

State of Wisconsin/Department of Transportation
RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: Sept 30, 2006

Program: SPR-0010(36) FFY99		Part: II Research and Development	
Project Title: Specification and Design of Fiber Reinforced Bridge Deck Forms for use on Wide Flange T-Girders		Project ID: 0092-06-07	
Administrative Contact: James McDonnell		Sponsor: WHRP	
WisDOT Technical Contact: Scot Becker		Approved Starting Date: 10/3/2005	
Approved by COR/Steering Committee: \$94,735		Approved Ending Date: 10/2/2007	
Project Investigator (agency & contact): Lawrence C. Bank, UW-Madison			

Percent Complete: 68%

Project Description:

Wide-flange W54 and W72 prestressed concrete girders are currently being used in Wisconsin for highway bridge construction. As the spans get longer the spacing between the girders gets smaller to carry the required dead and live load moment on the bridge. The use of permanent, stay-in-place forms made of fiber materials (i.e., not made of plywood) may be able to provide significant benefits in terms of constructability for Wisconsin wide-flange bridges. Benefits should accrue from decreased costs of materials, decreased cost of labor, and decreased costs due to shorter construction times. These will accrue from the fact that no formwork will need to be manually constructed before deck casting and stripped after deck placement (labor savings), shallow haunches can be used since standard haunching hardware will not be required (saving on concrete material quantity), and that permanent forms will be quicker to install than conventional systems (saving in construction time).

This research investigation will evaluate a number of different fiber reinforced deck forming materials and systems. Experimental load testing and tests of specific haunching and lapping details of selected systems will be conducted at the University of Wisconsin. Based on the results of these tests, numerical finite element analyses, and economic cost/benefit analysis recommendations will be made to the WisDOT for the preferred system(s) to be used in Wisconsin. Specifications and design guidelines compatible with the Wisconsin Bridge Manual will be developed for use by WisDOT.

Specific research objectives are as follows:

1. To investigate different material systems that can be used for fiber reinforced bridge deck forms for short spans (1 – 4 ft). Variables will consist of material type, manufacturing method, cost, availability, and durability. Bridge contractors in WI will be consulted as to their current and preferred systems to ensure close coordination with industry practices and to obtain cost figures.
2. To conduct physical experiments on prototype fiber reinforced deck forms made of different material systems to determine their stiffness, load carrying capacity and failure modes.
3. To develop and compare methods of placing, supporting and attaching different types of bridge deck forms to the flanges of T-girders. Experiments will be conducted to assess the constructability of different haunching or tie down details.
4. To develop a standard material and/or performance specifications for different deck form systems. The specifications will be of the form appropriate for Contract Documents and will include quality control and quality assurance provisions.
5. To develop design standards for WisDOT for different types of fiber reinforced bridge deck forms. The designs will be compatible with the Bureau of Structures Bridge Manual. The design standards will allow designers to select and specify the most suitable form system for a specific application (gap

span, deck type, durability requirement, cost)

Progress This Quarter:

(Includes project committee mtgs, work plan status, contract status, significant progress, etc.)

Task 1: Advisory Group

A project advisory group was established the last quarter of 2005 which consisted of local bridge contractors, pre-casting companies and suppliers.. The advisory group is scheduled to meet periodically to review the progress of the project and to guide the researchers in their studies. For this quarter, discussions were held with the following members of the advisory group

- Zenith Tech Inc.
- Nippon Electric Glass America

In addition to the above, valuable information for the research was gathered from the following local suppliers / Contractors.

- D&S Pre-stressing
- Propex Concrete Systems
- Saint Gobain

Task 2 –Current State of Art in Wisconsin and Literature review

Our previous literature review had identified three major types of SIP form as listed below. The decision was based on availability of the systems, manufacturing, costs, constructability and prior use or experience with the system. Further down-selection is possible once economic/constructability analysis is carried out in the later stage of the research.

TYPE 1: FRP Pultruded Section

TYPE 2: FRP reinforced SIP Forms

- a) Textile fiber cements,
- b) FRP rebar reinforced concrete,
- c) FRP thin-grid reinforced concrete

TYPE 3: Fiber reinforced cements

- a) Pre-mix FRC SIP (1in. – 1.5in)
- b) Spray-on GFRC or “Off the shelf” system (<1 in.)
- c) Corrugated/ Stiffened “Spray-On” GFRC (<1 in.)
- d) Other “Off the shelf” systems

Most of the literature review this quarter was focused on the use of fiber reinforced concrete and understanding the strength, ductility and impact properties of introducing fibers in concrete. Literature review on various test methods for evaluating these properties is currently ongoing with the intention of testing in the Laboratory in the near future.

Task 3 – Selection of fiber reinforced systems for further study

In this quarter a very preliminary attempt was made to get some cost data for the various formwork systems and compare them. No specific comparison can be made at this time as the comparison only involves material cost comparison of the various reinforcement system used in a 1.5 inch thick section. Cost comparisons are made with respect to the factored moment capacity available (See Attachment-1). It is our intention to use steel reinforced section and steel fiber reinforced section as a benchmark for comparison in terms of flexure performance, ductility, impact characteristics and the overall associated costs.

Task 4 – Tests and analysis of selected fiber reinforced forms

Substantial collection of specimens and casting of new specimens have been performed in the laboratory this quarter in preparation for testing and data analysis in the next quarter. Specimens cast in Mosinee (28 June 2006) were collected to be stored in the WSTML for further testing (See attachment 2 for pictures).

The following standard flexure specimens were cast in the laboratory for testing to ASTM C1018 on 1st Sept 2006 (See attachment-3).

1. None – Plain Concrete
2. Concrete with glass fibers (0.5% by volume)
3. #2 Aslan 100 FRP Reinforcement Bar
4. LW 110 (Nippon Electric Glass)
5. LW 110 (Nippon Electric Glass) - No Cover
6. TD 5x5 (Nippon Electric Glass)
7. TD 5x5 (Nippon Electric Glass) – No Cover
8. SRG 45 (Saint Gobain)
9. C3000 (TechFab)
10. C5500 (TechFab)
11. G2800 (TechFab)

The following full size formwork panels were cast in the laboratory on 29 Sept 2006 together with 4x12 control flexure specimens with the intention for impact testing in the next quarter (See attachment-4). A total of 2 specimens were cast for each of the full sized panels.

1. W2 Steel Mesh
2. SRG-45 FRP grid reinforcement

Two “off-the-shelf” products were carefully reviewed for potential application as bridge deck formwork. Numerous experiments were performed to characterize their failure behavior as well as their durability performance. “DuRock Cement board” and “Fortacrete panel” from US Gypsum were studied in detail and the summary of the test results are summarized in Attachments -5, 6 & 7. Attachment-5 details the test works for the Durock board while attachment 6 & 7 summarizes results for Fortacrete panels.

Work Next Quarter:

Type-1 SIP Form: FRP Pultruded Section

Further testing will be carried out to provide more data for the buckling behavior of the SAFPlank system. The experimental buckling behavior will be used to establish the upper bound to the ultimate capacity of the section. Finite element analysis on the SAFPlank will be carried out to compare the buckling behavior to those observed experimentally.

Type-2 SIP Form: FRP reinforced SIP Forms

Analytical and experimental studies shall be carried out on all the three sub-systems in this category. Analysis will utilize the current code of practice/design guide to determine the applicability of the three systems for various span ranges based on serviceability and ultimate limit state criterion. Extensive testing works will be carried out on the 20 nos. of samples that has been cast in Mosinee (Attachment-2) in order to characterize its strength / impact properties.

Type-3 SIP Form: Fiber reinforced cements

Type 3a: Pre-mix FRC SIP Form (1in. – 1.5in.)

Concrete samples used for existing bridge SIP form (Obtained from Zenith Tech and Lunda Construction) will be cut to the required size and tested to ASTM C1018 to complete the characterization of the flexural behavior that is currently ongoing.

Energy absorption and ductility properties will be calculated for these forms. Impact testing will also be conducted by the drop weight method described by Reinhardt (2000). Analysis based on the current available design guide will be carried out to establish the flexural strength of the FRC SIP form for all the various systems studied.

Type 3b: Spray-on GFRC or “Off the shelf” system (<1in.)

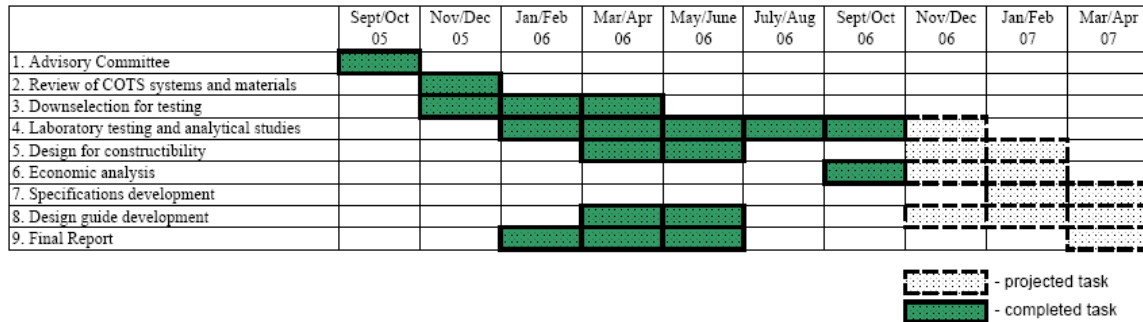
None

Type 3c: Corrugated/Stiffened “Spray-On” GFRC (<1in.)

Analytical studies shall be carried out on corrugated GFRC shapes to determine an ideal shape for manufacturing purpose based on a range of spans. Contact shall be made with a local pre-caster for possible manufacture for our testing.

Circumstances Affecting Progress/Budget: None

Gantt Chart:



Attachments included with this report

- Attachment 1 – Preliminary Cost Comparison
- Attachment 2 – Collection of specimens from Mosinee
- Attachment 3 – Casting of specimens at WSTML (1st Sept 2006)
- Attachment 4 – Casting of specimens at WSTML (29th Sept 2006)
- Attachment 5 – Summary of test results on Durock Board
- Attachment 6 – Summary of test results on dry Fortacrete Panel
- Attachment 7 – Summary of test results on wet Fortacrete Panel