National Concrete Pavement Technology Center

Tech Center

Superabsorbent Polymer in Concrete to Improve Durability

tech transfer summary

The use of superabsorbent polymers in concrete mixtures is a potential method for internal curing and may be an alternative to the use of lightweight fine aggregates.

March 2025

RESEARCH PROJECT TITLE
Superabsorbent Polymer in Concrete to Improve Durability

SPONSORS
Iowa Highway Research Board
(IHRB Project TR-793)
Iowa Department of Transportation
(InTrans Project 21-752)

PRINCIPAL INVESTIGATOR
Peter Taylor, Director
National Concrete Pavement Technology Center, Iowa State University
515-294-9333 / ptaylor@iastate.edu
(orcid.org/0000-0002-4030-1727)

CO-PRINCIPAL INVESTIGATOR
Kejin Wang, Professor
Civil, Construction, and Environmental Engineering, Iowa State University
(orcid.org/0000-0002-7466-3451)

MORE INFORMATION
cptechcenter.org

CP Tech Center
Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-5798

The mission of the National Concrete Pavement Technology Center (CP Tech Center) at Iowa State University is to unite key transportation stakeholders around the central goal of developing and implementing innovative technology and best practices for sustainable concrete pavement construction and maintenance.

IOWA STATE UNIVERSITY
Institute for Transportation

Objectives

This research aimed to assess the potential use of superabsorbent polymers (SAPs) for internal curing in concrete mixtures. Specific objectives were as follows:

- Specify SAP products based on an investigation of their different types, absorption kinetics, and particle sizes
- Determine the quantity of SAP required for a concrete mixture
- Evaluate the feasibility of dry batching SAPs with additional water
- Assess the impact of SAPs that have been optimized for internal curing on properties that affect concrete performance, including strength and durability

Background

Internal curing involves adding small, uniformly distributed reservoirs of water within concrete. This method allows the concrete mixture to maintain a low water-to-cementitious materials (w/cm) ratio while gradually supplying the stored water to the concrete as the cement hydrates and the paste dries.

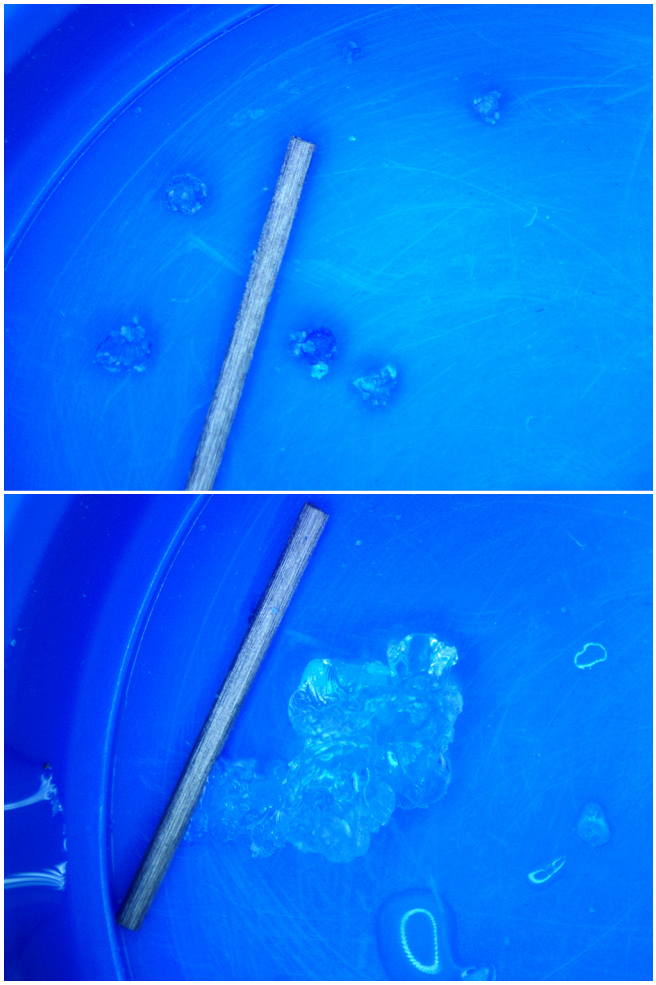
Internal curing has been reported to be effective in reducing shrinkage cracking, improving the potential durability of concrete mixtures, and, most notably, reducing cracking caused by curling and warping in pavements and slabs on grade.

The use of lightweight fine aggregate (LWFA) is the most common internal curing method in the United States. However, this method requires aggregate to be presaturated at concrete batch plants within a set timeframe, which may increase costs related to stockpile management and the production and hauling of LWFA. Furthermore, the use of LWFA can reduce the elastic modulus of concrete.

SAPs are synthetic materials that absorb significant amounts of water. When incorporated into concrete, they can act as internal water reservoirs for internal curing. SAPs are commonly used in high-performance concrete, where the w/cm ratio is often relatively low, to improve cement hydration, densify the microstructure, and reduce shrinkage.

Problem Statement

Relatively little work has been conducted on SAPs in the United States. Open questions include how SAP products should be specified, the SAP quantities needed in concrete mixtures, whether SAPs can be dry batched in mixtures without compromising performance, and how mixtures are affected by the use of SAPs.



Dry (top) and swollen (bottom) SAPs (with 0.5 mm pencil lead as reference)

Research Description

Several SAP products with different properties were selected as candidate internal curing materials and evaluated in two phases.

Phase I: Paste Testing

Eight SAPs were investigated as internal curing materials in cementitious mixtures. All specimens had the same water-to-cement (w/c) ratio (0.42), and the SAP content in all mixtures except for the control (which did not contain SAP) was 0.4% by weight of cement.

The SAPs' initial absorption rate, absorption volume, desorption mass, and particle size were measured in the mixtures. Based on the results, three SAPs were selected for further testing as internal curing materials in concrete: Hydromax, BASF, and PX-1A-TA.

Phase II: Concrete Testing

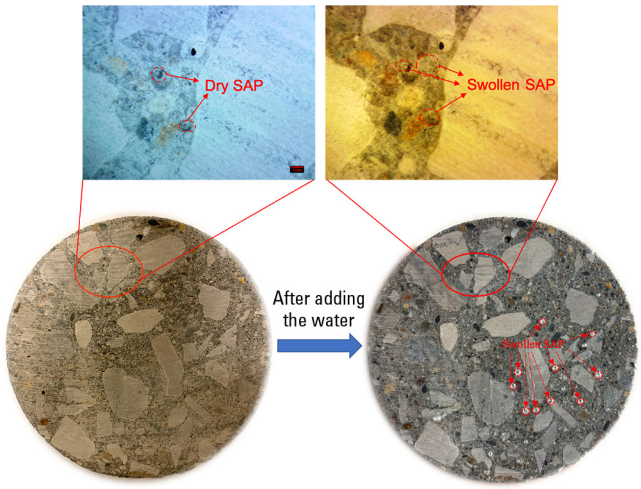
The same cement and paste contents used in Phase 1 were used along with coarse and fine aggregate to create the concrete specimens in Phase 2.

Additionally, water and high-range water reducer was added to obtain an initial slump of 1.5 to 2.5 in., and air-entraining admixture was added to achieve a target air volume of 5% ±1%.

Different concrete samples were prepared with either presoaked or dried SAP to compare the mechanical properties resulting from the different preparation options. The concrete mixtures were prepared in the laboratory using a drum mixer.

Several tests were conducted on the concrete samples to investigate the influence of the three types of SAP on cement hydration, fresh and hardened properties, absorption, and shrinkage. Tests included calorimetry, thermogravimetric analysis, slump, setting time, air content, unit weight, VKelly index, compressive strength, bulk and surface electrical resistivity, water absorption/degree of saturation, optical image analysis, and restrained shrinkage.

Thermogravimetric test equipment



Optical images of concrete cross sections

Key Findings

- The use of SAPs slightly reduced the strength and electrical resistivity of concrete, although these parameters remained within acceptable bounds, while the degree of hydration and shrinkage of the concrete were clearly improved.
- The use of SAPs can improve some of the properties that affect the performance of concrete. However, consistently controlling water absorption and desorption has proved to be a challenge, potentially leading to detrimental effects on performance.
- Slump loss tests indicated that the SAPs used in this study were absorbing some water over at least the first 30 minutes.
- Calorimetry and thermogravimetric analysis tests confirmed that the mixtures containing SAPs experienced increased cement hydration, likely due to the water provided by the SAPs.
- Hardened concrete with SAPs had lower compressive strength and resistivity values than the control concrete, likely because not all of the added water was absorbed into the SAPs.
- The concrete mixtures containing SAPs exhibited lower shrinkage up to 7 days, likely due to retention of water in the SAPs.
- All three SAP products tested performed similarly to each other.
- The addition of dry SAP was less detrimental to performance than the use of presoaked SAP.

Implementation Readiness and Benefits

The use of SAPs for internal curing can improve some of the properties that affect concrete performance and address problems related to the use of LWFA. The use of SAPs can also promote hydration and reduce the risk of early-age cracking.

However, the difficulty in controlling water absorption and desorption may lead to detrimental effects on performance.