

Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Application of Internal Curing to Improve Concrete Bridge Deck

Research Benefits

Internal curing has been found to greatly reduce the chance of early age cracking as well as concrete deterioration. In addition, the success of internal curing could reduce the current required extensive wet curing period, which is expensive. Even though internal curing could lead to an increase in materials cost to some extents due to the use of LWFA, there is a great potential to save life cycle costs by extending service life and shortening wet curing. This research provided NDOT with an effective practice for internal curing, allowing NDOT to apply the internal curing concept in various concrete projects, particularly for bridge deck construction, which will bring significant benefits to both short-term and long-term performance of concrete structures.

Background

Due to the relatively high cement content and low water-to-cement ratio (w/c) used, Nebraska's typical bridge deck concrete is more prone to early age cracking. Bridge deck cracking and deterioration coupled with the application of deicing chemicals during winter operations have been a primary concern. Nebraska Department of Transportation (NDOT) has employed mitigating reactionary strategies such as crack sealing and overlay to address early age deck cracking. However, these strategies are costly and have impacts on traffic operations. NDOT would clearly benefit if concrete decks are free from premature cracking associated with initial construction.

Research Objectives

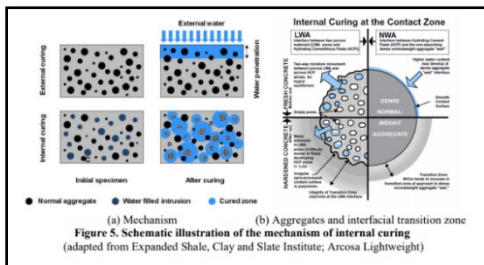
The overall goal of this study was to identify a cost-effective practice for internal curing of bridge deck concrete for NDOT.

To achieve the goal, three specific objectives of this study were to:

- Summarize the best practice of internal curing concrete for bridge deck application through an extensive literature review and survey
- Determine appropriate source and addition rate of LWFA for internal curing of Nebraska concrete bridge decks
- Evaluate the technical feasibility and benefits of internal curing for Nebraska bridge deck construction.

Conclusion

The research study demonstrated that it was possible to develop a local internally cured concrete mix. Even though the replacement of fine aggregates by LWFA's results in a decrease of 28-day modulus of elasticity, and modulus of rupture, the overall mechanical properties still meet bridge deck criteria. As the curing age decreases, internally cured mixes were found to be less affected owing to the curing water from within the concrete matrix provided by the saturated LWFA's, which demonstrated that internal curing could potentially decrease the required amount of curing period in the field. The new internally cured mix was also found to have comparable chloride penetrability compared to the control mix. The chloride penetration was categorized as very low based on lab study.



Mechanism of Internal Curing

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 Final report is available:
[HERE](#)

NDOT Recommendations Based Off Research Project – 2020 – RRL3

After some discussion with the Bridge Division, the Department will be looking for a project to try the internal curing on. The goal will be to cut back on the number of days of wet curing in the field from 10 days to 7 days. Further discussion is required on what additional testing NDOT Materials & Research will perform during the placement of the new mix.

NDOT will not move forward with the permanent implementation of the internal curing until a bridge deck is installed, and it is successful. Bridge Division is looking for a feasible bridge location to implement the internal curing for 2021 Construction season.

- As provided by Fouad Jaber and Wally Heyen, Lead TAC Member

Internal Curing Expanded Shale

NDOT Research Follow up Implementation Completed 2023
 Project: STP-50-1 (117)
 Pawnee City-Southeast Bridges
 ICC Test Pour

NDOT Field Implementation

All the mechanical and permeability properties were tested by Materials and Research PCC Laboratory.

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 Innovation for a Nation on the Move
 Enhancing Performance with Internally Cured Concrete EDC-7

Figure 1. Implementation flow up

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NDOT Recommendations Based Off of Research Project – 2025 – RRL4

During the 2023 construction season Figure 1, the Bridge Division selected a bridge project in Pawnee City to evaluate the performance of the internally cured concrete (ICC) in comparison to the Nebraska Department of Transportation (NDOT) standard bridge mix design. The primary objective was to assess the technical and economic feasibility of producing a locally sourced ICC mix by replacing a portion of the fine aggregate with lightweight fine aggregate (LWFA). A key goal of this initiative was to potentially reduce the required wet curing duration in the field from 10 days to 7 days.

Laboratory and Field Testing - The Materials and Research (M&R) Division conducted comprehensive testing of both the ICC and standard mixes, evaluating fresh properties, mechanical properties, and durability. All test results met NDOT standards. M&R also continued to monitor field performance. As of December 2023, the bridge deck exhibited no visible cracking.

Implementation Challenges - Several field-related challenges arose during implementation:

- Unexpected Heavy Rain: Inclement weather affected site accessibility and delayed operations.
- Pumping Issues Before and During Placement: The concrete pour was delayed due to pumping issues, primarily caused by the addition of approximately 50 feet of horizontal rubber hose at the end of the pump line. This adjustment was necessary due to limited site access resulting from the rain. Based on observations and past experiences, the use of rubber hose at the end of a pumping system significantly increases the risk of plugging unless properly primed with a cement slurry. Notably, the pumping issues were limited to the first two trucks, supporting the conclusion that insufficient priming of the rubber hose was the root cause.
- Lightweight Aggregate (LWA) Presoaking and Handling: To meet internal curing requirements, the LWFA was presoaked using a scheduled watering cycle (6 hours on / 6 hours off) via a sprinkler system controlled by a timer. The plant followed specifications requiring 72 hours of continuous watering, followed by a 13-hour drainage period. However, due to placement delays, the drainage period was extended to 18 hours.

These issues highlighted a need to revisit and potentially revise the specifications, particularly around better control of LWFA moisture conditions to mitigate future pumping concerns.

Field Performance and Observations –

- Short-Term Results: NDOT's short-term assessment found the ICC deck performing as expected with no cracking observed by December 2023.
- Mid-Term Evaluation: As scheduled, NDOT conducted a midterm evaluation in December 2024. The bridge deck and approach slab showed no major issues, with only a few minor cracks observed.
- Surface Scaling: Post-pour rainfall and inadequate plastic at the edges led to noticeable scaling on the shoulders of the deck. This appears to be a weather-related issue rather than a material defect.

Conclusion - The Pawnee City ICC trial has so far demonstrated the viability of using lightweight fine aggregate in bridge deck applications to support internal curing. While implementation challenges were encountered, the performance of the concrete—both in the lab and in the field—has met NDOT standards. Continued evaluation and minor adjustments to specifications, particularly concerning pumping practices and LWFA moisture control, are recommended to optimize future applications.

- As provided by Fouad Jaber and Wally Heyen, Lead TAC Members

Research Readiness Level (RRL) Assessment

Level 4: Implementation with Follow-Up

Research/Technology refined and adopted. Moved up from RRL3, assessed 2020.

Benefits of the implementation will be evaluated for a time frame of 3 years.

RRL 4

**This brief summarizes Project SPR-P1 (19) M083
“Application of Internal Curing to Improve Concrete Bridge Deck”
Nebraska Department of Transportation Research Program**