



# SPR RESEARCH PROGRAM

## SECOND-STAGE PROBLEM STATEMENT

### FY 2010

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#### I. PROBLEM NUMBER

ST-10-02

#### II. PROBLEM TITLE

Internal Curing of Concrete Bridge Decks

#### III. RESEARCH PROBLEM STATEMENT

Current Oregon Department of Transportation (ODOT) Standard Specifications for curing of high-performance bridge deck concrete requires wet curing be put into place within 20 minutes of the final pass of the finishing machine and not greater than 20 feet from the back of the pavement machine. This wet cure is specified for a duration of 14 days with longer curing possible if cooler ambient temperatures ( $T < 45$  °F) are encountered during the initial 14-day period. This long wet cure reduces evaporation that can lead to cracking, and it provides water to the bulk concrete to participate in the chemical reactions in the cement paste during hardening. While this curing period reduces bridge deck cracking, the time requirement represents a significant burden on constructability and project scheduling. There is a need for accelerated/alternate curing techniques that will allow for increased construction efficiency while still producing crack-free or crack-resistant concrete in these high-performance bridge decks.

Research has shown that lightweight aggregate saturated with water can provide internal curing to mitigate autogenous shrinkage (one form of shrinkage that can occur when cement reacts with water) and improve other engineering properties in high-performance concrete mixtures. Autogenous shrinkage can lead to early-age cracking if the stresses developed from this shrinkage exceed the tensile strength of the curing concrete. Most of the field internal curing trials have been done in conjunction with standard curing regimes as a means to improve properties and reduce cracking potential. However, internal curing could allow for earlier removal of external wet curing (e.g. 3-7 day external cure time) while relying on the inherent characteristics of well designed high-performance concrete to provide the specified engineering properties.

#### IV. RESEARCH OBJECTIVES

The goal of this research project is to determine if the incorporation of saturated lightweight aggregate into high-performance concrete bridge deck mixtures can significantly reduce external curing requirements (currently 14 days) while maintaining crack-free or crack-resistant concrete. Specific research objectives are:

- Identify high-performance concrete mixture proportions incorporating saturated lightweight aggregate that will provide sufficient internal curing to reduce autogenous shrinkage and subsequent cracking risk
- Demonstrate effectiveness of selected strategies in small scale field trials/applications identified through collaborative efforts with ODOT
- Provide guidance for contractors and finishers to take advantage of new materials/mixture proportions identified in this research program to provide internal curing in high performance concrete applications
- Expand existing literature and state-of-knowledge in this area and bring new expertise to the state of Oregon related to internal curing through use of lightweight saturated aggregate

#### V. WORK TASKS, COST ESTIMATE AND DURATION

##### Task 1: Background

*Estimated cost: \$20,000*

A literature review will be conducted to identify existing research related to the use of saturated lightweight aggregate to reduce autogenous shrinkage and subsequent cracking risk in high performance concrete. Current ODOT and contractor curing practices will be assessed to drive research efforts in the laboratory. Key climatic regions in the state will be identified where internal curing may be especially beneficial due to harsh environmental conditions (e.g. moderate to high day time temperatures combined with low humidity).

Task 2: Laboratory Evaluation

*Estimated cost: \$96,000*

Existing high-performance concrete mixtures will be selected for which saturated lightweight aggregate used as internal curing may be beneficial. Any mixtures identified as part of this project will still meet ODOT performance requirements for strength, durability, and permeability. While the high performance concrete mixtures investigated in this project will be for concrete bridge decks the outcomes of this research project will be applicable to other concrete mixtures where internal curing may be advantageous.

An experimental approach and specific testing methodologies will be defined to assess the potential reduction in external wet curing time through use of internal curing. Experiments will be designed to incorporate typical stresses on newly-placed deck concrete and Oregon-specific climatic conditions. Standard laboratory tests may need to be augmented and/or new tests developed to capture the performance of internal curing under these identified conditions. It is anticipated that the laboratory effort will provide several concrete mixtures employing reduced curing time methods for further evaluation.

Task 3: Field Trials

*Estimated cost: \$65,000*

Field trials will be conducted on the promising mixtures/methods from Task 2 by casting restrained slabs (~8'x12') outdoors using concrete from local concrete suppliers. The field trials will be conducted at OSU and/or at locations within the state of particular interest to ODOT. Evaluations will be conducted to determine whether the mixtures are appropriate for bridge decks from a constructability, performance, and economic standpoint. Evaluation of the efficacy of internal curing to reduce external curing duration will be a key component of the field trials.

Task 4: Reporting and Implementation

*Estimated cost: \$15,000*

The report for this research will include analysis of laboratory and field testing, a cost-benefit comparison, and guidelines for procedural and specification changes. A plan for implementing internal curing in concrete applications will be included. The project investigator will make presentations to ODOT and industry personnel regarding the findings and recommendations for implementation.

Cost:

OSU:	\$196,000
ODOT support:	\$20,000
Total:	\$216,000

Duration: 2 years

**VI. IMPLEMENTATION**

Key personnel from ODOT, FHWA, and the Oregon Concrete and Aggregate Producers Association will observe the field trials during casting and finishing and at key stages of curing. Input from these personnel will be critical for developing guidelines that are realistic for concrete production and construction practices that can be incorporated into ODOT specifications.

**VII. POTENTIAL BENEFITS**

Potential benefits include

- Decrease time of construction due to reducing external curing time requirement
- Reduced construction costs related to shorter curing requirements and improved project scheduling
- Reduced risk of cracking due to autogenous shrinkage in high-performance concrete bridge deck mixtures
- Increased durability of concrete bridge decks due to lower cracking, especially important as the use of deicing chemicals in the state of Oregon continues to increase
- Broad application of this technique to state-wide construction efforts both in bridge-decks and other high-performance concrete applications

**VIII. SUBMITTED BY**

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