Wisconsin Department of Transportation
Wisconsin Highway Research Program

Request for Proposal

Internal Curing of Bridge Decks and Concrete Pavement To Reduce Cracking

Questions submitted to research@dot.wi.gov regarding the Content of this RFP are due no later than 4:30 PM (CST) on December 12, 2017

Responses to questions will be posted to the WisDOT Research and Library website http://wisdotresearch.wi.gov/rfps-and-proposals by 4:30 PM (CST) by December 19, 2017

Researchers must submit a PDF version of their proposal by 4:30 PM (CST) by January 26, 2018 to: research@dot.wi.gov

Researchers will be notified of the proposal review decision by May 1, 2018

For more information regarding this RFP contact the WisDOT Research Program at: research@dot.wi.gov. This RFP is posted to the Internet at: http://wisdotresearch.wi.gov/rfps-and-proposals

Wisconsin Highway Research Program
Request for Proposals
Structures Technical Oversight Committee

Internal Curing of Bridge Decks and Concrete Pavement to Reduce Cracking

I. Background and Problem Statement

Wisconsin Department of Transportation (WisDOT) has been successfully managing 12,000 total centerline miles of highway system and 5,293 state-owned bridges. The 2016 data shows 98.1 percent of the backbone system and 79.2 percent of the non-backbone system in fair and above condition. Currently 96.9 percent of State owned or maintained bridges have a good rating or fair rating[1]. Even though the condition of majority transportation system in Wisconsin is in fair or above condition, WisDOT has struggled to control cracking on bridge deck and concrete pavement in our High-Performance Concrete (HPC) and conventional concrete bridge (Grade A) construction projects (Standard Specification Sec. 501 and Sec. 415). Higher strength, lower water to cement ratio (w/c) concrete has been promoted for over 20 years due to the desire for increased strength and reduced permeability. The lower w/c of these concretes makes them susceptible to autogenous shrinkage and cracking. Cracking of concrete leads to ingress of chlorides that also promotes deterioration. Bridge decks have been a primary concern for cracking and deterioration due to the wide, thin, and long pours used coupled with application of deicing chemicals during winter operations. The inability to control cracking in bridge deck and concrete pavement construction leads to deterioration of the concrete transportation infrastructure and shorter life cycles. WisDOT has employed mitigating reactionary strategies like crack sealing and thin polymer overlays to address early age deck cracking. However, these strategies are costly and have impacts on traffic operations due to the need for repeated applications through the life of the structure. WisDOT would clearly benefit from the ability to construct concrete transportation structures that are free from cracking associated with initial construction.

In recent years, some DOTs have examined the concept of internal curing of concrete bridge decks and concrete pavement to address the problem of early age cracking by advanced material properties. Internal curing provides moisture used for hydration and offsets moisture loss due to hydration and evaporation. Generally, internal curing is realized by using the pre-wetted expanded lightweight aggregate, recycled concrete aggregates, superabsorbent polymers, or cellulose fibers. It has been documented that internal curing reduces early age shrinkage and associated plastic shrinkage cracking. One of the most important effects of internal curing is that it makes the concrete more resistant to early-age cracking. This technique also makes the concrete less sensitive to variations in the application of curing method (Daigle et al. 2008[2]).

The Indiana Department of Transportation (INDOT) constructed four bridge decks utilizing internally cured, high performance concrete (IC HPC) during summer 2013. The results indicate that the IC HPC mixtures used in this study exhibited the potential to more than triple the service

[1] Wisconsin Department of Transportation (2017) MAPSS Performance Improvement. Retrieved from http://wisconsindot.gov/Documents/about-wisdot/performance/mapss/perf-report.pdf

[2] Daigle, L. D. Cusson, and Z. Louniz. (2008). "Extending Service Life of High Performance Concrete Bridge Decks with Internal Curing," *NRCC-50429, National* Research Council of Canada, Sept. 30, 2008.

life of the typical bridge deck in Indiana while reducing the early age autogenous shrinkage by more than 80% compared to non-internally cured concretes (Barrett et al. 2015[3]). Some DOTs suggest that the total life-cycle costs of bridge decks made of IC HPC might be reduced by 50% compared with those of bridge decks made of conventional concrete (Guo et al. 2014[4]).

Although internally cured concrete has mostly been used in bridge deck applications, the benefit of applying internal curing has been extended to pavements. The Louisiana Department of Transportation (LDOT) revealed in a field study that the internally cured pavement project showed significantly less cracking at one year over the controlled sections and that the reduced cracking should lead to longer service lives and more durable structures (Rupnow et al. 2016[5]).

From the successful practices in other State DOTs, WisDOT is interested in obtaining clear and concise documentation of what DOTs have used internal curing for bridge decks and concrete pavements, how internal curing has performed relative to conventional concrete, what were the lessons learned about specifications, costs, testing, performance of using internal curing. Most importantly, WisDOT pursues to determine what adjustments are needed to its specifications and testing of construction materials to accommodate internal curing. Internal curing is expected to produce better, stronger, more durable and less permeable concrete. To utilize the benefit of internal curing, research is needed that would address the above questions and provide details that would provide the justification and tools to implement internal curing in WisDOT concrete construction projects.

II. Objectives

The objective of this research is to examine and document the use of internal curing of concrete in bridge decks and concrete pavement and develop WisDOT specific implementation guidance, tools, and specifications to produce better concrete. Specific questions and issues that need to be addressed include:

- Does internal curing of concrete have a demonstrated history of reducing cracking in bridge deck and concrete pavement applications?
- Can internal curing of concrete advance the material property of strength, permeability, freeze and thaw etc., compared to the conventional concrete?
- What are the lifecycle cost savings associated with using internal curing for bridge decks and concrete pavements?
- What is the most effective method for WisDOT to attain internal curing of bridge decks and concrete pavement (e.g., pre-wetted expanded lightweight aggregate, recycled concrete aggregates, superabsorbent polymers, or cellulose fibers)?
- What are Wisconsin regional sources of lightweight aggregate that could be used for internal curing of concrete?

[3] Barrett, T. J., Miller, A. E., & Weiss, W. J. (2015). Documentation of the INDOT experience and construction of the bridge decks containing internal curing in 2013. (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2015/10). West Lafayette, IN: Purdue University. http://dx.doi.org/10.5703/1288284315532.

[4] Guo, Y., Peeta, S., Zheng, H., Barrett, T., & Miller, A. (2014). *Internal Curing as a New Tool for Infrastructural Renewal: Reducing Repair Congestion, Increasing Service Life, and Improving Sustainability* (No. NEXTRANS Project No. 082PY04).

[5] Rupnow, T., Collier, Z., Raghavendra, A., & Icenogle, P. (2016). *Evaluation of Portland Cement Concrete with Internal Curing Capabilities* (No. FHWA/LA. 16/569). Louisiana State Project No. 30000680 / LTRC Project No. 12-4C.

- The research will establish new mix design and curing recommendations of concrete made with internal curing materials.
- How would Wisconsin specifications for high performance concrete and other deck concrete need to be adjusted to incorporate internal curing?

III. Scope of Work

A. Conduct a comprehensive literature review and assessment of current internal curing practices at various other state DOTs, FHWA, industries, and manufacturers.

B. Summarize information available related to current practices at various other state DOTs, industries, and manufacturers.

C. Identify bridge decks and pavements that have been constructed with internal curing method to determine performance trends, cost information, specifications, and lessons learned.

D. Design and conduct laboratory investigation and experiments that would provide insight to the performance of internal cured concrete as a crack control mechanism. These laboratory tests and experiments would be focused at the properties of shrinkage, moisture loss, strength and other key parameters that reflect the overall effectiveness in controlling cracking in bridge decks and concrete pavement. Laboratory experiments should be designed and conducted unique to bridge decks and also unique to concrete pavements. These experiments are used to quantify the material benefits of using internal curing and to develop information needed to adjust parameters used in WisDOT bridge concrete mixes and testing (HPC and Grade A) as well as concrete pavement mixes for inclusion of internal curing.

E. Determine and make recommendations to updated Wisconsin specifications for high performance concrete, other deck concrete (WisDOT Grade A), concrete pavement. This would include materials testing to be included in the construction acceptance and administration process.

F. Develop recommendations and guidelines in a format consistent with WisDOT Bridge Manual, Facility Development Manual (FDM) (Chapter 14. Pavements), Standard Specifications, and associated presentation materials for WisDOT practitioners.

G. Recommend updates to the appropriate sections of the Standard Specifications including Section 715 QMP Concrete Pavement and Structures that will facilitate implementation of internal curing.

H. Recommend methodology to estimate the lifecycle cost savings associated with using internal curing for bridge decks and concrete pavements on future projects.

IV. WisDOT/TOC Contribution

WisDOT will provide the following support through the WHRP Project Oversight Committee and Regional Bridge Maintenance Engineers:

A. Work will be conducted with project oversight by the WHRP Structures and Rigid Technical Oversight Committees (TOCs). The TOC members will appoint a Project Oversight Committee (POC) to support the successful completion of the project.

B. The research team will not assume the availability of WisDOT staff or equipment in the proposal. If WisDOT or another entity donates equipment or staff time, a letter of commitment must be included in the proposal.

C. Expected level by staff/TOC members: Maximum of 40 hours over the duration of the project. The research team will consult with POC members in the selection of project sites.

D. WisDOT staff will assist research team in contacting the FHWA for access to the FHWA, Long Term Bridge Preservation Bridge Portal for collection of national bridge demographic and condition information.
E. If field work on or around in-service facilities is anticipated by the research, the proposal will need to discuss the nature and extent of needed traffic control and support assistance that will be requested from WisDOT. The researcher will need to closely coordinate with WisDOT regional personnel and possibly the county personnel where project fieldwork is being conducted. For WisDOT planning purposes, the Principal Investigator shall specify in his or her proposal, as practical, what specific traffic control will be required for this project, such as traffic flagging, signage, barricades, etc., as well as the duration needed (hours/day/location). It should not be assumed that WisDOT would fund the traffic control apart from the research project budget.

V. Required Travel

This project may require travel to Madison, WI for a meeting to finalize the work plan with the POC as well as interim reporting during the project. There may also be travel required to other states to collect information and document past implementations of internal curing. It is also expected the PI will deliver the final presentation in person in Madison, WI.

VI. Deliverables

A. Reporting Requirements: Six (6) hard copies and an electronic copy of the final report delivered to WisDOT by the contract end date. This includes the report, special provisions, and structural and pavement details. Please refer to the Implementation section for further details.
B. Policy recommendations for Bridge and Construction Manual, draft Specification and Special Provisions (SPV) related to implementation of internal curing of bridge decks and concrete pavement.
C. Methodology to estimate the lifecycle cost savings associated with using internal curing for bridge decks and concrete pavements on future projects.
D. Development of a PowerPoint presentation to serve as a training tool for WisDOT Bridge and pavement design and construction staff. WisDOT staff will provide the associated training.
E. Presentation Requirements: All projects require the PI to give an in-person closeout presentation to the TOC after submittal of the draft final report.

VII. Budget and Schedule

A. Project Budget shall not exceed **$200,000.**
B. Proposed project duration is **24 months** starting around **October 1, 2018.**
   - Deadline for submittal of draft final report is three months prior to contract end date to allow for report review activities.
   - Deadline for research close out presentation is six to eight weeks prior to contract end date.
   - Deadline for submittal of the Final Report is the contract end date.

VIII. Implementation

Successful implementation of this research will be achieved through the development of the following items:

- Clear and concise commentary on the effectiveness of internal curing of bridge decks and concrete pavement used to control the early cracking of concrete compared to the conventional concrete. This will include documentation of other DOTs past implementations and performance.
- Recommendations on a practical and effective approach to incorporate internal curing into the WisDOT bridge and pavement construction process. This would include method of attaining internal curing (pre-wetted expanded lightweight aggregate, recycled concrete aggregates, superabsorbent polymers, or cellulose fibers) and what are Wisconsin regional sources of lightweight aggregate that could be used for internal curing of concrete.
- Updates to WisDOT Bridge and Construction Manuals chapters related to using internal curing in bridge decks, their components and concrete pavements
- Draft Special Provisions (SPV) for HPC Bridge Deck, conventional bridge deck concrete (WisDOT Grade A), and concrete pavement that would be consistent with the format and nature of the current specifications. This would also include placement and curing recommendations of concrete made with internal curing materials. The Wisconsin DOT Standard Specifications should be used as a starting point for modification to Special Provisions as appropriate.
- Recommend methodology to estimate the lifecycle cost savings associated with using internal curing for bridge decks and concrete pavements on future projects.
- Information on cost and availability of materials used in internally cured concrete.
- A PowerPoint presentation to serve as a training tool for WisDOT Bridge Maintenance, Bridge Asset Management, Pavement Maintenance and Regional Planning staff.