NEW ENGLAND TRANSPORTATION CONSORTIUM

2019 RESEARCH PROBLEM STATEMENT SOLICITATON

Submit Research Problem Statements to: DOT Research Section by January 18, 2019

I. PROBLEM TITLE

Durability Testing of Closure Pour Materials.

II. RESEARCH PROBLEM STATEMENT

ABC projects utilizing precast elements are now common bridge designs. There has been significant research effort put towards the development of high performance materials to use for closure pours that provide high early strength to maintain shortened construction schedules. The most researched material, a proprietary UHPC, has been implemented in over 70 bridges (Perry (2018)). However, this material is not necessarily the ideal for this application due to the reliance on a proprietary material, requirement of specialized equipment and special handling, and the fact that use of UHPC cannot always maintain a tight construction schedule. Therefore there have been several regional, national and international studies to develop non-proprietary high early strength concretes for closure pours, both including and excluding fibers. Most New England states have developed mixture designs for closure pours that have implemented in bridge designs and tested for material properties and workability (Zhu and Ma (2018)), Brena et al. (2019)), though many being used but not reported in the literature. All of these mixtures aside from UHPC have been evaluated from a purely material perspective (workability, hardened properties, freeze thaw performance, etc.).

UHPC joints have also been tested in research to validate the system performance (rather than just material performance) with much of this work completed at the FHWA Turner Fairbanks Laboratory. Graybeal (2010 and 2011) tested proprietary UHPC longitudinal closure pour joints under eccentric cyclic load for implementation in a New York bridge. Aeleti et al. (2011) provided similar testing of transverse closure pours for implementation in an Iowa bridge. Haber and Graybeal (2018) reported results of cyclic bending tests on a transverse joint. Zhu et al (2012a and 2012b) reported static and fatigue tests on transverse and longitudinal joints, respectively, using a series of grout and HPC mixture designs for the closure pours (also reported in French et al (2011). The remainder of joint tests used static loading. Alkaysi and El-Tawil (2015) tested a non-proprietary UHPC joint with steel fibers in static flexure and shear tests, with static testing of transverse joints also tested in Deng et al. (2017).

Currently, the non-proprietary mixture designs developed by DOT's are more commonly used in closure pours. An issue that needs to be addressed is the long-term performance of closure pour materials in the context of the system performance. Currently results only exist for proprietary UHPC, so there is some uncertainty regarding how other mixtures will compare for long term durability. It is proposed that a series of tests be conducted to collect comparative data on the cyclic joint performance of multiple mixtures that are considered by New England DOT's for use in closure pours.

III. RESEARCH OBJECTIVES

The research shall experimentally compare the performance of existing closure pour mixture designs subjected to high cycle eccentric loading. Testing must be done in a similar state to the field implementation of a longitudinal closure pour between precast concrete elements, and account for the precast element/closure pour interactions. Direct comparison to FHWA tested UHPC materials should be considered.

IV. COST ESTIMATE

$185,000

V. RESEARCH PERIOD

24 months

VI. URGENCY AND PAYOFF POTENTIAL

All consortium members are utilizing ABC construction of precast elements with longitudinal or horizontal closure pours. Each state has tried multiple mixture designs for these closure pours, including UHPC and non-proprietary mixture designs. Currently, final decisions on which non-proprietary concrete mixture to use is based on characteristics specific to the closure pour material properties, but not necessarily related to long-term durability in a closure pour. Data related to how these mixtures compare in long term performance specific to the application will ensure durability and lower maintenance costs for these structures, with the potential of significant savings in maintenance cost of ABC structures, or in initial cost due to higher confidence in mixture designs that are ideally suited to ABC.

VII. PRELIMINARY LITERATURE SEARCH

A list of references are provided at the end of this document.

While there is significant literature on the development, material properties and applications of UHPC concrete, this is not directly relevant to this research project. The intention is to compare materials subjected to cyclic load in closure pour applications. Additional research is available that describes demonstration projects of ABC construction with closure pours, but these do not address long term performance.

Graybeal (2010 and 2011) tested proprietary UHPC longitudinal closure pour joints under eccentric cyclic load for implementation in a New York bridge. Aeleti et al. (2011) provided similar testing of transverse closure pours for implementation in an Iowa bridge. Haber and Graybeal (2018) reported results of cyclic bending tests on a transverse joint. Zhu et al (2012a and 2012b) reported static and fatigue tests on transverse and longitudinal joints, respectively, using a series of grout and HPC mixture designs for the closure pours (also reported in French et al (2011). The remainder of joint tests used static loading. Alkaysi and El-Tawil (2015) tested a non-proprietary UHPC joint with steel fibers in static flexure and shear tests, with static testing of longitudinal and transverse joints also tested in Deng et al. (2016 and 2017, respectively). Zhu et Al (2012) tested transverse closure pours loaded in pure tension for both static and fatigue loads.

VIII. RESEARCH KEY WORDS

Provide a list of key words that can be used to conduct an additional search of the TRID database for related research. To the maximum extent possible, key words should be selected from the Transportation Research Thesaurus (http://trt.trb.org/).

Closure Pour
Precast
Bridge
Experimental Testing
High Performance Concrete
ABC

TWO DOT ENDORSEMENTS ARE REQUIRED (To be signed by separate individuals.)

IX. ENDORSEMENT BY THE SPONSORING DOT

(To be signed by the DOT representative to the NETC Advisory Committee through whom the Problem Statement is submitted.)

By signing the endorsement, the DOT representative is certifying that:

1. *The Problem Statement follows the required format.*
2. *The required literature search has been conducted.*
3. *The Problem Statement addresses a transportation issue of relevance to NETC and does not duplicate another Problem Statement being submitted at this time.*

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A Emily Parkany	1/24/2019
Signature	Date

X. ENDORSEMENT BY A SECOND EMPLOYEE OF THE SPONSORING DOT who agrees to chair the project's technical advisory committee (TAC) if the Problem Statement is selected for funding.

(To be signed by a DOT staff person who has technical knowledge of the project topic and is committed to the research outcome.)

DOT Technical Endorsement: *I agree to chair the project's Technical Advisory Committee if this Problem Statement is selected for funding by NETC.*

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References:

Aaleti, Sriram R.; Sritharan, Sri; Bierwagen, Dean; Wipf, Terry J. Structural Behavior of Waffle Bridge Deck Panels and Connections of Precast Ultra-High-Performance Concrete. *Transportation Research Record: Journal of the Transportation Research Board*, Issue 2551, 2011, pp 82-92

Deng, Yaohua; Phares, Brent M; Putz, Andrew J; Carter, Curtis; Nop, Michael; Bierwagen, Dean. Performance Evaluation of Longitudinal Ultrahigh-Performance Concrete Closure Pour Connection for Use in Modular Bridge Construction: Pairwise Comparison of Capacity and Ductility at Failure Limit State. *Transportation Research Record: Journal of the Transportation Research Board*, Issue 2592, 2016, pp 65-75
https://trid.trb.org/view/1429248

Deng, Yaohua; Phares, Brent M; Putz, Andrew J; Carter, Curtis. Performance Evaluation of Transverse High-Performance Concrete Closure Pour Connection for Use in Modular Bridge Construction. *Transportation Research Record: Journal of the Transportation Research Board*, Issue 2642, 2017, pp 55-67
https://trid.trb.org/view/1438112

French, C E; Shield, C K; Klaseus, D; Smith, M; Eriksson, W; Ma, Z J; Zhu, Peng; Lewis, Samuel; Chapman, Cheryl E. Cast-in-Place Concrete Connections for Precast Deck Systems. NCHRP Web Document, Issue 173, 2011, 782p
https://trid.trb.org/view/1100465

Graybeal, Benjamin A. Behavior of Field-Cast Ultra-High Performance Concrete Bridge Deck Connections Under Cyclic and Static Structural Loading. Federal Highway Administration, 2010, 116p
https://trid.trb.org/view/1096600

Graybeal, Benjamin A. Fatigue Response in Bridge Deck Connection Composed of Field-Cast Ultra-High-Performance Concrete. Transportation Research Record: Journal of the Transportation Research Board, Issue 2251, 2011, pp 93-100
https://trid.trb.org/view/1093026

Haber, Zachary B; Graybeal, Benjamin A. Lap-Spliced Rebar Connections with UHPC Closures. Journal of Bridge Engineering, Volume 23, Issue 6, 2018, Content ID 04018028
https://trid.trb.org/view/1506154

Perry, V H. Ultra-high-performance-concrete Advancements and Industrialization - The Need for Standard Testing. Advances in Civil Engineering Materials, Volume 4, Issue 2, 2015, pp 1-16
https://trid.trb.org/view/1421507

Zhu, Peng; Ma, Zhongguo John; Cao, Qi; French, Catherine E.. Fatigue Evaluation of Transverse U-Bar Joint Details for Accelerated Bridge Construction. Journal of Bridge Engineering, Volume 17, Issue 2, 2012, pp 191-200
https://trid.trb.org/view/1135272

Zhu, Peng; Ma, Zhongguo John; French, Catherine E.. Fatigue Evaluation of Longitudinal U-Bar Joint Details for Accelerated Bridge Construction. Journal of Bridge Engineering, Volume 17, Issue 2, 2012, pp 201-210
https://trid.trb.org/view/1135273