other states' DOT's specifications, lessons learned, and challenges associated with current practices for HPIC in the US. Phase II, in turn, aimed to; 1) conduct a laboratory testing program tailored to evaluate the use of LWFA and SAP to produce more durable concrete, 2) assess the technical feasibility of implementing HPIC, and 3) perform a life-cycle cost analysis (LCCA) for the benefits expected. This research is devoted to promoting the application and production of HPIC in NJ.

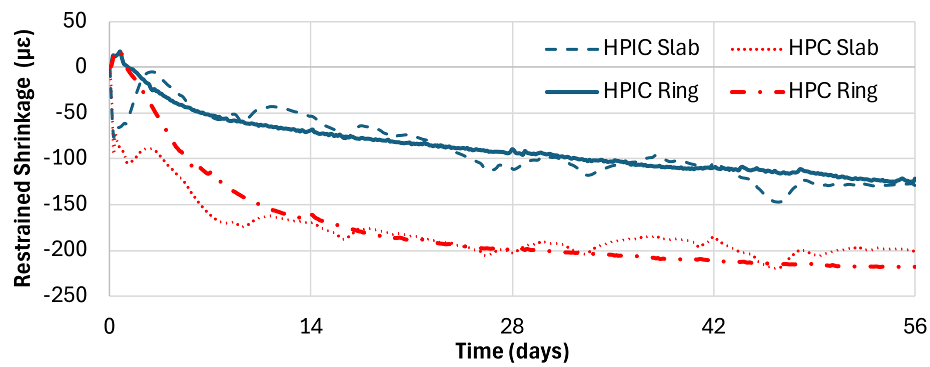
Methodology

NJDOT HPC formulations were modified to produce HPIC by replacing a portion of normal weight sand with locally available LWFA SAP by volume. Laboratory testing was undertaken and local concrete suppliers demonstrated HPIC production. Curing regimes were assessed to determine the feasibility of implementing accelerated curing durations. NJDOT inputs were used in LCCA to estimate the overall cost between HPIC and HPC over a 75-year analysis period.

Results and Conclusions

The HPIC formulations tested showed comparable strength properties to those of HPC. Freeze-thaw resistance and chloride permeability were not significantly changed by the selected LWFAs at typical dosages and differences in fresh property, castability, and finishability were deemed negligible.





Autogenous shrinkage (ASTM C157) and restrained shrinkage (AASHTO T334) were significantly reduced for all HPIC formulations. The simulated bridge deck slab segments showed a significant reduction in restrained shrinkage for HPIC incorporating expanded shale LWFA, especially at early ages, when HPC is most susceptible to early-age cracking.

The LCCA results comparing NJDOT HPC with HPIC predicts 30-45% agency cost savings under NJ conditions (e.g., high salt usage) over a 75-year analysis period. Bridge deck service life for HPIC is expected to be 40-50 years, compared to the 25-year service life of HPC bridge decks in NJ.

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