

Abbreviated Work Plan

Waffle Panel Design:

The demonstration project in Wapello County is being designed by the Iowa Department of Transportation, and is scheduled to be completed by September 2010.

Formwork:

The approval of the form design is scheduled for June 2009 and the fabrication of the form is to be completed by July 2009. Some minor form modifications are anticipated following the specimen casting and prior to the demonstration panel casting.

Project Validation:

One 8 ft by 10 ft waffle slab will be fabricated, and will be load tested at Iowa State University to validate performance. Several instruments including strain gauges and displacement and rotation devices will be used to test the performance of the waffle panel under flexure and shear loading to simulate their expected behavior when supported between girders. Based on the test data, global and local responses of the panel will be quantified. As needed, the connection details to be used between two adjacent waffle panels will be tested.

Theoretical prediction of the behavior of the waffle slab will be carried out and correlation between the theoretical and experimental results will be drawn. Both flexure and shear component responses will be examined based on the current state-of-knowledge. As needed, corrections to the theoretical approaches will be revised based on the observed data. This component of the study will verify the assumptions used for the design of the waffle deck bridge.

This is to be completed during the months of September and October 2009.

Demonstration Project:

The Wapello County Bridge has been chosen as a demonstration project for this Application. The bridge is 33'-2" wide by 60'-0" long. The slabs will be supported on 5 "B" Beam girders spaced at 7'-4" with 1'-11" overhangs. The panels will be jointed at the crown longitudinally and will be filled UHPC concrete. UHPC concrete will be used to fill the transverse joints as well.

Design for the project is scheduled to be completed by December 2009 with project award in April 2010. Plant modifications to accommodate the casting of the demonstration project waffle slabs will take place during the months of December 2009 through February 2010. These modifications include:

1. Allocation and preparation of enclosed production space.
2. Installation of a curing system.
3. Modification of existing tilt table for the rotation of waffle slabs.
4. Construction lifting devices for moving and erecting waffle slabs from the edges (eliminating the need for lifting devices in the final wearing surface).
5. Allocation and preparation of an extended moist curing space.
6. Concrete delivery mechanism.

Casting of the waffle slabs for Wapello County will be completed in the months of March and April 2010. Bridge construction will take place in the months of April through August 2010.

In-Situ Testing and Evaluation:

A specific instrumentation plan will be developed to evaluate the structural performance of the bridge (specifically the waffle slab component) using strain, deflection and acceleration sensors. The laboratory testing results performed prior to the field test will also provide insight into developing the instrumentation plan. It is anticipated that the instrumentation plan will enable the evaluation of at least the following structural characteristics:

- Deck strain (stress) levels and load distribution
- Overall superstructure live load transverse distribution and strain (stress) levels
- Overall bridge superstructure deflections
- Bridge end member restraint
- Edge stiffening
- Dynamic amplification factor

After the bridge construction is completed, the instrumentation plan noted above will be implemented during the performance of a live load test to evaluate the structural performance of the bridge. This testing will provide insight into the validity of the bridge design assumptions and provide any identification of potential undesirable serviceability behavior. A second similar load test will be performed after the bridge has been in service for approximately 3 months to determine any potential changes in service behavior. A visual inspection will also be performed prior to each load test.

The testing (both static and dynamic) will be conducted with controlled live loads (at service level) using a typically loaded standard truck. A series of different transverse static load positions will be used to create worse case loading conditions in the waffle slab and the bridge. A series of dynamic tests will also be conducted to provide some quantification of bridge dynamic performance.

A final report will be completed detailing the findings from the in-situ testing. Also, design recommendations and production standards will be outlined in a separate document.

Testing Equipment and Plant Modifications:

Testing equipment is required to perform required physical testing of UHPC and will be purchased in Phase I during June 2009–prior to Specimen casting.

The anticipated equipment includes:

1. Flow table
2. Variable amplitude vibrating table
3. Molds for prisms and cylinders
4. Various hardware

Initial plant modifications are to take place in July and August 2009 and include the following:

1. UHPC premix delivery system to the mixer/truck
2. Fiber delivery system to the mixer/truck
3. rotation station
4. curing chamber
5. Grooming tools
6. (Use commercially available formliner)
7. Sure cure system

Life Cycle Cost Analysis – A LCC analysis will be provided for future projects and include within that analysis a discussion of the costs of first deployments (where fabrication facility construction costs would be included) and later deployment costs (with no fabrication facility construction costs).

Promotion and Awareness:

All project information, test results, reports and recommendations will be made available on FHWA Web Pages per Grant Requirements.

Regional and national marketing efforts will continue to increase awareness of the possibilities of UHPC Waffle Slabs.

COMMERCIALIZATION PLAN

Commercialization plan will be evaluated on sound business judgment at the conclusion on the FHWA HfL Grant

In addition to funding provided from FHWA Highways for Life Grant, ongoing investment will be evaluated and allocated based upon market demand. Coreslab Structures will actively seek financial and/or technical support as necessary from key strategic partners (e.g. FHWA, State DOTs, Lafarge North America, and PCI). Coreslab Structures will also pursue alternate project specific funding made available for innovative practices and sustainable infrastructure.

Coreslab Structures has adequate core manufacturing infrastructure and personnel, and can make the adjustments necessary in building capacity, equipment and labor force to support the full scale commercialization of the

UHPC Waffle Panels. Lafarge North America will offer application specific technical assistance for UHPC (e.g. selection of the correct UHPC product, selection of the implementation team, pre-qualifications, trouble-shooting, and project review and debriefing upon completion).

Market conditions are favorable for the commercialization of the UHPC Waffle Panels. In the U.S. today there are over 160,000 bridges that are structurally deficient or obsolete with more than 3,000 new bridges added each year.¹ UHPC Full Depth Waffle Deck Panels can be used for new construction as well as the rehabilitation of existing deteriorated bridge decks. A market opportunity clearly exists to address the common concerns that engineers, designers, and owners face during the construction or rehabilitation of bridges. The use of UHPC provides superior durability against chlorides, freeze-thaw effects, salt scaling, abrasion, accidental impact, fatigue and overload, thereby extending the useful life of the bridge deck.² Combining these positive attributes of UHPC and the efficiency of the Waffle Panel design provides an extremely durable option that enables longer spans, efficient use of materials, less weight, and faster construction to help meet the needs of the marketplace.

One of the key challenges facing the successful commercialization of the UHPC Waffle Panels is the product's acceptance from State DOTs, engineers, and owners without a proven "in use" performance history. State DOTs must be willing to take responsibility for a "new" material and product. In order to effectively address this concern, Coreslab Structures will focus on the expedient development of design and construction specifications as well as education materials including test results, inspection procedures, maintenance, and repair guidelines. External support from engineers, universities, and testing facilities will be needed to assist in the development of these resources. Coreslab Structures is positioned well to address these concerns due to its extensive experience in the Highway Construction Industry and its existing relationships with State DOTs, engineers, contractors, and universities. States such as Virginia, Florida, Iowa, and New York have already expressed interest in UHPC Waffle Panels. Coreslab Structures will seek to build upon that momentum by pursuing additional demonstration projects and making the test results available to industry decision makers and influencers.

Justification of substantially higher initial costs in comparison to other systems will also be a key challenge to overcome. The increased market focus on Life Cycle Costs will be essential to the commercialization efforts. Coreslab Structures will create a Life Cycle Cost Analysis to help justify the higher initial investment. Coreslab Structures will actively pursue support from organizations that promote the use of sustainable products (e.g. USGBC). Several market factors are favorable to the adoption and continued use of UHPC. The FHWA's continued interest in rebuilding the American transportation infrastructure using products that are durable and resistant to corrosion³, and a new Presidential Administration focused on providing

funding for infrastructure projects and sustainable design concepts to conserve resources and create jobs⁴ will all work collectively to create a favorable environment for UHPC Waffle Panels.

Coreslab Structures has several strengths that will enable the company to capitalize on the advantages of this new technology as well as overcome the challenges of implementation. The talents of the company's professional engineers, technical sales representatives, and marketing staff are readily accessible for the commercialization of this technology. Financial strength, strategic partnerships, the presence of existing sales channels into the target market, relationships with key decision makers and influencers, and the company's history of activity in the Highway Construction Industry will prove to be critical factors for the successful commercialization of Full Depth UHPC Waffle Bridge Deck Panels.

References:

¹ Bhide, S., *"Material Usage and Condition of Existing Bridges in the US"*, PCA, Skokie, Illinois USA, 2001.

² Publication No. FHWA-HRT-06-103.

³ Benjamin Tang, P.E. and Walter Podolny, Jr., Ph.D.,P.E. *"A Successful Beginning for Fiber Reinforced Polymer (FRP) Composite Materials in Bridge Applications"* (Published in the FHWA Proceedings, International Conference on Corrosion and Rehabilitation of Reinforced Concrete Structures, December 7-11, 1998, Orlando, FL.)

⁴ USGBC Advocacy & Policy Update, November, 2008.

AGC of America *"New President, New Congress, New Threats and Opportunities"*, November, 2008.